Energy System Modelling for Green Development of Africa

Grant Agreement N° 101118278

D1.1 – Knowledge Base and Engagement Methodology

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D1.1 – Knowledge Base and Engagement Methodology

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Executive summary

Deliverable 1.1, titled "Knowledge Base and Engagement Methodology," serves as a foundational element of the EMERGE project, which aims to support the green transition in several African regions by developing innovative energy system modelling tools. The deliverable focuses on two key areas: the creation of a comprehensive Knowledge Base and the design of a Stakeholder Engagement Methodology, both tailored to the needs of experts and relevant stakeholders.

The Knowledge Base is designed to centralize all relevant information, tools, and best practices regarding energy system modelling, providing project members and external stakeholders with access to crucial resources. This will facilitate collaboration, enhance decision-making, and support the growth of a community of energy system modelling experts.

In parallel, the Stakeholder Engagement Methodology is developed to ensure that stakeholder perspectives are integrated throughout the project. By incorporating input from diverse stakeholders—ranging from regulatory bodies to local communities—the project aims to align its outcomes with broader societal needs and the unique challenges faced by African countries during the energy transition.

The deliverable also draws from past projects, such as LEAP-RE, FOCUS-Africa, and others, to identify effective methods for stakeholder engagement and value-based proposition design. It outlines a strategy that fosters collaboration, co-creation, and knowledge exchange, ensuring that the project's objectives are met through the active involvement of its stakeholders.

Looking forward, the Knowledge Base will continue to evolve and expand as more data and insights are collected through the project's activities, particularly during the implementation of pilot programs. These pilots will provide real-world feedback that will help refine the tools and methodologies developed, ensuring they are effective in addressing the specific energy system challenges faced by African countries. Additionally, the Stakeholder Engagement Methodology will remain a dynamic process, adapting to new feedback and ensuring that stakeholders are consistently involved in co-creating solutions that meet their needs.

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Abbreviations

Abbreviation	Definition
AfriLabs	African Technology Innovation Hubs
AI	Artificial Intelligence
AR	Augmented reality
AU	African Union
CAPEX	Capital expenditures
CSA	Common System Architecture
D	Deliverable
D&C	Dissemination and communication
DFI	Development Finance Institutions
D4D	Digital for development
ECREEE	Ecowas Centre for Renewable Energy and Energy Efficiency
EIB	European Investment Bank
EU	European Union
EUMS	European Union Military Staff
GDPR	General Regulation on the Protection of Personal Data
GHG	Greenhouse gases
IoT	Internet of things
IRR	Internal rate of return
LEAP-RE	Long-Term Joint European Union - African Union Research and Innovation Partnership on Renewable Energy
LGEM	Electrical Engineering and Maintenance Laboratory
GIS	Geographic Information Systems
GPS	Global Positioning System
MEL	Monitoring, evaluation and learning
ML	Machine learning
NPV	Net present value
ODK	Open Data Kit
OPEX	Operating expenses
PV	Photovoltaic
SADC	Southern African Development Community
SSH	Secure Socket Shell
T	Task
UEM	Universidade Eduardo Mondlane
UMP	Mohammed Premier University
UNIZAG	University of Zagreb – Faculty of Mechanical Engineering and Naval Architecture
WP	Work Package
VR	Virtual reality

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1. Introduction

1.1. Objectives

The EMERGE project aims to develop tools and methods contributing to solve some of the challenges related to the green transition in several African regions. Deliverable 1.1, titled "Knowledge Base and Engagement Methodology," is a critical milestone in laying the groundwork for further accomplishments in the project. The subject of this deliverable will be to design a Knowledge Base and a stakeholder engagement methodology, both tailored to meet the needs of experts and stakeholders involved in the project.

The primary objectives of Deliverable 1.1 are:

- To map and define the Stakeholder Groups which aims at identifying and categorizing relevant stakeholders that are project members or external entities, who will play a crucial role in the creation of a community of energy system modelling experts.
- To develop a comprehensive Knowledge Base that will serve as a central repository of information, tools, and best practices related to energy system modelling, with a focus on meeting the needs of stakeholders identified in the project.
- To design a stakeholder engagement methodology that integrates the wishes, needs, and recommendations of stakeholders, ensuring their active involvement and reflecting their input in the project's outcomes.
- To incorporate societal values by identifying and addressing the values and needs of communities and citizens, beyond just financial considerations, to ensure the project's outputs are aligned with broader societal goals.

1.2. Structure of the document

This document is organized into several sections, each addressing a specific aspect of the deliverable:

- Section 1: This section introduces the objectives of the deliverable, the structure of the document, the contribution of the participating partners to this deliverable and the relationship with the other project tasks.
- Section 2: Initial Stakeholders' Engagement details the process of categorizing stakeholders, conducting initial surveys to identify their needs, and organizing an initial stakeholder engagement workshop.
- Section 3: Knowledge Base elaborates on the objectives and goals of the Knowledge Base, its conceptual framework, the organization of information, and the interaction between the Knowledge Base operator and users.
- Section 4: Stakeholder Engagement Methodology and Value-Based Proposition Design presents the methodology for engagement, including a summary of relevant practices from past and current projects, the selection of methodologies and tools, and the design of the initial version of the EMERGE stakeholder engagement methodology.
- Section 5: Conclusion and Future Steps provides a summary of the deliverable and outlines the next steps in the project.
- Section 6: This section lists all the references used in the document, providing a complete bibliography of sources.

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- Section 7: This section provides textual version of the initial stakeholders survey and reports from the initial stakeholders workshops in pilot locations.

1.3. Contribution of partners

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

Table 1 Table of contributing partners

Partner	Short name	Country
University of Zagreb – Faculty of Mechanical Engineering and Naval Architecture	UNIZAG	Croatia (HR)
EnGreen Srl	EnGreen	Italy (IT)
Fundación CARTIF	CARTIF	Spain (ES)
Fundación CIRCE	CIRCE	Spain (ES)
Artelys	Artelys	France (FR)
African Technology Innovation Hubs	AfriLabs	Nigeria (NI)
European Sustainable Energy Innovation Alliance	ESEIA	Austria (AT)
Ecowas Centre for Renewable Energy and Energy Efficiency	ECREEE	Cape Verde (CV)
Universidade Eduardo Mondlane	UEM	Mozambique (MZ)
Brain Information Technologies	BrainIT	Croatia (HR)
Universite Mohammed Premier 1	UMP	Morocco (MO)

- **UNIZAG FSB**: prepared the structure and main content of this deliverable as a leader of the T1.1. and WP1. It summarised the results of the initial stakeholder's survey and finalised the document.
- **UMP, ECREEE and UEM**: organised stakeholder's workshops and summarised the workshops reports related to the three use cases (North-West Africa: Morocco, South-East Africa: Mozambique, river basin) as leaders of tasks: T5.2, T5.3 and T5.4 respectively.
- **ENGREEN:** supported the definition of EMERGE stakeholder engagement strategy, as leader of task: T4.1 Co-design of user engagement for capacity building.
- **CARTIF and BRAINIT** elaborated the objectives and goals of the Knowledge Base, its conceptual framework, the organization of information, and the interaction between the Knowledge Base operator and users.
- **UEM**: drafted the Stakeholder Engagement Methodology and Value-Based Proposition Design which presents the methodology for engagement, including a summary of relevant practices from past and current projects, the selection of methodologies and tools, and the design of the initial version of the EMERGE stakeholder engagement methodology
- **UMP** and **BRAINIT** as deliverable content reviewers.

1.4. Relation to other tasks

Deliverable 1.1 is deeply interconnected with several other tasks and work packages within the EMERGE project, playing a pivotal role in shaping the project's direction and outcomes. This deliverable not only sets the foundation by defining the Stakeholder Group and creating the Knowledge Base but also directly supports the activities in other crucial tasks.

Task 1.1, which focuses on the Knowledge Base and Stakeholder Group definition, is directly addressed by this deliverable. The stakeholder engagement methodology developed here is closely tied to Task 1.2, where insights from previous projects are analysed to inform the engagement strategy. Additionally, Task 1.3, which deals with identifying and integrating methodologies and tools, and Task

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1.4, which focuses on innovative approaches to energy system modelling, both draw on the foundational work done in this deliverable.

Task 2.4 is also relevant, as the Knowledge Base will serve as a critical resource in gathering and organizing the data required for energy system modelling. The engagement strategies outlined in this deliverable will guide ongoing activities in Task 4.2, ensuring that stakeholder feedback is continuously integrated into the project's development process. Furthermore, Task 6.1, which involves dissemination and communication activities, will rely on the engagement methodologies established here to effectively reach and involve the broader stakeholder community.

In terms of work packages, Deliverable 1.1 has strong connections with WP2, WP3, and WP4. WP2 aims to develop a Common System Architecture (CSA) for the EMERGE Toolbox, addressing African-specific energy challenges and opportunities by integrating economic, social, environmental, and technical parameters into energy system models, informed by policy, regulatory insights, and stakeholder engagement, to maximize cross-sectoral synergies and overall social welfare. WP3, which deals with the development of innovative tools and models, will benefit from the Knowledge Base and methodologies developed here, ensuring that these tools are grounded in practical needs and expert input. WP4, which centres on stakeholder collaboration and value proposition development, will directly utilize the engagement strategies and Knowledge Base to foster effective collaboration and co-creation among project participants.

By establishing these interconnections, Deliverable 1.1 ensures that the project's foundational elements are well-aligned with the broader objectives and tasks of the EMERGE project, providing a cohesive approach to achieving impactful and sustainable outcomes.

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2. Initial stakeholders' engagement

Effective stakeholder engagement is essential for the success of the EMERGE project, as it ensures that the project's outcomes are aligned with the needs and expectations of those who will be most affected by its results. This section outlines the initial steps taken to engage stakeholders, including the categorization of stakeholders, the design and execution of an initial survey to identify their needs, and the organization of a workshop to facilitate deeper engagement and collaboration.

2.1. Categorizing the stakeholders

The first step in the stakeholder engagement process involved categorizing the stakeholders to better understand their roles, interests, and potential contributions to the project. Stakeholders were mapped and classified into several categories based on their relationship to the project, including Academia & Research, Policy makers, Investors and Civil society. This categorization was crucial for tailoring the engagement strategy to address the specific needs and interests of each group, ensuring that their perspectives are adequately represented in the project.

Mozambique site

Academia, Research	Policy makers	Investors	Civil society
Universidade do Save	National Directorate of Energy / Ministry of Natural Resource and Energy (DNE / MIREME)	The World Bank (WB)	Associação de Energias Renováveis em Moçambique (AMER)
Instituto Politécnico do Songo	National Directorate of Planning and Cooperation (DPC / MIREME)	The European Union (EU)	KULIMA - integrated Socio - Economic development
	Energy Regulatory Authority (ARENE)	African Development Bank (AfDB)	Coordinamento delle Organizzazioni per ill Servizio Volontario (COSV)
	Ministry of Economies and Finance (MEF)	Confederação das Associações Económicas de Moçambique (CTA)	CNetherlands Development Organization (SNV)
	Electriciade de Moçambique (EDM) - the tional power utility		HELPCODE
	National Energy Fund (FUNAE)		LVIA

Figure 1 Stakeholder identification and categorization in Mozambique site

Morocco site

Academia, Research	Policy makers	Investors	Civil society
University Mohammed First UMP	Ministry of Energy Transition and Sustainable Development	CDG	Municipality of Oujda
	National office of Water and Electricity ONEE	Government	Oriental Regional Council
	Solar Energy and New Energies Research Institute - IRESEN	National office of Water and Electricity ONEE	
	Masen - Group	Solar Energy and New Energies Research Institute - IRESEN	
	Multi-service regional companies	Banks	

Figure 2 Stakeholder identification and categorization in Morocco site

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Niger basin site

Academia, Research	Policy makers	Investors	Civil society
Faculty of Science and Technology (FST Ecole Nationale d'Ingenieurs Abderhamane Baba Touré (ENI-ABT) IPR-IFRA	The National Energy Directorate of Mali (DNE), The Malian Agency for the Development of Domestic Energy and Rural Electrification (AMADER), The National Agency for Biofuels Development (ANADEB), Renewable Energies Agency (AER) National Commission for Renewable Energies (CER) The General Directorate of Water and Forests (DGEF), The Niger River Basin Agency (ABFN) The National Hydraulic Directorate (DNH), Electricity and Water Regulation Commission (CREE) AEDD	African Development Bank (AfDB), EU, BAD, GIZ, World Bank, UNDP, BIDC, BOAD, AFD, USAID, UEMOA, UA, ECOWAS	Local Water Committee (CLE) The local Chamber of Agriculture (CLA) Permanent Assembly of the Chambers of Agriculture of Mali (APCAM) The National Coordination of Users of Natural Resources in the Niger Basin in Mali (CNU-Mali),

Figure 3 Stakeholder identification and categorization in Niger river basin site

Figures 1, 2, and 3 present the categorization of the stakeholders from pilot sites. Academia and research institutions provide the technical expertise and analytical skills necessary for developing and validating energy models. Civil society represents community interests, ensuring that the models address social and environmental concerns. Policymakers are instrumental in integrating the models into national energy strategies and policies, while investors provide the financial resources needed for implementing and scaling energy solutions.

2.2. Initial survey for identification of stakeholder needs

Effective stakeholder engagement is pivotal for the success of energy modelling initiatives. It ensures that the models are grounded in reality, addressing the actual needs and constraints of different communities and regions. In the project, a mixed-methods approach for stakeholder engagement was employed to capture the diverse and multifaceted viewpoints of stakeholders. This approach combined an initial survey, complemented by qualitative interviews and focus group discussions, providing a comprehensive understanding of the energy landscape. The primary objective of the data collection process was to understand the energy needs and priorities of different regions and communities, assess current energy practices, facilitate stakeholder collaboration, and gather insights for policy recommendations. Quantitative surveys provided a statistical basis for understanding common trends and issues related to energy needs and priorities. These surveys were complemented by qualitative interviews and focus group discussions, which offered deeper insights into specific challenges and opportunities faced by different stakeholder groups. The discussions, as well as the process of filling out the survey, were held during the workshops in all three countries that were selected as case studies. Workshop in Mozambique took place on 24th of April 2024, workshop in Morocco was held on 25th of May 2024, while the workshop in Mali on 12th and 13th of June 2024.

The initial survey, which can be found in Annex, was conducted to gather detailed insights into the needs, expectations, and concerns of the identified stakeholders. This survey aimed to capture a broad range of inputs from stakeholders and was made of 6 different categories: Data collection; Energy markets; Regulatory, administrative and legal support; Infrastructure aspects; Methods and technical

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and financial tools; Value and needs of citizens and communities on a social level. The survey results provided a valuable foundation for understanding the specific challenges and opportunities that stakeholders face, informing the development of both the Knowledge Base and the engagement methodology.

The results highlight key differences and similarities in stakeholder perspectives across these regions, reflecting the diverse social, environmental, and economic contexts within the African Union. Across all three regions, the integration of social values into energy system models is paramount, but the emphasis differs based on local conditions. Environmental sustainability is a shared priority, aligning with global efforts to mitigate climate change. However, the focus on energy resilience in Morocco, contrasted with the emphasis on community engagement and empowerment in Mozambique and Mali, suggests that energy system models must be adaptable to regional needs. Morocco's focus on resilience likely stems from its more advanced energy infrastructure and the need to ensure stability, while the emphasis on empowerment in Mozambique and Mali indicates a pressing need to involve communities in the decision-making process, addressing issues of equity and social justice.

The results also reveal varying degrees of attention to environmental and social justice considerations across the regions. Morocco's holistic approach, which includes considerations of greenhouse gas emissions, water consumption, and ecosystem impacts, contrasts with Mozambique's focus on gender equity and the Mali's emphasis on local economic development. These differences highlight the necessity of customizing energy system models to address the specific environmental and social challenges faced by each region. This regional customization is essential for ensuring that energy transitions are not only technically sound but also socially inclusive and environmentally sustainable. In terms of capacity building, the results identify significant regional disparities in anticipated growth and the associated needs for capacity development. Morocco's focus on collaboration, knowledge sharing, and access to data reflects a more advanced stage in its energy transition, where the enhancement of existing systems is critical. Conversely, Mozambique and Mali demonstrate a need for more fundamental capacity-building initiatives, particularly in strengthening institutional frameworks and engaging local communities. This disparity underscores the importance of a tailored approach to capacity building that addresses the specific needs of each region, ensuring that all stakeholders can effectively contribute to and benefit from the energy transition. Engagement with local communities emerges as a critical factor across all regions, with varying approaches suggested for ensuring active participation in the energy system modelling process. While Morocco emphasizes the use of digital tools and communication strategies to mobilize communities, Mozambique and Mali highlight the importance of public consultations, hearings, and the involvement of local leaders.

These findings suggest that successful energy transition efforts in the African Union will require flexible engagement strategies that consider local communication preferences and cultural contexts. The findings also underscore the importance of a nuanced, region-specific approach to energy system modelling within the African Union, guided by the Quadruple Helix framework. By integrating the perspectives of government, industry, academia, and civil society, energy models can better reflect the diverse needs and values of stakeholders across different regions.

A tabular presentation of results and discussion is presented below for every section of the survey.

2.2.1. Data collection for energy modelling stakeholder views

This analysis focuses on several key aspects, including involvement in energy system modelling, data collection and management methods, crucial data types for modelling, challenges in acquiring reliable data, needs for model creation or expansion, and reliance on specific data sources or databases. Stakeholders across Morocco, Mozambique, and the Niger River Basin in Mali are similarly involved in

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energy system modelling. They engage in activities like research, consulting, and participating in government initiatives. Despite regional differences, this consistent involvement shows a widespread recognition of the importance of collaboration in developing comprehensive energy models. In all regions, stakeholders use a mix of government databases, public data sources, and modern technologies like IoT devices for data collection. This approach underscores the importance of both traditional and advanced methods. However, the reliance on publicly accessible data highlights potential vulnerabilities, particularly if these sources are limited or outdated. The types of data considered essential are consistent across regions, with a focus on energy production, infrastructure, weather, market prices, and policy information. However, slight differences in prioritization reflect local needs; for instance, Mozambique places higher importance on policy data, indicating a need for regulatory clarity. All regions face similar challenges, including limited data access, high costs, and reluctance from data suppliers. These common barriers highlight the need for improved data governance and infrastructure across Africa. The impact of these challenges may vary depending on local technological and economic conditions. These main results as well as topics for discussion are shown in Figure 4.

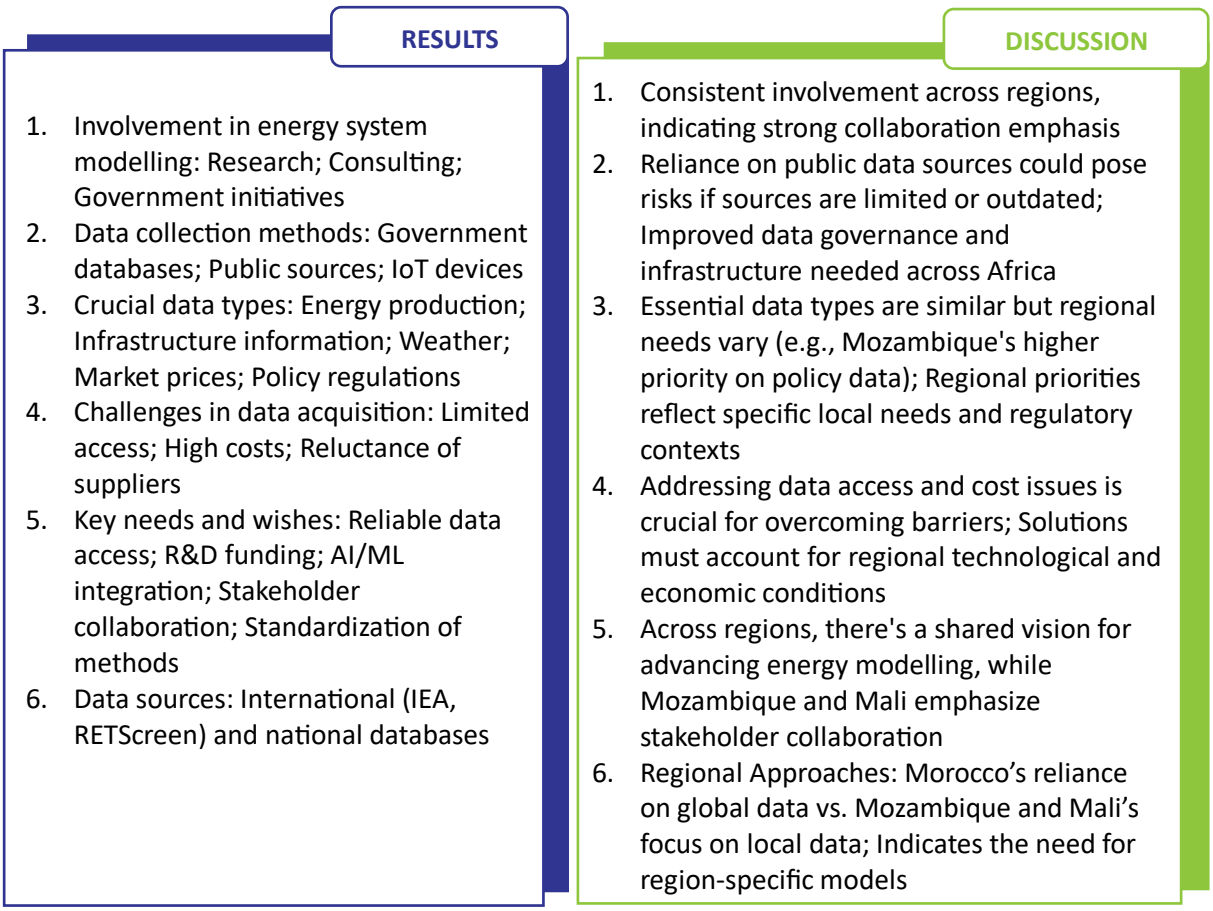

Figure 4 Main conclusions for the data collection in energy modelling

Stakeholders share common needs: access to reliable data, financial support, collaboration opportunities, and the use of advanced technologies like AI. These needs reflect a shared vision for advancing energy modelling across Africa, though the emphasis on collaboration in Mozambique and the Niger River Basin in Mali suggests a greater need for partnerships. There are regional differences in data sources. Morocco relies on international databases like RETScreen, while Mozambique and the Niger River Basin in Mali use more localized data. These differences reflect the varying levels of data infrastructure and the specific needs of each region, with Morocco possibly having more access to

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global resources due to its more developed energy sector. In summary, while the regions face similar challenges and share common goals, there are important differences in their approaches to energy modelling. Morocco's reliance on global data systems contrasts with Mozambique and Mali's focus on local data, highlighting the need for region-specific models and greater collaboration to overcome shared challenges.

2.2.2. Energy markets for energy modelling stakeholder views

Stakeholders in all three regions agree on the importance of incorporating several market trends into energy system models and the main results and topics for discussion are presented in Figure 5. These include technological advancements in energy production and distribution, fluctuations in energy prices driven by supply and demand, and shifts in consumer preferences towards renewable energy.

RESULTS

1. Influence of energy markets: Energy markets influence models by providing critical data on supply, demand, and price dynamics; Market regulations and policies are key factors shaping the inputs and outputs models
2. Key market trends: Energy price fluctuations driven by supply-demand dynamics are crucial; Technological developments in energy production and distribution are essential to incorporate
3. Adapting to market dynamics: Integration of ML for dynamic model calibration and updating; Use of real-time data to mirror current market conditions; Scenario analysis to anticipate and respond to market fluctuations
4. Optimizing market operations: Models forecast energy demand and supply, aiding in efficient resource allocation; They identify cost reduction and revenue generation opportunities through optimization

DISCUSSION

1. Across all regions, energy markets significantly shape the inputs and outputs of energy system models. However, Morocco's more established market structures may allow for more detailed and dynamic modelling compared to Mozambique and Mali, where regulatory influences and market inefficiencies play central role
2. Technological advancements and consumer behavior shifts are universally recognized as critical; Morocco's focus on integrating these trends may be more advanced due to its more mature energy market; Mozambique and Mali, while also recognizing these trends, may be more constrained by infrastructural and market maturity challenges
3. Morocco appears to be leading in integrating machine learning and real-time data, which could indicate a more advanced approach to dynamic market adaptation; Mozambique and Mali are also adapting, but may face greater challenges due to less developed data infrastructure and market dynamics
4. All regions focus on forecasting and cost optimization, but Morocco's more developed grid infrastructure likely allows for greater emphasis on improving network stability; Mozambique and Mali, while equally concerned with efficiency, may prioritize resource allocation due to more pressing infrastructural needs

Figure 5 Main conclusions for the energy markets in energy modelling

The uniformity in these concerns across the regions highlights a shared recognition of the need for models that can adapt to evolving market conditions and technological innovations. To adapt to changes in market dynamics, stakeholders in Morocco, Mozambique, and the Niger River Basin in Mali suggest the integration of machine learning algorithms for dynamic model calibration and the inclusion

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of real-time data to better reflect current market conditions. Additionally, implementing scenario analysis is seen as essential for anticipating and responding to market fluctuations. This approach emphasizes the need for energy models to be not only reactive but also predictive, enabling them to better manage uncertainty in energy markets.

Energy system models play a critical role in optimizing market operations and efficiency in these regions. By forecasting energy demand and supply, they facilitate more efficient resource allocation. Additionally, these models can identify opportunities for cost reduction and revenue generation through market optimization. Improving network stability and reliability by simulating various operating scenarios is another significant contribution, ensuring that energy systems remain robust under different conditions. The analysis reveals a consistent understanding across Morocco, Mozambique, and the Niger River Basin in Mali of how energy system models and markets interact.

Despite regional differences, there is a shared emphasis on the need for energy models to be closely integrated with real market data, adapt to dynamic conditions, and contribute to market efficiency. This commonality reflects the broader challenges and opportunities faced by African countries as they work to develop sustainable and efficient energy systems.

2.2.3. Regulatory, administrative and legal support for energy modelling stakeholder views

Stakeholders across Morocco, Mozambique, and the Niger River Basin in Mali identified several key areas of regulatory, administrative, and legal support necessary for the success of energy system modelling projects shown in Figure 6. Clear and streamlined regulatory processes for data acquisition and sharing were universally seen as essential, ensuring that models have access to the necessary data without unnecessary bureaucratic delays. Adequate funding mechanisms were also highlighted as crucial across all regions, reflecting the need for financial support to drive modelling initiatives.

Furthermore, collaboration between regulators and industry stakeholders is necessary to address regulatory gaps, with legal frameworks ensuring the protection of intellectual property and data privacy. Standardized administrative procedures for project approval and implementation were also emphasized as important for reducing the time and complexity involved in launching modelling projects. The regulatory hurdles encountered by stakeholders are consistent across the regions, with limited access to essential data due to regulatory constraints being a common issue. Complex licensing requirements for proprietary software tools also pose significant barriers, potentially limiting the capabilities of the models. Additionally, unclear regulatory guidelines for integrating renewable energy sources into models were identified as a challenge, pointing to the need for more precise and supportive regulations in this area.

Administrative hurdles, such as lengthy permit and approval procedures for data acquisition, were consistently cited as obstacles across all regions. The lack of standardized protocols for sharing data between organizations further complicates efforts, as does the complexity of bureaucratic requirements for securing project funding and grants. These challenges highlight the need for streamlined administrative processes to facilitate smoother project implementation. Legal considerations that need more attention or clarification include intellectual property protection, data privacy, and transparency in regulatory processes.

In Morocco, stakeholders also pointed out the importance of collaboration with legal experts to navigate these challenges effectively. Mozambique highlighted the need for more attention to privacy and data protection issues, reflecting a broader concern about safeguarding sensitive information. To better support the development and deployment of energy system models, stakeholders across the regions suggested increased collaboration between regulators and industry players. This collaboration

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would help bridge the gap between regulatory needs and industry capabilities. Implementing flexible regulations that can adapt to evolving technology was also seen as crucial, ensuring that the regulatory environment remains conducive to innovation. Providing incentives for research and development in energy modelling was another common recommendation, indicating a need for policies that actively promote the advancement of energy system models.

RESULTS

1. Necessary support for modelling: All regions emphasize the need for clear regulatory processes for data acquisition and sharing; Adequate funding mechanisms are considered crucial; Collaboration between regulators and industry stakeholders is necessary
2. Regulatory barriers encountered: Limited access to essential data due to regulatory constraints; Complex licensing requirements for using proprietary software tools
3. Administrative Challenges: Lengthy permit and approval procedures for data acquisition are major obstacles across all regions; Complex bureaucratic requirements for project funding slow down progress
4. Improving regulatory frameworks: Increased collaboration between regulators and industry players is key to overcoming current regulatory barriers; Implementing flexible regulations that can adapt to evolving technologies is a shared priority innovation

DISCUSSION

1. All regions recognize the need for clear regulatory processes and funding; Morocco, with a more mature legal framework, may experience fewer barriers compared to Mozambique and Mali, where regulatory gaps and funding challenges are more pronounced
2. Data access and licensing issues are common across regions; However, Morocco's relatively more developed infrastructure may mitigate these challenges slightly compared to Mozambique and Mali, where bureaucratic hurdles might be more significant
3. Bureaucratic hurdles and permit processes are widespread, with Morocco potentially having a slight edge due to better-established protocols; Mozambique and Mali may face more significant delays and complexities due to less streamlined administrative systems
4. Intellectual property and data confidentiality are universally important, but Morocco's more developed legal frameworks may provide better protections compared to Mozambique and Mali, where legal infrastructure might still be evolving

Figure 6 Main conclusions for the regulatory, administrative and legal support in energy modelling

In summary, while stakeholders in Morocco, Mozambique, and the Niger River Basin in Mali face similar challenges in terms of regulatory, administrative, and legal support, there are subtle differences in emphasis. Morocco's focus on legal collaboration and transparency, Mozambique's concern with data privacy, and the Mali's issues with complex licensing requirements suggest that tailored approaches may be necessary to address these regional nuances effectively. However, the overall consistency in the challenges and needs indicates that broader, continent-wide reforms could also be beneficial in supporting energy system modelling across Africa.

2.2.4. Infrastructure aspects for energy modelling stakeholder views

In the realm of energy system modelling, Morocco, Mozambique, and the Niger River Basin in Mali all identify critical infrastructure needs (Figure 7), though their priorities differ somewhat. Morocco prioritizes high-performance computing and integration with existing energy systems, followed by data management and collaborative platforms. Cybersecurity is also a key focus across all regions.

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Mozambique places a strong emphasis on collaborative platforms, highlighting the need for shared resources and tools. High-performance computing and data management are also crucial, with integration and cybersecurity following closely. Stakeholders in Mali prioritize data storage and management, reflecting its need to handle extensive datasets. High-performance computing and collaborative platforms are similarly important, with integration and cybersecurity remaining essential.

RESULTS

1. Important infrastructure considerations: High-performance computing; Data storage & management; Collaborative platforms; Integration with existing infrastructure; Cybersecurity measures
2. Challenges in infrastructure compatibility & integration: Diverse data formats & standards; Complex stakeholder coordination; Scalability issues
3. Technological advancements for scalability & accuracy: Advanced sensors & IoT devices; Cloud computing & big data analytics; Smart grid technologies; ML integration
4. Innovative approaches & technologies: AI & ML: Recommended for analysing large datasets, providing deeper insights and predictions; Big data technology; Resilient infrastructure development

DISCUSSION

1. High-performance computing and data management are critical across all regions, but Morocco's more advanced infrastructure may facilitate better integration and cybersecurity; Mozambique and Mali may face greater challenges due to less mature infrastructures, making collaboration and data management more difficult
2. All regions face issues with diverse data formats and scalability; Morocco may have an advantage due to better coordination mechanisms and infrastructure maturity, while Mozambique and Mali may struggle more with integrating complex systems and ensuring security
3. AI, IoT, and blockchain are seen as critical across all regions, but Morocco may be better positioned to implement these due to more advanced infrastructure; Mozambique and Mali, while recognizing the importance of these technologies, may face slower adoption due to existing infrastructural and financial constraints
4. Morocco's focus on cutting-edge technologies like AR/VR and machine learning suggests a forward-looking approach, possibly driven by better access to resources; Mozambique and Mali emphasize resilience and long-term infrastructure development, reflecting their need to build foundational systems before adopting more advanced innovations

Figure 7 Main conclusions for the infrastructure aspects in energy modelling

All regions face challenges with diverse data formats and standards, which hinder interoperability. Coordinating stakeholders and managing resources for integration is complex and scalability issues related to processing large-scale data are common concerns. Advancements such as IoT devices for real-time data collection, cloud computing for scalable solutions, and smart grid technologies are pivotal. These technologies help improve the accuracy and scalability of energy system models, addressing many of the challenges identified. This analysis highlights the shared priorities and unique focuses of each region, alongside the common challenges and technological solutions relevant to energy system modelling infrastructure.

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2.2.5. Methods and Technical & Financial tools for energy modelling stakeholder views

In energy system modelling, technical and financial tools are critical for developing effective and cost-efficient solutions. Morocco, Mozambique, and the Niger River Basin in Mali each identify key tools and approaches that are crucial for their modelling tasks, though their preferences and focuses exhibit some variations (Figure 8).

All three regions emphasize the importance of optimization algorithms for identifying cost-effective solutions, financial modelling software for assessing project viability, and simulation software for modelling complex system dynamics. Geographic Information Systems (GIS) for spatial analysis and visualization are also highlighted as essential tools, particularly in Mozambique and the Niger River Basin in Mali, reflecting a common need for advanced spatial analysis capabilities. This uniformity in the choice of tools indicates a shared understanding of the core technical requirements for effective energy system modelling.

When it comes to specific software tools, Morocco prefers Plexos, HOMER Pro, EnergyPlus, MATLAB/Simulink, and OpenDSS, indicating a diverse toolkit for various aspects of modelling and simulation. Mozambique leans towards MAED, LEAP, FINPLAN, WASP, and SIMPACTS, which reflects its focus on models suited for demand analysis, supply strategy, and financial planning. Stakeholders from Mali use models like MAED and MESSAGE, and tools such as HOMER Pro and ESST, aligning with its needs for energy demand analysis and environmental impact assessments. These preferences highlight regional variations in software use, tailored to specific modelling requirements and project contexts.

In assessing financial feasibility, all regions conduct comprehensive cost-benefit analyses to evaluate project returns. They also estimate initial investment costs and ongoing operational expenses and analyse potential revenue streams and cost savings derived from modelling insights. Comparing net present value (NPV) and internal rate of return (IRR) of alternative approaches is emphasized, reflecting a focus on evaluating different modelling strategies' financial impacts. Additionally, assessing uncertainties and risks is a common practice, underscoring the importance of understanding potential financial variability in project performance.

Looking ahead, all regions anticipate significant impacts from several technological advancements. Artificial intelligence (AI) and machine learning are expected to enhance predictive modelling capabilities. The Internet of Things (IoT) will improve real-time data collection and integration, while blockchain technology is anticipated to ensure secure and transparent data management. Quantum computing is seen as a potential solution for complex optimization problems, and augmented reality (AR) and virtual reality (VR) may offer immersive visualization and analysis tools. These anticipated advancements reflect a forward-looking approach to enhancing the accuracy and efficiency of energy system modelling.

The analysis of technical and financial tools for energy system modelling across Morocco, Mozambique and the Niger River Basin in Mali reveals both shared priorities and distinct regional preferences. All three regions recognize the importance of optimization algorithms, financial modelling software, and simulation tools as foundational elements for developing cost-effective and accurate energy models. The consistent emphasis on these tools highlights a universal need for robust solutions that can handle the complexity and scale of modern energy systems.

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RESULTS

1. Valuable technical & financial tools: Optimization algorithms; Financial modelling software - Important for assessing project viability and investment returns; Simulation software; Geographic information systems (GIS)
2. Preferred software tools:
    - Morocco: Plexos, HOMER Pro, EnergyPlus, MATLAB/Simulink
    - Mozambique: MAED, LEAP, FINPLAN, WASP, SIMPACTS
    - Mali: MAED, MESSAGE, HOMERE, ESST
3. Assessing financial feasibility: Cost-benefit analysis; Investment cost estimation; Net present value (NPV) & Internal rate of return (IRR); Risk assessment
4. Anticipated technological advancements: Artificial intelligence (AI) & Machine learning; Internet of Things (IoT); Blockchain technology; Quantum computing; Augmented reality (AR) & Virtual reality (VR)

DISCUSSION

1. Optimization algorithms are fundamental to ensuring that energy systems are cost-efficient; Their integration with financial modelling tools allows for a comprehensive evaluation of project viability; The use of simulation software is essential for understanding and predicting the behaviour of energy systems under various scenarios; GIS tools are particularly valuable in regions like Mozambique and Mali, where spatial analysis is critical for planning and managing energy resources
2. Regional Tool Preferences: The preference for specific software tools in different regions reflects varying local needs and conditions
3. All regions employ a comprehensive financial assessment approach, but Morocco shows a particular emphasis NPV and IRR calculations, reflecting possibly more complex energy projects; Mozambique and Mali also use these calculations but seem to integrate them more within broader strategic frameworks
4. AI and ML are universally recognized as game-changers, but Morocco appears to be more forward-looking in integrating IoT with these technologies, indicating a move towards more integrated and responsive energy systems; Mozambique and Mali also see these technologies as critical but may face more immediate infrastructure challenges that could delay their adoption

Figure 8 Main conclusions for the methods and technical & financial tools in energy modelling

2.2.6. Values and needs of citizens and communities on a social level for energy modelling stakeholder views

The analysis of social-level values and needs in energy system modelling across Morocco, Mozambique, and the Niger River Basin in Mali (Figure 9) highlights both commonalities and region-specific priorities. All three regions emphasize environmental sustainability, community engagement, and equity in access to energy as crucial components of energy system models. However, the nuances in their responses reflect unique regional contexts and challenges. Across the board, environmental sustainability and reducing carbon emissions are universally prioritized. This reflects a broad recognition of the need for energy systems that not only meet current demands but also mitigate environmental impacts, contributing to global climate goals.

In Morocco and the Niger River Basin in Mali, there is an additional focus on ensuring energy resilience and reliability, which is critical for withstanding disruptions, particularly in regions prone to instability or natural disasters. Mozambique and the Niger River Basin in Mali place a strong emphasis on community engagement and empowerment in the decision-making process, signalizing a shift towards more participatory approaches in energy planning. This approach is seen as essential for fostering local

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ownership and ensuring that the benefits of energy systems are equitably distributed. Mozambique also highlights the importance of gender equity in energy strategies, reflecting broader social justice considerations in its energy planning.

When it comes to integrating environmental and social justice considerations into energy system models, all regions acknowledge the need to address greenhouse gas emissions, water consumption, and the impact on ecosystems. Mozambique additionally points to the need for community awareness in the energy transition process, particularly regarding environmental protection and the benefits of renewable energy. This indicates a need for robust public education and engagement efforts to support the adoption of sustainable energy practices.

In envisioning a value-based proposition for energy system models, the regions uniformly prioritize environmental sustainability, equitable access to energy resources, and economic development through clean energy initiatives. This alignment suggests a shared understanding that energy systems must be both environmentally and socially sustainable to achieve long-term success. Looking ahead, the regions anticipate significant growth in energy systems, which will necessitate capacity-building measures. For instance, Mozambique underscores the importance of strengthening institutional capacity in energy modelling, while Morocco emphasizes collaboration, knowledge sharing, and access to data. These insights point to a need for targeted training and education programs to build the technical expertise required for effective energy system modelling. In terms of addressing the needs of local communities, all regions agree on the importance of engaging communities in the modelling process, conducting awareness programs, and collaborating with local organizations to develop solutions tailored to local needs. Effective community engagement is seen as a critical factor in ensuring that energy systems are aligned with the values and priorities of the people they serve.

To promote equity and inclusivity, the regions advocate for conducting community needs assessments, partnering with community-based organizations, and providing training to empower marginalized groups. Mozambique highlights the importance of outreach programs to engage underrepresented groups, ensuring that energy system models reflect diverse perspectives. Health-related concerns are also prominent across the regions, with a shared focus on the impacts of energy production on air quality, public health, and social determinants of health. These concerns underline the importance of integrating health considerations into energy system models to safeguard community well-being.

Lastly, effective communication channels such as social media, radio, television, and public forums are seen as essential tools for reaching different demographic groups and involving citizens in decision-making processes. The regions agree that long-term societal benefits of successful energy system modelling include reducing greenhouse gas emissions, increasing energy access, creating green jobs, and improving public health outcomes. In conclusion, while the core values and needs are consistent across the regions, the specific approaches and priorities reflect the unique social, environmental, and economic contexts of Morocco, Mozambique, and Mali. These insights provide a comprehensive framework for developing energy system models that are not only technically sound but also socially responsive, ensuring that they meet the diverse needs of communities and contribute to broader societal goals.

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RESULTS

1. Social values beyond financial aspects in energy system models: Environmental sustainability and carbon reduction; Energy resilience and reliability; Equity in energy access; Public health and safety; Community engagement in decision-making
2. Environmental and social justice considerations: Greenhouse gas emissions, water usage, and ecosystem impact; Gender equity and community awareness; Local authority involvement and data use
3. Community needs and public participation: Engage communities in modelling; Awareness and education programs; Collaboration with local organizations; Transparency in information
4. Promotion of equity, inclusivity, and long-term societal benefits: Community needs assessments; Training for marginalized groups; Partnerships for inclusive energy solutions; Long-term benefits: emission reduction, energy access, green jobs, and public health
   - Health concerns: Air quality, health impacts, public health initiatives
   - Communication channels: social media, radio, television
   - Public participation: Surveys, public forums, advisory committees
5. Long-term societal benefits: Reduction of greenhouse gas emissions; Increased energy access; Green jobs creation; Enhanced energy resilience

DISCUSSION

1. All regions emphasize environmental sustainability and equity; Some regions prioritize energy resilience, while others stress community engagement; Health and safety considerations are crucial in specific regions, highlighting varied impacts of energy systems
2. Advanced regions address multiple environmental and social justice factors; Some regions focus on gender equity and raising awareness, reflecting different stages of development; Emphasis on local authorities and economic development shows targeted regional priorities
3. Advanced regions create solutions tailored to specific community needs; Strong focus on transparency and collaboration in areas where community trust is critical
4. Consistent emphasis on equity and inclusivity across regions; Common long-term goals include sustainability, economic development, and improved health outcomes
5. Emphasis on air quality and health impacts is consistent across regions, reflecting common concerns about energy production and consumption
6. Effective communication channels and public participation mechanisms are critical; Variations in preferred channels and methods reflect different regional priorities
7. All regions agree on the importance of reducing emissions, increasing access, creating green jobs, and improving resilience; The emphasis on specific benefits may vary, with some regions focusing more on economic development while others prioritize resilience or access

Figure 9 Main conclusions for the Values and needs of citizens and communities on a social level in energy modelling

2.2.7. Conclusion for energy modelling stakeholder views

The analysis highlights key differences and similarities in stakeholder perspectives across these regions, reflecting the diverse social, environmental, and economic contexts within the African Union. Across all three regions, the integration of social values into energy system models is paramount, but the emphasis differs based on local conditions. Environmental sustainability is a shared priority, aligning with global efforts to mitigate climate change. However, the focus on energy resilience in Morocco,

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contrasted with the emphasis on community engagement and empowerment in Mozambique and the Niger River Basin in Mali, suggests that energy system models must be adaptable to regional needs.

Morocco's focus on resilience likely stems from its more advanced energy infrastructure and the need to ensure stability, while the emphasis on empowerment in Mozambique and the Niger River Basin in Mali indicates a pressing need to involve communities in the decision-making process, addressing issues of equity and social justice. The survey also reveals varying degrees of attention to environmental and social justice considerations across the regions. Morocco's holistic approach, which includes considerations of greenhouse gas emissions, water consumption, and ecosystem impacts, contrasts with Mozambique's focus on gender equity and the Mali's emphasis on local economic development. These differences highlight the necessity of customizing energy system models to address the specific environmental and social challenges faced by each region. This regional customization is essential for ensuring that energy transitions are not only technically sound but also socially inclusive and environmentally sustainable.

In terms of capacity building, the study identifies significant regional disparities in anticipated growth and the associated needs for capacity development. Morocco's focus on collaboration, knowledge sharing, and access to data reflects a more advanced stage in its energy transition, where the enhancement of existing systems is critical. Conversely, Mozambique and the Niger River Basin in Mali demonstrate a need for more fundamental capacity-building initiatives, particularly in strengthening institutional frameworks and engaging local communities. This disparity underscores the importance of a tailored approach to capacity building that addresses the specific needs of each region, ensuring that all stakeholders can effectively contribute to and benefit from the energy transition.

Engagement with local communities emerges as a critical factor across all regions, with varying approaches suggested for ensuring active participation in the energy system modelling process. While Morocco emphasizes the use of digital tools and communication strategies to mobilize communities, Mozambique and the Niger River Basin highlight the importance of public consultations, hearings, and the involvement of local leaders. These findings suggest that successful energy transition efforts in the African Union will require flexible engagement strategies that consider local communication preferences and cultural contexts. The findings of this survey underscore the importance of a nuanced, region-specific approach to energy system modelling within the African Union, guided by the Quadruple Helix framework. By integrating the perspectives of government, industry, academia, and civil society, energy models can better reflect the diverse needs and values of stakeholders across different regions.

The analysis also highlights that while there are common goals, such as environmental sustainability and social equity, the pathways to achieving these goals vary significantly based on local contexts. For Morocco, the emphasis on energy resilience and comprehensive environmental considerations suggests that energy models should focus on enhancing existing infrastructure while maintaining sustainability. In Mozambique and the Niger River Basin in Mali, where community empowerment and equity are paramount, energy models must prioritize inclusive decision-making processes and capacity-building initiatives that engage local communities and address social disparities.

In conclusion, a successful energy transition in the African Union will depend on the ability of energy system models to adapt to the unique social, environmental, and economic conditions of each region. By leveraging the Quadruple Helix framework, stakeholders can ensure that energy models are not only technically robust but also socially inclusive, environmentally sustainable, and responsive to the needs of all communities. This tailored approach will be crucial for achieving a just and equitable energy transition across the African Union.

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2.3. Initial stakeholder engagement workshop

The initial stakeholder engagement workshops served as a key event to bring together the identified stakeholders and begin fostering meaningful collaboration. These workshops were designed to be interactive and participatory, allowing stakeholders to share their insights, experiences, and expectations related to the EMERGE project. During the workshop, stakeholders had the opportunity to discuss challenges they face in energy system modelling and the green transition, as well as potential opportunities for collaboration.

The workshop also played a pivotal role in establishing trust and relationships among participants, laying the foundation for ongoing engagement and cooperation throughout the project. The insights and recommendations collected during this event will be instrumental in shaping both the Knowledge Base and the stakeholder engagement methodology, ensuring that they are responsive to the practical needs and interests of all involved parties. More detailed summaries of the workshops can be found in the Annexes.

2.3.1. Mozambique workshop

The Mozambique Energy System Modelling Workshop under the EMERGE project was held online on April 24, 2024, with twelve participants from sectors such as civil society, investors, policymakers, and academia and research institutions. The workshop had several key objectives: introducing stakeholders to the EMERGE project, presenting the stakeholder data collection survey, and emphasizing the importance of stakeholder engagement. This event also facilitated discussions on energy modelling and challenges related to data collection and sharing within Mozambique. While many participants were unfamiliar with energy modelling specifics, they recognized the potential impact of EMERGE in accelerating energy access and the transition to cleaner energy. Following the workshop, the survey (translated into Portuguese) was distributed to participants for further input. Overall, the workshop successfully introduced the project, gathered initial insights, and laid the groundwork for greater stakeholder engagement in Mozambique's energy transition efforts. Future steps will focus on deeper stakeholder collaboration and refinement of the project's methodologies.

2.3.2. Morocco workshop

The Morocco EMERGE energy transition workshop was held on May 25, 2024, at Mohammed Premier University (UMP) in Oujda, Morocco. Organized by the UMP EMERGE team in collaboration with the Electrical Engineering and Maintenance Laboratory (LGEM), this event brought together researchers, policymakers, and industry professionals to discuss the future of energy transition in Morocco and beyond. The workshop aimed to highlight the achievements and challenges in energy transition, introduce the EMERGE project, and gather valuable stakeholder input for energy system modelling. Data collection was carried out through the initial survey, which participants completed at the end of the workshop. Unlike previous workshops where participants worked as groups, this survey was answered individually, allowing for a more detailed understanding of stakeholder needs and perspectives. While this approach made compiling responses more complex, it provided deeper insights into the preferences and challenges faced by different sectors, including academia, civil society, investors, and policymakers. The workshop opened with remarks from university leadership and key project figures, followed by presentations on the EMERGE toolbox and various tools such as CEPIA, METRIX, and GREENADVISE. The event featured interactive sessions and technical workshops on topics such as energy systems management, electric vehicles, and renewable energy storage, all moderated by experts in the field. These sessions facilitated constructive dialogue among participants and allowed for a robust exchange of ideas on advancing Morocco’s energy transition. The event concluded with the collection of survey responses and a closing session, marking the end of a productive and enriching workshop. Moving forward, the data collected will be analysed and integrated into the EMERGE

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project's toolbox and methodologies, which will continue to support the wider energy transition in Morocco and the African continent.

2.3.3. Mali workshop

The EMERGE project workshop in Mali, organized by ECREEE on June 13, 2024, in Bamako, aimed to engage local stakeholders and initiate data collection efforts for energy system modelling. Participants included policymakers, academics, investors, and civil society members, all crucial to achieving the project's goal of creating a sustainable and inclusive energy future. The workshop's primary objectives were to introduce the EMERGE project, explain its goals, share experiences, and collect data crucial for the project's implementation. Key tools like CEPIA, METRIX, and GREENADVISE were also presented. Participants were grouped by sector, ensuring that their collective feedback was gathered, validated, and harmonized. The workshop successfully raised awareness among stakeholders highlighted the need for reliable dana. Stakeholders also expressed a strong interest in the project tools and requested additional training sessions. These virtual training sessions were held on June 28 and July 12, 2024. The next steps involve compiling the collected data, organizing next workshops, and continuing work on other tasks, ensuring the effective progress of the EMERGE project.

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3. Knowledge Base

3.1. Objectives and goals

The Knowledge Base will serve as a central hub of information, tools, and resources that will guide the EMERGE project. Its creation is aimed at supporting both internal project members and external stakeholders by providing a well-structured, accessible platform for sharing and accessing knowledge related to energy system modelling, stakeholder engagement, and green transition strategies. The primary objective of the Knowledge Base is to create a comprehensive repository of information that supports the EMERGE project's goals, ensuring that all stakeholders have access to the resources they need to actively participate and contribute. The specific goals include:

- Centralizing knowledge on energy system modelling, including methodologies, data, best practices, and case studies.
- Facilitating collaboration between project participants and external stakeholders by providing a shared platform for communication and learning.
- Supporting decision-making by integration and development of tools and database in a centralised repository
- Ensuring inclusivity by addressing the diverse needs of stakeholders, from energy experts to community representatives, ensuring the Knowledge Base reflects their varied interests and goals.

3.2. Knowledge Base concept elaboration

The concept behind the Knowledge Base is to serve as a dynamic and evolving resource that adapts to the project's progress and stakeholder needs. It is designed to be a user-friendly platform that integrates various types of information—technical, regulatory, social, and financial—related to energy system modelling. The Knowledge Base will include curated content from the EMERGE project, as well as insights from external sources such as research papers, case studies and data sets or similar projects.

In addition, the Knowledge Base will function as a collaborative space where stakeholders can share experiences, best practices and lessons learned, thereby enhancing the collective knowledge within the energy modelling community. The platform will be regularly updated to reflect the latest developments in the project and in the field, ensuring that it remains a relevant and valuable resource.

3.3. Information placement and organisation

The organization of information within the Knowledge Base is critical to ensuring that users can easily access and navigate the resources they need. The content will be categorized into several key sections:

- Energy system modelling resources – including technical guidelines, tools, and methodologies for developing and accessing energy models.
- Stakeholder engagement practices – covering engagement methodologies, surveys, and workshops aimed at fostering collaboration among different stakeholder groups.
- Case studies and examples – featuring real-world applications of energy modelling and green transition strategies from previous and ongoing projects.
- Data and regulatory frameworks – providing relevant data sets, legal frameworks, and policy guidelines that support energy system planning and implementation.

The development of a central database in the EMERGE project is critical as it serves as the most important part of the Knowledge Base. The purpose of the central database is storing and managing

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energy-related data, facilitating seamless integration across various tools. This database is designed to consistently provide necessary data for analysis, forecasting, and optimization, making it a key component for energy system operations. Its flexible structure supports adaptability, allowing for future updates and new features as the project evolves. The core functionality of the database includes managing both historical and predictive data, which is linked to geographical locations and time intervals. This enables comprehensive spatial and temporal analysis of energy consumption and generation. Additionally, the database supports varying time granularity, from hourly snapshots to annual summaries, making it versatile for different analytical needs. Custom scripts streamline the data ingestion and export process, ensuring compatibility across tools and reducing manual data handling. The database also stores diverse datasets, including energy types (e.g., electrical, heat), generation costs, consumption profiles across sectors, and critical socio-economic and climate data. These data points provide a rich foundation for the project's tools to generate insights and inform decision-making. Technically, the database runs on a secure virtual machine with SSH key-based authentication, designed for scalability to accommodate future project developments. Although still in its preliminary state, the database structure is robust enough to support current needs, with further refinements expected in future deliverables. The scheme of the current state of the database is shown below.

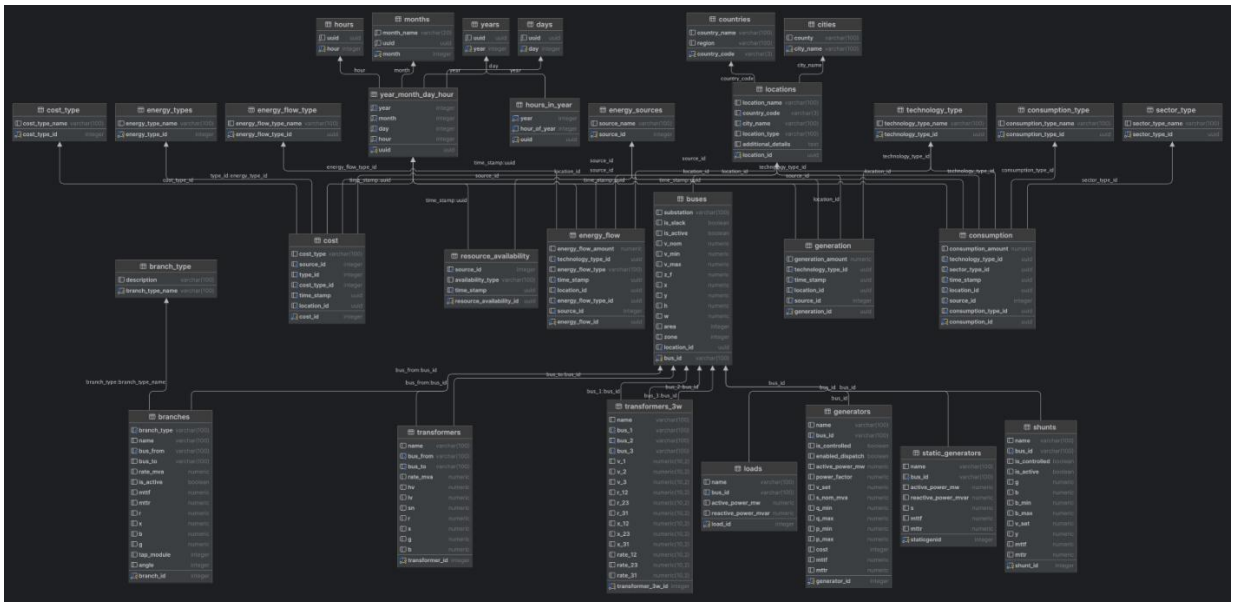

Figure 10 Preliminary central database schema (better quality figure in annex)

3.4. Interaction between Knowledge Base operator and users

The Knowledge Base will be operated by designated project members responsible for curating and maintaining the content, ensuring that it remains up-to-date and relevant. The operators will play a key role in managing the platform, facilitating interactions, and responding to user feedback. They will also ensure that the content is regularly updated to incorporate new findings, insights from stakeholder engagements, and developments in energy system modelling.

Users of the Knowledge Base, including project members, stakeholders, and external participants, will have various levels of interaction depending on their needs and roles. Users will be able to access information, submit requests for specific content, provide feedback on the resources, and contribute their own insights or data. This two-way interaction is essential for keeping the Knowledge Base responsive and aligned with the evolving needs of the EMERGE project and its stakeholders.

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By maintaining a strong connection between operators and users, the Knowledge Base will function as a living resource, fostering continuous learning and collaboration throughout the lifespan of the project.

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4. Stakeholder engagement methodology and value-based proposition design

4.1. Introduction

Stakeholder engagement is a crucial aspect of any methodology or project management approach. Engaging stakeholders effectively ensures that their perspectives, interests, and concerns are considered, leading to better decision-making and outcomes. This section focusses on the definition of the EMERGE methodology for citizen and expert engagement and value-based proposition design for energy system modelling, towards inclusive regional-based energy system modelling. The methodology enables its users to design socio-economic value-based propositions with environmental benefits and a suitable energy system organization to provide these propositions. This task will set the basis for the work performed on the expert engagement field, both in WP4 and T6.1 (D&C activities and promotion), which will then input the development of outcomes (WP2, WP3), based on stakeholders' feedback.

The result of this analysis will be integrated in the methodology for expert engagement and value-based proposition design for energy system modelling of AU. The methodology will also help partners and stakeholders to identify important methodologies, methods and tools to be integrated in the Knowledge Base (T1.1, T2.4); innovative approaches to energy system modelling in AU (T1.4, WP3); and the relevant policies and regulatory frameworks (WP2, WP4). A major output from this task is the EMERGE value proposition design methodology to be further developed in WP4. Results from the application and evaluation of the EMERGE methodology engagement and value-based proposition design for AU energy system modelling in the pilots (WP5) will be communicated in activities in T6.1.

4.2. Summary of state of art from past and current projects

First, a summary of the State of the Art and feedback from past or current projects (e.g. LEAP-RE, ONEPlaNET, FOCUS-Africa, D4D Hub etc.) will be carried out to identify and classify the relevant methodologies, methods and tools related to individual and collective engagement and co-creation, and will provide an analysis of pros, cons and lessons learned of the investigated strategies and processes.

By connecting and networking to other initiatives such as ONEPlanET Project, LEAP-RE, FOCUS-Africa, D4D Hub, CESET, OpenMod4Africa, Productive Uses of Energy in Ethiopia - Agricultural Value Chain and Electrification and similar, the network will significantly extend, building on currently involved experts and Stakeholder Group. EMERGE will assure the infrastructure for knowledge exchange between the experts by setting up website, social media, exchange material, organising live and online events and using these channels to stimulate discussion and promote joint activities. Such cooperation between the expert network members will result in new policy designs, modelling approaches and other transversal topics related to energy, environment and social topics.

4.2.1. Methods for stakeholder engagement and communication in LEAP-RE project

LEAP-RE, "Long-Term Joint European Union - African Union Research and Innovation Partnership on Renewable Energy", is Horizon 2020 EU-funded project that stems on a long-term network of stakeholders. The project is looking to promote a pathway for empowering local research and innovation through Africa-Europe cooperation, while fostering the conditions for transforming research into effective innovation, tailored to specific societal needs, the capacities and aspirations in Africa, acknowledging regional discrepancies.

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LEAP-RE gathers **85 partners** committed to using research and innovation to fight climate change by addressing key renewable energy challenges. The partners will contribute to the production of new knowledge and technologies, therefore accelerating the inclusive transition to reliable and affordable renewable energy. Together, they will share their knowledge and findings and build a long-term partnership for an efficient AU-EU collaboration in the field of renewable energy.

LEAP-RE goal is to empower communities, organizations, and individuals to make sustainable energy choices, reduce dependence on fossil fuels, and mitigate the impacts of climate change.

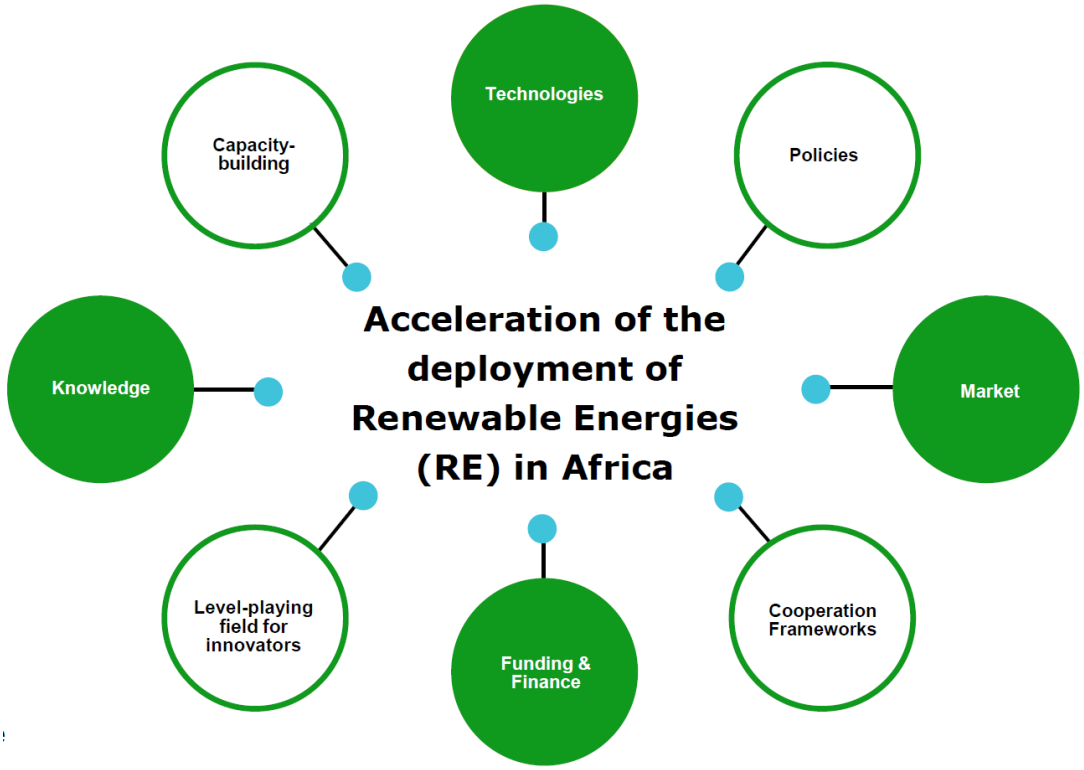

Figure 11 Structure of the LEAP-RE project

The LEAP-RE program seeks to create a long-term partnership of African and European stakeholders in a **quadruple helix approach (**4 types of stakeholders): government (program owners and funding agencies), research and academia, private sector, and civil society. Impact will be achieved by creating framework, methodology, and cooperation models. The aim is to reduce fragmentation by aligning existing bilateral and multilateral frameworks. LEAP-RE will establish and jointly implement research, innovation, and capacity-building activities.

LEAP-RE is based on 3 programmatic pillars, which consists in the management, coordination, monitoring and evaluation of the program, and in the development of the future long-term collaboration model of the AU-EU partnership in renewable energy (Pillar 3).

LEAP-RE comes in a context where climate action and the development of renewable energy sources are top priorities for the European Union and the African Union. Alongside other European Union policies and directives, the European Green Deal propels EU Member States towards a 55% cut in emissions by 2030 and climate neutrality by 2050. In Africa, the AU "Agenda 2063: The Africa We Want" envisions a climate resilient Africa with reduced emission levels arising from agriculture, biodiversity loss, land use, deforestations, as well as reductions in loss of life and property due to natural and anthropogenic disasters and weather and climate extreme events.

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The LEAP-RE program is designed as a pilot for the future long-term partnership. Building a community, strategy, organization, methodological assets and tools to set the foundations of a long-lasting AU-EU partnership to address the post-2025 challenges and policy priorities is therefore the ambition of LEAP-RE. Pillar 3 will promote cooperation and systemic change through building a long-lasting partnership beyond LEAP-RE implementation.

To achieve its goals, LEAP-RE implements **transnational proposals for research, innovation, and capacity building**, on top of building a long-term EU-AU partnership and conducting in-house research and innovation projects. The proposals are co-funded by **16 African and European national funding organizations** members of the LEAP-RE consortium and the European Commission.

Figure 12 Partnership represents 33 European and African countries

Stakeholder Forum is the main event for engaging stakeholders in LEAP-RE. LEAP-RE Stakeholder Forum is an event organized to enrich the LEAP-RE Community. It aims to create and expand an international multi-stakeholder community dealing with renewable energy, science-based policymaking, funding and research, innovation, monitoring, evaluation and learning, in Africa and Europe. Its objectives are to identify, design, and implement the services and functions of LEAP-RE and to foster collaboration with similar initiatives.

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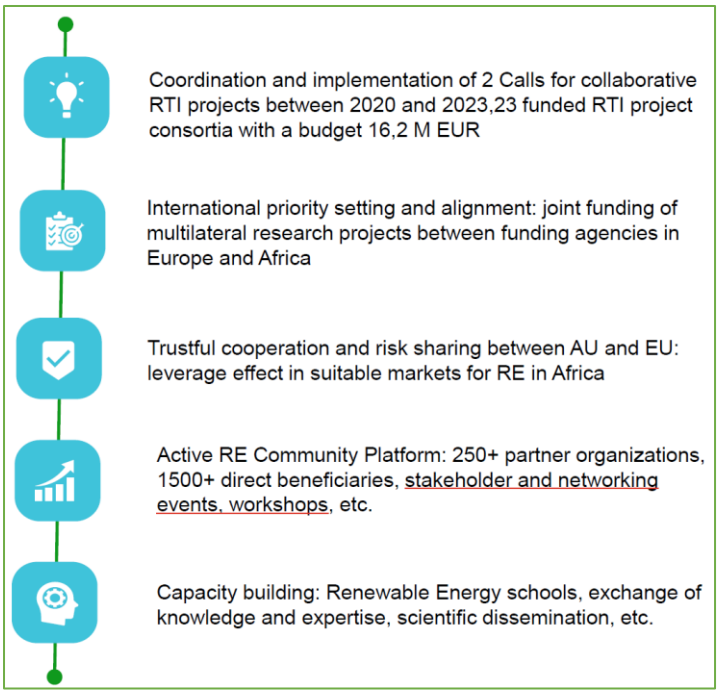

Figure 13 Main achievements of the LEAP-RE project

Other options on the engagement of the stakeholders are shown in the events calendar. There is also and newsroom which shows updates of the news relevant to the stakeholders as well as a webinar series which goes more into details on the topics relevant for stakeholders. Other options to engage stakeholders include:

- Dialogues – Physical and virtual meetings of actors for discussion, exchange, and peer support. For dialogues to be effective, they should be well facilitated, utilizing both guided methods for discussion and allowing space for freely bringing forward topics of interest.
- Formal and informal reporting – Formal reporting channels include project reporting and deliverables, MEL (monitoring, evaluation and learning) activities, and other formal means. Informal reporting includes discussions, the LEAP-RE online community, and other informal means.
- Dissemination – Dissemination activities are specifically intended for sharing information with the science community, stakeholders, and the public. This includes, for example, publishing scientific publications, project reports or other documents, creating videos or other communications materials, and giving presentations at relevant occasions. Dissemination activities are primarily unidirectional, making them less effective as a means for sharing and mutual learning. It also involves promoting the project at real and physical events, public speaking at industry events, etc.
- Channels for knowledge sharing – Knowledge sharing will be facilitated and supported by the platform chosen for the online community management. The tool is expected to support user-led engagement, ideally creating dynamic and interactive exchanges. Moreover, the tool should support interaction beyond the lifetime of the LEAP-RE program. This will offer opportunities for continuing interactions and development into the future and can support future cooperation and activities.

4.2.2. Methods for stakeholder engagement and communication in FOCUS – Africa project

In this project, main communication methods are: Direct contact and meetings, webinars, focus groups, interviews and surveys, conferences, social media, specialized workshops and training sessions.

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Table 2 FOCUS-Africa communication matrix of objective, audience, content, measure and frequency

Target audience	Objective	Material/content (and responsibility)	Method/communication measures	Frequency
FOCUS-Africa consortium	Ensure an effective and integrated project	• Progress and results (WP8) • Risks/benefits/issues (WP8) • Queries/questions (WP8)	Project intranet	Continuous updates
			Partners' Forums	Annual
			Email, Web and teleconferencing	Frequent
EC Project Officer	Ensure EC is fully informed of project progress	• Overall project progress (WP8) • Issues (WP8) • Deliverable progress (WP8)	One-page progress reports	Quarterly
			Deliverable and periodic reports	As per deliverable dates
			FOCUS-Africa website	As per reporting periods
Service Users	Awareness of capabilities and discussion of needs	• Presentations (WP1) • Workshop discussions (WP1) • Advisory Board meetings (WP1)	International conferences, GFCS PAC meetings, RCOFs	As they occur and as required
Wider scientific and technical	Advertise progress and obtain expert advice	• Deliverables and other reports (WPLs) • Presentations at conferences including case studies (WPLs)	Project website	As per timetable
			Project & task team meetings	Monthly
			Conferences, GFCS PAC	As opportunities arise
community		• Papers (WPLs)	meetings, RCOFs	
			Publication in open literature	When ready
Other EU bodies	Mutual awareness	• Discussion of needs (WP1) • Plans and results (WPLs)	Project website	Monthly
			EC or project meetings	As required
Policy and decision makers	Exploitation of new capabilities	• Presentations (WP1)	Meetings organised by EC and AU	As they occur
		• Summary information (WP1)	FOCUS- Africa website	Quarterly
Wider public	Project visibility & raise public awareness	• Relevant results and their implications including case studies (WP1) • Communication campaigns: Content creation (infographics, factsheets, posts, success stories, testimonials...)	FOCUS-Africa website, social media and African relevant events	Monthly

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The aim FOCUS – Africa project is to develop and execute a Communications and Dissemination Plan to outreach a wider stakeholder community in coordination with other relevant ongoing projects in the Southern African Development Community (SADC) region and using the strong network of the project Consortium.

In addition to the project partners and stakeholders directly involved with the project case studies, the project will involve a wide range of other relevant projects and activities, including climate service projects that FOCUS-Africa partners are currently involved with. This network is further extended to include a wider user-community through an extensive stakeholder engagement programme. Close stakeholder engagement is thus an integral part of FOCUS-Africa. Specific collaboration will be with:

(i) Downstream operators (national water managers, farmers);
(ii) Energy and food producers;
(iii) Planning authorities and other stakeholders (e.g. retailers, policy makers, environmental organisations, technological research centres, society as a whole); and
(iv) Research community

Dissemination Plan: the objectives of the communication plan are to:

- Ensure that the project outputs and results reach the relevant target groups, especially end-users, in and beyond the participating countries.
- Ensure transparency and visibility of the project activities and to acquire the needed support from crucial stakeholders.

Dissemination Channels Dissemination channels within the plan are the tools that will be used to spread the key messages and results of the project to the target audience. They define how the FOCUS-Africa project will be communicated and are designed to ensure a two-way communication approach. They will include:

- Dissemination materials
- Visual identity materials
- Infographics, strong visuals and short videos
- Blog posts, success stories, testimonials
- FOCUS-Africa official website
- E-newsletter: an annual e-newsletter
- E-newsletter: an annual e-newsletter
- Research communities
- Policy briefs: FOCUS-Africa
- Training
- Stakeholder workshop
- Community Radio
- Social Media
- Announcements within religious groups
- Press releases

Project reports: The project deliverables will be made accessible on the FOCUS-Africa website to widely share useful results and conclusions. The most relevant deliverables for the audiences will be turned into a more appealing format to maximize their reach.

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Table 3 FOCUS-Africa communication actions per targeted audience

Target Audience	Food security, Water and Energy users/sectors	National, Regional and International Organizations	Climate services providers
Method of Communication	•Website •Dissemination material •Specialized workshops & training sessions •Webinars •Focus groups •Interviews and surveys •Conference presentations •National and regional GFCS UIPs •Social Media •Direct contact and 1:1 meeting	•Website •Dissemination material •Scientific publications •GFCS PAC meetings •RCOFs and NCOFs •Specialized workshops & training sessions •Webinars •Focus groups & questionnaires •Conference presentations •Social Media	•Website •Dissemination material •Scientific publications •Focus groups & questionnaires •Conference presentations (e.g., ICCS, EGU, EMS/ECAC) •Questionnaires
Information Type	•Outcomes •Best practices •Lessons Learned •Summary of case studies •Training on the tools	•Best practices •Summary of case studies •Lessons Learned	•Information on the compete technology and its application
Aim	•Ensure tools developed are directly relevant •Share knowledge •Share experience •Motivate adoption	•Share experience •Ensure replicability and sustainability •To promote project results as potential guidance to policy making	•Raise awareness and mobilize sector interest in complete solutions •Ensure operationalization of services

Stakeholder Engagement Workshops: workshops will be organized in each of the partner African countries to obtain inputs from key internal and external stakeholders that are engaged in the development of the FOCUS-Africa climate services. The objectives and the programme of each workshop will be defined on a case-by-case basis and in consultation with the WP leaders, to consider the latest progresses made in the project. All project partners are expected to contribute to stakeholder engagement via, e.g., workshops organizing committee, participation and input into reporting.

4.2.3. Methods for stakeholder engagement and communication in D4D Hub project

The Digital for Development (D4D) Hub was launched in 2020 by the European Commission and the European Union (EU) Member states. It is a multi-stakeholder platform for joint interventions to co-ordinate support for digital transformation in EU partner countries and leverage the expertise, resources and strengths of the private sector, civil society organizations, financial institutions and other stakeholders.

D4D Hub Principles

The D4D Hub is guided by five operating principles:

- *Local ownership & win-win partnerships:* Facilitate partnerships that provide added-value and base cooperation activities on local demand.

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- *Multi-Stakeholder involvement & expertise:* Promote a sustainable digital transformation requires a whole-of society approach (governments and administrations, private sector, civil society, academia).
- *Sustainable & green digital transformation:* Promote the twin green and digital transition.
- *Human-centric approach:* Put people at the heart of the digital transformation to ensure the full protection of human rights in the digital age.
- *Data security & protection:* Promote a comprehensive and consistent response to safeguard the global threat of cyber breaches, misuse of data and breaches of data privacy.

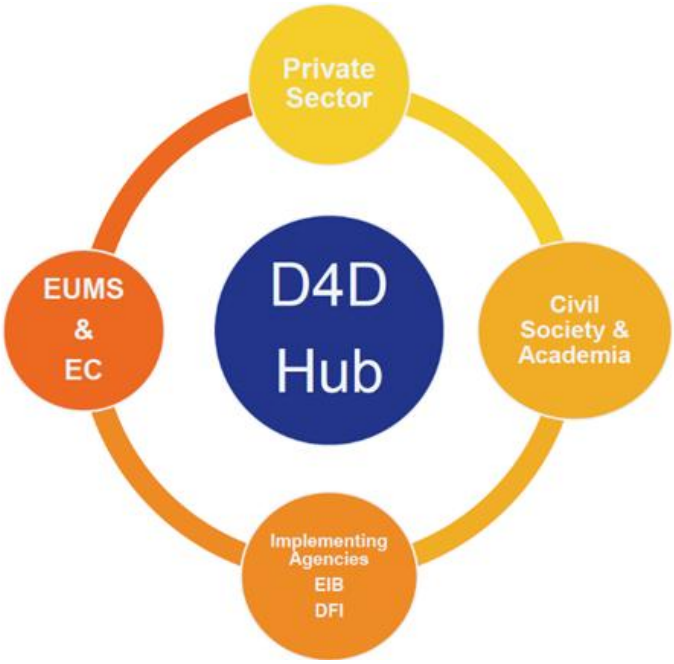

Figure 14 D4D Hub Structure

The D4D Hub is an instrument for external policy aligned to the EU Communication "Digital Compass: The European Way for the Digital Decade". Through this initiative, EU members aim to build partnerships and scale up digital investment while promoting a human-centric model focused on addressing digital divides and risks that can accompany accelerated digital transformation, such as exclusion, injustice and inequality. This approach draws from the experience of the EU Digital Single Market and is grounded in EU standards and values emphasizing human rights and data protection, net neutrality, privacy by design, and ethical use of technology. D4D Hub initiatives include:

- **Direct emergency response and building resilience**

The D4D Hub contributed to the design and implementation of a package of digital projects, part of the Team Europe Global Response to COVID-19. For instance, through the Smart Development Hackathon project, D4D Hub members and more than 50 partners produced more than 1 000 digital solutions to tackle COVID-19 challenges related to health, economy and society. Projects include the Callvs Corona hotline, which provides prevention information in local languages to more than 200 000 people in Madagascar, and the Digital Enquirer Kit, which helps journalists and others in several African countries identify and navigate misinformation.

- **Multi-stakeholder workshops for sharing good practices and identifying challenges and opportunities**

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European and Senegalese stakeholders shared experiences and good practices in the areas of digital training and skills development, digital trust and cybersecurity, e-governance, and digital services in the agricultural sector. In May 2021, more than 100 representatives of government agencies and authorities in Senegal and EU members, and from the private sector participated in discussions that helped identify possible joint, co-funded interventions in line with Senegal's 2016-25 digital strategy.

Similar workshops were held in Kenya and Niger, and many more are in the pipeline for the coming year. In addition to the Global D4D Hub, which oversees Team Europe co-ordination, the hub relies on regional branches to foster strategic partnerships between European and local stakeholders in partner countries. These take an "among equals" approach to development. While the initial focus of the D4D hub operation was on Africa, other regions of the world are now gaining attention. The D4D Hub branch for Latin America and the Caribbean is being launched in December 2021 at a high-level event under the Slovenian Presidency of the Council of the EU.

- **Engaging with the Private Sector under the D4D Hub**

To address the global challenge of digital transformation and untap related opportunities, the EU is leveraging on the expertise, networks and presence of its Member States as well as European private sector, civil society and academia and other relevant stakeholders to ensure the promotion of EU values and standards.

The private sector is a fundamental partner to boost employment opportunities, growth, investment, trade and innovation and it has a central role to play in achieving poverty reduction, sustainable development and inclusive growth. The private sector is in the first line to enforce the human centric approach to digital transformation promoted by the EU and the D4D Hub. It is playing a crucial role in providing and using digital technologies such as e-health services, e-governance or blockchain applications to enhance supply chain transparency.

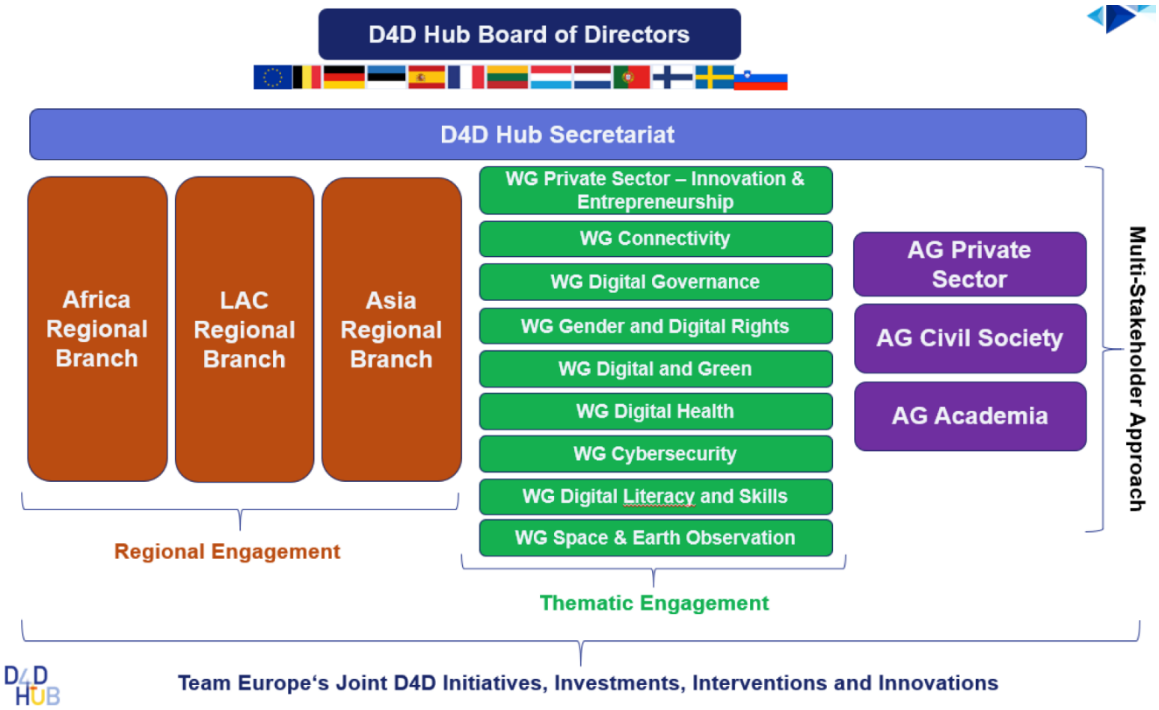

Figure 15 D4D Hub Governance & Multi-stakeholder approach

As multi-stakeholders´ platform, the D4D fosters inclusive and co-creating processes to identify joint interests and innovative cooperation opportunities, assessing technical feasibility, economic viability,

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socio-cultural and political acceptance. In engaging with the D4D Hub, private sector may support scaling up investments in partner countries, when possible, adopting a market system development approach.

Apart from the mentioned, D4D also uses a knowledge sharing platform: D4D Access. It is a new knowledge platform that centralises, promotes, and disseminates good practices and lessons on Digital for Development (D4D). Covering a wide range of topics, from e-governance to digital entrepreneurship, D4D Access contains many useful resources to support digital stakeholders in Africa and Europe – including public institutions, donors, academia, companies, and civil society organisations – to advance an inclusive and sustainable digital transformation.

The D4D Hub is a strategic multi-stakeholder platform that fosters digital cooperation between the European team and its global partners. The platform serves for **joint interventions** to co-ordinate support for digital transformation in EU partner countries and leverage the expertise, resources and strengths of the private sector, civil society organisations, financial institutions and other stakeholders.

An example of the **multi-stakeholder workshops** for sharing good practices and identifying challenges and opportunities is that of European and Senegalese stakeholders who shared experiences and good practices in the areas of digital training and skills development, digital trust and cybersecurity, e-governance, and digital services in the agricultural sector.

4.2.4. Methods for stakeholder engagement and communication in OnePlanET project

The ONEPlanET project, a consortium of African and European partners, seeks to empower African policymakers, researchers, investors, and citizens with the knowledge and tools needed to increase clean energy production while reducing inequalities and cultural and social gaps. The main features of the project are following:

- ONEPlanET will co-design and test a Toolkit, built upon existing WEF Nexus models and methodologies, that allows to simulate scenarios to optimize existing resources with the most appropriate policies considering social, climate, economic and biophysical constraints.
- In addition, a Knowledge Hub including a set of capacity-building materials and knowledge exchange activities will also be developed.
- ONEPlanET will undertake a participatory approach to building local communities in three African case studies: Songwe (Malawi/Tanzania), Inkomati-Usuthu area (South Africa) and Niger (Nigeria) river basins.

The following approaches were used to engage stakeholders during the project.

ONEPlanET knowledge communities - Community and Stakeholders

ONEPlanET is building knowledge communities from existing partners' communities around the Nexus initiative, mixing experts and future users of the platform from the EU and AU. The knowledge communities will also build on the existing networks of the EU and AU partners, particularly linked to the UNESCO institutions and collaboration.

Case Studies

ONEPlanET concept is built using three relevant case studies in Africa that represent different types of river basins, social, economic and energy contexts. The representativeness of the case studies ensures broad replicability of the project solutions and provides an interesting opportunity to progress in the development of a just energy transition in Africa that provides energy access for local communities and the conservation of resources and the environment.

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Co-design & Test - User engagement and co-design methodologies to build the ONEPlanET Toolkit

Building the ONEPlanET Toolkit with knowledge from Local Communities, will allow the design the user experience of the whole Toolkit adapted to real problems and challenges.

ONEPlanET Model - Novel Nexus model for African continent

Most of the existing models simulate the WEF Nexus in a one-way direction rather than fully investigating the feedback and interconnections of each element. ONEPlanET is addressing these missing aspects which include:

- Connections with other sectors (i.e. socio-economic)
- Inclusion governance policies
- Bottom-up approach

Capacity Building Materials - A comprehensive capacity building approach

Through capacity building, organizations and more generally all actors in the Nexus can develop competencies and skills that enable them to use resources more effectively and sustainably. ONEPlanET capacity building strategy has been conceived at two main levels: informing and learning.

ONEPlanET participates in the LEAP-RE Stakeholders' forum in Rwanda

The pursuit of sustainable energy solutions in Africa was put in the spotlight at ONEPlanET's recent **participation in the LEAP-RE Stakeholder Forum session** on energy modeling. This pivotal event featured members of the LEAP-RE Consortium and transpired on the 12th of October in Kigali, Rwanda, convening an assembly of experts and innovators committed to addressing the energy-related challenges affecting the African continent. A presentation on ONEPlanET's was delivered and unveiled its substantial contributions and insightful perspectives on sustainable energy solutions. The LEAP-RE Consortium's session served as the ideal platform for ONEPlanET to highlight its objectives and share its vision for a more sustainable future. The session epitomized the fusion of passion, expertise, and shared goals to ameliorate the energy scenario in Africa

4.2.5. Methods for stakeholder engagement and communication in 'Community Energy Systems and Sustainable Energy Transitions in Ethiopia, Malawi and Mozambique (CESET)'

A collaborative multi-institutional research partnership funded by the Global Challenges Research Fund, CESET explores the potential of community energy systems to accelerate inclusive, just, and clean energy transitions in Ethiopia, Malawi, and Mozambique.

We use the example of Malawi who produced a stakeholder analysis that identifies the different stakeholders involved in implementing community energy systems in rural areas in the Malawi energy sector. Identifying and engaging stakeholders early in the process builds support to help the project succeed. Benefits include:

- The opinions of the most relevant stakeholders can help to shape the project at an early stage
- Their input can also improve the quality of the project
- Communicating with stakeholders early and frequently, help the stakeholders keep track of project and understand the project activities which will lead to active participation.

Project Stakeholder Analysis

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Engaging various stakeholders in each country within the energy sector implementing various community energy systems in rural areas which has contributed to energy transition.

Communicating with stakeholders early and frequently, will help the stakeholder to keep track of project and understand the project activities and the benefits attached and this will lead to active participation when necessary.

Table 4 CESET project Stakeholder Analysis

N	Stakeholder	Supportive?	Importance (H/M/L)	Potential contribution to project success	Project Activities/ Output	Communications approach
1	Department of Energy Affairs	Yes	High	• Providing data on Minigrids mapping in Malawi • Reviewing of project outputs • Issuing of site visits permits • Participation in CESET project meetings • Providing feedback about the CESET project and possible advice, guidance on survey approach (key Informants)	• Formulation of database and landscape of CES in Malawi • Field visits, case studies and surveys	Face-to-face meeting, Workshops
2	Malawi Regulatory Authority	Yes	Medium	• Providing data on Minigrids projects/CES in Malawi • Participation in CESET project meetings, providing inputs in project reports	• Database and landscape of CES in Malawi • An analysis on the development of mini-grids in Malawi	Face-to-face meeting, Workshops
3	Community Energy Malawi	Yes	High	• Providing data on Minigrids projects/CES in Malawi • Participation in CESET project off meetings	• Database and landscape of CES in Malawi • Field visits, case studies and surveys	Face-to-face meeting, Workshops
4	United Purpose Malawi	Yes	High	• Providing data on Minigrids projects/CES in Malawi • Participation in CESET project meetings	• Database and landscape of CES in Malawi • Field visits, case studies and surveys	Face-to-face meeting, Workshops
5	Mzuzu Institute of Technology and Innovation	Yes	Medium	• Technical support Of Minigrids in Northern Malawi • Participation in CESET project meetings	• Database and landscape of CES in Malawi • Field visits, case studies and surveys	Face-to-face meeting, Workshops
6	FISD	Yes	Medium	• Technical aspect support on Minigrids in Northern Malawi	• Database and landscape of CES in Malawi	Face-to-face meeting,

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				• Providing data on minigrids implemented by them directly or through partnerships • Participation in CESET project meetings	• Field visits, case studies and surveys	Worksho ps
7	Churches Action in Relief and Developmen t (CARD)	Yes	High	• Participation in CESET project meetings • Providing data on Minigrids implemented	• Database and landscape of CES in Malawi • Field visits, case studies and surveys	Face-to-face meeting, Worksho ps
8	Practical Action	Yes	High	• Technical support on Minigrids in Northern Malawi • Providing data on Minigrids implemented	• Database and landscape of CES in Malawi, • Field visits, case studies and surveys	Face-to-face meeting, Worksho ps
9	MEGA	Yes	High	• Technical support on Minigrids in Northern Malawi • Providing Data on possible minigrids implemented	• Database and landscape of CES in Malawi, field visits, case studies and surveys	Face-to-face meeting, Worksho ps
10	Kumudzi Kuwale	Yes	Medium	• Technical Support on Minigrids in Malawi • Providing data on possible minigrids installed/Implemented	• Data Base development, landscape of CES/Minigrids in Malawi	Face-to-face Meeting, worksho ps
11	Cooperation Network for Renewable Energy in Malawi	Yes	High	• Providing support on policy review on community energy systems • Providing data on possible minigrids in Malawi	• Data Base development, landscape of CES/Minigrids in Malawi • Energy Policy Review paper	Face-to-face Meeting, worksho ps
12	Renewable Malawi	Yes	High	• Technical Support on Minigrids in Malawi • Providing data on minigrids installed/ Implemented	• Data Base development, landscape of CES/Minigrids in Malawi	Face-to-face Meeting, worksho ps

4.2.6. Methods for stakeholder engagement and communication in 'OpenMod4Africa: An EU funded Global Collaboration to Empower Africa's Energy Future'

The project OpenMod4Africa seeks to support access to clean, affordable energy for all in by creating an open modelling toolbox for long-term energy transition pathways for Africa.

The project aims to developing modelling toolbox adapted to African needs and uses, based on collaboration between African and European partners. The toolbox provides science-based results to policymakers and local actors, to assist them in analysing the environmental, social and economic synergies and trade-offs to be achieved in a clean energy transition in African countries, as well as the impact of increasing clean energy generation.

OpenMod4Africa specific objectives are to:

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- Develop a network of stakeholders
- Engage stakeholders in Western and Eastern Africa in the development of the OM4A
- Develop knowledge and understanding among a wider group of African stakeholders about energy system modelling
- Organise stakeholder discussions around project case studies
- Disseminate OpenMod4Africa results to a wider African audience
- Contribute to strengthening the Partnership on Climate Change and Sustainable Energy and cooperate with other ongoing initiatives

- The capacity building program, replication strategy and strong involvement of African academic institutions and other stakeholders guarantees that OpenMod4Africa can help increase African energy modelling competence and establish a network of local experts and users of the open Toolbox in the long-term.
- Energy industries and universities players will be invited to use the Toolbox, and to be involved in training activities. They will also be invited to a permanent network of expertise, which will be developed for further capacity building and collaboration beyond the project.

Case Studies and Collaboration from East to West: Africa is divided into five power pools. OpenMod4Africa will focus on the countries included in the West Africa Power Pool and in the Eastern Africa Power Pool. These cases will examine and develop energy pathways specific to each region, addressing the unique challenges and opportunities they face.

4.2.7. Methods for stakeholder engagement and communication in 'Productive Uses of Energy in Ethiopia - Agricultural Value Chain and Electrification'

The Productive Uses of Energy in Ethiopia project seeks to identify opportunities to electrify agricultural productive uses, how they can be developed through feasible business models, and the strategies and initiatives stakeholders can use to overcome barriers to deployment.

The project explores prevalent activities, community practices, and economic returns that indicate demand and local capacities in and potential benefits for rural communities. End-users are directly consulted through field surveys as well as through planned field visits and community workshops in the next stage of the project.

Steps to consultation and field testing:

Carry out community and national consultation (Design Sessions). The Design Sessions uses a three-*tiered* approach for connecting with end-users. The first two *tiers* focus on connecting with end-users to understand the barriers and opportunities at the community level. The third *tier* will convene national level stakeholders to build on and connect these community-level solutions with top-down broader actions to support and scale implementation of community-level projects.

Implement a Data Pilot to build a database and insights to estimate potential load and revenue growth for a mini-grid system serving milling loads, and better understand milling profitability and end-consumer preferences. The team will use this information to fine-tune the financial models and design of the pilots and demonstration projects proposed in the preliminary productive use program.

Disseminate study results. The team will lead cross-sectoral engagement across the agriculture, electricity, and finance sectors to share results, build consensus, and connect projects to actors and funding to prepare for implementation.

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Key stakeholders, including the ministries of energy, agriculture, economic planning, and finance are invited. Specific participants within these organizations should include sector specialists with experience in project design and implementation. They can then bring the required knowledge of ongoing projects and identify opportunities for collaboration. They can also leverage cross-sectoral initiatives and make recommendations on how to channel those collaboration opportunities into programmatic recommendations.

4.3. Selection of methodologies, methods and tools for Knowledge Base

This subchapter will summarise the important methodologies, methods and tools to be integrated in the Knowledge Base from the previously analysed projects as well as innovative approaches to energy system modelling in AU.

The methodologies and tools to be integrated in the knowledge base can be drawn from previous and ongoing projects similar to EMERGE that are summarized above. A multi-stakeholder engagement process was initiated by conducting a comprehensive survey to assess the level of energy modelling understanding as well as the needs of the evolved institutions and organizations in each country represented by the partners. Workshops were held by each partner for the project presentation followed by Questions & Answers for further clarification.

The above review of previous and ongoing projects describes important methodologies and tools such as direct contact and meetings, webinars, focus groups, interviews and surveys, conferences, social media, specialized workshops and training sessions, as main communication methods, for instance in the *FOCUS – Africa project*.

The approach of identifying and engaging stakeholders early in the process to build support and help the project to succeed adopted in the project *Community Energy Systems and Sustainable Energy Transitions in Ethiopia, Malawi and Mozambique* were also timely adopted in EMERGE. This approach emphasizes the need for communicating with stakeholders early and frequently, to help the stakeholder to keep track of the project and understand its activities and benefits.

As with the above summarized projects, dissemination channels in the EMERGE include stakeholder workshops, the project webpage, training, social media, dissemination materials and publications in scientific journals; this methodology will ensure that the project outputs and results reach the relevant target groups, especially end-users, in and beyond the participating countries. It also allows for transparency and visibility of the project activities and to acquire the support needed from crucial stakeholders

The quadruple helix approach adopted in the *LEAP-RE program* is an important lesson for EMERGE since engaging government, research and academia, private sector, and civil society would have a potential impact that would be essential for creating framework, methodology, and cooperation model in EMERGE.

An important lesson can also be learned from the *ONEPlanET project* which seeks to empower African policymakers, researchers, investors, and citizens with the knowledge and tools needed to increase clean energy production while reducing inequalities and cultural and social gaps. Similar to EMERGE this project will co-design and test a Toolkit, built upon existing WEF Nexus models and methodologies, that allows to simulate scenarios to optimize existing resources with the most appropriate policies considering social, climate, economic and biophysical constraints. With knowledge from Local Communities, will allow the design the user experience of the whole Toolkit adapted to real problems and challenges.

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The OpenMod4Africa project is also a good example of a project that seeks to support access to clean, affordable energy for all in by creating an open modelling toolbox for long-term energy transition pathways for Africa. By developing modelling toolbox adapted to African needs and uses, based on collaboration between African and European partners, this program constitutes a relevant reference for the EMERGE initiative.

The detail description of the tools and methods for Stakeholder inclusion which will be used in the EMERGE project is listed below:

- **EMERGE webpage** – it serves as a central location to access all the project's outcomes;
- **Hackathon** – which will be an open challenge that will enable knowledge sharing with collaborators outside the consortium and speed the creation of ideas for EMERGE project;
- **Research training and exchange** – AU to EU exchanges for 8 researchers will be organized in each of the tool developers premises;
- **Gamification tool GREENADVISE** – an open-access platform for energy system modelling, results evaluation and education will be developed in form of a simulation game based on the existing tool GREENADVISE;
- **Network of experts** – An online directory of energy modelling experts from EU and AU will be created as part of the initiative.

Hackathon: open challenge that will enable knowledge sharing with collaborators outside the consortium and speed the creation of ideas for EMERGE. This effort will make it possible to encourage original thinking in relation to EMERGE subjects and to strengthen EU-AU and AU-AU cooperation. The participants will work in small groups to discuss the outcomes of the EMERGE project and its consequences during this event (i.e. models, web platform). The hackathon's output will be the formulation of a plan to strengthen the EMERGE models and outcomes even more. Since this D&C phase will also determine the best approach to optimize the dispersion of the EMERGE approach and to support its further development, it will also feature a significant component related to replication. By better detailing the procedure for integrating new test cases for future assessments, including which data are required, data format, number of details, and practical assistance for their implementation, the replication phase will increase the model's flexibility. At least six sites for the testing and deployment of the EMERGE solutions are anticipated to be identified. It is crucial to emphasize the critical role played by African stakeholders in the project. They serve as mentors for finding modelling-motivating problems, validate model outputs, and serve as a target audience for learning about the modelling process and project outcomes. To promote knowledge sharing between the two continents, a community made up of various European and African stakeholders will be created and taught in energy system modelling.

Research training and exchange: with the objective to boost the AU-EU collaboration and knowledge transfer, AU to EU exchanges for 8 researchers or students will be organized. Researchers will visit the EU energy system modelling experts (Artelys, CIRCE and UNIZAG) where a specialized training sessions will be designed and held. This will directly involve AU partners ECREEE, UEM, UMP, AfriLabs and/or members of the Stakeholder Group. The exchanges will be designed for capacity building in modelling and will be promoted on EMERGE website where other mobility opportunities for other initiatives (e.g. ONEPlanET project) will be promoted as well.

GREENADVISE: is an investment advisor based on a Python module and used for the optimization of small-scale energy systems on a community or small city scale. Its' application can range from household or building level to small city and is suitable for citizens and civil societies without the energy

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background in formal education. Moreover, the capacity the used technologies such as PV plant, battery storage, heat pumps etc. is also included in the model. GREENADVISE finds optimal renewable capacities for the modelled system, develops hourly (or sub-hourly level based on user preference) optimized system operation, and finds economically optimal solutions. Therefore, model results with the optimal system capacities and operation displaying the economical results in form of savings and earnings, total system costs including CAPEX and OPEX costs, GHG emissions reduction and energy streams between the actors in the observed system on the user-defined time scale.

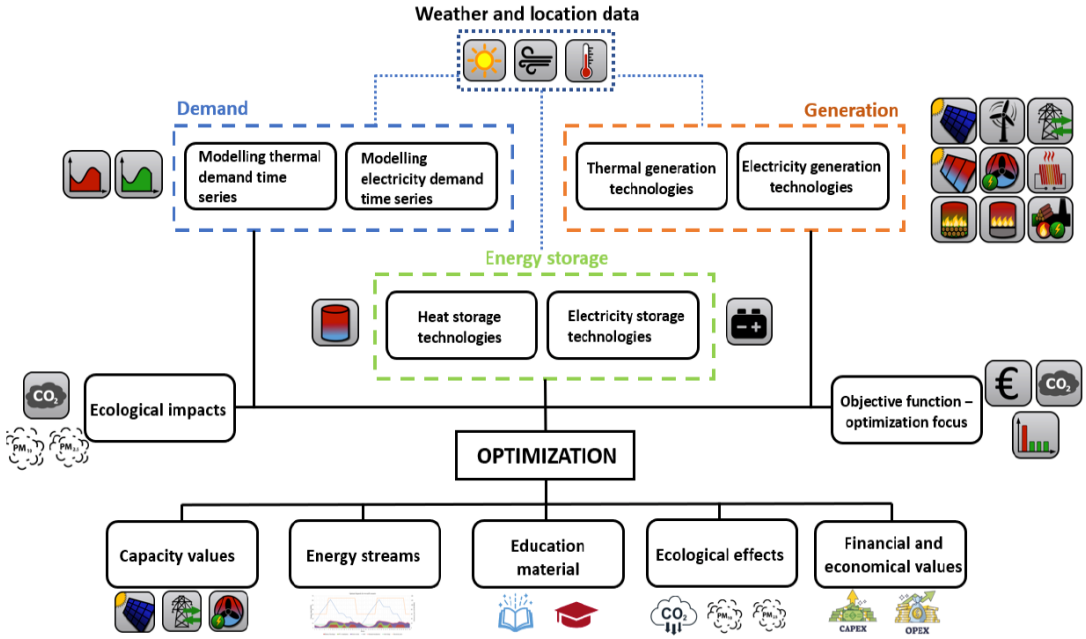

Figure 16 Overview of GREENADVISE structure

Network of EMERGE experts: An online directory of energy modelling experts from the EU and AU will be created as part of the initiative. Through a special part of the website called "Ask the expert," users of the model will be able to consult them or request assistance with specific tasks. Network of experts in EMERGE project already started in proposal preparation stage by contacting potential stakeholders and including them in Stakeholder Group

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Disciplines, complementarities and contributions to achieve EMERGE objectives	UNIZAG	CARTIF	EnGreen	ESE	Artelys	ECREEE	CIRCE	BrainIT	UEM	AfriLabs	UMP
Modelling capacities and expertise											
Expertise in modeling and informatic languages	■	■			■		■	■	■		■
Complex cases definition	■	■	■		■	■	■	■	■		■
Co-design methodologies		■	■	■	■	■	■	■			■
Energy system expertise											
Previous experience in energy sector	■	■	■	■	■	■	■	■	■	■	■
Expertise in energy modelling	■	■			■		■	■	■		■
Resource management in the African continent	■	■				■			■	■	■
Multidisciplinary approach	■	■	■	■	■		■	■			■
AU-EU partnership											
Physical presence in AU	■		■			■			■	■	■
Interactions with AU based initiatives		■	■	■	■	■			■	■	■
Active exchange programme EU-AU	■	■	■			■			■	■	■
Policy, regulation, social and stakeholders' acceptance											
Policy development capacity	■		■	■		■			■	■	■
Stakeholders' inclusion in governance definition processes and activities				■		■		■		■	■
Stakeholders' engagement strategies	■			■		■	■	■		■	
Replicability and capacity building of innovative solutions, stakeholder's engagement											
Replication in complex environments	■	■	■	■	■	■	■		■		
Training about energy system topics	■			■	■	■	■	■	■	■	■
Scalability			■	■	■			■			
Communication & Dissemination	■			■	■		■		■	■	■
Cross-sector impact assessment	■	■	■			■		■			

Figure 17 Expertise of project participants and consortium

4.4. Initial version of EMERGE stakeholder engagement methodology and value-based proposition design

4.4.1. Introduction to stakeholder engagement methodology and value-based proposition design

Draft of the initial stakeholder engagement methodology and value-based proposition design based on the analysis of previous projects is the main output from the task 1.2 and will be further developed in WP4. Results from the application and evaluation of the EMERGE methodology engagement and value-based proposition design for AU energy system modelling in the pilots will be communicated in dissemination activities in T6.1.

The EMERGE methodology is based on a cross-sectoral approach aimed at developing a user-friendly set of tools connected through a Common System Architecture that reflect on economic, environmental, social and technical aspects of the energy system. The methodology is aimed at using the EMERGE toolbox as a means for energy system modelling through which different experts and stakeholders (both AU and EU) will be connected as it is shown in the general EMERGE approach (Figure 18).

The EMERGE project is designed to support sustainable energy development in African regions by establishing a comprehensive framework for stakeholder engagement and value-based proposition design. This approach is structured to involve key stakeholders: government, industry, academia, and civil society, ensuring that the project outcomes align with regional needs, social values, and environmental priorities. By fostering collaboration among these diverse groups, EMERGE seeks to develop energy solutions that are not only technically robust but also socially and culturally inclusive.

In developing this engagement methodology, EMERGE builds upon successful models from other EU-funded projects, such as LEAP-RE and FOCUS-Africa, which emphasize the importance of stakeholder participation throughout the project lifecycle. These initiatives provide a foundation for EMERGE's

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quadruple helix approach, which brings together public and private stakeholders to co-create energy systems tailored to regional realities. Through this inclusive framework, EMERGE aims to enhance community ownership of energy solutions, reduce reliance on fossil fuels, and promote equitable access to energy resources.

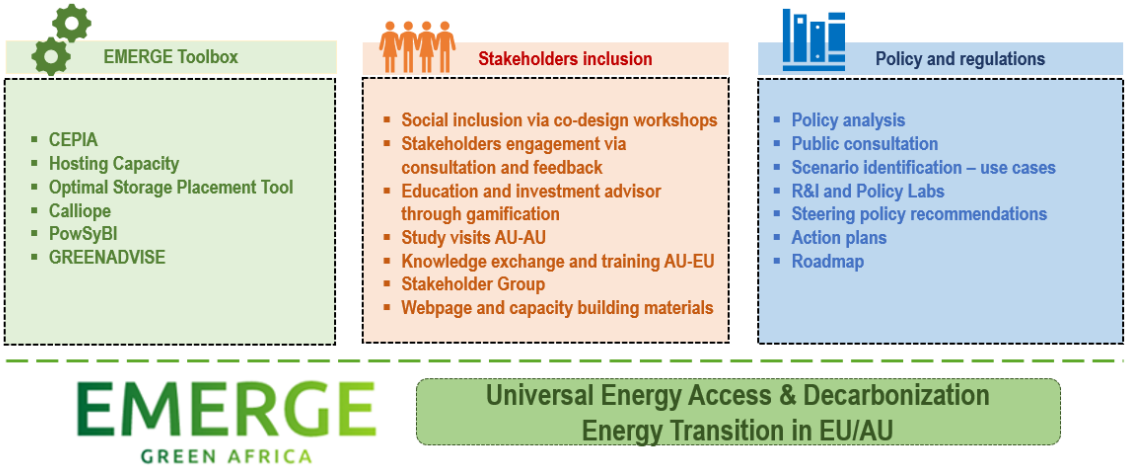

Figure 18 EMERGE project approach

Specifically, the methodology for developing stakeholder engagement plan is referring to identify the real needs and challenges that must be addressed at the local level with a particular focus on the project demo sites, and to assess how the EMERGE toolbox can support stakeholders in overcoming future energy challenges. Thus, the methodology is focused on the engagement of the stakeholders in the EMERGE project activities and outcomes, mainly leveraging on stakeholder consultations to develop a dynamic tool to be adopted during the project implementation as well as in ex-post evaluations.

Having the ambition in progressing the development of EMERGE toolbox, a set of activities aligned to the stakeholder groups (also described in D5.1), should be monitored and evaluated. A preliminary list of activities is reported in the table below, each activity can be associated to a specific group of stakeholders, having then different objectives. Therefore, it is important to underline that these project activities may be different in terms of contents (i.e. EMERGE Toolbox usage and testing, training sessions and co-design workshops).

Table 5 EMERGE stakeholder co-design process

Type of stakeholders	Main project activities that include stakeholders
Expert stakeholder	Focus Groups with country-based experts (IRESEN, ...)
	WSs with other EU funded project (co-design WSs)
	Training activities (AU-EU exchanges)
	AU-AU Study visits
Other stakeholders	Interactive surveys for project stakeholder at 3 demo site location
	Hackathon

These considerations underscore the need for a stakeholder's engagement plan that can assess a wide range of activities while effectively interacting with diverse stakeholder groups, and it clearly outlines the responsibilities of the various actors involved, the timeline for evaluation activities, and the success criteria that will be used to measure the project's impact.

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In brief, the methodology for developing the stakeholder's engagement plan and value-based proposition design is summed up in the following flowchart, and it outlines key contents of the stakeholder's engagement strategy. It is divided into five different phases, which have the objective of producing specific outputs. Each Phase is described in the following sections.

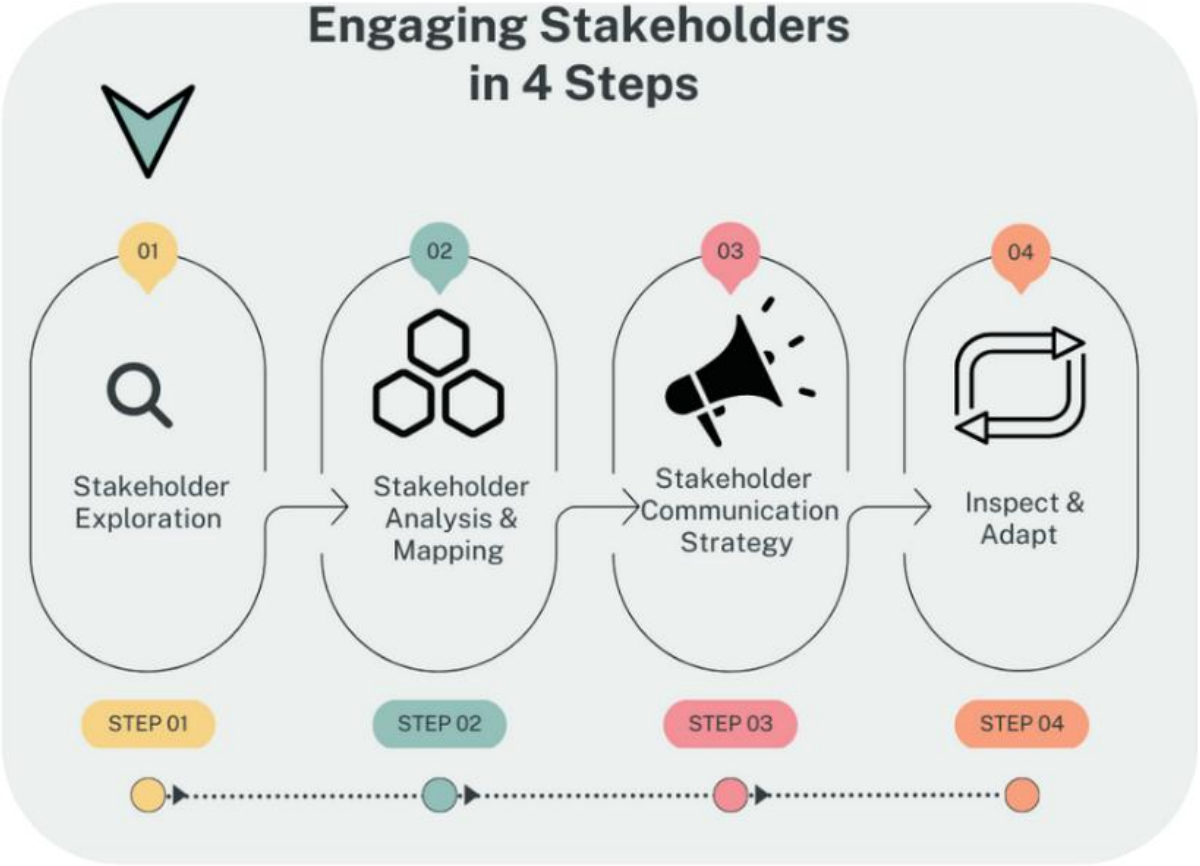

Figure 19 Flowchart of the stakeholder engagement

4.4.2. Purpose of the stakeholder engagement methodology

The purpose of the EMERGE stakeholder engagement methodology is to build a foundation for inclusive, regionally adaptable energy system modelling that aligns with social, environmental, and economic priorities across African communities. According to the "co-design approach" which will be described in D4.1 (Task.4.1), the development of the stakeholder engagement methodology is organized to engage with stakeholders on different levels.

To ensure that all stakeholder perspectives are considered, the methodology actively involves representatives from government, industry, academia, and civil society. This inclusivity not only enhances transparency but also ensures that solutions reflect a broad range of perspectives and needs. To emphasizes collaboration at every stage, project invites stakeholders to take part in co-designing energy models and other project activities. Through workshops, training, and collaborative tools, the methodology fosters knowledge exchange, building local capacity for energy modelling. This capacity-building element is crucial, as it equips local stakeholders to sustain and expand energy solutions beyond the project's lifespan. By empowering stakeholders to shape project outputs, EMERGE enhances ownership and trust among communities, helping to ensure long-term viability.

Feedback loops are embedded in the engagement process, allowing stakeholder insights to inform project partners in order to adapt outputs to fit the local needs. This adaptive approach ensures that

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the project can respond to evolving regional needs and challenges, creating flexibility for diverse social and economic contexts. By including stakeholder's inputs into the design process, the methodology aligns project goals with local priorities such as economic resilience, equitable energy access, and environmental protection. This alignment ensures that the project delivers not only technical efficiency but also social and cultural relevance.

4.4.3. Identification of the target groups (quadruple helix)

To effectively address the objectives of the stakeholder engagement strategy defined above, the overall methodology adopts a cross-cutting consultation process, which engages with different layers of stakeholders, ranging from technical experts to political/business representatives, to describe a broader picture of the engaged actors, which is aligned with the EMERGE Evaluation Plan which will be set in WP4. The EMERGE project's stakeholder engagement framework is based on the Quadruple Helix model, which brings together four primary stakeholder groups: Policy makers, Investors, Academia, and Civil Society. This model is designed to integrate perspectives from each of these groups, fostering a collaborative environment where all voices are valued and represented:

- Policy makers: Includes government, regulatory bodies, and local authorities which are essential for providing the legal, administrative, and financial support needed to implement sustainable energy solutions. They play a central role in establishing frameworks that enable renewable energy projects and can also introduce incentives or mandates that support green transitions. Their involvement ensures that energy solutions align with national policies and benefit from regulatory support, making projects more scalable and sustainable. Policy makers representatives should be engaged in workshops where they provide insights on policy needs and regional constraints.
- Investors: Industry partners, including private energy companies, technology providers, and SMEs, bring essential technical expertise and investment capacity to the project. They can contribute to cutting-edge technology, innovative solutions, and funding, making them key players in transforming energy models into practical applications. Their expertise helps ensure that the energy solutions developed are not only feasible but also market-oriented, cost-effective, and scalable. They can often provide technical data, participate in pilot implementations, and help refine models to ensure they meet market requirements. They may also collaborate on testing new technologies and sharing best practices for integrating renewable energy into local infrastructure.
- Academia: Academic institutions, researchers, and scientists contribute the analytical and technical knowledge required for rigorous energy modelling and data analysis. They are instrumental in developing and validating models, offering review and conducting analyses that inform project decisions. Through research partnerships, they can test hypotheses, gather data, and provide critical assessments that enhance the accuracy and effectiveness of energy solutions. They can be supportive in the development of the project energy modelling tools or analyse data from pilot projects. They also contribute by training future professionals, ensuring a steady flow of expertise to support energy transitions.
- Civil Society: including local communities, non-profit organizations, and advocacy groups, represent the public's needs and priorities, focusing on transparency, inclusivity, and equitable access to resources. They ensure that the energy models consider social dimensions, including community values, environmental justice, and equitable access to resources. Their participation encourages community ownership and trust, fostering long-term engagement and alignment with local interests. They will participate in surveys, contribute to workshops, and provide feedback on project impacts.

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Each of these categories are engaged by means of different activities in the EMERGE projects. Thus, their type of contribution to the project is set according to their different degrees of awareness. The number of stakeholders and the level of engagement in the project activities varies according to the closeness to the project.

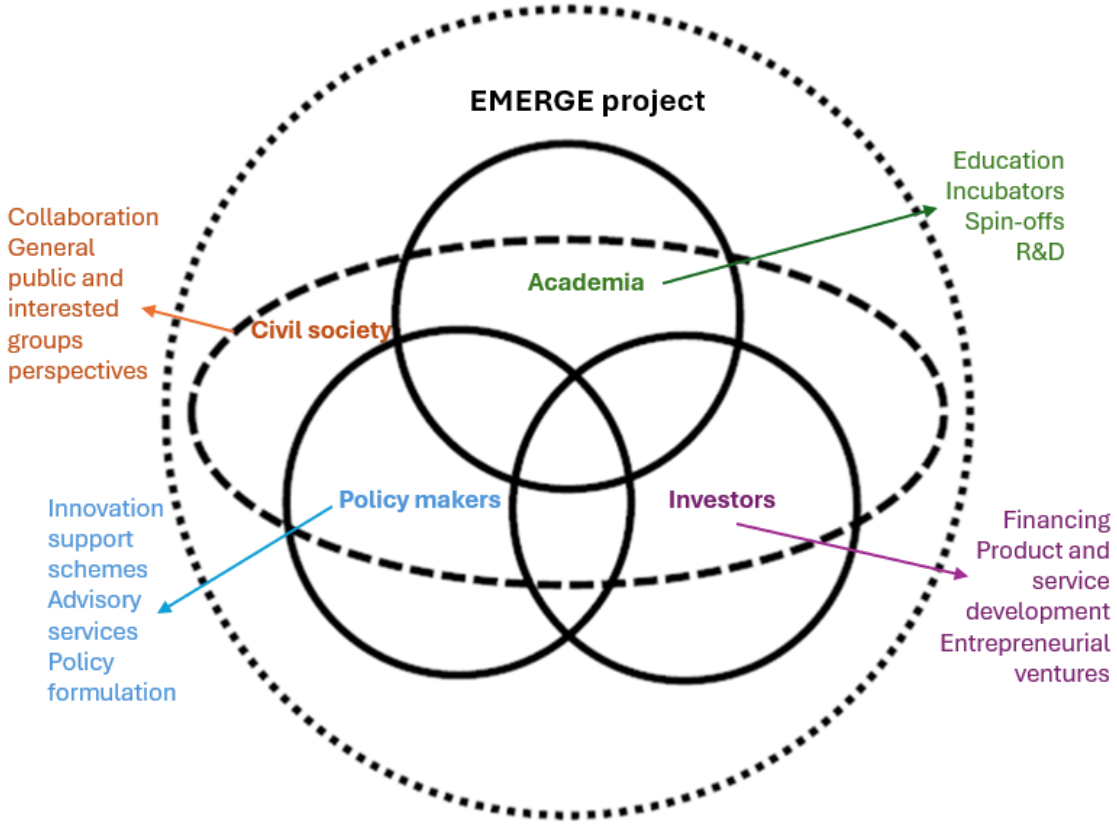

Figure 20 EMERGE Quadruple Helix stakeholder engagement

4.4.4. Criteria Definition for stakeholder engagement

To ensure that the EMERGE project's engagement process is impactful and aligned with the project's objectives, a set of criteria has been established for identifying and involving stakeholders. This criteria-based approach prioritizes relevance, influence, expertise, and commitment, ensuring that engaged stakeholders can meaningfully contribute to the project's energy modelling efforts. By setting clear guidelines, EMERGE ensures a strategic selection of stakeholders that not only represent key sectors but also actively support the project's goals. The criteria are presented in table below.

Table 6 Stakeholder Engagement Criteria

Criteria	Description	Examples
Relevance to Project Objectives	Alignment with sustainable energy and project goals	Regional governments, energy focused NGOs
Influence and Capacity	Ability to impact policy or project implementation	National energy agencies, business leaders
Technical Expertise	Knowledge in energy modelling, policy, or technology	Energy researchers, technology developers
Commitment	Willingness to participate consistently throughout the project	Community leaders, academic institutions

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Geographic & Cultural Relevance	Regional representation and cultural understanding	Local NGOs, community organizations
Community Advocacy	Capacity for mobilizing public support and promoting equitable access	Grassroots organizations. public interest groups

Stakeholders are selected based on their alignment with EMERGE's goals, specifically in areas such as energy system modelling, sustainable development, and social equity. This criterion ensures that stakeholders possess a vested interest in energy transition topics relevant to the project's scope. By choosing groups and individuals directly impacted by or contributing to sustainable energy, EMERGE builds a coalition of participants with a genuine commitment to the project's success.

Priority is given to stakeholders with the ability to influence policy, public opinion, or project implementation, as well as those who bring significant resources or networks. Engaging influential stakeholders enables EMERGE to leverage their networks and resources, amplifying the project's reach and impact. These stakeholders, whether in government or businesses, have the power to facilitate regulatory support, mobilize funding, or scale solutions.

On the technical expertise criteria stakeholders are chosen based on their expertise in areas essential to energy modelling, renewable technology, policy development, and community organization. This criterion ensures that EMERGE benefits from cutting-edge technical knowledge, methodological review, and sector-specific insights. Expert stakeholders can contribute significantly to the quality and accuracy of energy models, data collection, and analysis.

Engagement efforts prioritize stakeholders with a demonstrated willingness to contribute consistently throughout the project's duration and can create a long-term participation commitment. This enables project to develop a stable and productive collaboration environment. Committed stakeholders are more likely to provide continuous feedback, adapt to project needs, and contribute to iterative improvements in the engagement process.

Stakeholders should represent the cultural and geographic diversity within African regions targeted by the EMERGE project. Selecting stakeholders with region-specific knowledge and cultural understanding ensures that project outcomes are relevant and adaptable to local contexts. This criterion is essential for ensuring that the solutions are respectful of, and responsive to, cultural practices, language differences, and regional environmental factors.

Engagement also prioritizes stakeholders capable of mobilizing community support and advocating for equitable energy access. Community advocates, especially within civil society, help build trust and encourage local participation, ensuring the project's social acceptance and long-term sustainability.

For capacity-building and workshop activities, different criteria may apply, with a focus on understanding the activities, ease of participation, and the degree of engagement throughout the process.

4.4.5. Data Collection process

The data collection process is designed to gather valuable insights from a diverse array of stakeholders, enabling an understanding of the social, economic, and environmental factors that influence energy needs and preferences. This process employs multiple methodologies to ensure inclusivity, data richness, and validity, using both quantitative and qualitative techniques to gather actionable insights. Through surveys, workshops, and interviews, EMERGE captures diverse perspectives across various

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regions, sectors, and demographic groups, ensuring that the project's models are both accurate and reflective of stakeholder priorities. Key Steps in the Data Collection Process are following :

- Initial Stakeholder Survey

To gather baseline information on stakeholder priorities, needs, and expectations regarding energy modelling. Surveys were distributed to a wide range of stakeholders, including representatives from government, businesses, academia, and civil society, focusing on initial perceptions and priorities for energy modelling and EMERGE tool design. Survey questions covered topics such as data collection, energy markets, regulatory, administrative, and legal support, infrastructure aspects, methods and technical & financial tools, value and needs of citizens and communities on a social level. Both closed and open-ended questions are included to allow for statistical analysis and in-depth qualitative responses. This step generated a foundational dataset that highlights initial trends, identifies pressing issues, and provides a snapshot of stakeholder expectations. This information guides subsequent data collection phases, helping to refine engagement efforts.

- Co-creation Workshops and Focus Groups

To facilitate in-depth discussions and collaborative feedback, enabling stakeholders to engage with each other and the project team in a structured setting. Workshops are organized at regional levels and in online formats to accommodate various groups, with participants split into smaller focus groups based on topics. Each workshop is facilitated by project members to guide discussions around key topics, mentioned before. Workshop activities include brainstorming sessions, case study analysis, and exercises, which encourage participants to contribute openly and collaboratively. Visual aids, data projections, and sample models are provided to facilitate informed discussion. Workshops help to deepen the understanding of stakeholder needs, highlight sector-specific concerns, and encourage cross-sectoral insights. Focus group discussions enable the project team to capture detailed, context-specific data that complements survey findings.

- One-on-One Interviews

In order to gain qualitative insights from key stakeholders on specific topics, challenges, and recommendations related to energy modelling and system implementation one-on-one interviews are suggested. Semi-structured interviews are conducted with selected stakeholders who have specialized knowledge or represent unique viewpoints, such as policymakers, industry innovators, or community advocates. Interview topics include energy markets, regulatory, administrative, and legal support, infrastructure aspects, and stakeholder-specific needs. The flexible, semi-structured format allows interviewers to explore complex topics in greater depth, encouraging interviewees to share detailed perspectives. Interviews provide in-depth, qualitative data that reveal individual motivations, concerns, and strategic insights. This rich dataset adds context to survey and workshop findings, offering a holistic understanding of stakeholder views.

- Pilot Testing Results

To observe real-world applications of energy solutions in pilot regions and test preliminary models to validate assumptions and data accuracy. This involves site visits to pilot locations, allowing the project team to gather firsthand data on environmental, social, and economic factors influencing energy use. In addition, pilot testing is conducted to assess the feasibility and functionality of proposed solutions. Observations focus on factors like community engagement, environmental impact, and operational challenges. Feedback from local stakeholders is actively solicited during these visits through earlier mentioned methods, providing a grounded perspective on the practicalities of model deployment. AU-

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EU training and AU-AU visits will provide practical insights into the effectiveness of proposed tools, helping to identify necessary adjustments and improvements. These findings are used to enhance model accuracy and tailor solutions to real-world conditions.

- Continuous Feedback Loops

To maintain an iterative, adaptive data collection process that incorporates stakeholder feedback at every project phase. Feedback loops are established through regular communication channels, including online platforms, email updates, and follow-up surveys. These channels allow stakeholders to review project progress, provide input, and highlight emerging issues as the project evolves. Stakeholders are invited to provide feedback on model adjustments, implementation strategies, and observed outcomes. Open channels for feedback ensure that the project remains responsive to stakeholder concerns and can adapt to changing conditions or emerging needs. Ongoing feedback helps refine models and tools, aligning project outputs with stakeholder expectations and fostering a culture of transparency and collaboration.

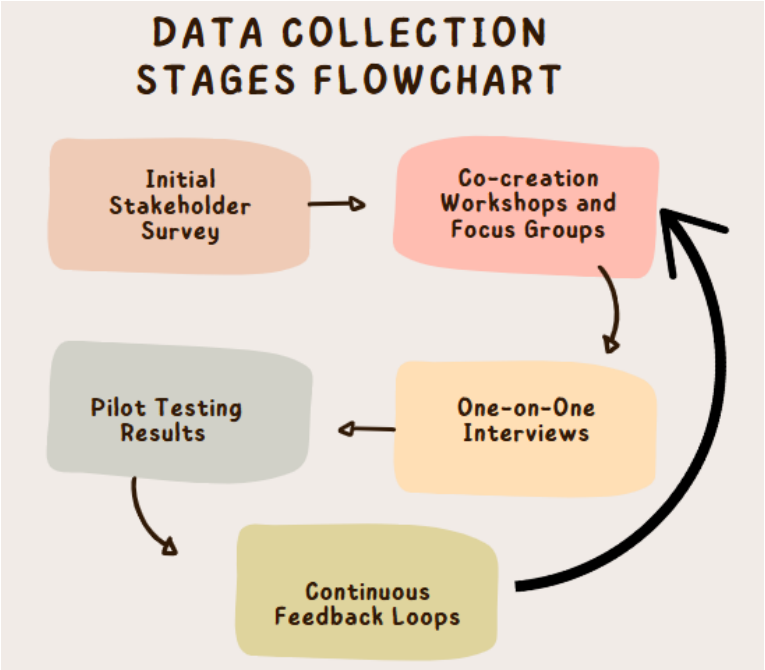

Figure 21 Data collection stages flowchart

In the following table, the three key methods of the stakeholder's project evaluation (ranking survey, satisfaction survey for training activities and the satisfaction survey for co-design workshops) are presented and additional details are given in the D5.1.

Table 7 Three key methods of the stakeholder's project evaluation

	A.1	A.2	B.1 / B.2	C.1	C.2
Expert Stakeholder	Satisfaction survey (1)	Satisfaction survey (2)	Ranking survey (extended version)	-	Ranking survey (extended version)
	Platform: ODK	Platform: Mentimeter	Platform: ODK	-	Platform: ODK

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Other Stakeholder	Satisfaction survey (1)	Satisfaction survey (2)	Ranking survey (basic version)	Satisfaction survey (1)	-
	Platform: ODK	Platform: Mentimeter	Platform: ODK	Platform: ODK	-

According to the presented table it emerges that different levels of interactions will be adopted between Expert and Other Stakeholders. Moreover, the activities involving project stakeholder are in the table as results will be considered separately by stakeholder's results as per a conflict-of-interest issue. Two platform will be used to prepare and tailor the tool's contents: ODK and Mentimeter.

4.4.6. Data management and analysis

Collected data from previous phase will be organized via digital methods for allowing the data aggregation and processing. Data coming from the surveys and evaluation activities will be cleaned and processed to catch feedback from stakeholders. The data will be kept and managed in accordance with the General Regulation on the Protection of Personal Data (GDPR). This chapter describes the protocols for data handling, security, and analysis that ensure accuracy and transparency, supporting the project's iterative adaptation and responsiveness to stakeholder feedback. By structuring data management around a centralized Knowledge Base, EMERGE aims to streamline access to valuable insights and maintain data integrity, facilitating effective decision-making.

The data management process generally consists of five phases:

1. Data Storage and Security: To securely store all stakeholder data, ensuring confidentiality and integrity while making data readily accessible for analysis and project team use. All data from surveys, workshops, interviews, and observations are stored in a secure, centralized database with restricted access, ensuring that only authorized team members can access sensitive information. Data is encrypted during storage and transfer to protect against unauthorized access. The database adheres to industry-standard security protocols, protecting stakeholder data from potential breaches.
2. Data Organization and Structuring: To structure data in a way that facilitates easy access, retrieval, and analysis by categorizing it based on criteria relevant to stakeholder engagement and energy modelling. Data is organized based on its source (e.g., survey, workshop, interview) and type (e.g., quantitative, qualitative), making it easy to locate and analyse specific datasets. As data is refined through analysis, previous versions are preserved in a structured format, supporting transparency and traceability of data changes. An organized data structure that ensures efficient retrieval and utilization, supporting streamlined analysis and adaptability across different stages of the project.
3. Quantitative and Qualitative Data Analysis: Conducting both quantitative and qualitative analyses to extract actionable insights and identify patterns that inform energy model development and stakeholder engagement strategies. Statistical analysis is conducted on survey data to identify trends, correlations, and priorities among stakeholder groups. Qualitative data from workshops, interviews and survey responses is analysed using thematic analysis. This approach allows the project team to identify recurring themes, stakeholder concerns, and unique insights that provide context for quantitative findings. For interviews sentiment analysis tools assess stakeholder attitudes toward various project aspects, providing a nuanced understanding of stakeholder satisfaction, concerns, and priorities. A comprehensive understanding of stakeholder needs, expectations, and preferences that guides

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the project's decision-making and enhances the relevance and effectiveness of its energy solutions.

4. Feedback Integration and Continuous Improvement: Creating a feedback loop that continuously refines data collection and analysis methods based on stakeholder inputs and project progress. Regular sessions are held to review the latest data analysis results, discussing how stakeholder insights align with project goals and identifying areas for improvement. Feedback from these review sessions informs modifications to survey questions, workshop agendas, and interview protocols, ensuring data collection remains relevant and effective. Ongoing quality checks assess the reliability and validity of collected data, addressing potential biases, missing data, or inconsistencies. This process ensures that data integrity is maintained, supporting trustworthy project outcomes. An adaptive data collection and analysis framework that aligns with the evolving needs of stakeholders, enabling EMERGE to remain responsive and relevant.
5. Data Sharing and Reporting: To communicate findings transparently with stakeholders while protecting sensitive information and supporting collaborative project efforts. Deliverables summarize data analysis outcomes, sharing insights and project progress with stakeholders while maintaining confidentiality. Visual tools like graphs, charts, and dashboards are used to present data analysis results in an accessible format, making complex information understandable for a broad audience, especially in the project website and database (Knowledge Base). Key insights are stored in a user-friendly knowledge base, allowing stakeholders and project members to access the data they need to inform decisions and track progress. Clear, accessible, and secure data sharing that maintains transparency and fosters stakeholder collaboration, strengthening trust and engagement.

Table 8 Data management and analysis

Data Management Aspect	Description	Protocols
Storage and Security	Secure, centralized storage with encrypted data	Role-based access control, encryption protocols
Organization and Structuring	Efficient data categorization and tagging	Source/type categorization, metadata tagging, version control
Quantitative and Qualitative Analysis	Statistical and thematic analysis for comprehensive insights	Statistical tools, thematic coding, sentiment analysis
Feedback Integration	Continuous refinement of data processes based on insights	Iterative review, data quality checks, adjustment of collection methods
Data Sharing and Reporting	Transparent reporting while protecting sensitive information	Regular reporting, data visualization, accessible knowledge base

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5. Conclusion and future steps

Deliverable 1.1 of the EMERGE project marks a critical first step in establishing the framework necessary to support the project's overall success. With the completion of this deliverable, the project has made significant progress in laying the groundwork for both a comprehensive Knowledge Base and an inclusive Stakeholder Engagement Methodology. These two components are foundational, not only for the successful implementation of the project but also for its long-term sustainability and relevance in addressing energy system challenges across African regions.

The Knowledge Base, as outlined in this deliverable, serves as a central repository of all necessary information, tools, data, and best practices that are essential for energy system modelling. It is structured to be both user-friendly and dynamic, continuously evolving as new insights and developments emerge throughout the project. By offering a space where technical, regulatory, and practical knowledge can be consolidated, the Knowledge Base plays a crucial role in enabling informed decision-making and fostering collaboration among a diverse group of stakeholders. It includes not just project members but also external experts and communities, ensuring that the information it contains is applicable and accessible to all involved parties.

On the other hand, the Stakeholder Engagement Methodology developed in this deliverable is pivotal for ensuring that the project's outputs are aligned with the real-world needs and concerns of those involved or impacted by energy system transitions. By mapping out and categorizing a broad range of stakeholders, the methodology ensures that the engagement process is inclusive and representative of all key voices, including experts, policymakers, communities, and local citizens. Through initial engagements, such as surveys and workshops, the project has already begun the process of gathering input and feedback from stakeholders, which will continue to shape both the Knowledge Base and the broader project outcomes.

Lastly, one of the unique strengths of the EMERGE project, as reflected in this deliverable, is its ability to draw on lessons learned from previous and ongoing projects, such as LEAP-RE, FOCUS-Africa, D4D Hub, ONEPlanET, and others. The analysis of the State of the Art from these projects provides valuable insights into effective methods for stakeholder engagement, communication, and value-based proposition design. These past experiences allow the EMERGE project to build on proven strategies, while also identifying areas where innovations can be made.

As the project moves forward into the subsequent tasks and work packages, including the development of energy system modelling tools and the implementation of pilot programs, the Knowledge Base and stakeholder engagement practices established here will play an essential role in guiding the project to successful outcomes. Ongoing collaboration and feedback loops will allow the EMERGE project to remain adaptable, ensuring that its innovations in energy system modelling are both practical and impactful in driving Africa's green energy transition.

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6. References

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7. Annexes

7.1. Initial survey

EMERGE- Stakeholder data collection

The EMERGE project seeks to provide African policy makers, academics, investors, and citizens with the tools and knowledge required to increase the production of clean energy and the sustainable use of resources. This objective is going to be accomplished by designing a Toolbox that would simulate several scenarios with the aim of optimizing the use of current resources while taking into consideration social, economic, climatic and technical constraints.

Furthermore, a Knowledge Base with a collection of initiatives, materials and knowledge-exchange activities is going to be created. The creation of the Knowledge Base will be based, among other things, on needs and recommendations of the Stakeholders which are partially going to be gathered through this survey and later on, stored in the Knowledge Base.

EMERGE - Stakeholder data collection

In accordance with the General Regulation on the Protection of Personal Data (GDPR), by subscribing to this service you allow us to use your personal data (name and surname, email) for the purpose of contacting you with information about events, activities and information related to the project "EMERGE" nuanced by the HORIZON EUROPE grant no. 101118278 and similar upcoming events that might interest you.

GENERAL INFORMATION

1. Name of Stakeholder:

_____

2. Country of Stakeholder:

_____

3. Type of Stakeholder:

- ◯ Academia and Research
- ◯ Policy maker
- ◯ Investor
- ◯ Civil society

4. Name of the person filling the questionnaire:

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5. Stakeholder contact:

DATA COLLECTION

6. How are you currently involved or planning to be involved in energy system modelling or related projects?

- ☐ Conducting research and development in energy system modelling methodologies.
- ☐ Collaborating with industry partners on modelling projects for infrastructure planning.
- ☐ Providing consulting services for energy market analysis and optimization.
- ☐ Integrating energy system modelling into academic curricula and training programs.
- ☐ Participating in government initiatives to inform policy-making through modelling insights.
- ☐ Other:

7. How do you currently collect and manage data for energy system modelling purposes?

- ☐ Utilizing government databases and publicly available data sources.
- ☐ Collaborating with industry partners to access proprietary data sets.
- ☐ Deploying sensors and IoT devices for real-time data collection.
- ☐ Conducting surveys and interviews to gather qualitative information.
- ☐ Developing custom data management systems and databases for organizing and analyzing data.
- ☐ Other:

8. What types of data do you consider most crucial for accurate energy system modelling?

1-Most Crucial 5-Least Crucial

	1	2	3	4	5
Energy production and consumption	◯	◯	◯	◯	◯

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data.

Infrastructure and grid topology information.	⬭	⬭	⬭	⬭	⬭
Weather and climate data.	⬭	⬭	⬭	⬭	⬭
Market prices and economic indicators.	⬭	⬭	⬭	⬭	⬭
Policy and regulatory information.	⬭	⬭	⬭	⬭	⬭

9. Please specify other types of data, if any, you find crucial and important:

10. What challenges do you encounter in acquiring reliable data for energy system modelling and how do you address them?

11. What are your key needs and wishes regarding the creation or expansion of energy system models?

1-Most Important 5-Least Important

1	2	3	4	5	
					Access to high quality, reliable data sources for accurate modelling

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Collaboration opportunities with industry stakeholders and policymakers for informed decision making

Funding support for research and development to enhance modelling capabilities

Standardization of methodologies and best practices to ensure consistency across models.

Integration of advanced technologies such as AI and machine learning for improved model accuracy and efficiency.

12. Please specify other key needs and wishes, if any, you find important:

13. Are there specific data sources or databases you rely on for energy system modelling, and what improvements would you suggest for them?

ENERGY MARKETS

14. How do you see energy markets influencing or being influenced by energy system models?

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- ☐ Energy markets influence energy system models by providing data on supply, demand, and pricing dynamics.
- ☐ Energy system models help identify market inefficiencies and opportunities for optimization, thus influencing market strategies and operations.
- ☐ Market regulations and policies shape the inputs and outputs of energy system models, influencing their accuracy and relevance.
- ☐ Energy system models support market participants in decision-making by providing insights into potential risks and opportunities.
- ☐ Collaborative efforts between energy market stakeholders and model developers enhance the integration of market insights into modelling practices.
- ☐ Other: _____

15. What market trends or factors do you believe should be incorporated into energy system models?

- ☐ Fluctuations in energy prices due to supply and demand dynamics.
- ☐ Shifts in consumer preferences and behaviour towards renewable energy sources.
- ☐ Regulatory changes impacting market structure and operations.
- ☐ Technological advancements influencing energy production and distribution.
- ☐ Global factors such as geopolitical events and climate change policies affecting energy markets.
- ☐ Other: _____

16. How can energy system models adapt to changes in energy market dynamics?

- ☐ Incorporating real-time data integration to reflect current market conditions.
- ☐ Implementing scenario analysis to anticipate and respond to market fluctuations.
- ☐ Integrating machine learning algorithms for dynamic model calibration and updating.
- ☐ Enhancing flexibility in model architecture to accommodate evolving market structures.
- ☐ Collaborating with industry stakeholders to incorporate market insights and expertise into model design.
- ☐ Other: _____

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17. In what ways do you think energy system modelling can contribute to optimizing market operations and efficiency?

- ☐ Forecasting energy demand and supply to facilitate efficient resource allocation.
- ☐ Identifying opportunities for cost savings and revenue generation through market optimization.
- ☐ Analysing the impact of policy changes and market reforms on energy market dynamics.
- ☐ Enhancing grid stability and reliability by simulating various operating scenarios.
- ☐ Supporting decision-making processes for investments in infrastructure and technology upgrades.
- ☐ Other: _____

REGULATORY, ADMINISTRATIVE AND LEGAL SUPPORT

18. What regulatory, administrative, and legal support do you believe is necessary for successful energy system modelling projects?

1-Most Necessary 5-Least Necessary

	1	2	3	4	5
Clear and streamlined regulatory processes for data acquisition and sharing.	☐	☐	☐	☐	☐
Adequate funding mechanisms to support modelling initiatives.	☐	☐	☐	☐	☐
Legal frameworks ensuring intellectual property protection and data privacy.	☐	☐	☐	☐	☐
Collaboration between regulatory bodies and industry stakeholders to address regulatory gaps.	☐	☐	☐	☐	☐

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Standardized administrative procedures for project approval and implementation.

☐ ☐ ☐ ☐ ☐

19. Please specify other regulatory, administrative and legal support, if any, you find necessary:

20. What regulatory hurdles or barriers do you encounter in implementing energy system modelling projects?

- ☐ Limited access to essential data due to regulatory constraints.
- ☐ Complex licensing requirements for utilizing proprietary software tools.
- ☐ Unclear regulatory guidelines for integrating renewable energy sources into models.
- ☐ Compliance challenges with environmental regulations affecting modelling outcomes.
- ☐ Delays in obtaining permits for conducting eld studies or data collection.
- ☐ Other:

21. What administrative processes hinder progress in energy system modelling initiatives?

- ☐ Lengthy permit and approval procedures for data acquisition.
- ☐ Complex bureaucratic requirements for project funding and grants.
- ☐ Inefficient coordination among government agencies and departments.
- ☐ Lack of standardized protocols for sharing data across organizations.
- ☐ Cumbersome reporting and compliance obligations for modelling projects.
- ☐ Other:

22. Are there legal considerations specific to energy system modelling that you believe need more attention or clarification?

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23. How can regulatory frameworks be improved to better support the development and deployment of energy system models?

- ☐ Increased collaboration between regulators and industry stakeholders.
- ☐ Streamlining approval processes for energy system model projects.
- ☐ Implementing flexible regulations to adapt to evolving technology.
- ☐ Providing incentives for research and development in energy modelling.
- ☐ Enhancing transparency and accessibility of regulatory decision-making processes.

Other: _____

INFRASTRUCTURE ASPECTS

24. What infrastructure considerations are important for the development and implementation of energy system models?

1-Most Important 5- Least Important

	1	2	3	4	5
High-performance computing resources for complex modelling simulations.	☐	☐	☐	☐	☐
Data storage and management systems capable of handling large datasets.	☐	☐	☐	☐	☐
Collaborative platforms for sharing and accessing modelling tools and resources.	☐	☐	☐	☐	☐
Integration with existing energy infrastructure and grid systems.	☐	☐	☐	☐	☐
Cybersecurity measures to protect sensitive data and modelling algorithms.	☐	☐	☐	☐	☐

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25. Please specify other infrastructure considerations, if any, you find important:

26. What challenges do you foresee regarding infrastructure compatibility and integration with energy system models?

- ☐ Diverse data formats and standards across different infrastructure components.
- ☐ Limited interoperability between modelling software and existing infrastructure systems.
- ☐ Scalability issues in handling large-scale infrastructure data for modelling purposes.
- ☐ Security vulnerabilities arising from interconnected infrastructure and model integration.
- ☐ Complexity in coordinating stakeholders and resources for infrastructure-model integration projects.
- ☐ Other:

27. How can technological advancements in infrastructure support the scalability and accuracy of energy system models?

- ☐ Implementation of advanced sensors and IoT (Internet of Things) devices for real time data collection.
- ☐ Utilization of cloud computing and big data analytics for scalable modelling solutions.
- ☐ Integration of machine learning algorithms for dynamic model calibration and optimization.
- ☐ Development of high-resolution spatial and temporal modelling techniques.
- ☐ Adoption of distributed energy resources and smart grid technologies for enhanced modelling accuracy.
- ☐ Other:

28. Are there innovative approaches or technologies you recommend for enhancing the infrastructure aspects of energy system modelling?

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METHODS AND TECHNICAL & FINANCIAL TOOLS

29. What technical and financial tools do you find most valuable in the context of energy system modelling?

- ☐ Optimization algorithms for identifying cost-effective solutions.
- ☐ Geographic Information Systems (GIS) for spatial analysis and visualization.
- ☐ Financial modelling software for assessing project viability and investment returns.
- ☐ Simulation software for modelling complex system dynamics.
- ☐ Data analytics tools for processing and interpreting large datasets.
- ☐ Other: _____

30. Are there specific software tools or platforms you prefer for conducting energy system modelling tasks?

_____

31. How do you assess the financial feasibility and cost-effectiveness of energy system modelling projects?

- ☐ Conducting a comprehensive cost-benefit analysis to evaluate project returns.
- ☐ Estimating initial investment costs and ongoing operational expenses.
- ☐ Analysing potential revenue streams and cost savings resulting from modelling insights.
- ☐ Assessing the impact of uncertainties and risks on project financial performance.
- ☐ Comparing the net present value (NPV) and internal rate of return (IRR) of alternative modelling approaches.
- ☐ Other: _____

32. What advancements in technology or tools do you anticipate will have the most significant impact on energy system modelling in the future?

1- Most Significant Impact 5-Least Significant Impact

	1	2	3	4	5
Artificial intelligence and machine learning for advanced predictive modelling.	☐	☐	☐	☐	☐

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Blockchain technology for secure and transparent data management.	☐	☐	☐	☐	☐
Quantum computing for solving complex optimization problems at scale.	☐	☐	☐	☐	☐
Internet of Things (IoT) for real-time dana collection and integration.	☐	☐	☐	☐	☐
Augmented reality and virtual reality for immersive visualization and analysis.	☐	☐	☐	☐	☐

33. Please specify other advancements in technology or tools, if any, you think have significant impact:

_____

VALUE AND NEEDS OF CITIZENS AND COMMUNITIES ON A SOCIAL LEVEL

34. Beyond financial aspects, what values and needs do you think are essential for communities and citizens in the context of energy system models?

- ☐ Environmental sustainability and reduction of carbon emissions.
- ☐ Energy resilience and reliability to withstand disruptions.
- ☐ Equity and social justice in access to energy resources and benefits.
- ☐ Public health and safety considerations related to energy production and consumption.
- ☐ Community engagement and empowerment in decision-making processes.
- ☐ Other:

_____

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35. Are there particular environmental or social justice considerations that should be integrated into energy system modelling efforts?

36. How do you envision a value-based proposition for energy system models that aligns with societal values?

- ☐ Prioritizing environmental sustainability and promoting renewable energy integration.
- ☐ Ensuring equitable access to energy resources and addressing energy poverty.
- ☐ Enhancing energy resilience and reliability to withstand disruptions and emergencies.
- ☐ Fostering community engagement and empowerment in energy decision-making processes.
- ☐ Supporting economic development and job creation through clean energy initiatives.
- ☐ Other:

37. What growth do you anticipate in the field, and what capacity building measures do you think are necessary?

38. How can energy system models better address the needs and concerns of local communities and citizens?

- ☐ Engaging local communities in the modelling process to incorporate their perspectives and priorities.
- ☐ Conducting outreach and education programs to enhance public understanding of energy issues.
- ☐ Incorporating social impact assessments to identify and address community concerns.

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- ☐ Providing transparent and accessible information on modelling assumptions, methodologies, and outcomes.
- ☐ Collaborating with community organizations and stakeholders to develop tailored solutions that meet local needs.
- ☐ Other: _____

39. What mechanisms do you recommend for ensuring community engagement and participation in energy system modelling initiatives?

_____

_____

_____

40. In what ways can the energy system modelling project promote equity and inclusivity among different socioeconomic groups within communities? (Equity and Inclusivity)

- ☐ Conducting community needs assessments to ensure diverse perspectives and concerns are considered in modelling initiatives.
- ☐ Implementing outreach programs to engage underrepresented groups and provide opportunities for participation in decision-making processes.
- ☐ Partnering with community-based organizations to address energy access disparities and promote inclusive energy solutions.
- ☐ Incorporating equity metrics and social justice considerations into modelling frameworks to prioritize equitable outcomes.
- ☐ Providing training and capacity-building initiatives to empower marginalized communities to participate in and bene t from energy system modelling projects.
- ☐ Other: _____

41. Are there any specific training programs or initiatives that you think would be beneficial? (Education and Awareness)

_____

_____

_____

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42. Are there specific health-related concerns or considerations that should be addressed? (Health and Well-being)

- ☐ Air quality impacts from energy production and consumption, such as emissions from fossil fuel combustion.
- ☐ Health effects of exposure to pollutants and toxins released during energy extraction, transport, and processing.
- ☐ Potential health risks associated with siting energy infrastructure, such as power plants or transmission lines, in proximity to residential areas.
- ☐ Health disparities and social determinants of health related to energy access and affordability, particularly for vulnerable populations.
- ☐ Opportunities for promoting public health through clean energy initiatives and sustainable transportation options.
- ☐ Other: _____

43. What communication channels or tools would be most effective in reaching different demographic groups? (Access to Information)

_____

_____

_____

44. How do you envision the involvement of citizens in the decision-making processes related to the energy system modelling? (Public Participation in Decision-Making)

- ☐ Holding public forums and town hall meetings to gather input and feedback from community members.
- ☐ Establishing citizen advisory committees or working groups to provide ongoing input and guidance.
- ☐ Conducting surveys and focus groups to assess public preferences and priorities regarding energy system modelling.
- ☐ Providing opportunities for citizens to review and comment on modelling assumptions, methodologies, and outcomes.
- ☐ Incorporating community feedback into decision-making processes and adjusting modelling approaches to reflect public concerns and priorities.
- ☐ Other: _____

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45. In your opinion, what are the long-term societal benefits that can be achieved through successful energy system modelling? (Long-Term Societal Benefits)

- ☐ Reduction of greenhouse gas emissions and mitigation of climate change impacts.
- ☐ Increased energy access and affordability, particularly for underserved communities.
- ☐ Enhanced energy resilience and reliability to withstand disruptions and emergencies.
- ☐ Creation of green jobs and economic development opportunities in the clean energy sector.
- ☐ Improved public health outcomes through reduced air pollution and environmental degradation.
- ☐ Other: _____

Thank you for taking the time to complete this survey. We truly value the information you have provided. Your responses will contribute to our analyses and suggest new lines of approach to the corpus data.
We would also be truly thankful if you could follow the EMERGE project on these social networks:

- LinkedIn: https://www.linkedin.com/company/emerge-eu-project
- Facebook: https://www.facebook.com/EUprojectEMERGE
- X: https://twitter.com/emergeEUproject
- Website: https://emerge4green-africa.eu/

In accordance with the General Regulation on the Protection of Personal Data (GDPR), by subscribing to this service you allow us to use your personal data (name and surname, email) for the purpose of contacting you with information about events, activities and information related to the project "EMERGE" financed by the HORIZON EUROPE grant no. 101118278 and similar upcoming events that might interest you.

7.2. Workshop in Mozambique

7.2.1. Introduction

The Energy System Modelling Workshop, under the EMERGE project in Mozambique, was held on 24th of April 2024 via online. The event was attended by twelve participants from different sectors, namely the Civil Society, Investors, Policy Makers and Research and Academia. EMERGE is funded under the Horizon Europe program for research and innovation and seeks to provide African policymakers, academics, investors, and citizens with the tools and knowledge required to increase the production of clean energy and the sustainable use of resources while bridging cultural and socioeconomic divides.

The project was launched in December 2023 and is coordinated by the University of Zagreb - Faculty of Mechanical Engineering and Naval Architecture (Croatia) and brings together 11 multidisciplinary partners from nine European and African countries. EMERGE envisions a future where shared knowledge accelerates sustainable development, uniting African communities in the pursuit of a greener and more inclusive tomorrow. To simulate scenarios that optimize the use of current resources while considering social, climatic, economic, and technical constraints, EMERGE will co-design and test a Toolbox by integrating and building upon existing tools, methodologies, and approaches. Additionally,

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a Knowledge Base with a collection of initiatives, materials, and knowledge- exchange activities will be created.

Mozambique is one of the nine countries involved in the project and, moreover, one of the selected pilot locations for the case studies in Africa. The representative cases ensure broad replicability of the project solutions to advance a just energy transition in Africa that addresses the need for energy access for local communities while promoting the conservation of resources and protection of the environment.

The objectives of the workshop were to:

- Gather all mapped stakeholder and introduce to them the EMERGE project, its concept and objectives;
- Present the stakeholders' data collection survey;
- Explain to the stakeholders the importance of their engagement in the project and that the inputs from the workshop and the survey will be used for the definition of the project knowledge base.

7.2.2. Workshop summary and accomplishments

The workshop was a good opportunity to present the EMERGE project, including other relevant aspects related to energy transition and climate in the global approach and in Africa in particular. The event was also an excellent occasion to gather stakeholders from different segments to discuss about energy modelling, the challenges on the data collection and data sharing, in the Mozambican context.

Although most participants are not very much familiar with energy modelling aspects, they have a good understanding of the process and hence acknowledge the contribution that EMERGE may bring to accelerate energy access and energy transition in Africa at large and in Mozambique.

After the workshop, the translated survey (in Portuguese) was sent to all participants and other mapped stakeholders to complete and the feedback was already sent to the project coordination. The presentation was also shared and the team is available for any further clarification

7.2.3. Conclusion and next steps

This was the first EMERGE workshop in Mozambique and was intended to introduce the project and attract the stakeholder's attention for their engagement. This aim was achieved through the presentation of project and the concept behind it and the questions and answers that followed the presentation. The stakeholders are keen to collaborate to the achievement of the project goals and we think that the next steps, determined by the project tasks, including the consolidated methodology, will be helpful for the stakeholders to have a better understanding and hence more engagement in the project.

ANNEX I – List of Participants

List the participants and their related organizations in a table.

Field	Organization	Stakeholder Name	Contact Details
Academia, Research	Universidade do Save	Tomas Nhabetse	nhabetse@gmail.com

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Policy makers	National Directorate of Energy / Ministry of Natural Resource and Energy (DNE / MIREME)	Iazalde José	iazaldejose@gmail.com
	Electricidade de Moçambique (EDM) - the National power utility	Olga Utchavo Madeira	olgautchavo@yahoo.com.br
Investors	National Energy Fund (FUNAE)	Castro António Soares	castrosoares07@gmail.com
	National Energy Fund (FUNAE)	Nelso Bila	nelsobila@gmail.com
Civil society	Associação de Energias Renováveis em Moçambique (AMER)	Helena Macune	hmacune@amer.org.mz
	AMER	Ricardo Pereira	ricardocostapereira@gmail.com
	KULIMA integrated Socio - Economic development	Anathalie Musabyemarya	Anathalie2004@yahoo.fr
	KULIMA	Camilo J Sitoe	camilojsitoe@gmail.com
	Coordinamento delle Organizzazioni per ill Servizio Volontario (COSV)	Roberto Novelli	Roberto.novelli@cosv.org
	Netherlands Development Organization (SNV)	Pedro Moleirinho	pedrofmoleirinho@gmail.com

ANNEX II – Agenda

List of activities that will take place during the workshop – it serves as a guide for all of participants providing them an overview and duration of the activities.

The workshop had a duration of approximately and one and half hour and followed the below structure.

- Introduction, Context
- Energy situation in Africa;
- United Nations Agenda 2030;
- The Paris Agreement;
- Energy transition;

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- Energy modelling, the EMERGE project;
- Objectives,
- Methodology
- Expected results
- Questions and Answers
- Closing

ANNEX III – Photos from the Workshop

Photos taken during the workshop.

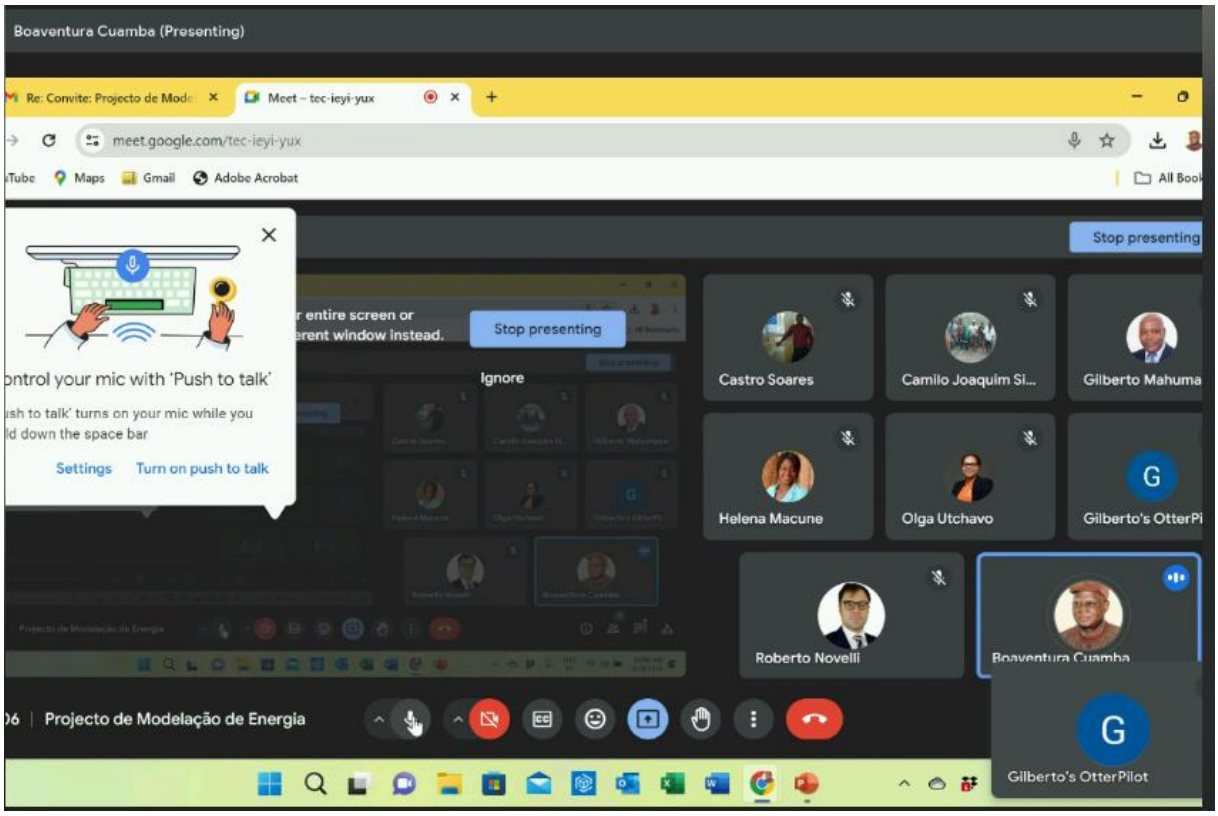

Figure 22 Mozambique workshop - photo 1

Figure 23 Mozambique workshop - photo 2

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7.3. Workshop in Mali

7.3.1. Introduction

The ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE), along with ten (10) other organizations, are implementing the project titled: Energy System Modelling for Green Development of Africa (EMERGE). EMERGE brings together 11 multidisciplinary partners, including 9 different countries in Europe (EU) and Africa (AU) (5 in the EU and 4 in the AU) and also ensuring balanced coverage of countries on both continents, with the intention to connect knowledge, accelerate the clean energy transition and capitalize on project results.

EMERGE envisions a future where knowledge sharing accelerates sustainable development, uniting African communities in pursuit of a greener and more inclusive future. To simulate scenarios that optimize the use of current resources while considering social, climatic, economic and technical constraints, EMERGE will co-design and test a toolbox by integrating and relying on tools and methodologies. and existing approaches. In addition, a knowledge base of knowledge exchange initiatives, materials and activities will be created.

The objective of the EMERGE project is to provide African policy makers, academics, investors, and citizens with the tools and knowledge required to increase the production of clean energy and the sustainable use of resources while bridging cultural and socioeconomic divides. The Northwestern Africa (Morocco), Niger river region (Mali/Nigeria), and east Africa (Mozambique) are three African ecosystems where EMERGE will develop knowledge communities through a participatory approach. Specific objectives are:

- Establish a network of African experts in energy system analysis through value-based design methodology that reflects on technical, economic, environmental and social aspects of energy planning
- Connect with other AU-EU cooperation activities through liaison with similar project and initiatives, for deployment of sound strategy for exploitation and replication of EMERGE results
- Demonstrate innovative EMERGE Toolbox based on a cross-sectoral CSA for energy system analysis and planning as a support mechanism for the policy and decision-makers
- Identify and evaluate regulatory frameworks, energy markets and potential opportunities for clean energy technologies integration to foster an enabling environment for current and future energy transition of the African countries
- Promote, raise awareness and facilitate the adoption of the solutions in EMERGE Toolbox to support the wide-scale energy transition of African countries through actions that contribute to the R&I strategy development and AU-EU cooperation

Consequently, on June 13, 2024, in collaboration with local stakeholders in Mali, ECREEE organized a workshop for data collection in Bamako, Mali. The specific objectives of the workshop were to:

- Officially kick off the project in Mali
- Explain the main and specific objectives of the project to the stakeholders and provide a better understanding of the project to the stakeholders
- Share experiences and promoter better collaboration among the stakeholders
- Collect and validate the data collected by the stakeholders
- And finally present some of the selected tools of the project: CEPIA, METRIX (menti.com), GREENADVISE

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7.3.2. Methodology for the data collection

The official kick off the meeting was followed by the presentation of the project, its objectives, expected output and outcome, and more importantly the relevance and role of the partners for the successful implementation of the project.

In order to validate and harmonise the results the following approach was used:

- participants were grouped according to the following specific target groups: Academic, Civil society, investors, and policy makers
- Consequently, the answers to the questionnaires are not individual responses, but the agreed responses of each target group.
- This approach made it easy to compile the results since each group has agreed upon the answers.
- Some groups, who had many participants, were divided into two (2) groups to enable the active participation of all the participants.
- Also, after the group works, it was requested to give more additional couple of days to the groups reporters to look for information and specifically for references they were not able to get immediately in the meeting room.

7.3.3. Workshop summary and accomplishments

The following objectives were achieved:

- Relevance of the project by energy stakeholders at the national level understood
- Understanding the data collection questionnaire, and the challenges to be overcome
- The need for reliable data and the data sources are identified
- Stakeholders' capacity is strengthened
- The data collected is validated by stakeholders at the national level
- Interest of stakeholders in the various tools (CEPIA, Metrix, Greenadvise, PowerSyB, Optimal Storage Placement, Hosting Capacity), who requested more presentation of the tools.

7.3.4. Conclusion and next steps

The collection of data is a critical step for the implementation of the project. Reliable data is necessary for design the Common System Architecture (CSA). The participation of different stakeholders from the academia, research institutions, civil society, investors as well as policy and decision makers confirmed the interest of the Niger River Basin stakeholders in the project.

In view of the interest of the stakeholders in the program, two (2) additional virtual trainings had been scheduled to better understand the different tools. The trainings were held respectively on June 28, and July 12, to better understand all the tools.

Next steps:

- Send the data collected summaries to the consortium team
- Send the final report to the consortium
- Work on the other tasks

ANNEX I – List of Participants

Participants to the meeting were:

- Policy makers and energy experts (Ministry of Energy and agencies)
- Universities and research centers/institutes (ENI, FAS)

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- Civil society and general public (local communities, development association) [4]
- Investors (energy production and distribution companies)

ANNEX II – Agenda

The workshop had a duration of approximately 2 days and followed the below structure:

June 12, 2024:

i. Meeting at the Ministry Energy with the Point focal
ii. Development of logistics
iii. Meeting with renewable energy agencies
iv. Meeting with Faculty of science
v. Meeting with School of national engineers

June 13, 2024:

i. ECREEE focal point
ii. Presentation from the Ministry of Energy on the energy situation in the Niger river basin, the energy policies, constraints, opportunities, expectations
iii. EMERGE presentation
iv. University presentation on software analysis of energy data, the contribution of the university and research centres, expectations and opportunities
v. Presentation of the project and the questionnaire – by ECREEE
vi. Q&R
vii. Group work
viii. Group work and collection of questionnaires
ix. Presentation of questionnaire data
x. Data validation
xi. Guided site visit (production system energy, management, operation software, software data collection, data analysis

ANNEX III – Photos from the Workshop

Photos taken during the workshop.

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Figure 24 Mali workshop - photo

7.4. Workshop in Morocco

7.4.1. Introduction

On May 25, 2024, Mohammed Premier University (UMP) in Oujda, Morocco, hosted an international workshop on energy transition, organized by the UMP EMERGE team in collaboration with the Electrical Engineering and Maintenance Laboratory (LGEM) at the Higher School of Technology Oujda (ESTO). This event brought together experts, researchers, policymakers, and professionals from the energy sector to discuss achievements and prospects in the field of energy transition.

7.4.2. Methodology for the data collection

At the end of the day, participants needed to answer the survey while the results were processed and sent to the project coordinators:

- participants were grouped according to the following specific target groups: Academic, Civil society, investors, and policy makers
- The answers to the questionnaires are individual responses, divided into 4 named groups
- This approach made it a bit more complex to compile the results since it would be easier that each group has agreed upon the final answers, but also gave a better insight in the needs and wishes of the participants.
- Also, after the group works, it was requested to give more additional couple of days to the participants to look for information and specifically for references they were not able to get immediately in the meeting room.

7.4.3. Workshop summary and accomplishments

The workshop began with the welcome and registration of participants. The official opening of the workshop was marked by the presence of Pr. Yassine ZARHLOULE, President of Mohammed Premier

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University, who inaugurated the session and highlighted the importance of the EMERGE project within Morocco's strategy. Pr. Abdelhafid CHAFI, Director of the Higher School of Technology (ESTO), then shared his vision on the impact of academic research in the energy field. Pr. Jamal BOUCHNAIF, Director of the LGEM laboratory, presented an overall report on scientific research at the Higher School of Technology and specifically within the LGEM laboratory. Finally, Pr. Smail ZOUGGAR emphasized the ambitious objectives and prospects of the EMERGE project. This session, moderated by Pr. Hassan ZAHBOUNE, was followed by a coffee break, providing a fresh opportunity to network and deepen the discussions initiated during the presentations. The afternoon began with a conference dedicated to the EMERGE toolbox, featuring several presentations on the tools within the EMERGE Toolbox. Adrian Alarcon (CIRCE), Alexis Godefroy (Artelys), and Ven Rajlic (UNIZAG FSB) successively presented their tools and methodologies. Francesco Roncallo (EnGreen) led the data collection on the importance of these tools. The moderators of this session, Pr. Mostafa AZIZI and Pr. Taoufik OUCHBEL, ensured an interactive and enriching dynamic between the speakers and the audience. Subsequently, Mohamed DIB, an engineer and doctor in electrical engineering from ONEE, presented the projects of the National Office of Electricity and Water (ONEE), detailing current initiatives and future projects aimed at facilitating the energy transition in Morocco. This presentation, which aroused great interest, was followed by an interactive discussion moderated by Pr. ELHAFIANI Larbi Mohammed.

After a lunch break, participants joined different specialized technical sessions held in parallel. Four sessions were offered: management of energy systems, design and control of energy systems, electric vehicles, and renewable energies and storage units. Each session, led by moderators who are experts in their respective fields (see program), allowed for in-depth exchanges and constructive debates. The day concluded with the collection of responses to the distributed questionnaires and a closing session, marking the end of this enriching workshop.

7.4.4. Conclusion and next steps

The energy transition workshop was a success, providing an enriching platform for the exchange of knowledge and experiences. The discussions and presentations highlighted the advances and challenges in this crucial area for sustainable development. The EMERGE project, with its ambitious objectives and participatory approach, looks promising in contributing to a successful energy transition in Africa.

ANNEX I – List of Participants

Participants to the meeting were:

- Policy makers and energy experts
- Universities and research centres/institutes
- Civil society and general public

ANNEX II – Agenda

8h30 - Welcome and Registration

09h00 - 09h30

- Official Opening of International Workshop
- M. President of Mohammed First University, Oujda;
- Mme. Ministry of Energy Transition and Sustainable Development;
- M. Director of Higher School of Technology, Oujda.
- Moderator: Smail ZOUGGAR

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09h30 – 11h00

- Smail ZOUGGAR: Presentation of the EMERGE project;
- Mohammed DIB: Presentation of ONEE's projects: Energy transition.
- Moderator: Jamal BOUCHNAIF

11h00 – 12h00 - Coffee break

12h00 – 13h00 - Conference: Toolbox EMERGE

- Adrian ALARCON (CIRCE): Exploring advanced software's capabilities in analyzing the electrical grid's state (Hosting Capacity and optimal storage Tools);
- Alexis GODEFROY (Artelys): Modelling of flexibility solutions for the network (such as battery storage) with Metrix PowSibl;
- Alexis GODEFROY (Artelys): Towards Sustainable Transformation:
- Empowering Decision-Makers with CEPIA;
- Ven RAJLIC (UNIZAG FSB): GREENADVISE Tool.
- Moderators: Taoufik OUCHBEL – Hassan ZAHBOUNE

13h00 – 15h00

- Debate: Energy transition in Morocco
- Moderator: Mohamed Larbi ELHAFYANI – Francesco RONCALLO

15h00 – 16h00 LUNCH

16h30 – 18h00

- Session 1: Energy systems management
- Moderators: Abdelhak AZIZ – Hassan ZAHBOUNE – Abdelhafid MASSAOUDI

16h30 – 18h00

- Session 2: Design, modelling, and control of energy systems
- Moderators: Moustafa ZIANI – Badredinne LAHFAOUI – Abdelmalak MEHDI

16h30 – 18h00

- Session 3: Electric vehicles
- Moderators: Kamal KASSMI – Moustafa ELOUARIACHI – Abdelkader BENBOUAZA

16h30 – 18h00

- Session 4: Renewable energy and storage units
- Moderators: Taoufik OUCHBEL – Khalid GRARI – Rachid ABOUTNI

18h00

- Collection of questionnaire responses
- CLOSING OF WORKSHOP

ANEX III – Photos from the Workshop

Photos taken during the workshop.

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Figure 25 Morocco workshop - photo 1

Figure 26 Morocco workshop - photo 2

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Figure 27 Morocco workshop - photo 3

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7.5. Database scheme

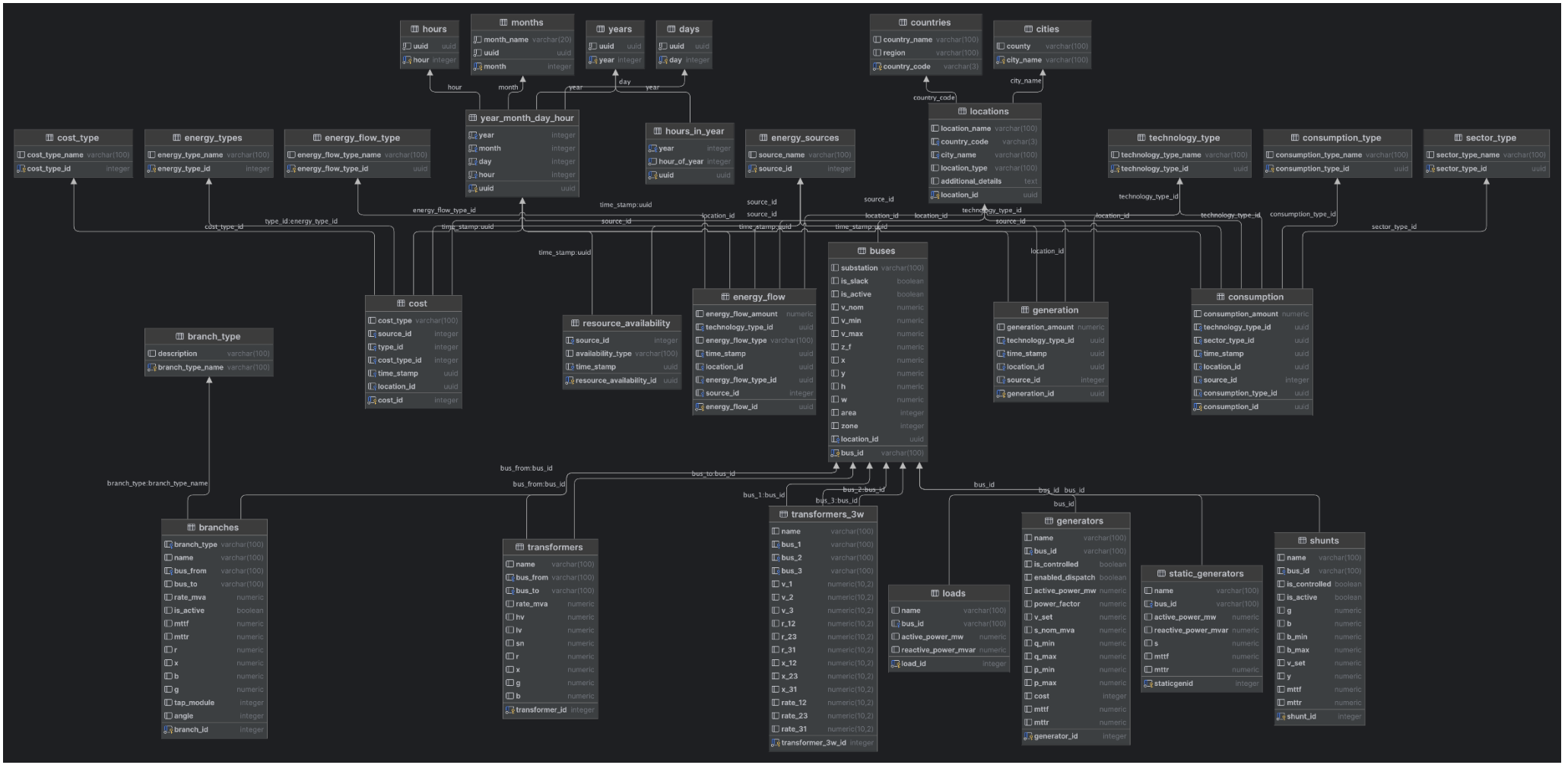

Figure 28 More detailed database scheme

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