BACKGROUND PAPER #1
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PRE-LEAP-RE

Roadmaps & Ecosystem

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The Background Papers are documents in progress, which will form the basis for the discussion with committed stakeholders, who want to contribute to the joint programme LEAP-RE and who may want to become a consortium member or associated partner. Feedback and suggestions for these documents are welcome. The intention with the Background Papers is to foster an inclusive process as possible. The Background Paper series will be finalized in June/July 2019 after the PRE-LEAP-RE #2 Strategic Workshop from 24-26 June 2019 in Stellenbosch, South Africa.

The current Background Papers:

#1 BP Roadmaps & Ecosystem
Multi-Annual Roadmaps on Research &Innovation and Human & Institutional Capacity Building - Agendas & Pathways | Outcomes from the PRE-LEAP-RE Ecosystem Analysis

#2 BP Funding & Private Sector
Funding Concept | Private Sector Involvement | Open Philosophy & Intellectual Property Rights

#3 BP Long-Term Perspective
Theory of Change and Impact Pathways | Programme and Innovation Management Cycle | Knowledge Management and Communication Framework | Monitoring & Evaluation Concept

#4 BP Individual Funding & Contribution Regulations
Individual (National) funding regulations will be collected and have to be applied supplementing the general agreed funding regulations of the consortium.

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Executive Summary

This Background Paper is a **synthesis of the methodological approach** adopted by the PRE-LEAP-RE consortium for highlighting and integrating the Research and Innovation agenda along with the Human and Capacity building agenda and related topics, both needed to empower the EU-AU collaboration in the **research field related to renewable energies.**

The rationale from the ecosystem analysis

The analysis carried out aimed at highlighting the gaps, trends and potential opportunities for a renovate EU-AU collaboration in the renewable energy (RE) sector. The analysis has been based on information provided by PRE-LEAP-RE consortium members and relevant international literature or existing studies having undertaken a similar synthesis task. As the main output an *Initiatives & Network Matrix* was built with 89 selected initiatives respecting given criteria.

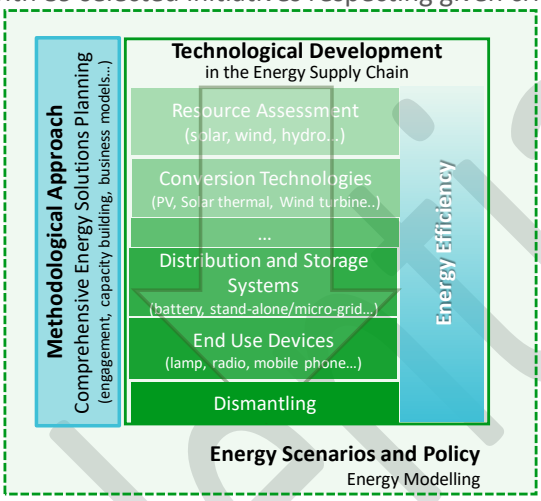

Fig. 1: Schematic representation of the PRE-LEAP-RE multidisciplinary framework for an R&I agenda.

The ecosystem analysis highlights that REs are of vital importance in tackling the global challenge posed by climate change and in providing reliable energy access to millions of people worldwide. Key recommendations for research and innovation in the field are summarised below and schematically represented in Fig. 1:

1) **Technological development** needs to be deepened at all points along the energy supply chain, including conversion technologies and end use devices. Resource assessment is still crucial for some sources while distribution is an important area for research and innovation when dealing with integration of renewables via smart hybrid mini grid, either in their off-grid configuration, or when considering their long-term integration within the national grid. This is one of the most attractive areas of research where leapfrogging can be done by leveraging innovation with the digital revolution that is currently taking place in Africa and allowing integration of sources and additional storage opportunities.
2) Technological development cannot stand alone. A **comprehensive methodological approach** is needed, able to address the different phases of the energy supply chain by taking into account societal needs, market evaluation, business models for long-term sustainability, and solution deployment as well as the long-term impact on society. As underlined by the roadmap of the AU-EU High Level Policy Dialogue (HLPD) on climate change and sustainable energies (CCSE) for R&I in the renewable sector, such an approach is essential for guaranteeing the long-term social, economic and environmental sustainability of technology.
3) Renewed attention to **energy scenarios and policy** is vital for understanding the contexts in which technologies and energy solutions will be developed, helping to minimize unforeseeable consequences. There is a clear need for supporting further research and capacity building on energy scenario analysis, including modelling approaches and tools that support policy and decision makers to build a long-term plan at country and regional level.

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Such a multidisciplinary approach encourages the development of scenarios that are appropriate to local contexts and can be further utilised to support policy makers. Moreover, while not reported in Fig.1, this approach requires the development of capacity building activities to increase local empowerment and ownership. Hence the choice of including Human and Institutional Capacity Building activities across all Multi-Annual Roadmaps.

Research and Innovation Agendas and impact pathways – the Multi-Annual Roadmaps

The multidisciplinary framework for R&I agenda derived from the ecosystem analysis, brought together with suggestions from the European Commission (EC), led to a preliminary list of 13 multi-annual roadmaps (MAR), representing the main topics related to REs development. After a stakeholder consultation exercise those 13 were reduced and merged into 6 multi-annual roadmaps (see Fig.2), described in term of societal challenges, research scope (aligned with Fig.1) and expected output, outcome and impact.

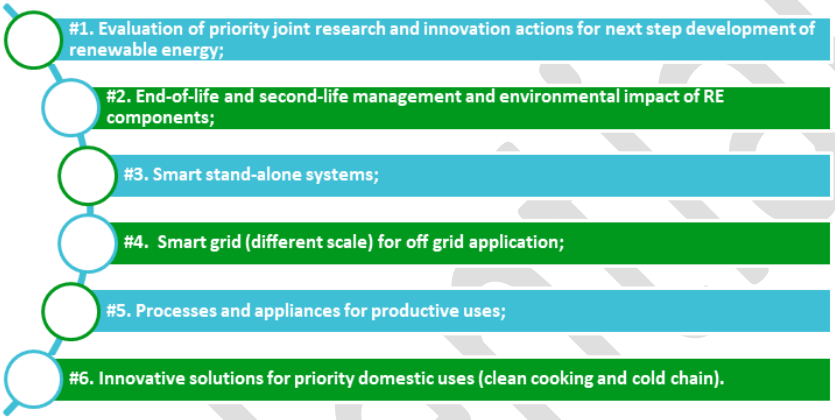

Fig.2: The Multi-Annual Roadmaps

Human and Institutional Capacity Building Agenda - the Holistic PRE-LEAP-RE approach

As the Research and Innovation Agenda, this multidisciplinary framework for a Human and Institutional Capacity Building Agenda also derives from PRE-LEAP-RE's WP1 *Ecosystem Analysis*. As such, capacity building in LEAP-RE is conceived across the main axes identified in the aforementioned analysis: **technological development, methodological approach, and energy scenarios and policy analysis**. Additionally, since capacity building is a complex notion that involves **individual and organisational learning**, which builds social capital and trust, develops knowledge, skills and attitudes and creates an organisational culture, the methodological approach to capacity building suggested here is based on 3 different levels: **Individual, Institutional and System level**. This holistic vision comprehensive of the 3 axes and of 3 three levels is integrated within the Multi-Annual Roadmaps.

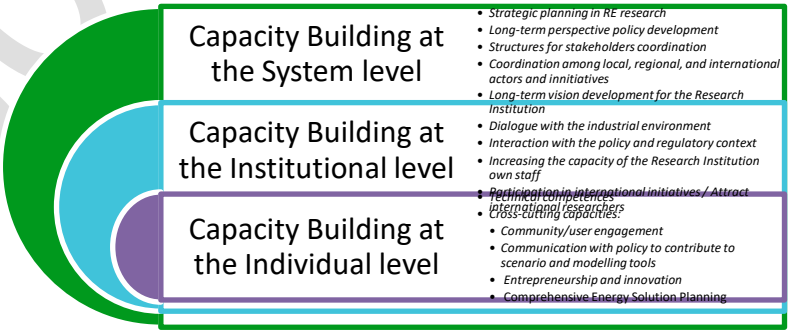

Fig.3: Methodological approach to capacity building

Recommendations for the PRE-LEAP-RE Agendas

As a result of the review and analysis of the existing landscape of cooperation and activities in the field of Renewable Energies, a set of suggestions were developed for research and capacity building needs in the area of technological development, methodological approaches, and energy scenarios analysis. These suggestions, below detailed, served as the basis for the development of the R&I agenda as explained in Fig.1.

Technology Development

Research on technology development for energy systems based on **renewable energy** can be confirmed, as highlighted in the High Level Policy Dialogue (HLPD) Roadmap on CCSE (Climate Change and Sustainable Energy) and in the ECORYS, as one of the solutions to support Africa in the energy transition that is needed to promote leapfrogging, cost-effective, locally adaptive and sustainable energy systems. In this framework, drivers and barriers are still present for different renewable energy technologies development in Africa and requires further research. By matching the recommendations coming from the HLPD Roadmap on CCSE with the results of the PRE-LEAP-RE review, some key elements emerge and may represent the seed of the PRE-LEAP-RE Roadmap.

Solar Photovoltaics Energy and Solar Thermal Heat research is confirmed to be pivotal. Attention should be paid to lifetime, behaviour and adaptation of solar panels in extreme conditions and related maintenance and energy storage systems. Furthermore, photovoltaic systems for agriculture, mining operations, environmental applications, solar heating & cooling, and concentrated solar power should be taken into consideration for research purposes. Indeed, the majority of the initiatives within the PRE-LEAP-RE review are solar energy-based for its potential as source for electricity and thermal heat.

This is confirmed by the fact that 50% of the initiatives collected in the matrix were reported to have focused on solar technologies for electricity generation (i.e. PV technology). The growing interest in some areas on solar thermal is recent. This predominance, despite the relatively higher cost of PV compared to the other alternatives, is mainly linked to the global diffusion in the continent of solar radiation, which makes it a reliable source of energy.

Wind Power Research is also recognized as crucial, with 25% of the initiatives mapped in the present study including wind power. Particular attention should be paid on the development of decentralised generation and stand-alone systems, including energy storage. Furthermore, additional research needs to be carried out in fields that go beyond the technological aspects, as will be better addressed in the next paragraph.

Hydro Power is the cheapest resource that may be used for power production, despite the competition over water and the transboundary problems in managing the water basin, which has led to privileging small-hydro power run of river solutions rather than big dams. Despite this, less than 20% of the initiatives are devoted to hydro power, the HLPD Roadmap on CCSE and ECORYS study, as well as the Agenda 2063 of the Africa Union, confirm that this is a space where research and innovation should keep on working in terms of choice of technologies and configurations which need to be adapted to local conditions.

Geothermal energy is characterised by large-scale activities, which make the implementation complex and dependant on local policy and governmental actions and funds. In terms of research, the many issues related to geothermal exploitation are a fruitful area for future cooperation, and particularly exploring the environmental implication in areas with existing potential for geothermal activities. Some attention should also be given to geothermal cooling and heating with special reference to food and beverage.

Bioenergy is used both for power or thermal generation, in the case of big size power plants, and also for domestic needs, such as for cooking. Both aspects need to be deepened in terms of research and innovation: mainly on the sustainability of the supply chain and adaptation to local context through the introduction of new fuels from urban solid waste, agri-food processes and combustion chamber design, improved cookstoves and other alternatives to traditional and unhealthy domestic cooking systems. Attention must always be paid to the competition between bioenergy and food needs when dealing within the sector.

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Few initiatives are dedicated to **marine energy** where research is still needed at the level of Resource Assessment, site localization and exploitation.
Looking at technology development within the **energy supply chain**, from the perspective of single source renewable energy systems, it also becomes evident that efforts need to be mostly focused on Conversion Technologies and End Use Devices.
Resource Assessment is still crucial for marine energy and for a full assessment of the mini-hydro potential.
Distribution is an important area for research and innovation when dealing with integration of renewables via smart **hybrid mini grid**, either in their **off-grid configuration** or when considering their long-term **integration within the national grid**. This is one of the most attractive areas of research where leapfrogging can be done by leveraging innovation with the **digital revolution** that is currently taking place in the continent.
Indeed, from the PRE-LEAP-RE review, an emerging interest in **resource integration** is envisaged in line with the HLPD Roadmap on CCSE and other grey literature from reference institutions. Roughly 15% of the projects are dealing with "All Renewables" thus it is clear that more research efforts should be placed on the effective integration of different sources in a way that could lead to overall grid stability, cost saving, technological advantages (reduce use and better life time for batteries), and non-technological opportunities (like local job creation and better exploitation of resources).
There is an urgent need for more R&I for **storage systems** and alternative solutions to traditional backup diesel generators (like CSP/biomass hybrids with high temperature thermal storage, stationary fuel cell etc.), as evidenced by the discovery that more than 95% of the projects involving "All Renewables" are indeed testing distribution systems (the remaining being associated to stand alone devices): half in mini-grids and half in grid-connected configurations, as reported in Fig.2.
From the HLPD Roadmap on CCSE, it is clear that renewable energy and technological development need to go side-by-side with **energy efficiency** as a cost-effective strategy for the energy transition that is needed to promote prosperity in Africa.
As stated by the AEEP: "enhancing energy efficiency in Africa plays a crucial role and induces high impact opportunities, providing the same economic services with a reduced consumption of primary energy, or more services with the same consumption of primary energy. Indeed, the International Energy Agency (IEA) recognizes the twofold role of energy efficiency: first, it is a key to ensure a safe, reliable, affordable and sustainable energy system for the future; secondly, it can be seen as one type energy resource that every country possesses in abundance, and it is the fastest and probably least cost way of addressing energy security, environmental and economic challenges…"
Nevertheless, less than 10% of the initiatives analysed involve, partially or fully, energy efficiency with an equal distribution between Demand Side Efficiency and Supply Side Efficiency. This reduced attention is a recognised gap that needs to be further supported in any future Roadmap, as also concluded by the AEEP report on Energy Efficiency in Africa
Technology development with specific reference to integration of different sources for off-grid or on-grid solutions, heat applications (process heat, cooling etc.) as well as energy efficiency are areas where **capacity building** and **local empowerment** need to be designed in order to create the enabling environment to promote more long term and equitable native innovation.

Methodological Approach

Besides the well-recognized importance of technological aspects described above, another crucial aspect is related to the **methodological approach** that needs to be investigated in research and innovation projects. The approach widens from the evaluation for the *needs*, that are at the base of any load curve creation, to the analysis of the *expected impact*. Indeed, technology development and design need to be completed by a more **comprehensive design,** which includes society, market evaluation, business models for long-term sustainability as well as impact on development. This approach is strongly needed to guarantee the long-term social, economic and environmental sustainability of the technologies developed in research and innovation projects as well underlined by the HLPD Roadmap on CCSE for R&I in the renewable sector.

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The need for more research and innovation with the frame of **comprehensive energy solutions planning** is also evidenced in the ECORYS study, where economic, social and environmental impacts of RET uptake is analysed concluding that renewable energy in itself is not necessarily positive or negative for the economy, society and environment of the specific context, but it depends on how the energy technology is designed, built, operated, financed and maintained (e.g. thorough project preparation, solid business models, engagement of local expertise and population, etc.). The study also shows evidence of a current gap in the impact assessment work related to RE technology deployment.

The aspects highlighted in the HLPD Roadmap on CCSE and ECORYS studies are confirmed by the PRE-LEAP-RE review. The gap evidenced by ECORYS is confirmed by the number of projects where a methodological approach beyond technological development is not applied at all (approx. 20% of the projects). On the other hand, it can be positively observed that when the project goes beyond the technological development, it includes almost all the steps that are relevant for the Comprehensive Energy Solutions Planning. This can be therefore formalised with further dedicated methodological research confirming the importance given to the inclusion of non-pure technological aspects in the analysis and application of the energy systems to ensure their long-term sustainability in both research and innovation projects.

It is also evident, as underlined by ESAMP in the special feature report of the Sustainable Energy Annual Report (2017), that multidisciplinary and holistic **capacity building** is strongly needed for promoting innovation with the frame of the Comprehensive Energy Solution Planning: cross fertilisation among disciplines and competences may increase the chance of breakthrough innovation even along non-technological pathways.

Energy Scenarios and Policy Analysis

The Technological Development and Methodological Approach described above must be included in a more general framework directly related to the capacity of understanding and designing energy scenarios at the local, country, and global levels. Middle and long-term sustainability of energy scenarios, as well as the assessment of the needs and potential resources at country or regional levels is also needed to be able to understand the potential implication of technology or energy solutions with the local boundary conditions (economic, environmental and even cultural).

There is a strong need for supporting further research and capacity building on **Energy Scenario Analysis**, which include all modelling approaches and tools aimed to support policy and decision makers to build a long-term plan for energy systems development at the country level.

Specifically, the HLPD Roadmap on CCSE indicates the development of models and tools in order to achieve a systemic view on energy demand, energy access, energy security and sustainability is one of the five main action fields. This is also confirmed by the fact that the United Nation (UN) system and the International Energy Agency (IEA) are approaching and promoting a new programme for research and capacity building on energy scenario and modelling as a fundamental element at the country level to set up technological roadmap and energy solutions trends.

The importance of this aspect, even if well-recognized in the main objectives of most of the *Mapping Report* and *High Level Initiatives* analysed in the present PRE-LEAP-RE review, is not converted into specific studies and analysis. The aspect is present as the main activities in a very limited number of analysed Initiatives (less than 8% of the total) evidencing a potential gap in the present *Research & Innovation Initiatives*, thus giving some space for further research cooperation between AU-EU.

Multi-annual Roadmaps

The multi-annual roadmaps of Research and Innovation are briefly described in the following section and further details can be provided on request. The holistic approach to human and Institutional Capacity Building is also introduced as a cross cutting added value shared by all the Roadmaps.

Capacity building in LEAP-RE: a holistic approach addressing the identified gaps through

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generation of competence and capacity in a multilevel system.

As the PRE-LEAP-RE ecosystem analysis shows, capacity building activities should be linked to research performing actions across the three main axes identified: technological development, methodological approach, and energy scenarios and policy analysis. Hence in each of the six Multi-Annual-Roadmaps, the design of the capacity building activities should be made across three axes:

- Concerning **technological development** for any kind of RE technology, capacity building and local empowerment activities need to contribute to generate the enabling environment that allows technology to be impactful for long-term local innovation.
- In the area of **methodological approach**, capacity building shall put an emphasis on fostering a shared culture among stakeholders of the Comprehensive Energy Solution Planning approach (technology but also how it is designed, built, operated, financed and maintained) to increase the chances of impactful innovation and societal change. Indeed, the ecosystem analysis showed, almost 20% of technology research does not include an analysis of the societal needs, the technological solution's market potential, the design of a business model for its long-term sustainability, or the formulation of its expected impact.
- **Concerning energy scenarios and policy analysis**, capacity across is required in order to build robust energy scenarios and modelling as well as policy analysis for understanding the potential implications of energy solutions against local economic, environmental, cultural and other boundary conditions.

Therefore, to improve the chances for renewable energy innovative solutions to be impactful and sustainable, and generate development within local, national and regional African communities PRE-LAP-RE will work on 1) empowering local understanding, engagement and ownership of technologies in all stakeholders; 2) supporting a skilful and knowledgeable community that understands technology but also knows how to operate it and maintain it on the long term, and 3) fostering the capacity to understand and manage a variety of short, middle and long-term energy scenarios as well as to formulate adequate policy.

This is why PRE-LEAP-RE proposes (also in line with the academic literature on the subject) to work in a threefold systemic approach in which capacity building activities address 3 levels (Fig. 3):

- **Capacity building at individual level**: the overall aim in this level is to provide researchers with the knowledge and skills to lead the design, delivery, and dissemination of high-quality research. In LEAP-RE, capacity building initiatives for researchers shall include the provision of the required technical competences related to technology research and development, as well as the cross-cutting skills required to foster local knowledge among, and engagement from, the local environment, including community empowerment. Also, it should aim at equipping researchers to engage continuous dialogue with public sector stakeholders to understand needs and provide modelling tools for decision-making. Likewise, researchers shall be engaged in capacity building activities related to the application of the Comprehensive Energy Solution Planning methodological approach. Finally, researchers shall receive specific training on entrepreneurship and innovation so they understand better the market and societal conditions in which their solutions are developed, as well as the chances for these solutions to be uptaken by the market.
- **Capacity building at institutional level**: the main goal is improving organisational structures, processes, resources, management and governance issues of research organisations. In the context of LEAP-RE, we aim at planning capacity building activities for research organisations so they increase their ability to develop a long-term vision deeply rooted in society in order to facilitate technology acceptance and therefore impact. By doing so, research organisations increase their role as contributors to local, national and regional cohesion and development, a factor that also reinforces their chances to persist in the long term. Likewise, related to the methodological approach, capacity building at the institutional level should be also oriented at increasing the capacity of the research organisation's own staff for designing, building, operating, using, supporting and managing research infrastructure, as well as the technologies entering the market. Finally, capacity building activities for research organisations shall aim at increase and improve their dialogue with 1) policy-makers, to coordinate and support their, as well as the

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institution's own, long-term ambitions, and 2) the industrial sector, to foster innovation and an innovation ecosystem, as well as to improve the research organisations own innovation culture and market drive. Finally, research organisations should increase their ability to attract new researchers, including international, new funding opportunities, and to participate in international networks.

- **Capacity building at system level**: it is designed to improve national and regional innovation environments. The emphasis here is to provide knowledge and tools for developing coherent policies, strategies and effective coordination across sectors and among governmental, non-governmental and international actors, as well as at local, national, regional and international level. It shall include strategic planning and priority setting through the energy scenario and modelling tools provided by the research activities.

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LEAP RE priorisation and potential for capitalisation with other initiatives

Though an ideal scenario would require acting on each of the three levels described in Fig. 3, after the stakeholder consultations, and given the time and budget constrains in the upcoming RIA, the consortium opted for undertaking a prioritisation exercise.

A further consultation with the European Commission advised to keep the main focus on the capacity to perform research and therefore, as a result, the capacity building program proposed by the PRE-LEAP-RE consortium has a focus on the two first levels: the capacity building for researchers (individual level) and for research organizations (institutional level).However, to achieve the ambitious goal of improving and adapting renewable energy technology solutions to the real needs of communities, capacity building for other actors at System level should be considered in the LEAP-RE approach in the near future. In fact, it is expected that entrepreneurs, NGOs and local community representatives (System level) will valorise the results produced by research (second stage) and build capacity when interacting with researchers and research organisations. In the opposite direction, entrepreneurial capacities will be most likely needed by researchers to translate the real needs expressed by communities into innovative products; they can build capacity on those by interacting with industry and entrepreneurs in the System level. Hence, providing an operational framework in which all three levels (researchers, research institutions and the system) interact bidirectionally within the two stages should ensure an improvement of the solutions developed and deployed to the real needs of communities (third stage). . Additionally, LEAP RE will also, where necessary, build on existing capacity-building actions already undertaken by the African Union and European Union partners in the field of renewable energies.

Finally, given the long-term vision of the LEAP RE project, this step should also explore the possibility of actions whose ultimate goal is to establish a Master's program that may be jointly offered by AU and EU-based universities.

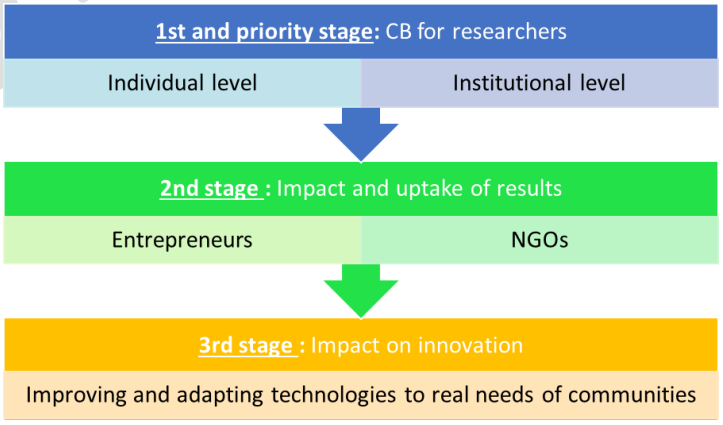

Fig 4: Perspective process for CB agenda implementation in LEAP RE and beyond

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 # 1: Mapping joint research and innovation actions for next-step development of RES

Specific Challenges

Energy is a key driver of national development and energy access is crucial to the delivery of fundamental services such as healthcare and education. African countries need energy to improve quality of life and transition to higher income countries. Within the energy transition , African countries need to adopt low carbon energy sources. This is nowadays possible since the continent has a lot of renewable energy potential which can serve different development needs. This transition will also require research and innovation actions to support the rethinking of energy infrastructure, energy access and energy uses, taking into consideration different political, cultural and social contexts on the continent. Recent deployments of renewable energy systems (RES) in Africa have been achieved using pre-existing technologies built for centralized and grid connected systems in high income countries. Most renewable energy systems are suitable for this context but can also be used in decentralized and off grid contexts. Therefore, there is need to optimize existing solutions and support innovation of solutions specifically designed for RES deployment in Africa.

This Mapping exercise will be maintained by the consortium as a common data base of incoming open and close actions from which lesson and direction can be taken for driving R&I for RES. Therefore, this roadmap proposes to keep up the stage of the Africa-Europe collaboration in research and innovation to develop new solutions and adapt existing solutions to local context. Scientific and grey literature will be continuously investigate to update the mapping. Next step development of RES in Africa will be defined by LEAP-RE aligned with the scientific and international community. It will provide a detailed map of updated research and innovation initiatives in Europe and Africa by technology and application with the aim of assisting the RE industry to prioritize and contextualize target areas of RES deployment. This mapping will grow up on the PRE-LEPA-RE meta-analysis of existing initiatives and will go beyond those confines. The PRE-LEAP-RE meta-analysis suggests that the mapping exercise would be drawn in line with the following criteria alongside the desirable outputs, outcomes and impacts: (i) compliance with national policies for RE development; (ii) compliance with the needs of local population is essential; (iii) focus on efficiency and reliability; (iv) compliance with low carbon and a replacement of conventional energy solutions; and (v) focus on achieving universal access for all in the short term.

Expected outputs, outcomes and impacts of the MAR 1:

The mapping exercise in this MAR will allow:

Outputs

- a global reference of the **huge amount of literature and science and joint projects** that have been undertaken in the last decade as far as R&I on RES in Africa will be updated
- **KPIs, Categorisations and prioritization of Res** will be set in a consistent way with the literature (scientific and grey) in order to align our work to that of the international community
- A methodology for **measuring technology readiness levels** and the identification of TRLs of different RE technologies in different African countries
- **A precise map** of RES components and systems dedicated to African needs
- **Identification of key R&I actors** and stakeholders for joint Europe/Africa future initiatives;
- **Identification of key parameters** for feasibility of RE projects and the mapping of RE resources;
- Identification of areas of profitability and limits of projects according to the RE availability.

Outcomes

- Updated **knowledge** and base data on the scenario and progress of EU-AU R&I cooperation on RES
- Increased **awareness** of existing networks in RE in AU -EU by researchers on both continents
- Information from this Mapping can be used as a starting point by RE researchers;

Impact

- Closer long-term oriented collaboration between African and European funders of R&I and H&ICB;
- Closer collaboration between researchers, innovators and funders of innovations through the systemic development of innovation hubs;

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 # 2: End-of-life and second-life management and environmental impact of RE components

Specific Challenges

End-of-life (EoL) components (batteries from electric cars, solar panels from large PV plants, etc.) used in **renewable energy (RE) production or storage** present a new environmental challenge, but also an unprecedented opportunity to create value and pursue new economic avenues. More energy systems will get decommissioned at the end of life, or when out of specification (OoS) for their initial purpose as RE technology is mainstreamed. To contextualize this, the volume of decommissioned solar PV panels will increase as the global solar PV market increases thus large amounts of EoL PV components are anticipated. The International Renewable Energy Agency (IRENA) estimates that there will be a surge in solar panel disposal in the early 2030s, and that by 2050, there will be 60 to 78 million cumulative tons of **photovoltaic panel waste** globally. The rise of electric vehicles and the increase in adoption of storage systems will also lead to a large amount of **EoL/OoS batteries**.

There will also be a yearly increase in decommissioned wind turbine blades. In some cases, these components may still have enough performances to be used in 'second life' applications. At the same time, new energy paradigms are emerging in both Africa and Europe where 'second life' components could be an appropriate solution applications, for example the **substitution of lead-acid batteries by second-life Li-ion batteries**.

In this regard, RE EoL/OoS components and their supply chains require research, development, innovation and capacity support. Materials that enable RE should be recycled or reused to prevent a scenario where the envisaged clean energy future becomes anything but clean. In Africa, off-grid solar products are revolutionizing the quality of life. Current EoL component volumes from this sector are small in proportion to the quantity and environmental impact of the total e-waste stream. However, due to a rapid sector growth, there is a need to develop the **end-of-life management of off-grid solar products** without delay. In Africa, and in most developing countries, collection of EoL components is done very effectively by informal collectors who purchase the components from consumers. Informal collectors then re-sell components to other informal sector players such as local repair shops. Informal sector EoL component streams do not usually incur the costs associated with proper treatment and disposal of hazardous e-waste due to their use of rudimentary methods. These rudimentary methods however tend to be unsafe and environmentally unfriendly. There is need to regularize this sector, ensuring that the informal collection and re-purposing of **EoL RE components becomes part of formal, regulated systems**.

Capacity Building Focus

Across all the areas of second life components, and for its successful uptake, further **technical and managerial competences** and capacities need to be developed.

<u>At individual level:</u>

Researchers need both **technical competences and cross-cutting capacities** to successfully support additional value creation from RE end-of-life components. These should include market knowledge, business savviness (including business models), and activities should also target the fostering of an entrepreneurial mindset. Researchers should participate in the **definition of, and fully integrate in their research performing activities, management schemes for waste from RE components** to be adapted to the unique conditions of each country or region. Additionally, they should be capable to **design metrics for environmental impact** categories.

<u>At institutional level:</u>

Research institutions should **promote international standards and rigorous testing protocols**. To achieve this, collaborative capacity building activities involving European and African research institutions are highly recommended. Within this transcontinental perspective, collaboration is also needed for research institutions to **provide input to policymakers** for them to create the international enabling regulatory framework for sustainable end-of-life management policies for RE components. This will naturally be creating awareness and capacity at the system level.

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Expected outputs, outcomes and impacts of the MAR 2:

The **research and capacity building activities** within this multi-annual roadmap will allow:

Output

- **Map of the EoL/OoS component value chain**, identification of key stakeholders & business models
- Creation of **categories of components found in EoL/OoS components** and proposed safe methods of handling
- Development of **comprehensive models and standard operating procedures** for EoL/OoS component management
- Proposal of **methods for EoL/OoS component recycling** which address local environmental impact through effective management;
- **Identification of second life components with a benefit for African countries**: lower cost; higher reliability, less environmental impact
- **Dissemination of acquired knowledge**, among the African and European community to extend support for sustainable EoL/OoS component management

Outcome

- **Promotion of environmental and ecological sustainability** of renewable energy systems;
- Increase in innovation around the use and reuse of EoL/OoS components before disposal
- **Increased awareness among researchers** on the importance of accounting for EoL/OoS components in RE research work.

Impact

- **Creation of jobs** through use and reuse of EoL/OoS components management e.g. creation of jobs through repair of systems and proper collection of EoL/OoS components
- **Creation of policy incentives towards RE production**, including handling and disposal at EoL/OoS component stage e.g. financial incentives to encourage manufacturing of easily repairable systems
- **Reduced materials used for new products** and thus cost and environmental impact reduction

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3: Smart stand-alone systems

Specific Challenges

Integrating renewable energies into the global energy mix through versatile, stand-alone systems can help to address the energy needs of off-grid areas in Africa.
Over **45% of the African population live in isolated rural communities**, which could benefit from the introduction of **RE technologies fitting their unique environment and availability of RE sources**.
In addition, in the vast landscape of the Sahel, steppes and open areas, **nomads[1], tuaregs and shepherds rarely have access to electricity**.
Severe climate disasters and conflicts have resulted in **increased migration and 'climate refugees' in many African regions**.
RE and technology can provide a **unique opportunity to equip communities with new facilities without interfering with their way of life** and preventing their being left behind.
The utilisation of renewable energies can also be a **good opportunity to fight climate changes**, such as **desertification and dryness in the Sahel**, and keep communities alive by encouraging young people to stay on their traditional lands.
Access to energy, especially electricity, is thus a **fundamental component to address rural or isolated communities** and support economic and social development.
Specific needs include cooking, clothes washing, **studying**, walking safely (by night), connecting fridges and fans, phones charging, **refrigeration (store food and medication)**, **lighting**, communications, and **water pumping**.
RE stand-alone systems (RE-SAS) are mandatory to ease access to energy in all its forms (electricity for lighting, domestic appliances and pumping, heat for cooking, potable water, etc.) from **local renewable sources** and for **local use of population and economy**.

Capacity Building Focus

Across all these areas to be further researched **technical and managerial competences** and capacities need to be developed.

At individual level:
Researchers shall be involved in **improving the technology of stand-alone components and usability of the whole systems**.
The **knowledge transfer** should be ensured **regarding the final purpose of different devices** and **established standards for increasing the compatibility of systems and components**.
Capacity building activities shall also aim at training of **local electrical technicians** regarding the research outputs in order to link **the new technologies and uses** provided by research to **the needs of the local communities** promoting the **behavioural changes** aimed to have a **more reliable, efficient and safety energy access**.

At institutional level:
Concerning infrastructures, activities and programmes shall be organised to establish and provide **accreditation for laboratories to test stand-alone systems** and provide **programs to address the policy makers** about the **potential of the RE-SAS systems in specific social and geographic contexts**

[1] Nomads are characterized by moving from one place to another in search of pasture and water, setting up tents and nurturing livestock.

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Expected outputs, outcomes and impacts of the MAR 3:

The **research and capacity building activities** within this multi-annual roadmap will allow:

Output

- To **provide avenues** for the development of RE-SAS demonstrator(s), considering the diversity of potential local RE sources and the local effective environment;
- To **develop tools for RE-SAS design**.

Outcome

- The development of **reliable stand-alone system architecture** that can be easily and widely deployed in off-grid African rural and remote areas;
- **Sharing acquired knowledge** to develop a sustainable RE-SAS systems deployment.
- Stakeholders and **business model** are identified
- To increase the **share of renewables and reliability**;
- To **promote environmental sustainability** of renewable energy systems;

Impact

- The creation of **jobs in RE production** and uses through RE-SAS systems installation, management and maintenance
- To give access to **affordable energies** to the largest number of beneficiaries and to maximise the socio-economic impact.
- To promote **income generating activities**

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 # 4: Smart grid (different scale) for off grid application

Specific Challenges

Currently, more than **600 Million people** in Africa do not have access to electricity, 80% of which live in rural areas. In addition to small stand-alone systems for individual households and extensions of the national grid, **there is a growing need for small- to medium-scale Distributed Generation (DG) solutions** capable of integrating a diverse mix of Renewable Energy Sources (RES) for supply to small- and medium-sized communities. Increasing the attention of governments to **regulated penetration of REs** into the national grid will help overcome the dichotomy between centralized and decentralized electrification.

Moreover, using hybrid solutions **coupling different RES with conventional sources** combines a bottom-up and top-down approach.

Such solutions may contribute to an increase in the **reliability of the power** supply and reduced dependence on storage and fossil backup systems, thus also mitigating energy poverty.

Hybrid and Smart RES Grids have a role in addressing the many technological challenges that may arise from the integration of different RE technologies, distribution, and storage systems. These systems must **be optimised and integrated** to be able to respond to rapidly evolving energy needs.

They can play a role addressing **environmental challenges** since they contribute to reducing local air pollution and GHGs emissions. If properly designed, they can also decrease energy-**water-food competition** by reducing reliance on traditional biomass and contributing to wise water management.

Furthermore, Smart and Hybrid Grids can respond to local **socio-economic challenges**. They can be scaled-up to meet growing demand, tailored to **match productive uses** in either agriculture or rural industries, and support community service delivery in education and health.

With the deployment of **appropriate business models**, improved energy affordability may be achieved for local people and job opportunities may be created associated with manufacturing, installation and maintenance.

Capacity Building Focus

Across all these areas to be further researched **technical and managerial competences** and capacities need to be developed.

<u>At individual level:</u>

Researchers shall be involved in improving smart grid components, connections and management and all activities shall be programmed to ensure **knowledge transfer and established standards for the smart grid system and components**.

Capacity building activities shall also aim at training of **local electrical technicians**: these trainings should be updated according to the research outputs so **technicians' competences address the needs of the communities in respect with the new technologies and uses** provided by research. Likewise, capacity building activities shall as well target the triggering of **behavioural changes** to have energy access with reliable systems.

<u>At institutional level:</u>

Concerning infrastructures, activities and programmes shall be organised to establish and provide **accreditation for laboratories to test smart grid systems**.

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Expected outputs, outcomes and impacts of the MAR 4:

The **research and capacity building activities** within this multi-annual roadmap will allow:

Output

- Development of **new tools for optimizing capacity in planning and dispatching strategies** based on people's needs;
- Reduction of energy dependence on fossil fuel and increase in the share of RES;
- New **open-source code access** for researchers worldwide.

Outcome

- **Researcher capacity** will be strengthened with **holistic and multidisciplinary thinking and needed technical competences** through capacity building. Additionally, increased awareness of people's needs will support **longer-term behaviour change**;
- Research and related capacity building will be valorised as instrumental to the **creation of native and local innovation and behavioural change**;
- Technologies design will be increasingly people-driven, increasing **efficiency**;
- **Local people and civil society** will feel more **engaged in the research-innovation process**;
- Private players will benefit from a **new instrument for supporting sustainable business**.

Impact

- **Increased energy access in rural areas** and use of REs;
- **Improved living conditions and social inclusive growth** in the local context;
- I**mproved economic development** and promoting job creation in the local context.
- **Behavioural change** as far as energy usages

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 # 5: Processes and appliances for productive uses

Specific Challenges

According to a 2017 State of Food and Agriculture report by the UN's Food and Agriculture Organisation, the key to achieving the Sustainable Development Goals in Africa is transforming rural communities and promoting agriculture. This is because approximately **60% of Africans derive their income from agriculture and agricultural processes.** It is therefore important to prioritize boosting small-scale farmers' productivity and incomes in the agricultural production stage and creating off-farm employment in expanding segments of the food supply and value chains.

Food supply and value chains segments involve processes such as harvesting, drying, cooling, transportation and retail. These processes require variations of cold chain technologies, and electrical power. The demand is met differently by different industries and countries in Africa. An example of such is industries where thermal power demand is met through biomass while cold chain energy needs are met through grid supply supplemented by diesel generators in cases of blackouts.

Technologies like combined **heat and power systems (cogeneration)** can help improve fuel use efficiency while improving pollution control. In order to **transform rural communities**, access to lighting systems alone is not enough for economic empowerment.

To do this, it is important to support technological innovations and solutions such as **productive use (PRODUSE) appliances in agriculture** as a way of improving rural livelihoods. These appliances can be used to **increase productivity and/or efficiency in agriculture** and other Income Generating Activities (IGAs), such as **rural industrial processes**, and to **improve healthcare systems delivery**. PRODUSE appliances are relatively new to bottom of the pyramid markets, which are mostly found in rural communities, since system costs are as sensitive as the need for the appliances.

The uptake and utilization of emerging RE can easily be slowed or curtailed by quality assurance concerns, energy efficiency gaps, lack of consumer financing and policy interventions. To avoid this, the following challenges should be addressed: the **cost of energy should be low for bottom of the pyramid consumers**; the **power provided should be reliable to prevent loss** of trust in technology; **technologies used should account for cultural interactions**; utilised **appliances should be of good quality**; **system operation and maintenance capacity** should exist locally.

Capacity Building Focus

Across all these areas to be further researched **technical and managerial competences** and capacities need to be developed.

<u>At individual level:</u>

Researchers shall be involved in improving the **adaptability of existing PRODUSE systems that match the identified needs** and should be included on **in-depth training on productive systems that could use renewable energy sources.**

Capacity building activities shall also aim at training of **local technicians** to get competences and skills to **install or maintain PRODUSE equipment/system** in order to address the needs of the communities **introducing the new technologies and uses** provided by research.

<u>At institutional level:</u>

Concerning infrastructures, activities and programmes shall be organised to establish and provide appropriate results generated by research to bring **positive advocacy to policy makers and donors**.

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Expected outputs, outcomes and impacts of the MAR 5:

The **research and capacity building activities** within this multi-annual roadmap will allow:

Output

- Categories **of IGAs performed by off grid communities**, existing PRODUSE appliances supporting these IGAs and IGA categories and existing gaps that RE PRODUSE appliances can fill
- **Existing PRODUSE appliances** in small and large scale agriculture (livestock, fisheries and farming) and proposed RE appliances that can be improved or developed
- **Cold chain and thermal PRODUSE appliances** in different sectors such as healthcare and agriculture
- **PRODUSE appliances used by industries**, alternative appliances that can be used and energy efficiency measures that can be taken to improve the energy consumption of existing ones
- **PRODUSE appliances available to on-grid consume**rs vs off grid consumers to assist with assessment of levels of service expected from RE PRODUSE appliances by off grid consumers
- **Existing business models** used to sell PRODUSE appliances and quality issues related to PRODUSE appliances in on grid and off grid markets

Outcome

- **Understanding** of opportunities for PRODUSE appliances to address IGA related challenges by researchers
- **Reduction of post-harvest losses** especially in the agricultural sector
- Adoption of **energy efficiency measures by industries**
- Improved partnerships and joint research opportunties between European and African researchers

Impact

- Increase in **productivity of the informal sector** such rural industries
- Improved **socio-economic development of off-grid communities** due to support of their IGAs
- **Creation of jobs** and improved energy access through support of IGAs in off grid communities
- **Reduced GHGs, local pollution and deforestation** due to improvement in energy efficiency in industries

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 # 6: Innovative solutions for priority domestic uses (clean cooking and cold chain)

Specific Challenges

Today, there are about 2.7 billion people – one third of the world's population - who still have no access to clean cooking mechanism. Fifty percent of these people are living in developing countries. In Africa alone, **700 million people lack access to clean cooking**. Currently, traditional devices used are typically fuelled with **firewood**, or with **charcoal**, and have **very low efficiency**.

The utilization of traditional biomass poses numerous environmental challenges:

- Traditional biomass utilization is a recognized contributor to **deforestation & land degradation**;
- Biomass burning in traditional cook-stoves has been found to be responsible for about **20% of global black carbon emissions**;
- Indoor cooking with traditional devices causes respiratory illness, which contribute to the **premature death of millions of people** from associated diseases.

In addition, the utilization of traditional biomass also poses social challenges, including:

- The **time spent by women and children** in gathering fuel;
- **Absenteeism from school** caused by Illness due to respiratory infections, common in some countries of sub-Saharan Africa.

Actions necessary to overcome the challenges associated with the use of traditional cooking systems represent technological challenges and can be divided into two categories:

- **Improving the design of existing stoves**, or developing new, more efficient designs;
- Increasing the opportunities for **fuel switching**.

Complementary to clean cooking is **food and drug preservation**, a second common issue at domestic and community level in Africa. In sub-Saharan Africa nearly **40% of food perishes before it reaches the consumer**, while the lack of effective refrigeration limits the possibilities for vaccine distribution in rural, and in remote areas. Here the cold chain can play a crucial role in reducing food waste, improving public health, and enabling African communities, especially in rural areas, to participate in national and international trade as producers and consumers. The technological challenges are mainly based on the energy vector, with the use of heat in place of electricity to generate low temperatures in domestic and community systems, or the use of static and compact technologies with higher reliability compared to traditional systems, and the coupling of refrigeration units with off-grid electric power systems. The development of movable autonomous systems is another important element. Finally the need for compact and fully reliable systems that avoid breaking the cold chain for medicine, and for food preservation with reasonable costs represents a significant socio-economic challenge.

Capacity Building Focus

Across all these areas to be further researched **technical and managerial competences** and capacities need to be developed:

<u>At the individual level:</u>

Researchers need to be involved in **improving, managing and maintaining solar photovoltaic systems, cookstoves and cold chain** components. They also need to be capacitated to be involved in **establishing the standards for the renewable energy components and supply chain**, and very importantly in the knowledge transfer towards local communities and the value chain stakeholders. Additionally, capacity needs to be improved for researchers to **interact with policymaking to foster an appropriate, supporting, long-term and stable policy environment** to ensure **market and fast community uptake**. Specialised technicians need to be trained in the specific technologies and their different usages and applications, and updated regularly according to research results. Likewise, capacity building activities shall trigger behavioral changes to have energy access with reliable systems.

<u>At institutional level:</u>

For what concerns infrastructures, activities and programs shall be organised to establish and provide **accreditation for laboratories to test photovoltaics, cook stoves and cold chain systems**.

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Expected outputs, outcomes and impacts of the MAR 6:

The **research and capacity building activities** within this multi-annual roadmap will allow:

Outputs

- **Innovative cooking device** design;
- New and **appropriate modern cooking systems**;
- **Local and low-cost materials** used for stove construction;
- **Technical improvements in fuel processing** or **fuel production technologies**, and the technical and managerial capacities related to these improved processes and production technologies;
- **Improvements to existing technologies**, and **new technologies for cold chains**, including refrigeration units based on solar or biomass resources, as well as long-term sustainability and management capacities.

Outcomes

- Researchers provided with **capabilities for lab and field testing of cooking stoves**;
- Use of **modern fuels promoted** and its required skills;
- **Sustainable fuel supply chains** promoted:
- Effective and **low-cost food preservation** promoted;
- **Efficient air conditioning** promoted;
- **Greenhouse gas (GHG) emissions** due to lower power consumption from the grid or diesel generators **reduced**.

Impacts

- **GHGs, local pollution, land degradation and deforestation reduced**;
- **Medicines and vaccines in remote areas** better preserved;
- Social conditions of local stakeholders as well as **job creation** improved;
- **Drudgery for girls and women reduced** and their social power and health conditions (female empowerment) improved;
- **Food and nutrition security** strengthened;
- **Individual health, and public healthcare** improved.

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Glossary

2iE	Fondation 2iE Association, Burkina Faso
ACU	Association of Commonwealth Universities, UK
AESG	Africa Energy Services Group Ltd., Rwanda
AMGA	Annotated Model Grant Agreement
ANER	Agence Nationale pur les Energies Renouvable, Sénégal
ANME	Agence Tunisienne de la Maitrise de l'Energie; Tunis
AU	African Union
BLE	German Federal Office for Agriculture and Food | Bundesanstalt für Landwirtschaft und Ernährung
CA	Consortium Agreement
CCSE	Climate Change and Sustainable Energy
CEA	Commissariat à l'énergie atomique et aux énergies alternatives, France
CoI	Confirmation of Interest (of those who sent a letter of support before the GA)
CSIR	Council for Scientific and Industrial Research, South Africa
CSP	Concentrated Solar Plant
DEDEAT	Economic Development, Environmental Affairs and Tourism, South Africa
DLR	German Aerospace Center
DLR-PT	German Aerospace Center - Project Management Agency
DoA	Description of Action
DoW	Description of Work
DST	Department of Science and Technology, South Africa
ECCP	Electronic Content Collaboration Platform , PRE-LEAP-RE partners only
EERA	European Energy Research Alliance
EJP	European Joint Programming
EoI	Expression of Interest
EU	European Union
FCT	Fundação para a Ciência e a Tecnologia, Portugal
FNSSA	Food and Nutrition Security and Sustainable Agriculture
GA	Grant Agreement; also AMAGA
GC	Group of Contributors (Ministries, funding agencies, public and private research institutions and actors from the private sector like e.g.entrepreneurs)
HLPD	Hich Level Policy Dialogue
IE	KIC Innoenergy SE, Belgium
IPR	Intellectual Property Rights
JYU	Jyväskylä Yliopisto/University of Jyväskylä, Finland
KINNO	Knowledge & Innovation Consultanta Symvouleftiki Monoprosopi Epe, Greece
KMCF	Knowledge Management and Communication Framework
LEAP	Long-term Joint EU-AU Research and Innovation Partnership
LEAP-Agri	Long-term Joint EU-AU Research and Innovation Partnership on FNSSA (ERA-Net Cofund)
LEAP-RE	Long-term Joint EU-AU Research and Innovation Partnership on Renewable Energy (RIA)
LGI	LGI Consulting, France
MESRS	Ministry of Higher Education and Scientific Research, Algeria
MI	Mission Innovation
NRF	National Research Foundation, South Africa
NWO	Netherlands Organisation for Scientific Research

OA	Open Access
PAUWES	Pan-African University of Water and Energy Services
PIMC	Programme and Innovation Management Cycle
POLIMI	Politecnico di Milano, Italy
PRE-LEAP-RE	PREparing for a Long-term Joint EU-AU Research and Innovation Partnership on Renewable Energy (CSA)
RD&D	Research, Development and Demonstration
RE	Renweable Energy
REA	Research Executive Agency under the power delegated by the EC
RES	Renewable Energy Sources
SG	Stakeholder Group
SOM	Senior Official Meeting
SU	Strathmore University, Kenya
WASCAL	West African Science Service Center on Climate Change and Adapted Land Use

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PROJECT PARTNERS

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