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Mapping of R&I and horizontal skills need and actions in place in Africa for capacity building

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Summary

Deliverable 3.3 (D3.3) concerns the mapping of research and innovation (R&I) and horizontal skills needs and actions in place in Africa. This is the first deliverable of Task 3.2 and valorizes the expertise of the technical and scientific partners in Pillar 2. The deliverable is based on a mapping exercise that is conducted internally in Pillar 2 and is organized geographically and thematically (aligned with the MARS). The exercise is then complemented in WP4 with the overall LEAP-RE Community. D3.3 is meant to provide Pillar 2 with a broader view on the long-term capacity building chances and needs in the context of action, highlighting the gaps and opportunities covered by LEAP-RE as a whole. In fact, each work package (WP) within Pillar 2 includes tasks devoted to capacity building, which have been coordinated and monitored by a specific cluster group led by Fraunhofer IEG and UCT, involving: Fraunhofer IEG, UDSM, UNIFI, SU, AESG, AAU, UNILO, IIASA, HEAS, UCT, POLIMI, BIUST, MU, Uwasa, Next Energy Consumer, Odit-e, LGI, Université de Picardie Jules Verne. LEAP-RE aims to contribute to the R&I capacity building sector by fostering the technical cooperation and knowledge dissemination between African and European partners, promoting devoted workshops and peer-to-peer technical partnerships. Consistent monitoring of these activities is performed in the technical reporting throughout the project.

Approval

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LEAP-RE
Long-Term Joint EU-AU Research and Innovation Partnership on Renewable Energy

WP3

Pillar 2 Scientific Coordination

Deliverable D3.3

Mapping of R&I and horizontal skills need and actions in place in Africa for capacity building

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GLOSSARY

AU	African Union
CESP	Comprehensive Energy Solution Planning
CB	Capacity Building
DoA	Description of Action
RE	Renewable Energy
MS	Milestone
M&E	Monitoring & Evaluation
MARs	Multi-Annual Roadmaps
MOOCs	Massive open online courses
O&F	Organisational & Funding
tbd	to be determined
WP	Work Package
UN	United Nations
EU	European Union
RE	Renewable Energy
RETs	Renewable Energy Technologies
RES	Renewable Energy Sources
R&I	Research and Innovation
WoS	Web of Science

LIST OF FIGURES

1. Introduction

Deliverable 3.3 (D3.3) concerns the mapping of research and innovation (R&I) and horizontal skills **needs and actions** in place in Africa. This is the first deliverable of Task 3.2 and valorizes the expertise of the technical and scientific partners in Pillar 2. The deliverable is based on a mapping exercise that is conducted internally in Pillar 2 and is organized geographically and thematically (aligned with the MARS). The exercise is then complemented in WP4 with the overall LEAP-RE Community.

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The scopes covered by the present work are here reported:

- to map some main **capacity building programs already existing** informing possible users or interested beneficiaries of their existence.
- to highlight the **chances and needs in term of horizontal skill coming from LEAP-RE**, such that future training programs will be efficiently deployed (inside and outside LEAP-RE).
- to provide LEAP-RE partners and externals with a useful and **taxonomy to be used within LEAP-RE and in future mapping exercise s**in the renewable energy sector.

The organization of the document follows the three main scopes.

The first section of the report will introduce the subject of **capacity building for the renewable energy sector in Africa, proposing the overall LEAP-RE vision**. Then, a non-exhaustive mapping of the actions already in place in the continent will be advanced, followed by a general assessment of needs reported in existing documents.

The second section will track the **capacity building needs and actions in place at Pillar 2 level**, collecting information mainly from the technical reports and set of interviews made with each WP of Pillar 2 as well as the research results conducted by the Capacity Building cluster group, through an online investigation as well as qualitative interviews with the LEAP-RE partners.

The third section is dedicated to the introduction of a **taxonomy for capacity building activities in renewable energy sources (RES) in Africa** which is structured into the proposal of: multi-level concept of capacity building,

The report concludes with recommendations for long-term actions at LEAP-RE level and delivers a clear and replicable taxonomy for future capacity building activities.

2. Mapping the main R&I capacity building activities and needs in Africa

When it comes to renewable energy sources, the exploitation of the available potential has to be met by adequate solutions and skills. These include a variety of non-merely technical capacities, which span from policy and regulatory design and management to project preparation, evaluation, development, implementation and financing in government ministries, financing institutions, regulatory agencies, and utilities. The lack of massive plans for knowledge, skill and capacity development in the renewable energy sector is hindering the diffusion of new renewable energy technologies (RETs) in developing countries (DCs) [1]. This is even more evident when it comes to research and innovation (R&I) activities. In previous literature, the inadequateness of investments in R&I has been positively correlated to the low rate of penetration of new RETs in local markets, also reducing the interests of external investors for the countries in consideration [2]. However, the overall impact achieved by said investments remains hard to be evaluated [3].

In this frame, it is relevant to note the number of initiatives of capacity building in Africa (sub-sections 2.1, 2.2) as well as the needs for horizontal skills within the domain of LEAP-RE Pillar 2 (section 3). These actions are summarized in the following sub-sections, leading to the focalization of a taxonomy in the last sections of this work.

2.1 Actions in place in Africa for RES

To review the state-of-art of actions for capacity building in the RE sector, the work has been coordinated with the Capacity Building cluster group, led by Fraunhofer IEG and UCT. The research has been conducted by mean of online investigation as well as qualitative interviews with LEAP-RE partners. The information has then been collected in shared Excel files and disseminated among the partners through FLEXX and SharePoint platforms in spring 2022 (M18-M20). These documents, named "Gap_analysis_of_skills_initiatives_2022.xlsx" and "LEAP-RE_Training_Opportunities.xlsx" saved in WP5 repositories, contain extended data, references, and information. This deliverable aims to valorise the findings of the cluster group, elaborating the mapping towards a more comprehensive tracking of possibilities and actions in place for capacity building in the African RE sector. The mapping exercise is rather large but non-exhaustive, given the wideness of the topic, and will therefore need for further monitoring and update in the upcoming months. A particular focus has been put on SSA, where the lack of information on the topic is evident.

The first step of the mapping exercise studies the distribution of skill and capacity training activities in the RE sector for the African continent, aggregating results for: **academic programmes** (e.g., higher education renewable energy initiatives, and higher education curricular programmes, etc.) and **practical training programmes** (e.g., vocational training initiatives, higher education vocational skills training, etc.). These activities vary in a wide span of actions, such as: pilot projects of innovative teaching, technical assistance training programs, technical higher education programs, under or postgraduate courses, programs of technical empowerment for disadvantaged women, and so on.

The second step of the mapping of the actions in place for capacity building consists in listing a selection of short-term courses that can be considered **MOOC's technical training for practitioners**.

2.1.1 Aggregated results analysis

To provide useful and updated information, all the activities considered are ongoing to the date. A first aggregated map, in Figure 1 , depicts the geographical distribution of these activities. Most of the tracked programmes, however, takes place in the south and south-east of the continent with South

Africa and Kenya constituting more than the 60 % of the sample. This shows much room for further programs in the rest of SSA.

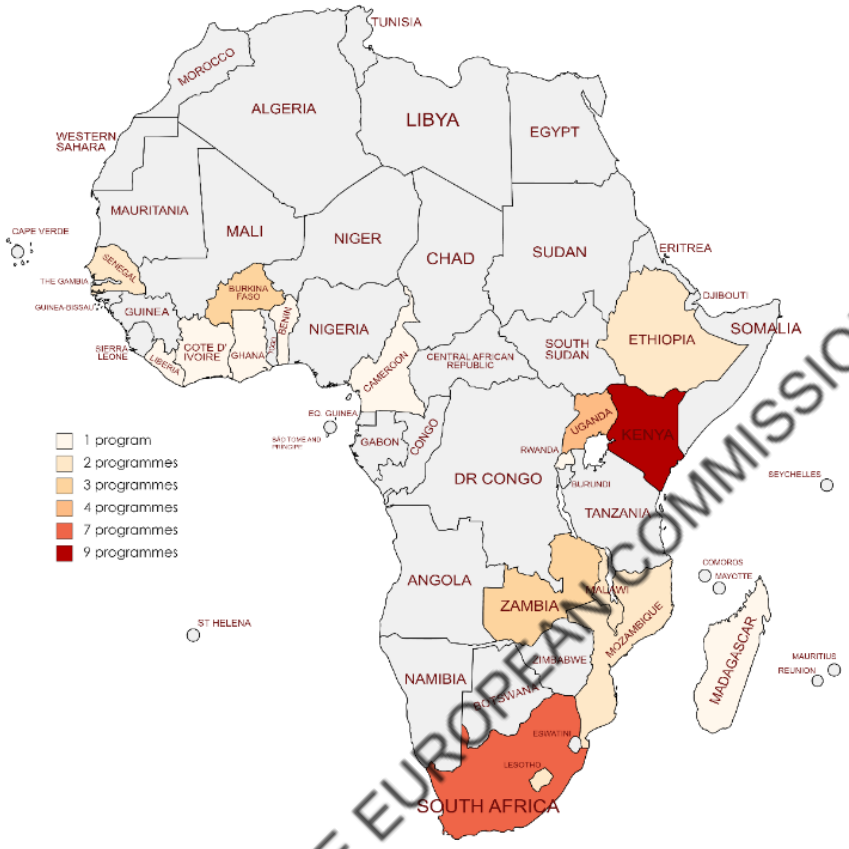


Figure 1 - First mapping of RE programmes in the african continent

A more accurate mapping has then been conducted focusing on **academic programmes** on RE-related topics. The investigation concerned a total of 86 academic programmes, the majority of which are held in SSA. Among these, more than half of the mapped programmes are MSc courses, while very few concern PhD or other high-level programmes (in the category "Other"). The figures are depicted in Figure 2.

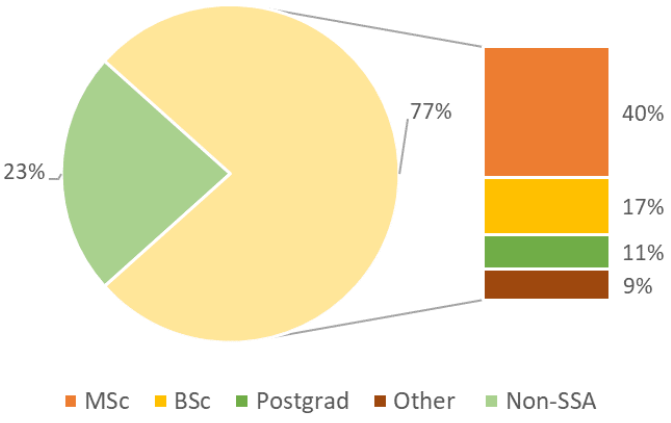


Figure 2 - Mapping of academic RE programmes (total 86) in SSA and african non-SSA countries

Finally, a third mapping has been conducted focusing on a total of 47 **practical training programmes** on RE-related topics, such as academies, intensive technical courses, workshops, etc. These activities have then been clusterised by renewable energy source (RES) of interest and the results are represented in Figure 3. A major interest can be noticed on the delivery of training programmes related to solar resource: almost all the countries investigated provided with at least one course on the topic. A great number of programmes (28%) covered one or more RES in the same course, offering wider training to the participants. This results handful when dealing with RES, since greater knowledge on their chances of exploitation expands the set of technological solutions to be adopted, as well. Hybrid technologies, such as 3rd generation hybrid mini grids, are crucial in this sense, but still poorly covered by devoted training courses to the date.

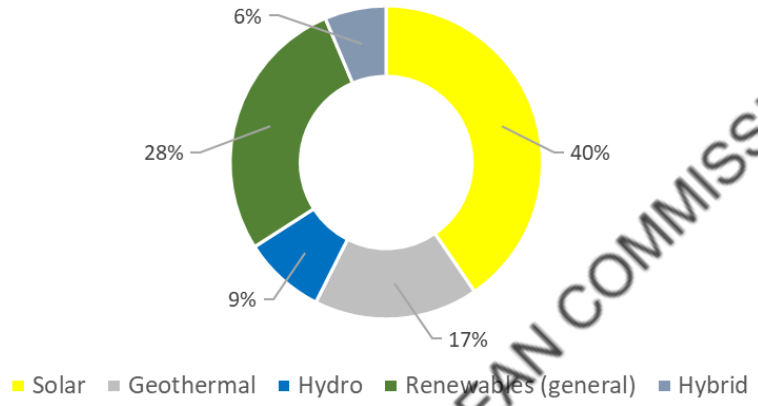


Figure 3 - Mapping of practical training RE programmes (total 47) in Africa, by RES of interest

2.2 List of actions in Place in Africa

The below table is based on the research conducted by mean of online investigation as well as qualitative interviews with LEAP-RE partners. The information has then been collected in shared Excel files and disseminated among the partners through FLEXX and SharePoint platforms in spring 2022 (M18-M20). The document, named "LEAP-RE_Training_Opportunities.xlsx" saved in WP5 repositories, contain extended data, references, and information.

Table 1 - mapping of actions in place in Africa for capacity building for RES

Designation	Duration	Description	Link
		Training women to become Solar Engineers. More than 2500 engineers trained in villages across the globe	https://www.barefootcollege.org/solutions/
Household Solar Workforce Challenge		Solar training grants for third party training provides 'for initiative to manage training staff, technicians, or sales agents for the off-grid energy sector'	https://www.usaid.gov/householdsolar/call-for-proposals
Short course on Solar PV	2 days	https://aceesd.ur.ac.rw/short-course-photo-voltaic-technology	https://www.strathmore.edu/open-africa-power-initiative/

	8 weeks	Technical and sales training through certified skills courses (solar design, installation, maintenance & servicing, safety, project management, solar water pumps and solar water heaters. Also provides on the job coaching for 'frontline staff and agents and employers for continuous development, sales and professional skills	https://www.enlightinstitute.org
Solar irrigation training		The University of Development Studies (UDS) signed a funding agreement partnership with GIZ to provide 'training to technicians, installers and agricultural extension agents'	http://www.faapa.info/en/2021/10/09/giz-uds-partner-to-train-actors-on-solar-powered-irrigation-system/
Solar Cooling	3 days	This course is open but not limited to maintenance engineers, field engineers from the humanitarian or development sector, product managers, technical staff and, independent consultants.	https://strathmore.edu/course/master-of-science-in-sustainable-energy-transitions/
Solar Water Pumping	5 days	Practical excersises in stand-alone and hybrid (grid or genset backup) configuration to learn the most important operational parameters. Proprietary manufacturer software will be used to design and calculate PV powered pumping and irrigation systems.	https://serc.strathmore.edu/programmes/
T1 and T2	20 days	This course is the entry point to become a licensed Solar technician or Solar products vendor. Participants receive comprehensive know-how for photovoltaics, hands-on training with technical components, designing optimized PV stand-alone systems to apply for a T2 license from the Energy Regulatory Commission.	https://serc.strathmore.edu/programmes/
T3 Grid Tie	20 days	Participants will learn the technical planning, design and cost calculations for larger PV systems. Positive course completion enables to apply for a T3 license at ERC.	https://serc.strathmore.edu/programmes/
Certification of Solar PV Installers		For successful RE and EE installations and projects, there is a need for quality assurance at various levels. This includes quality assurance of equipment, e.g. through the establishment and enforcement of product standards. However,	http://www.ecreee.org/certification

		high-quality products will only provide the desired services if RE and EE systems are designed, installed and maintained by highly qualified individuals. ECREEE and its partners, therefore, decided to support the development of the regional market for RE and EE services by establishing a scheme for certifying the skills of solar PV installers and other sustainable energy professionals. The objective is to introduce a quality mark for sustainable energy skills that is recognized by professionals and end users across borders in all 15 ECOWAS member states.	
ENEL Green Power Photovoltaic Skills Training		Solar PV Rooftop installer course and PV Enterprise & Sales Development Course (free course funded by ENEL green power)	https://www.green-cape.co.za/assets/Uploads/Course-Brochure-2018.pdf
Solar PV Installer course	5 days	The SARETEC Solar PV Installer course is a 5-day short course and it emphasizes the physical practical aspects of mounting solar modules on the roof, wiring of the combiner box, the inverter and the distribution box	https://www.saretec.org.za/solar/saretec-solar-pv-course/
PV GreenCard	2 days	The PV GreenCard contains details of the installation such as, what sort of PV modules and PV inverters were used, as well a checklist of all of the necessary installation steps that were completed.	https://www.saretec.org.za/solar/pv-greencard-assessment/
The Basics of Solar PV Systems	2 days	2-day interactive training course, hosted by SARETEC trainers and international Solar PV experts. Non-electricians permitted An attendance certificate will be provided	https://www.saretec.org.za/online-training/solar/
Solar Training		Our commitment does not end with the support. Through continuous training hundreds of participants in the pioneering field of solar energy can be trained year by year. Solar energy not only secures energy supply in resource-poor regions, but also creates sustainable jobs	https://sunfarming.de/en/business-areas/solar-training-center-en/south-africa

Capacity and human resource building for solar market development in Tunisia		The education and training courses available for the practice-oriented and needs-based qualification of PV specialists are improved. Training institutions network and cooperate closely.	https://www.giz.de/en/worldwide/58176.html
Basic and advanced courses	Ranges from 1 to 5 days per course	The GREEN Solar Academy PTY Ltd. is an independent training provider and a spin-off of the maxx-solar academy. Our academies follow the German DGS SolarSchool approach and all academies and courses are accredited by the German Solar Energy Society (DGS). GREEN stands for Global Renewable Energy & Efficiency Network as our goal is not only to provide training but to build up a network of PV installers all over Africa. GREEN is the link between manufacturers, wholesalers, associations and PV installers, our alumni.	https://solar-training.org
		BRILHO is a five-year programme, 2019 - 2024, that will catalyse Mozambique's off-grid energy market in order to provide clean and affordable energy solutions to the country's off-grid population. BRILHO's overall goal is to improve and increase energy access for people and businesses, leading to money saving, better well-being and livelihood opportunities for the low income population.	https://brilhomoz.com
Public Private Development Partnership for Renewable Energy Skills Training and Women's Economic Empowerment in Somalia		The project has two objectives: to economically empower women, especially women entrepreneurs in the MSME sector, and to develop skills to support an expanded electrical system with a greater proportion of renewable energy sourcing. The project will also establish a common curriculum for the design and installation of solar PV systems. At least 10% of the participants in each training are women.	https://www.ilo.org/africa/countries-covered/somalia/ppdp-wee/lang--en/index.htm

Geothermal Exploration and Development of Geothermal Resources Series			https://www.grocentre.is/gtp/capacity-development-gtp/short-courses-and-workshops/workshops
Workshop for Decision Makers on Geothermal Projects and their Management		The objective of arranging Workshops for Decision Makers in various parts of the world is to increase the cooperation between specialists of neighbouring countries and to promote geothermal development by enlightening top level decision makers on geothermal development, regulations, workforce, equipment, financing, and other issues concerning geothermal utilization. The main goal being that they lay the foundation for a continuous Short Course Series in support of the SDGs.	
In development		GETRI was founded as a response to an existing need in the geothermal industry in developing capacity to exploit geothermal energy in the region. GeTRI is expected offer the first-ever comprehensive program that brings together world-class experts to teach all elements of geothermal energy from resource discovery to utilization, including drilling, reservoir engineering, plant design, environmental impact and applicable business principles. Its core service areas include postgraduate training, research, publication, seminars & conferences in close collaboration with the geothermal industry, local and international universities. Initially, the Institute will have programmes at MSc level and, later, PhD level.	https://getri.dkut.ac.ke
An introduction to geothermal science and technology	15 days	The main objective of the training is to strengthen and enhance the capacities and skills of young Africans in geothermal science and technology that came from eleven Eastern Africa countries. The trainees are expected to use the acquired knowledge and skill during this training	https://theargeo.org/AGCE/augustlectures.php

		in implementation of various geothermal projects in their respective countries.	
Geoscience and Reservoir Studies for Advanced 3D Models Training	4 days		http://theargeo.org/AGCE/files/Leapfrog%20Training%20Progress%20Report_Day%202%203%20%204_Report.pdf
Training on introduction to ggeothermal science and technology	11 days	The main objective of the training is to strengthen and enhance the capacities and skills of young Africans in geothermal science and technology that came from eleven Eastern Africa countries. The trainees are expected to use the acquired knowledge and skill during this training in implementation of various geothermal projects in their respective countries.	https://theargeo.org/AGCE/lectures.php
Slimhole Drilling Webinar Series		Organised in collaboration with the New Zealand Geothermal Facility under the auspices of Interim Project Coordination Unit of theAfrican Geothermal Center of Excellence (IPCU-AGCE). These webinars hope to build awareness and knowledge of slimhole drilling. Representatives from the ten ARGeo member countries: Comoros, Djibouti, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Uganda, Tanzania and Zambia will attend the webinar series.	https://theargeo.org/AGCE/NZ.html
Serveral	Ranges from 21 to 45 days	The Geothermal Training Centre currently offers courses in various disciplines ranging from scientific, engineering, statutory and other related areas.	https://www.kengen.co.ke/index.php/geothermal-center-of-excellence/kengen-gtc.html
T3 Hybrid	20 days	Must have tertiary education to participate. Participants will learn all planning steps by designing and calculating their own PV hybrid systems.	https://serc.strathmore.edu/programmes/
Nigerian Energy Support		Offers training courses as part of the broader programme	https://www.giz.de/en/worldwide/26374.html

Programme II			
		The Micro-grid Academy is the main programme of RES4Africa focused on providing the necessary skills and knowledege for mini-grid development. 'It is a vocational capacity building programme aiming at creating a skilled and conscious workforce, in order to deploy decentralised renewable energy solutions and business skills.'local partners including the Institute of Energy Studies and Research (or IESR, formerly the Kenya Power Training School), the University of Strathmore, St Kizito Vocational Training Institute, and AVSI, a non-governmental organization	https://www.res4africa.org/micro-grid-academy
		Voith will consult with the Ministry for Energy and Water of the Republic of Angola (MINEA) in 2020 to determine a suitable location for the training center.	https://voith.com/corp-en/2020-02-07-vh-voith-signs-memorandum-of-understanding-to-build-training-center-in-angola.html
Several, ranging from electricity generation, distribution and system operation to leadership and safety courses		The Centre offers training in five (5) core focus areas as listed in the tabs below, The scheduled training programmes range in duration from two days to thirteen weeks and are conducted on a residential basis. All the courses are certified at skills award level for competency under the Technical Education, Vocational and Entrepreneurship Training Authority (TEVETA) in Zambia. In addition, the Centre offers tailor-made training programmes and conducts onsite training at clients' premises in order to cost effectively meet the specific needs of individual organizations.	https://www.kgrtc.org.zm
G-Res Tools Assessor of Hydropower Sustainability Tools		The Hydropower Sustainability Training Academy currently offers three professional training courses. Two of these courses are designed to help participants develop the skills and knowledge to become either a certified user or accredited assessor of the Hydropower Sustainability Tools.	https://www.esi-africa.com/industry-sectors/generation/ihas-new-training-academy-to-advance-sustainable-hydropower/

		The third course caters to practitioners who want to know how to accurately estimate greenhouse gas (GHG) emissions from hydro-electric projects using the G-res Tool. The courses will soon be available in a variety of languages with plans to expand the courses on offer in 2021.	
East African Regional Training Course on Operation and Maintenance of Small-scale Hydro Power Plants (SHPP	5 days	The course is aimed to provide competence of the specialized aspect of operation and maintenance of hydropower station including basics of the electro-mechanical equipment, upkeep, operation and maintenance during the operation of the plant. This course will explore the operations and maintenance (O&M) of SHPP plants and provides participants with an understanding of the key issues, challenges and coping strategies specific to small hydropower installations in the EAC. The course material is draw heavily from IHP's experience with the design and installation as well as training on SHP globally. After completing the course, participants will have a strong understanding of small hydropower O&M issues, enabling them to undertake important roles associated with plant oversight, management and upkeep.	https://www.eacreee.org/event/east-african-regional-training-course-operation-and-maintenance-small-scale-hydro-power-plants
Enel Foundation Advanced Renewable Energy Training for Africa		Building skills and competencies for the deployment of RE technologies	https://www.enelfoundation.org/topics/articles/2021/07/renewable-energy-for-africa--advanced-training-course
The Developing Developers programme		The South African Photovoltaic Industry Association (SAPVIA) and the South African Wind Energy Association (SAWEA) has launched its Developing Developers program, aiming to enhance local skills development across the renewable energy value chain.	https://www.engineeringnews.co.za/article/sapvia-sawea-partner-to-assist-local-renewables-project-developers-

		Boosted by a proactive clean energy policy, the country is looking to reap the full benefits of a lower carbon economy.	2020-09-21/rep_id:4136
Several	5 days generally	Structured around three- to five-day learning modules closely aligned to real-world industry applications, to cater for the varied requirements of the intended capacity building audience. The modules are designed in such a way that candidates can obtain a variety of qualifications while attending the same contact session, with the differentiation between qualifications determined through the additional assessments, assignments and projects.	https://www.sagen.org.za/publications/capacity-building-technology-innovation/123-power-systems-planning-and-operations-training-overview-brochure/file
		Skills development/technical and vocational education and training sub-programme of the larger BGFA programme	https://beyondthegrid.africa/news/promoting-the-job-creation-and-skills-development-agenda-in-the-off-grid-sector-in-uganda/
Power for All Powering Jobs Campaign		PoweringJobs is a global campaign to ensure that the needed skills and jobs in clean, distributed energy are created to achieve universal electricity access for 1 billion people, and to employ the energy workforce of the future, especially women and youth.' Awareness of the vast opportunity to create new jobs and positive economic impact by meeting the energy access employment needs of private and public sector stakeholders. »» Behavior Change among funders and governments, as well as academic, training and private sector institutions that recognizes workforce training as a benefit, not a cost. »» Market Activation through increased financial, policy and programmatic support to develop new, equitable, diverse, and inclusive training and employment opportunities.	https://www.powerforall.org/resources/calls-to-action/action-agenda-build-workforce-skills-needed-universal-energy-access
Transforming Energy Access Learning Partnership		The TEA Learning Partnership (TEA- LP) aims to support the achievement of SDG 7 through skills and capacity building to 8 partner universities in Africa, recognising the importance of human capital for universal access to energy. TEA-LP	https://tea-lp.org

		provides training through workshops, webinars etc	
Skills for Energy in Southern Africa (SESA) project		KGRTC will establish a new expanded training portfolio for renewable energy and energy efficiency, with support from ILO and private sector partners. The trainings will be based on demand from the industry and build on KGRTCs strategic position. More power technicians and managers in the region skilled in Renewable Energy, Energy Efficiency and Regional Energy Integration. This will be reached through training RE/EE/REI programmes for in total around 1600 trainees. This will be done through face-to-face trainings, around 140 trainees per year, blended face-to- face and e-learning, around 75 trainees per year, and e-learning trainings for around 240 trainees per year. In addition, dedicated training for 240 young female engineers will be conducted.	https://cdn.sida.se/app/uploads/2020/12/16073033/skills-for-energy-in-southern-africa.pdf
Skills for the Renewable Energy Sector (SkiDRES)		The Skills Development for the Renewable Energy Sector (SkiDRES) was a 19 months pilot project aimed at developing and building partnerships with the private sector, assess market needs, develop and test demand-driven training, and prepare for a three-year Public Private Development Partnership, with sub-regional coverage in Africa.	https://www.ilo.org/wcmsp5/groups/public/---africa/---ro-abidjan/---ilo-lusaka/documents/publication/wcms_761097.pdf
Modernising vocational training for renewable energies		To increased specialised local technical expertise and management skills available on the market for renewable energies and energy efficiency in Côte d'Ivoire. The project aims to strengthen the skills of teachers at vocational schools and universities, enabling them to act as multipliers for the dissemination of practical skills.	https://www.giz.de/en/worldwide/79018.html
Schneider Electric Vocational training		1400+ courses from our 91 training centers worldwide with practical face-to-face session, digital programs and electrical installation simulators.	https://www.se.com/ww/en/product-range/62301-technical-training-course-finder/18247010579-trainings/?N=96675186+3045984154+17340

			72006+3124198887+2492419691+1915941756+1854449066+1663370252+1380133721
Higher Education Programme for Renewable Energy and Energy Efficiency		Senegalese universities offer practice and labour-market-oriented degree courses as well as further training courses for professionals in renewable energies and energy efficiency and strengthen skills for business start-up in this field. The ISEPs are advised on developing practical degree courses on the productive use of renewable energies and energy efficiency in locally relevant sectors. To complement this, the programme supports the piloting of short-term ISEP training courses relating to energy, also for people without university entrance qualifications (including returnees)	https://www.giz.de/en/worldwide/39287.html
Energy Management	3 days	This program is designed for mid to senior level management who are interested in energy matters within their organisations. Participants will also be able to learn about what opportunities are available in their facilities and practical ways of tapping into those opportunities.	https://serc.strathmore.edu/programmes/
Capacity Building consultation services		KEREA has developed training for solar technicians and equipped training institutions with necessary materials to provide proper training. They focus on solar, hydro, geothermal, biogas, biomass and wind	https://kerea.org/capacity-building-consultancy/
Energy Statistics, Residential Sector, Energy Efficiency Data Collection and Initial Step towards the Creation of Energy Efficiency	3 days	Participants received hands-on training on the methodologies and tools on energy statistics and energy efficiency data collection and how to organize energy data at the national level through different resources and sectors of the economy. The workshop also stressed the lack of statistical data from AU Member States countries and focal point's difficulties in collecting and reporting data to AFREC. The focus was therefore on how to identify the best energy efficiency indicators for residential and Industry sectors and how to use the basic energy data to establish comprehensive and accurate	https://au-afrec.org/en/news-and-media-events/latest-news/regional-training-workshop-southern-african-countries-energy

Database for Industrial Sector		energy balances through a coherent definitions and units, thus, enable consistent regional and international reporting.	
Several	5 days on average	The Institute of Energy Studies and Research (IESR) is a Regional Centre of Excellence in Energy Training and Capacity Building. The institute offers Professional courses to corporate organizations, private companies and contractors in the fields of Energy, Electrical, Mechanical, Fiber Optics and Management. The Institute also offers tailor made courses in any topic within the fields.	https://www.iesr.ac.ke/index.php/capacity-building
Ecowas Energy Efficiency Technical Assistance Facility		The initiative was designed to create and operationalize a technical assistance facility for Micro, Small and Medium Enterprises (MSMEs) whose business model includes provision of energy audit services. It is a follow up of the first energy audits training jointly organized by ECREEE and NREL in December 2015 in Praia, Cabo Verde, where local companies expressed their concern on the serious challenges they are experiencing in selling their energy audit services to Clients.	http://www.ecreee.org/page/ecowas-energy-efficiency-technical-assistance-facility

3. Reviewing horizontal skills needs at LEAP-RE Pillar 2 level

LEAP-RE, from its origins in the PRE-LEAP-RE programme, positions as a horizontal-based programme, as emerges from the ecosystem analysis carried out for drafting PRE-LEAP-RE's Background Paper – Research and Capacity Building agendas. 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.

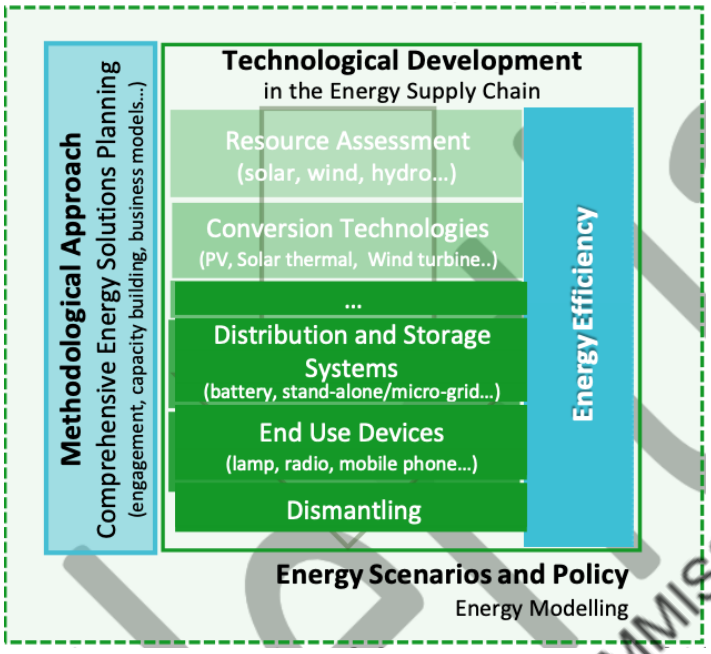


Figure 4 - Comprehensive Energy Solution Planning (CESP) as a methodological approach of analysis

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 Figure 4:

- **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.
- 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.
- 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.
- 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.

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 (Figure 5), described in term of societal challenges, research scope (Figure 4) and expected output, outcome, and impact.

Figure 5 - LEAP-RE Multi-annual Roadmaps (MARs)

Overall, two have been the main outputs of the ecosystem analysis:

- The **6 Multi-Annual Roadmaps (MARs)** as a programmatic framework of research,
- The **Comprehensive Planning approach** as a methodological approach of analysis.

The following analysis, framed at LEAP-RE Pillar 2 level, is based on the technical reports and on a set of interviews made with each WP of Pillar 2, as well as the research results conducted by the Capacity Building cluster group, through an online investigation and qualitative interviews with the LEAP-RE partners. This highlights the **comprehensive and horizontal nature of LEAP-RE**, being a programme that focuses on both R&I ouputs (MARs) but with a methodology that comprises the various facets of energy.

3.1 Needs from Pillar 2 interview abstracts

The Pillar 2 WP leaders were interviewed between the beginning of June and September 2021.

The content of the interviews has been resumed in this section with the main findings. For each interview the topics have been divided in two sections:

- **Mapping** the projects in term of 4 main areas
  - Technology,
  - Modelling tools,
  - Methodologies used and
  - Capacity building;

Comprehensive Planning: overview the current stage of the project throughout different subsequent step following the methodological approach of CESP (Comprehensive Energy Solution Planning), suggested during the PRE-LEAP-RE as a methodology to increase the success of any energy related

project. CESP is here reinterpreted as a useful tool to analyse the cross-sectoral actions of each WP (including capacity building activities), thus contributing to the definition of horizontal skill needs for LEAP-RE Pillar 2.

3.1.1 WP9 – Geothermal Atlas for Africa

Work Package 9 leader is Daniele Fiaschi, associate professor at the University of Florence. He is an expert in geothermal energy and coordinates the whole consortium of this WP. WP9 has recently experienced issues for the exclusion of three African partners, replaced by UNEP.

Mapping

The main *technology* involved in this Working Package is geothermal technology, in accordance with the main goal, which is to lay out a complete and detailed atlas of geothermal resources of the African continent. It will also describe current possibilities of exploitation, thanks to the state-of-the-art available technology. Particular attention will be given to the opportunity to exploit geothermal resources for heating but also for the cooling sector, exploring the possibilities for a safe and efficient cold chain.

Some *modelling tools* will be used to map the whole continent, while some other software will be employed: GPS information to evaluate distances and locations, while Engineering Equation Solver to design plants and technologies for the exploitation of the resource. Different aspects will be linked using python-based tools, to favor open-source access to the model and to the final atlas.

The working *methodology* of the WP begins with the assessment of the current situation, then by addressing the presence and quality of geothermal resource and finally outlining which current technology is best to exploit it. The output will be the Geothermal African Atlas, with different layers to highlight resource availability, its utilization, and technological possibilities.

Finally, some *capacity building* events will be organized to teach to researchers how to use the modelling tools properly and to exploit the atlas. This is crucial for the success of the WP, which aims at providing the necessary tools to the scientists for efficient creation and design of optimized geothermal plants and mini grids integrated with geothermal sources.

CESP

The whole idea of WP 9 started from the lack and necessity of a holistic mapping of the geothermal resource in the African continent, which could be crucial in the challenge to bring sustainable energy to unelectrified communities. This resource could be exploited to run local businesses, for irrigation water pumps and for safe drinkable water for the population.

The assessment of the resource is the first step for a correct exploitation and spread of geothermal technologies. In Africa the major candidates are Kenya and the Rift Valley, thanks to the elevate geological activity of the area.

WP9 will provide to policy makers and scientists a complete atlas and the guidelines for the optimization of different components of geothermal power plants. It will provide also lessons and capacity building for the modelling tools and for the different possibilities of exploitation of this resource, suggesting also innovative ways of utilization, such use cooling and heating.

In the end, the major outcome will be the diffusion and dissemination of the Geothermal African Atlas, that can be a milestone to favor the use of this under exploited renewable source for a more capillary electrification of the continent.

3.1.2 WP10 - PURAMS

Work Package 10 leader is Anne Wambugu. She is involved as researcher of Strathmore University. She is an electrical engineer with more than five years' experience in the energy access sector, with a focus on electricity access using renewable energy technologies.

Mapping

The main *technology* analyzed withing this project are solar cooking ones. The current data collection will be developed in three countries: Rwanda, Kenya, and Mozambique. Based on the information coming from surveys and smart meters on-side the WP will choose the appropriate technology to develop. Electric pressure cookers and induction cookers emerged as possible option during the interview.

The *modelling tools* are not decided yet. The WP will need firstly to decide which technology will be used.

Regarding the *methodology* there is first the need to clarify the participation of the partners involved (especially in Mozambique) to decide, collectively as WP, the most suitable technology in each context. During the interview it was clarified that knowledge obtained from past projects will be used to optimize the participation of the various partners, both in terms of coordination and data collection.

The *capacity building* is a pivotal step to train the beneficiaries regarding the opportunity that innovative cooking technologies could bring to the community. It will also be necessary to involve women in these awareness activities within the community to also understand the needs and requirements in terms of energy consumption and for cooking for the households (ex. Mama Mgoba in Kenya).

CESP

The data collection activity will understand the energy need of three communities in Rwanda, Kenya, and Mozambique. While Kenya's community is on-grid Rwanda and Mozambique are powered with mini-grid technologies. The measurement will last five months and involve 100 households. Using kettles or induction hobs and thanks to the use of smart meters it will be possible to understand eating and cooking habits. It will be possible to understand the amount of energy needed for cooking within the households.

The solution identification phase is pivotal in this project because after the data collection phase the WP will have to choose which pilot project must be developed to fulfill the energy needs of the community. During the interview a solar cooking technology seemed the most appropriate one. Mrs. Wambugu highlighted that a technology like fire cookstove seems promising for the context that the WP is going to work with. Right now, any decision hasn't been taking at the WP level for the technology to adopt.

The technology optimization will be fundamental to understand which is the most suitable configuration for the technology chosen. Currently, as the interview revealed, the WP is looking for the most suitable software to carry out this key piece.

The main ancillary activities are related to the definition of the business model best suited to the technology that will be selected and to the capacity building that will be used to increase the awareness of the local population on the use of alternative sources for cooking at home.

The expected impact of this project mainly concerns the use of the developed technology. For example, if the prototype that will be developed will be able to go out of the WP area of intervention to project itself on the pan-African market. In addition, we must also consider the impact on the academic and research landscape that, at best, will be interested in the developed of the prototype and will be discussed within academic venues outside of LEAP-RE.

3.1.3 WP11 – Geothermal Village

Work Package 11 leader is Professor Yves Geraud, from Université de Lorraine (UL), but the interview was conducted together with Bastien Walter, project manager from the same university.

Mapping

Thanks to the strong background of the partners involved, WP 11 aims to exploit geothermal *technology* to create a replicable pilot mini-grid to supply the energy needed for a small village.

The main *modelling tools* for the development and optimization of this model will be GIS databases linking geological and technological aspects.

The *methodology* put in practice aims at developing appropriate methods to efficiently identify and drill into the hot geothermal fluids, exploited in optimized plants, for the social and economic needs of the communities.

The *capacity building* is a pivotal step for this project because involve both the African partners as well as the beneficiaries of the WP pilot project. During the interview has been pointed out an exchange experience for African students in European institution that should start in September.

CESP

The first step of the WP will be to identify suitable sites for the installation of two geothermal villages, in the Eastern Rift Valley, where high enthalpy resources are present. To understand needs and priorities of the population, surveys and questionnaires will be conducted on field, concerning both energy needs and social aspects.

The second step will be to design the plant according to the uses and needs, after the assessment of the feasibility of the geothermal power plant and the optimization of the various components. Constant attention will be given to the social aspect since the different types of communities influence the ways of exploiting energy and thermal water.

For what regards the solution identification there are not clear answer yet. During the interview emerged that the WP hasn't decided the type of solution that would be adopted for the energy village. This decision will have to be planned after on field work.

In September, from what emerged during the interview, an institution partner in France will start the capacity building programming. All task leaders will have to determine and list training needs of the whole WP.

The WP leader point out that a meeting in September within task leader will be pivotal to identify properly the impact outside LEAP-RE.

3.1.4 WP12 - RE4AFAGRI

Work Package 12 leader is Manfred Hafner, coordinator of Fondazione Eni Enrico Mattei (FEEM) Future Energy Research Program (FEP) and he coordinates all 7 partners of RE4FAGRI. The WP aim to develop a tool available for local farmers that would boost socio-economic development. at the same time, the WP aim to develop a business model that would be used by farmers and local entrepreneur in the context of analysis.

Mapping

The WP does not focus us on a precise technology, but from what emerges in the interview, it seems that they will focus the generation side on solar and wind, leveraging geospatial data that allows to understand the energy potential of a territory.

The modelling tools used within the WP are the three energy models developed by the 3 partners involved (FEEM, IIASA, UCT). These will be distributed to the other partners on the African continent. The goal will be to create an integrated model that considers the energy-water nexus, which is fundamental for rural development.

The methodology of the work used within the WP includes a constant comparison of the three entities that will have to integrate the energy models. From the interview, the role of African partners is fundamental to understand the applicability of the various models in the field and test their validity.

Significant capacity building activities will be necessary, first and foremost, for entrepreneurs and stakeholders involved who will have to use the tool developed by the WP themselves. At the same time, activities will be needed to train researchers at African institutes so that they are able to exploit the unified model in an appropriate way, to develop the best solution for the local situation.

CESP

The main priority addressed by the WP which has emerged during the interview is a lack of modelling to size correctly agriculture equipment for irrigation.

Data collection may take place through field interviews, but geospatial software will certainly be used to determine the energy potential of the area.

The identification of the most suitable solution for the local context will depend very much on the feedback received during the various meetings that are planned for the coming months. A point that was stressed during the interview is the need to have a solution that is not totally defined a priori, but that allows it to be declined in the future according to the needs.

Similarly, the optimization of the technology is a step that has not yet been fully defined but it is expected that solar and wind technologies will be preferred in the model that will be produced.

Capacity-building activities will be a key element in enabling the project's long-term success. Both to have African researchers use the models and to find the most suitable business model during meetings with stakeholders

The impact expected from the WP is the greatest possible dissemination of the models with the African universities involved and, likewise, how many future users of the model developed within the WP there will be.

3.1.5 WP13 - SETADiSMA

The head of package 13 is Riccardo Mereu, currently a professor at Politecnico di Milano. There are a total of 14 European and African institutions within the WP. The WP aims to tackle the African mini-grid sector, thus addressing the challenging topics of technological, energy planning, digitalization research and development and related capacity building, focusing on communities to be electrified for the first time (green-field projects), as well as brown-field cases where old mini-grids are repowered including renewable sources, such as Algerian, Kenyan, and Rwandan national case-study.

Mapping

The technologies being analyzed by the WP are rural communities powered by the grid, diesel generators, or renewable technologies such as photovoltaics or wind.

The modelling tools that will be used are mainly Excel or Python based optimization tools. They would be needed to model the supply side of the minigrid as well as the business model. In more complex phases of programming, the WP could imagine the use of MATLAB as optimization tool.

It will be necessary to find a common methodology, among the various partners, for data collection such as the creation of the questionnaires. During the interview emerged that the WP would be able, at the end of LEAP-RE, to disseminate a methodological tool for the minigrid sizing starting from the resource assessment and a business delivery model that would be helpful to increase the economic sustainability of future projects.

Capacity building activities will include first a series of training meetings with partner universities to give new skills to researchers and students who will participate during the project. A repository on GitHub would be open to facilitate the diffusion of the model produced by WP.

CESP

Identification of priorities starts with a study of previously constructed mini-grid of both green and brown fields.

On the other hand, the study of an area's energy potential and demand is provided through a series of geospatial models.

The decision of the best solution instead will be carried out considering the context. The technological optimization will be undertaken to find the best solution.

The sharing of the projects on GitHub, as emerged from the interview, will be useful to facilitate the diffusion of the models within the academic community.

Finally, the impact evaluation will take into consideration how much this model has enriched the scientific community outside the WP.

3.1.6 WP14 – Energy village concept

Work Package 14 leader is Ari Haapanen, Project Manager from the University of Vaasa in Finland. He has experience in the coordination field and will plan to schedule frequent meetings with the partners to always keep everybody updated.

Mapping

The main goal of the WP 14 is to develop a precise and complete pattern for the elaboration and development of energy villages in rural areas, off-grid systems to provide clean electricity to the community. The technology proposed in the creation of this set of tools and methods is the most available in the territory, usually local biomass, and PV panels.

Excel will be a fundamental modelling tool for the optimization of the loads and the management of the data for the WP.

The demo projects of this Energy Village Concept will be shared and spread for the creation of a network, which could need some capacity building activity for the researchers involved.

CESP

Thanks to various interviews with local communities and African Partners it will be possible to identify most relevant needs for villagers.

The resources will be assessed using classical tool for this kind of modelling, based on Excel, but re adapted for the African context this will be used for. Simulations will be carried out to correctly evaluate the load demand for the Energy Village.

The selection of the most promising technology and strategy to provide clean electricity will be data-driven, based on availability and quality of resources.

The whole village will be optimized with modelling tools, to efficiently size the components of the mini grid.

It will be pivotal to implement trainings on the technical tools, outlining also different possibilities for the business models, depending on the local and specific situation: the implementation of a feasible business model is crucial to increment the replication potential.

The final goal and the main impact of this WP will be to put the basis to establish an African-wide network of smart energy villages, defining guidelines for the development of mini grids in rural communities.

3.1.7 WP 15 - EURICA

WP 15 interview was conducted with Luc Richaud from Odit-e. He showed determination and professionalism in the management of the Working Package: he decided to organize meetings for the partners and stakeholders on a regular basis, following a precise schedule. This organization will make everybody able to share information easily and keep the others updated on the new developments.

The WP15 refers to different types of electrification, a top-down approach in Burkina Faso, trying to connect suburban households to the national grid, and bottom-up microgrids in villages in Madagascar.

Mapping

WP 15 is based on two opposite technologies: on one hand it aims at extending the national grid to poor families in the outskirts of big cities in Burkina Faso, by developing safe electrical connections. On the other side it will connect various nanogrids in the North of Madagascar, testing the integration of different grids. These nanogrids can supply energy for 5 or 6 families and they mostly rely on solar panels on the rooftops of houses and on li – ion batteries.

In Madagascar capacity building trainings for on field technicians have already been implemented from previous projects.

The methodology proposed relies on a solid base: thanks to smart meters in Burkina Faso and historical data in Madagascar, numerous data will be retrieved: this will allow to correctly evaluate the load and implement an efficient technological solution. WP 15 will use their own modelling tools to optimize the energy system, sizing the components according to the availability of resources and the demand.

CESP

In Madagascar the need for a more capillary network of nanogrids was clear thanks to previous projects in the same area. In Burkina Faso the priorities of the communities were investigated with dialogue with villagers and African Partners.

The resource assessment will be carried out thanks to the employment of Smart Meters and the utilization of Machine Learning algorithms in the top-down approach, while for the bottom up it will use previous data.

The strategy to provide electricity to the communities has already been selected, since the WP 15 projects a top-down approach in Burkina Faso and a bottom up in Madagascar.

The first one will use electricity from the national grid will the second one will implement photovoltaic panels and batteries.

Some capacity building activities will be planned for the nanogrids in Madagascar, to train local technicians.

The main impact of the WP will be in the know how gained with the two pilot projects: they could be replicated and help to make access to electricity more spread in the territories.

3.1.8 WP16 - LEOPARD

The interview of WP 16 was conducted with Professor Ahmed Rachid, from the Université de Picardie Jules Verne. He has already set up a monthly meeting with the partners. He explained that they plan to finalize in the first meetings the definition of indicators and milestones of the WP.

Mapping

The pilot project is inspected to be implemented in Benin and Senegal, providing a containerized solution to supply electricity for the basic needs. The *methodology* used aims at obtaining the best solution through modular containers considering the expertise and the know-how of multiple actors.

They will be mainly based on solar *technology* since this resource can be very abundant in the continent.

Capacity building for installers and users are in the planning, to guarantee a long-lasting use of this technological solution. Since it will be an off-grid system, the *modelling tool* utilized will be HOMER, able to optimize and size mini grids.

CESP

WP 16 wants to tackle the needs of the population starting with dialogue with the local communities, to define habits and availability to use this containerized solution.

To size the solar panels the WP will start collecting data with local measurement tools, for example electrical and smart meters.

Thanks to the field measurements and the utilization of HOMER for the sizing, the number of modules and PV panels will be decided, creating the best solution for the specific situation of the community.

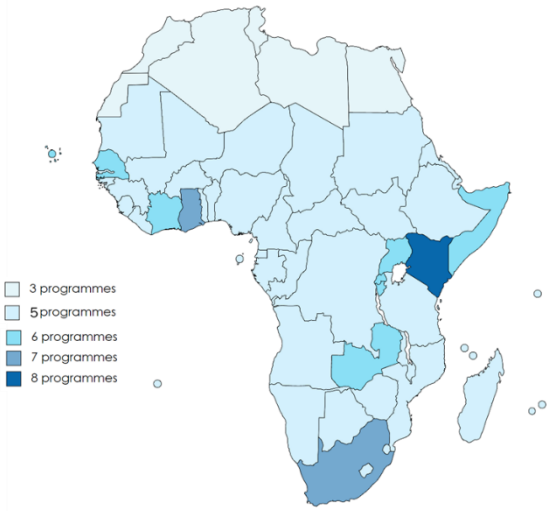
It will be crucial to develop an efficient business model: it can change for different situations, but it will be probably an end-user type, providing electricity at an affordable price. The use of electricity for agricultural or business activities can be fundamental to sustain economically the project. It will be also important to plan capacity buildings for the use of the containers for the villagers.

The final aim is to develop a solution for a clean access to electricity, easy to be transported and to be relocate in many other locations.

3.2 Main horizontal skill needs in Pillar 2

In the process of building a more precise taxonomy that will be developed later in the document, the horizontal skills are here generally identified as all the skills needed beyond the technical one associated to the energy sector. For instance, managerial skills, which may be argued as very technical ones, are here included in the horizontal skills. This analysis will be of crucial relevance for the identification and formulation of the taxonomy: it identifies the needs expressed in the different technical reports as dedicated trainings or provided as transversal skills within academic programmes.

Through the analysis of the technical reports of Pillar 2, common horizontal skills were highlighted, such as **Project management, Social sciences, communication skills, and entrepreneurship.. etc.** Many initiatives in Africa dedicated for investing in renewable energies such as “Solar 1000 MW” in Algeria require management skills and other related skills. As declared in the African Startup



conference (Link: http://africanstartupconference.org/), the entrepreneurship is a highly prioritised axis in all initiatives at a continental level. The following table is based on the document named "LEAP-RE_Training_Opportunities.xlsx" saved in WP5 repositories, contain extended data, references, and information.

Figure 6 - Mapping of the programmes in place by horizontal skills (general definition)

Table 2 - Mapping of the programmes in place by horizontal skills

Designation	Duration	Description	Link
Household Solar Workforce Challenge		Solar training grants for third party training provides 'for initiative to manage training staff, technicians, or sales agents for the off-grid energy sector'	https://www.usaid.gov/householdsolar/call-for-proposals
Programme of: Enlight Institute	8 weeks	Technical and sales training through certified skills courses (solar design, installation, maintenance & servicing, safety, project management, solar water pumps and solar water heaters. Also provides on the job coaching for 'frontline staff and agents and employers for continuous development, sales and professional skills	https://www.enlightinstitute.org
T1 and T2	20 days	This course is the entry point to become a licensed Solar technician or Solar products vendor. Participants receive comprehensive know-how for photovoltaics, hands-on training with technical components, designing optimized PV stand-alone systems to apply for a T2 license from the Energy Regulatory Commission.	https://serc.strathmore.edu/programmes/
Certification of Solar PV Installers		For successful RE and EE installations and projects, there is a need for quality assurance at various levels. This includes quality assurance of equipment, e.g. through the establishment and enforcement of product standards. However, high-quality products will only provide the desired services if RE and EE systems are designed, installed and maintained by highly qualified individuals. ECREEE and its partners, therefore, decided to support the development of the regional market for RE and EE services by establishing a scheme for certifying the skills of solar PV installers and other sustainable energy professionals. The objective is to introduce a quality mark for sustainable energy skills that is	http://www.ecreee.org/certification

		recognized by professionals and end users across borders in all 15 ECOWAS member states.	
ENEL Green Power Photovoltaic Skills Training		Solar PV Rooftop installer course and PV Enterprise & Sales Development Course (free course funded by ENEL green power)	https://www.green-cape.co.za/assets/Uploads/Course-Brochure-2018.pdf
Public Private Development Partnership for Renewable Energy Skills Training and Women's Economic Empowerment in Somalia		The project has two objectives: to economically empower women, especially women entrepreneurs in the MSME sector, and to develop skills to support an expanded electrical system with a greater proportion of renewable energy sourcing. The project will also establish a common curriculum for the design and installation of solar PV systems. At least 10% of the participants in each training are women.	https://www.ilo.org/africa/countries-covered/somalia/ppdp-wee/lang--en/index.htm
Programme of: The Micro-grid Academy Institute of Energy Studies and Research (IESR), formerly Kenya Power Training School		The Micro-grid Academy is the main programme of RES4Africa focused on providing the necessary skills and knowledege for mini-grid development. 'It is a vocational capacity building programme aiming at creating a skilled and conscious workforce, in order to deploy decentralised renewable energy solutions and business skills.'local partners including the Institute of Energy Studies and Research (or IESR, formerly the Kenya Power Training School), the University of Strathmore, St Kizito Vocational Training Institute, and AVSI, a non-governmental organization	https://www.res4africa.org/micro-grid-academy
Several, ranging from electricity generation, distribution and system operation to leadership and safety courses		The Centre offers training in five (5) core focus areas as listed in the tabs below, The scheduled training programmes range in duration from two days to thirteen weeks and are conducted on a residential basis. All the courses are certified at skills award level for competency under the Technical Education, Vocational and Entrepreneurship Training Authority (TEVETA) in Zambia. In addition, the Centre offers tailor-	https://www.kgrtc.org.zm

		made training programmes and conducts onsite training at clients' premises in order to cost effectively meet the specific needs of individual organizations.	
Modernising vocational training for renewable energies		To increased specialised local technical expertise and management skills available on the market for renewable energies and energy efficiency in Côte d'Ivoire. The project aims to strengthen the skills of teachers at vocational schools and universities, enabling them to act as multipliers for the dissemination of practical skills.	https://www.giz.de/en/worldwide/79018.html
Higher Education Programme for Renewable Energy and Energy Efficiency		Senegalese universities offer practice and labour-market-oriented degree courses as well as further training courses for professionals in renewable energies and energy efficiency and strengthen skills for business start-up in this field. The ISEPs are advised on developing practical degree courses on the productive use of renewable energies and energy efficiency in locally relevant sectors. To complement this, the programme supports the piloting of short-term ISEP training courses relating to energy, also for people without university entrance qualifications (including returnees)	https://www.giz.de/en/worldwide/39287.html
Energy Management	3 days	This program is designed for mid to senior level management who are interested in energy matters within their organisations. Participants will also be able to learn about what opportunities are available in their facilities and practical ways of tapping into those opportunities.	https://serc.strathmore.edu/programmes/
Programme of: The Akilah Institute for Women		The Davis College model is a unique hybrid of a liberal arts education with applied and technical curricula, combining competency-based academic programs with a customized, data-driven learning model to actualize practical experience and equip students with the tools needed to thrive in the fastest growing sectors of the economy. As East Africa's pre-eminent	https://akilah.org/

		higher education institution, our graduates have launched careers in finance, clean energy, eco-tourism, agribusiness, conservation, technology, and more. The Akilah Women's Center experience combines the Davis academic model with an intensive focus on women's leadership and career development.	
Programme of: Ashesi University		Ashesi University, "aims to educate a new generation of ethical, entrepreneurial leaders in Africa", with a strong emphasis on cultivating critical thinking and leadership skills among its students.	https://www.ashesi.edu.gh/
Programme of: The African Leadership Academy		With the goal of building the next generation of African leaders, the African Leadership Academy (ALA), has been educating students since 2008. Its training curriculum couples standard secondary school classes with a number of entrepreneurship courses and activities.	www.africanleadershipacademy.org
Programme of: The Meltwater Entrepreneurial School of Technology		this Ghanaian based institute provides aspiring African entrepreneurs with a fully sponsored twelve month- long intensive program aimed at equipping them with the skills to take their ventures to the next level. Subjects include computer programming, software development, product management, finance, marketing, sales and leadership training.	https://meltwater.org/
Programme of: Women Entrepreneurship For Africa		The virtual Acceleration Program, implemented by SAFEEM, seeks to provide 100 female entrepreneurs from the TEF alumni network, with access to €10.000 in grant funding that will be paired with 3 months of technical support.	https://safeem.org/women-entrepreneurship-4-africa/
Programme of: Digital Africa		As a super-aggregator of data, capacities, and opportunities, Digital Africa have a unique ability to intensify entrepreneur financing, training, support and promotional activities. Digital Africa develop expertise, create knowledge-based communities, provide technical assistance, finance projects and businesses, ease market access and the creation of a regulatory environment that supports African innovation. Digital Africa use these drivers to nurture innovative projects and help them grow into successful initiatives that can transform the everyday lives of African people and boost the	https://digital-africa.co/

		international competitiveness of Africa's digital industries.	
Programme of: African German Entrepreneurship Academy (AGEA)		African German Entrepreneurship Academy (AGEA) is a joint initiative consisting of a dynamic network coordinated by the International Small Enterprises Promotion and Training (SEPT) Competence Center at Leipzig University (Germany). The network collaborates with its dedicated academic and business partners in Africa and Germany. The aim is to promote cutting-edge practice-oriented entrepreneurship education, entrepreneurship promotion and start-ups and businesses development in Africa. AGEA contributes to improving graduate employability through the inclusion of a high level of hands-on training in African partner universities. AGEA empowers Higher Educational Institutions in entrepreneurship promotion activities, especially entrepreneurship promotion initiative, encourages the establishment of vibrant university-business linkages and knowledge sharing between universities and business associations in Germany and African partner countries.	https://www.ageacademy.de/
Renewable Energy Management and Finance Course	2 days	This course has been revised to take account of the changes in government support policy for all types of Renewables. The training will fully equip delegates with the latest information on financing all types of renewable energy projects to allow them to continue to participate successfully in the Renewables Industry, both in the UK and internationally.	https://www.renewableinstitute.org/training/renewable-energy-management-and-finance-course/

3.3 Actions in place in Pillar 2

Based on the aforementioned section, the following figure has been created detailing the list of initiatives (19 Actions in place) targeting the following horizontal skills: **management, sales/business skills, quality assurance, and entrepreneurship.**

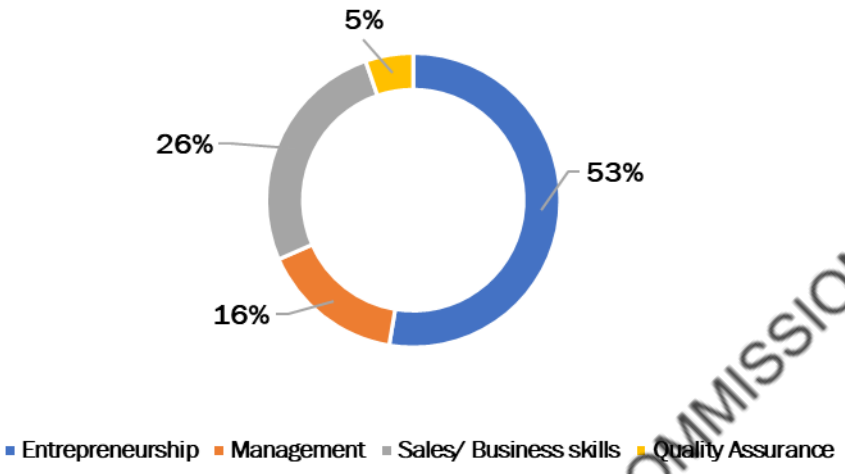


Figure 7 - Mapping of the actions in place by horizontal skills

Based on Figure 7, out of the identified 19 actions, 10 were focused on promoting entrepreneurship, 5 aimed to improve sales and business skills, 3 were designed to enhance management capabilities, and only 1 action was focused on quality assurance. It should be noted that 3 programmes of entrepreneurship are provided for Africa namely, Women Entrepreneurship For Africa, Digital Africa, African German Entrepreneurship Academy (AGEA); respectively by: Switzerland, France and Germany.

4. Towards a Taxonomy for capacity building activities in RES in Africa

As stated in the SEAR report 2017 by the World Bank [4], within the energy challenge the cross-cutting role of human capital (individually and collectively, as communities and institutions) is more and more crucial both as a catalyst and a booster. Indeed, without the proper human resources, it will be impossible to achieve a transformative change in energy access – one that is efficient, effective, equitable, empowering, and long lasting. This means that capacity building is much more than delivering training hours and embrace different levels. The following paragraphs advance a common taxonomy for capacity building activities.

4.1 The multi- level concept of Capacity Building

As reported by the WB in 2017, the idea of capacity building has undergone significant revision over the past 20 years [5]. First off, the idea of "capacity" has changed from one that emphasizes self-reliance to one that focuses on an organization or person's ability to be resilient and effective. Here, the emphasis is on people's capacity for action, self-sustainment, and self-renewal as well as their capacity for setting and achieving their own development goals. The process of releasing, enhancing, and maintaining these capacities is known as capacity building in this context. Capacity building also serves as a tactical tool for long-term and independent growth. Additionally, there is a need to expand on the direct analogy that characterized capacity building as training and to view education as a fundamental human right, as well as to broaden the functional dependency of capacity building. Such

a comprehensive vision calls for several different sets of actions, such as (i) developing people's abilities, relationships, and values; (ii) enhancing the systems and laws that influence both collective and individual behaviour; and (iii) improving people's technical competences, soft skills, and attitudes to enable them to be proactive players for development.

At UN level, the UN Sustainable Development Agenda 21 from 1992 suggests that the capacity of a country's people and institutions, which complements its ecological and geographic factors, greatly influences its capacity to pursue sustainable development paths [6]. In turn, UN Agenda 2030 for Sustainable Development – Transforming Our World includes Sustainable Development Goal 17 – Revitalizing the Global Partnership for Sustainable Development [7]. This accounts for several targets concerning capacity building, such as increasing technology and innovation in least developed countries and improving data collection and monitoring for the achievement of the SDGs themselves. Universities are here referred as capacity-building institutions through research, innovation and data collection and analysis. Particularly, Target 17.9 aims to enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the Sustainable Development Goals, including through North-South, South-North and triangular cooperation.

Given the variety of approaches to tackle the topic of capacity building, and to bring clarity to the discussion, the following definitions are preliminarily provided and will be used as a taxonomy to aggregate the mapped initiatives:

- **Capacity empowerment** is generally defined, in accordance with the UN, as "the process of developing and strengthening the skills, instincts, abilities, processes and resources that organizations and communities need to survive, adapt, and thrive in a fast-changing world" [8], able to support and sustain transformation over time. Concerning RES and RETs, the concept can be rephrased as the implementation of all those activities aimed to foster the process of integration of sustainable energy sources and technologies in the social, technical, and economic contexts of interest.
- **Curricular or Vocational training** is defined as the programmatic training supplied to future professionals to provide them with sector-specific skills. This level of capacity building provides training programs include high school programs, career, and technical education (CTE), but also trainings and apprenticeship programs as well as Bachelors, Master and Ph.D.
- **Skill training** is defined as the training needed to develop precise skills for a specific workplace. Work skills are generally divided into *hard* and *soft skills*. In the RES and RETs sectors, *hard skills* include technical knowledge (e.g., energy modelling skills, operation and maintenance skills, renewable resource assessment skills, etc.) and management skills (e.g., project management, project cycle management, financial reporting activities, etc.). *Soft skills*, on the other hand, space from communication skills to leadership, flexibility, and multitasking abilities. Skill training activities can be considered a sub-group of capacity empowerment actions.

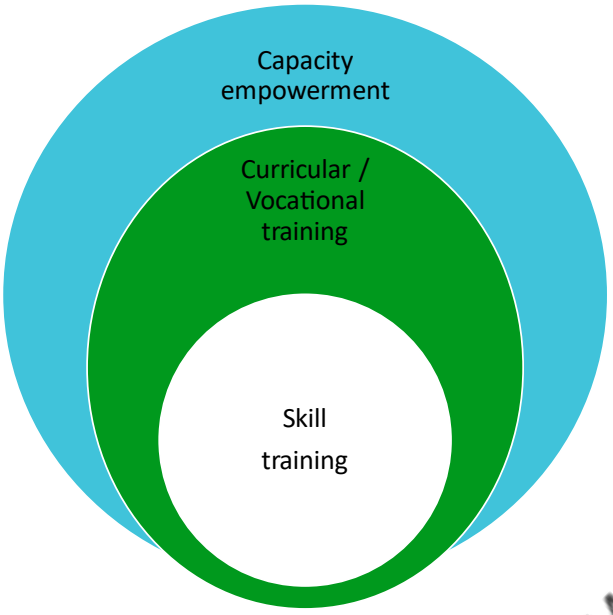


Figure 8 - Venn's vertical diagram of capacity building levels

4.2 Stated urgency and three pillars for capacity building in Africa in the RES sector

Suitable energy options and technological decisions should consider the requirements, abilities, and aspirations of people and be assimilated into the local culture or improved by the recipient community [9], [10]. To grant self-empowerment and community engagement, it is hence necessary to briefly track the existing and already-stated needs for capacity building in the RE sector in Africa. Many African governments acknowledged the contribution that renewable energy makes to sustainable development over time. However, among the various obstacles that still prevent renewable energy from reaching its full potential in the planning agendas, capacity building needs are mentioned as prioritary ones.

Africa's efforts to achieve a sustainable transition involve cooperation from all players in the energy eco-system, and capacity building may play a key-role in facilitating cross-fertilization and partnership. The national power utilities are expected to facilitate the transition to a more carbon-neutral future and contribute to preserving energy security, being the main providers of electricity. Capacity building options in this sector must be made readily available in order to define and commit to the energy transition paths. This will help to boost the mix of renewable energy sources, to which Africa needs to adapt at a reasonable rate. Additionally, it must be acted in accordance with the socioeconomic priorities and development mandate of the continent, as reported in the Agenda 2063 – The Africa We Want [11]. Based on the taxonomy presented in Figure 8, the following paragraph proposes a thematic distinction of the pathways that can be undertaken by each of the levels of capacity building.

According to the World Economic Forum [12], capacity building actions to undertake energy transition pathways span on three thematic pillars (“triple D”):

- **Decarbonization**: switching from fossil fuels to renewable energy won't be a one-size-fits-all answer; Africa's strategy and objectives must consider its own energy security circumstances and *hard skills* are required to scientifically advise the policymaking community.
- **Decentralization**: the energy transition in Africa is dependent on the state of its electricity grid. Historically, power utilities have held centre stage in managing the grid, which enables the generation, transmission, and distribution of electricity. Reaching non-grid consumers

requires a scaling up a new concept of decentralisation which can promote further connection also offering service to the national grid.

- **Digitalization**: the continent has immense opportunities to leverage its digital skills and capabilities to enable the energy transition; the uptake of smart mini-grid and digital off-grid solutions within Africa's rural communities continues to support improvements in energy access. In a report of 2017, Tambo et al. evidenced how cutting-edge educational technologies may enhance instruction and speed the development of human capital abilities in the RE sector [13] .

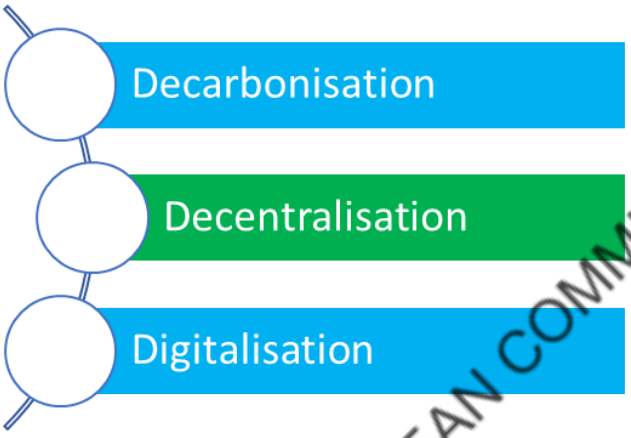


Figure 9 - The Triple-D of capacity building actions in the RES sector

4.3 Skills definition and nomenclature

In any professional domain of skill development, it is essential to obtain the best results and increase productivity as well as to improve them, to engage in discussion about **skills**, one needs to first know the different types of skills that can complement each other, and their definitions as stated by different authors:

- Knowing how to identify, implement one or two skills within a conceptual or disciplinary determined domain. To be more precise, a skill is associating a range of problems precisely identified with a programmed and determined assessment [14].
- A skill is part of knowing how to mobilise [15]
- A skill permits to confront a complex situation, to construct an adapted answer without drawing it from a programmed response [16]
- A skill is a complex 'know how to act' based on the effective mobilization and combination of several situations [17]

4.3.1 Technical skills

The Web of Science (WoS) Core Collection database is a selected citation index of scientific and academic publications comprising journals, conferences, books, and data compilations. It is the earliest citation index for the sciences, having been released commercially by the ISI in 1964 [18], first as an information retrieval tool named the Science Citation Index (SCI) .

Being considered nowadays as the world's leading scientific citation search and analytical information platform. It is utilized as both a research tool enabling a wide variety of scientific activities across multiple knowledge fields as well as a dataset for large-scale data-intensive investigations spanning multiple academic subjects. WoS has tens of millions of bibliographic entries with billions of citation links and extra information fields; and many thousands of more items are consumed on a regular basis. The WoS platform also contains software productivity functions namely EndNote and InCites [19]. Between 1998 and 2018, there has been a huge and constant surge in the number of articles discussing WoS as illustrated in Figure 1. [20]

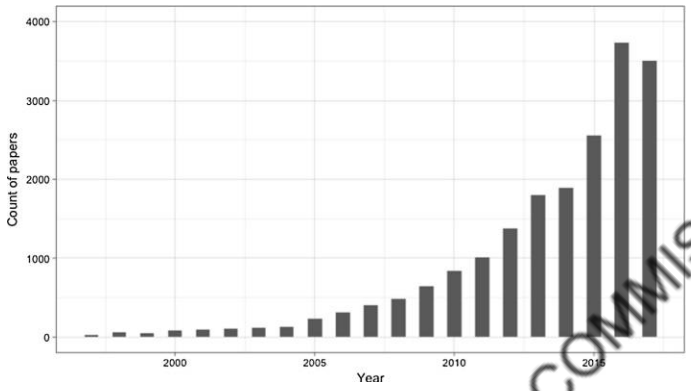


Figure 10 - Yearly distribution of all papers mentioning Web of Science

Considering the aforementioned characteristics, the use of the WoS database in this deliverable is deemed necessary and will constitute the basis of the presented results in this deliverable.

The number of publications provided from 2010 till November 2022 is recapitulated through the below Tables and Figures.

Table 2 - EU/AU research papers on RE based on WoS database

	Wind	Solar Thermal	PV	Biofuel	Geothermal	Green Hydrogen	Hydropower
EU	138945	24168	34624	16077	9760	7053	11051
AU	15058	4298	8554	1738	962	818	865

A preliminary aggregated data can be analysed in the below comparison Figure 11. More detailed mapping is available in Deliverable D5.8 of LEAP-RE. The below figure shows how most of the scientific research in AU belongs to solar thermal energy and biofuels, while Wind covers more than half of the sources in EU.

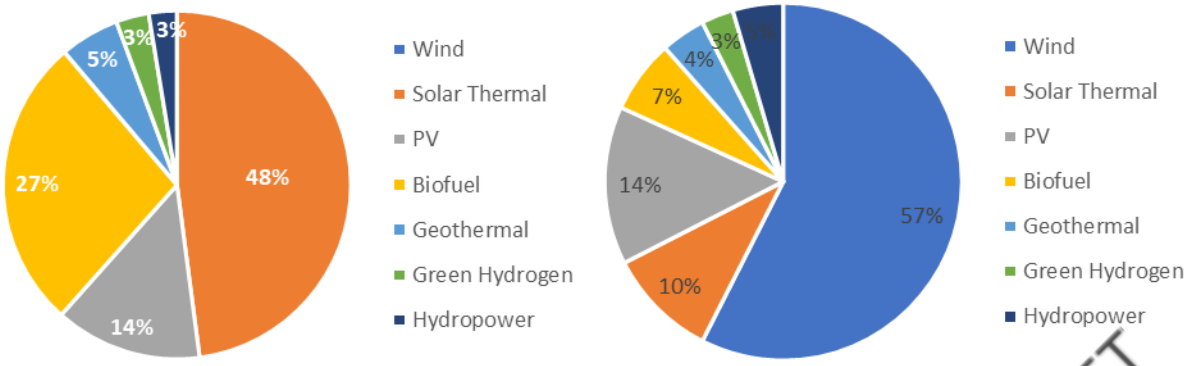


Figure 11 - AU (left) and EU (right) research papers, divided by RE of pertinence

Aside of Hydropower which would require an individual analysis, in the framework for the EAU-EU cooperation within LEAP-RE it is considered relevant deepen for 6 types of RE technologies:

- Biofuel
- Geothermal
- Solar Photovoltaic
- Wind
- Green Hydrogen
- Solar Thermal

For each of them, the more relevant skills necessary to a curricular or vocational training are depicted accordingly to the achievement of the Web of Science analysis:

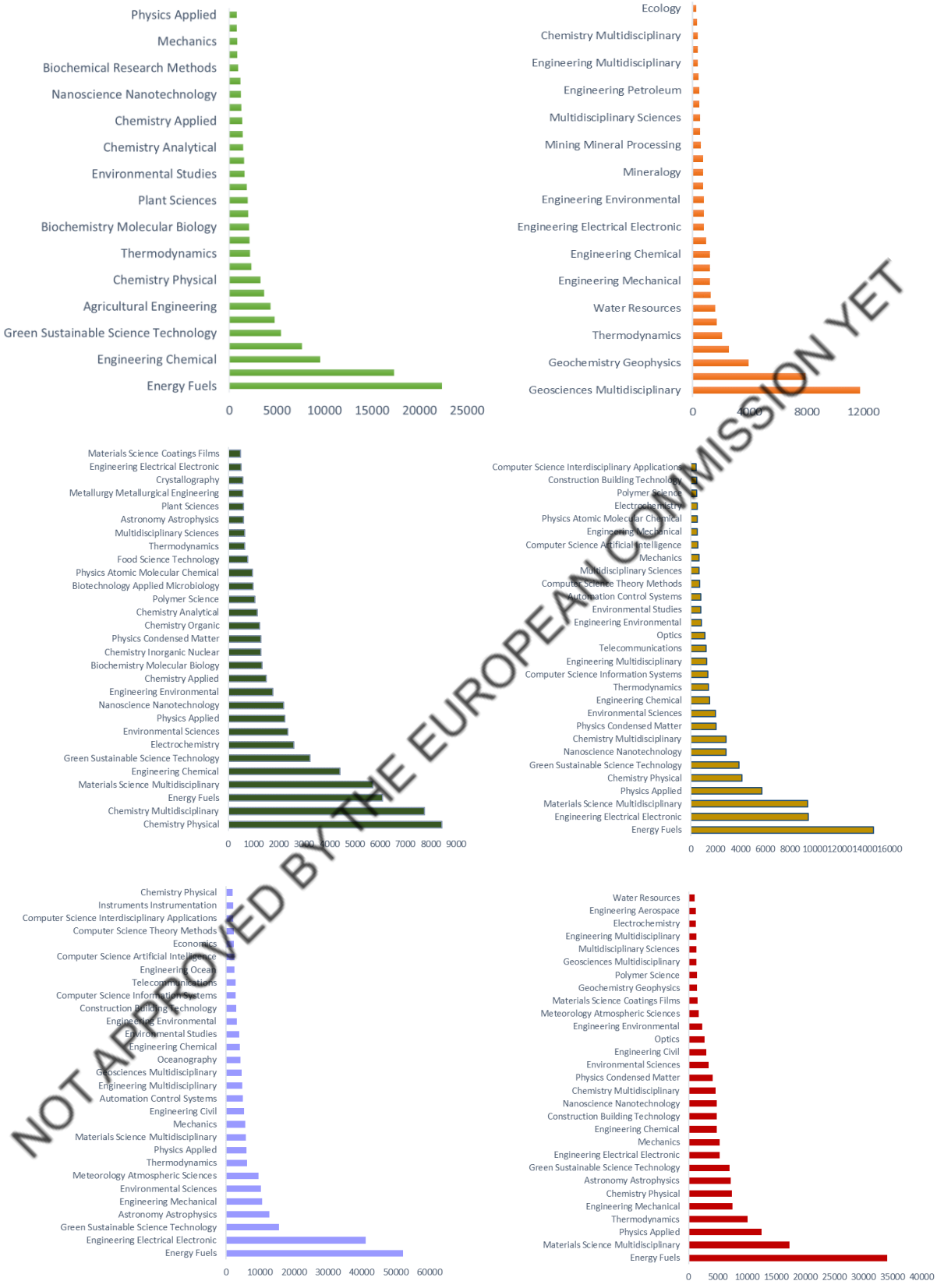


Figure 12 - Skills needed in the Biofuel (green), Geothermal (orange), Green H2 (dark green), Solar PV (dark yellow), Wind (violet), Thermal Solar (red)

Competence is an integrated and functional set of knowledge, know-how, and know-how to be that allows, in the face of a category of situations, to adapt, to solve problems, and to carry out projects.

From Figure 12 some technical skills could be extracted from the common disciplines related to the 6 RE technologies. They are below collected:

Table 3 - Top 5 technical skills by RE sources

RE sources	Top 5 disciplines
Biofuel	Energy Fuels Biotechnology Applied Microbiology Engineering Chemical Environmental Sciences Green Sustainable Science Technology
Geothermal	Geosciences Multidisciplinary Energy Fuels Geochemistry Geophysics Environmental Sciences Thermodynamics
Green Hydrogen	Chemistry Physical Chemistry Multidisciplinary Energy Fuels Materials Science Multidisciplinary Engineering Chemical
Wind	Energy Fuels Engineering Electrical Electronic Green Sustainable Science Technology Astronomy Astrophysics Mechanical Engineering
Photovoltaic	Energy Fuels Engineering Electrical Electronic Materials Science Multidisciplinary Applied Physics Physical Chemistry
Solar thermal	Energy Fuels Materials Science Multidisciplinary Physics Applied Thermodynamics Engineering Mechanical

The table can be used to drive **syllabus and curricula and syllabus definition for skill development** in the RES sector for both curricula and Vocational Activities.

4.3.2 Innovation and Patents analysis in EU/AU regions

The following analysis concerns the innovation patents in the EU/AU region in order to obtain an overview of the R&I potential and weaknesses through the number of patents using Orbit (Questel), which is a software publisher and service provider for the intellectual property, trademark and innovation sectors, with offices in 28 countries, and headquartered in Paris, France.

4.3.2.1 Geothermal Technologies

Based on Geothermal Collectors; Geothermal Systems category (F24T) of the International Patent Classification (ICP), 7293 patented inventions were found, 5% of which are owned by 10 players.

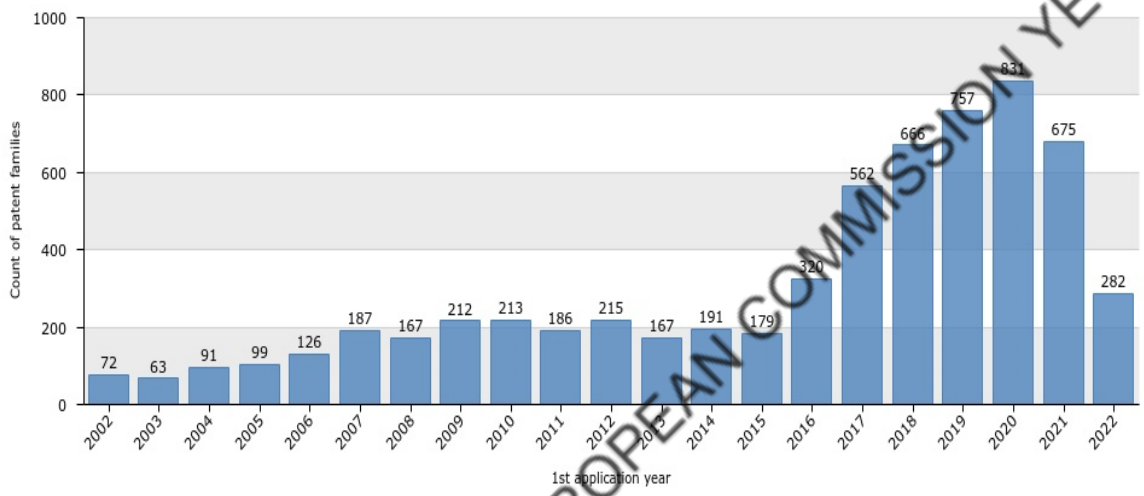


Figure 4.1 Investment over the last 20 years in Geothermal technologies

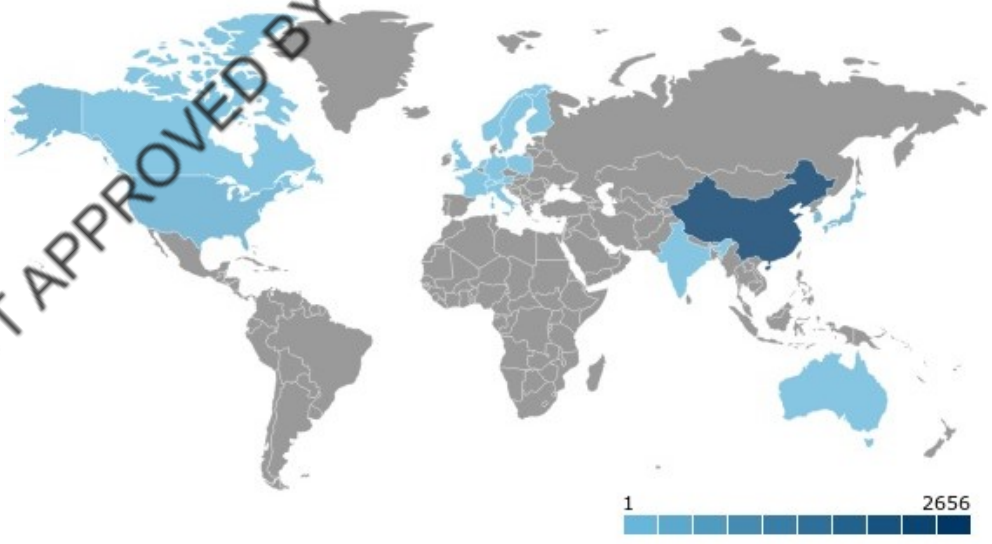


Figure 4.2 Patents protected by country in Geothermal technologies (Top 30)

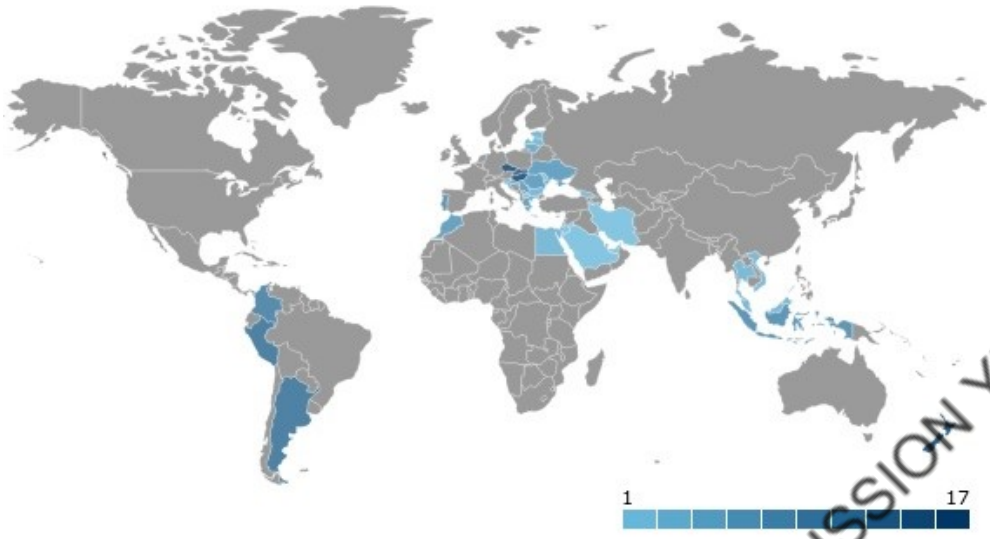


Figure 4.3 Patents protected by country in Geothermal technologies (Bottom 40)

4.3.2.2. Photovoltaic technologies

When it comes to Photovoltaic technologies, a total of 128495 patented inventions were found, 13% of which are owned by top 10 players.

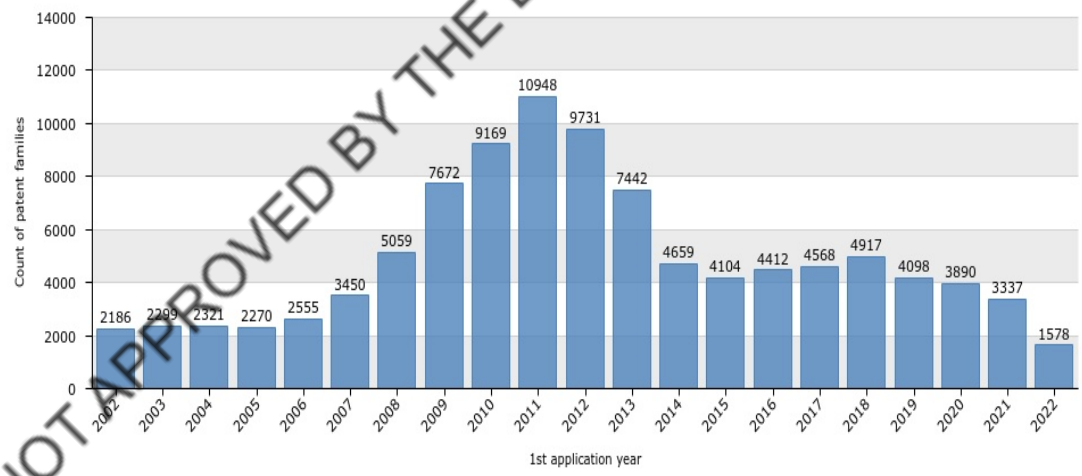


Figure 4.4. Investment over last 20 years in PV technologies

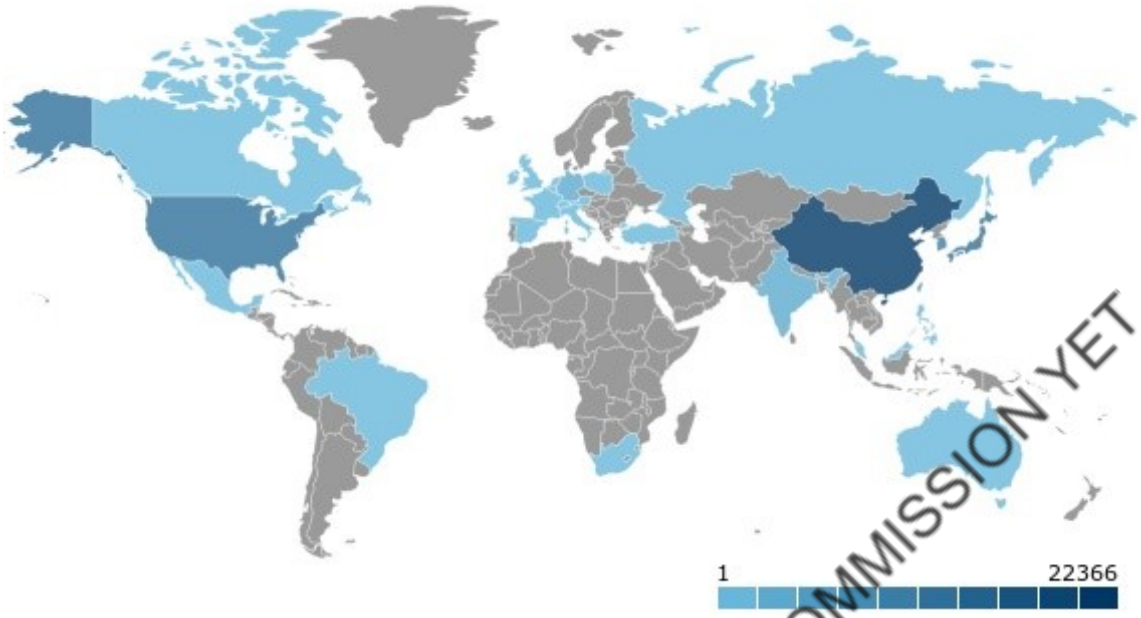


Figure 4.5 Patents protected by country in PV technologies (TOP 30)

Figure 4.6 Patents protected by country in PV technologies (bottom 30)

4.3.2.3. Solar thermal technologies

Based on “Solar Heat Collectors; Solar Heat Systems” category (F24S) of the International Patent Classification (ICP), 101286patented inventions were found, 3% of which are owned by 10 players.

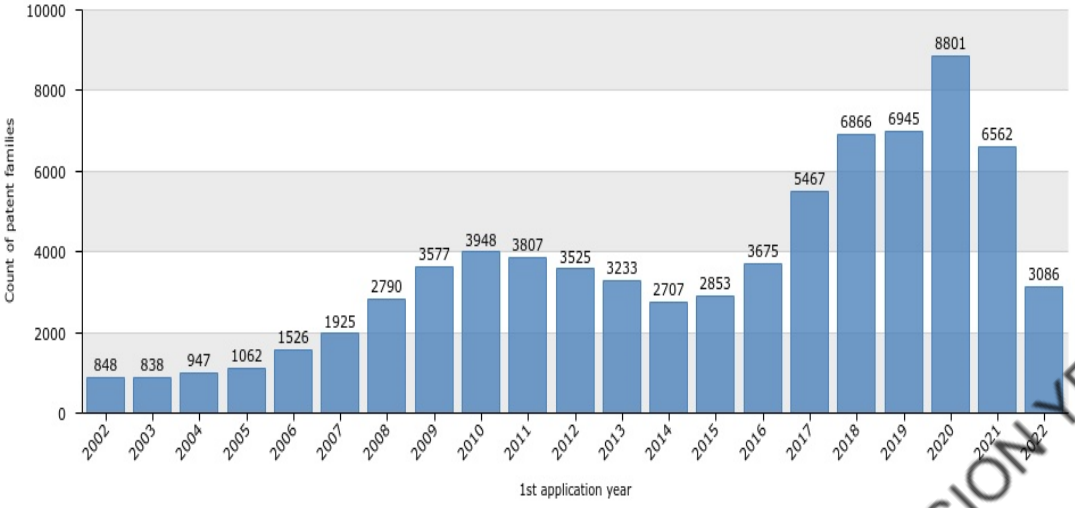


Figure 4.7 Investment over last 20 years in solar heat collector technologies

Figure 4.8 Patents protected by country in solar heat collector technologies (TOP 30)

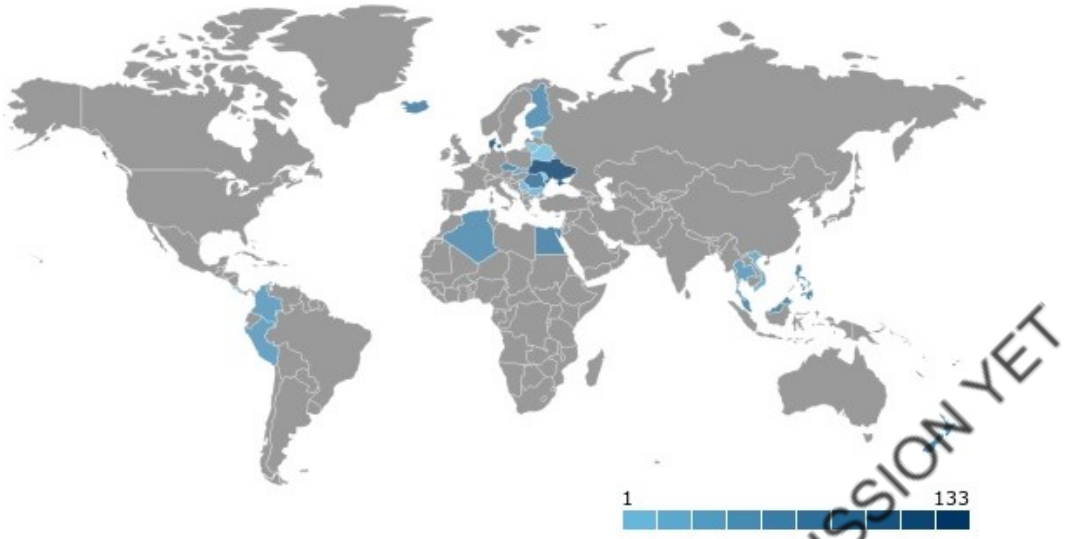


Figure 4.9 Patents protected by country in solar heat collector technologies (Bottom 30)

4.3.2.4. Wind Motors (Wind Energy) Technologies

When it comes to Wind Energy technologies, a total of 116281patented inventions were found, 8% of which are owned by top 10 players.

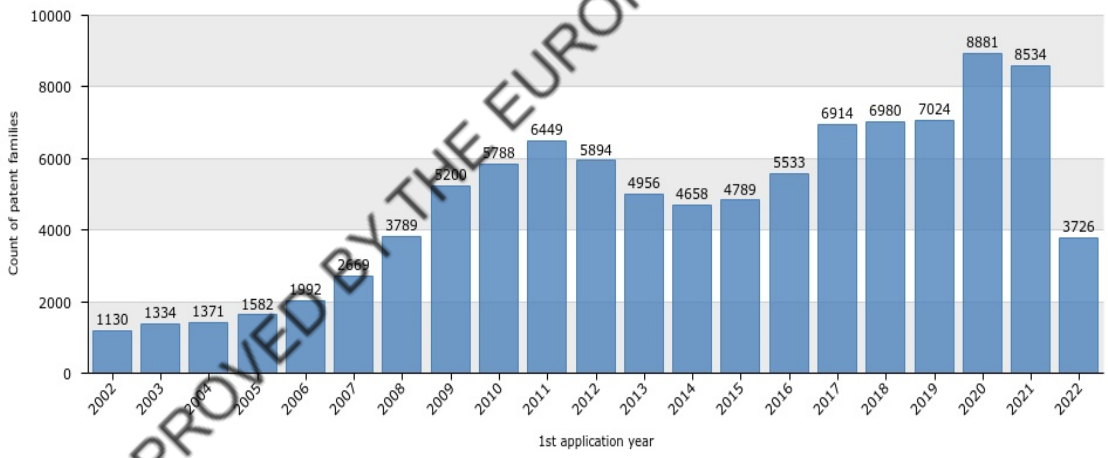


Figure 4.10 Investment over last 20 years in Wind technologies

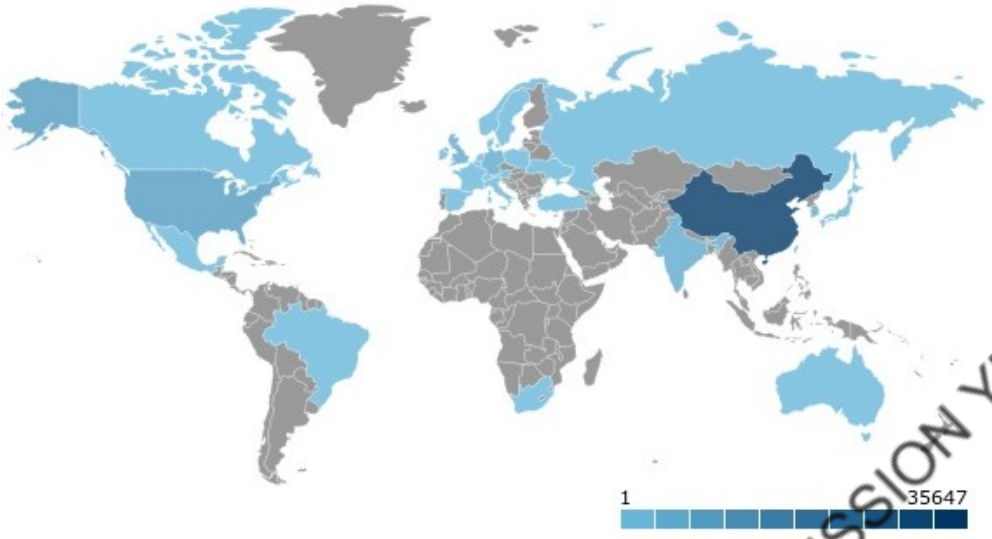


Figure 4.11 Patents protected by country in wind technologies (TOP 30)

Figure 4.12 Patents protected by country in wind technologies (Bottom 40)

4.3.2.5. Biofuels and others

Regarding Biofuels and other technologies, a low number of patents in the world was observed, namely:

- Ethanol from whey, corn (search by title only) : 203 patent families (no specific patent classification)
- Biodiesel: 903 patent families (C12P 7/649)
- Methane or other gases by Biological/Anaerobic treatment: 18046 (C02F 11/04)
- Biogas in general : 13660 patent families (C12M 1/107)

4.3.3 Horizontal skills

The horizontal skills definition could be interpreted in different manners. In order to avoid any confusion, all non-technical skills will be considered as horizontal/transversal ones such as entrepreneurship, communication skills, project management and ethics...etc.

This consideration is in line with the learning outcomes approach supported by the EU commission and many National Education system which is commonly referred to as the Dublin Descriptors.

They are general statements about the ordinary outcomes that are achieved by students after completing a curriculum of studies and obtaining a qualification. They are neither meant to be prescriptive rules, nor they represent benchmarks or minimal requirements, since they are not comprehensive. The descriptors are conceived to describe the overall nature of the qualification. Furthermore, they are not to be considered disciplines and they are not limited to specific academic or professional areas. The Dublin Descriptors consist of the following elements:

- Knowledge and understanding;
- Applying knowledge and understanding;
- Making judgements;
- Communication skills;
- Learning skills.

Indeed, any the learning outcomes need to include in addition to **know how to do also two other aspects: know how to be and know how to become.**

Therefore, we can create the following association and use it within the frame of LEAP-RE to generate a positioning of soft skills, see Figure 13.

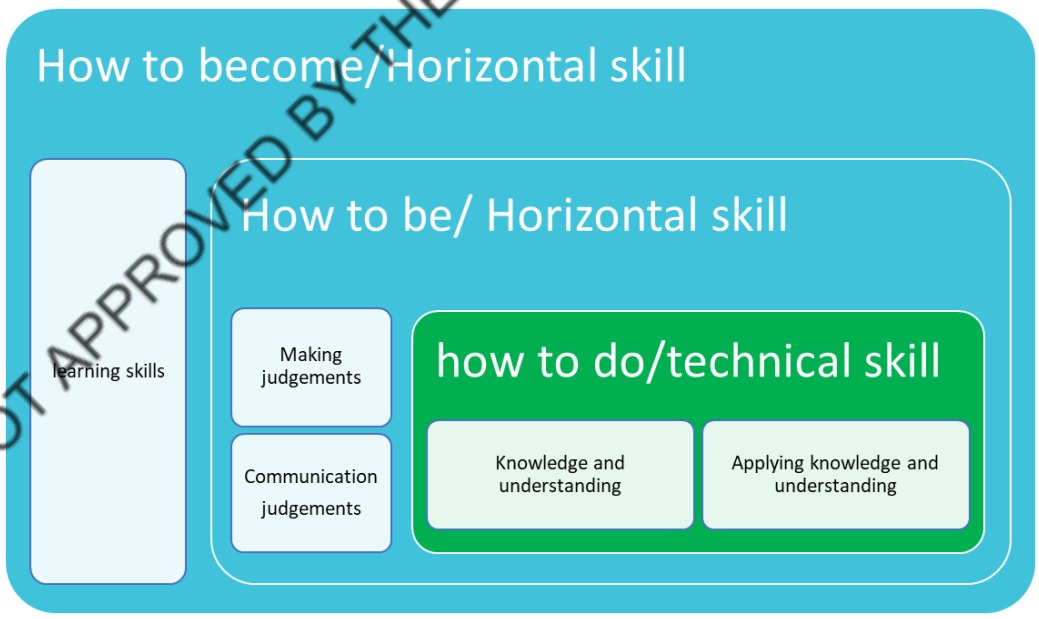


Figure 13 - Overall taxonomy of horizontal and technical skills

5. Conclusions and recommendations

Through this analysis, different aspects related to RE development in the African continent including research and innovation, dedicated infrastructure for research, topics and disciplines and published patents were elaborated using different databases (Web of Science, Orbit -Questel, the technical reports of each WP of Pillar 2 as well as the research results conducted by the Capacity Building cluster group, through an online investigation as well as qualitative interviews with the LEAP-RE partners).

In this context the main recommendation within LEAP-RE and beyond is the use of a new taxonomy for capacity building that can match with the complexity analysed. The taxonomy may be graphically represented with three main pillars each of which is then briefly re-summarised from the previous session of the document

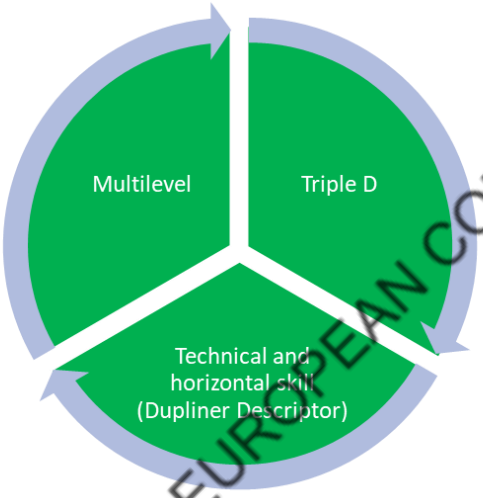


Figure 14 - the three pillars of the CB taxonomy within LEAP-RE

5.1 Multilevel capacity building

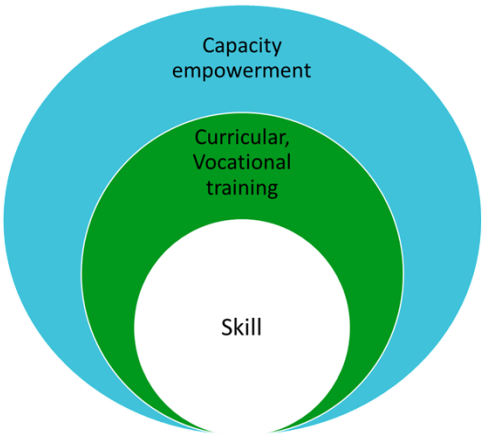


Figure 15 - proposed taxonomy for multilevel capacity building

A comprehensive strategy based on human, scientific, organizational, and institutional capacities should be used to enhance capacity in the Energy sector for Africa. The most active research institutions in the field of RE should be connected with their counterparts from the other continent for a long-term EU-AU partnership. A variety of local, national, and international stakeholders should

be involved due to the diversity of the necessary skills (even beyond the traditional players of the educational systems).

Recipient groups may have varying access to opportunities for technical, vocational, or institutional training, therefore capacity building should take these factors into account.

5.2 Conceptualisation of the "Triple D" in CB actions in the Energy Sector

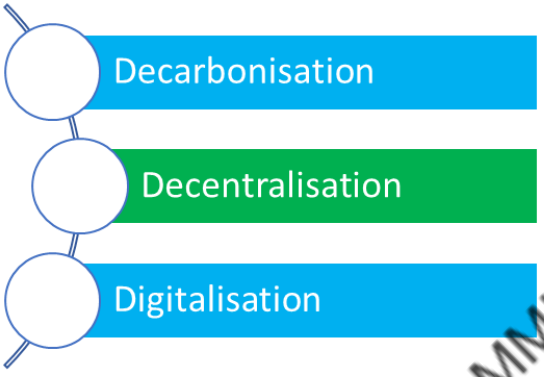


Figure 16 - proposed thematic taxonomy ("Triple D")

Change is sparked by and is driven by people. Their capacity must be developed throughout the design solution's supply chain where the "Triple D" find its space. Their capacity must be developed throughout the design solution's supply chain, and this strategy must be guided by the idea that work and skills go hand in hand. All nations should agree that strengthening national capacities is necessary to promote national priority definition, regional coordination, and to provide funding for project-based or targeted local activities. This makes space also for LEAP-RE actions.

5.3 Technical and Horizontal skill needs to be aligned to the Dubliner descriptor

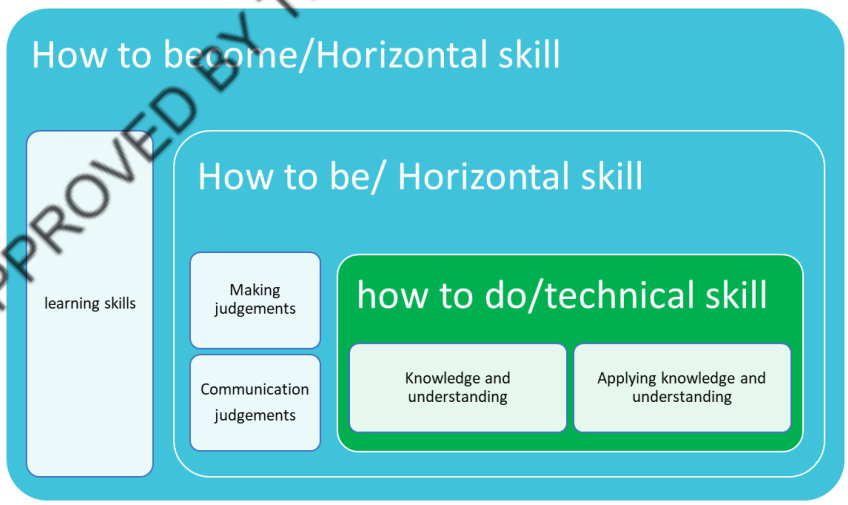


Figure 17 - proposed alignment of technical and horizontal skills, accordingly to the Dubliner descriptor

A variety of skills. Interventions for developing capacity should be varied to suit the various skill requirements present at various levels of the energy supply chain and within various local contexts—and be in line with the capabilities of the various target groups. Various tools may be utilized, depending on the objectives and anticipated learning results (including training, seminars, workshops, on-the-job tutoring, and site visits).

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