Study on Renewable Energy and Research and Innovation Capacity of Sub-Saharan Africa

Executive Summary

Client: DG Research & Innovation

Brussels, 12th June 2015

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Purpose of the study

For several decades already, Europe has invested in renewable energy in the SSA region through traditional development-aid cooperation. The aim of DG R&I is however to identify whether there is a basis for true partnership – which is a radically different starting point.

Promotion of sustainable energy is a major issue for both the EU and Africa. It represents an opportunity to engage with global players and to strengthen international partnership initiatives. EU cooperation with Sub-Saharan Africa (SSA) can therefore be intended as a two-way process:

1. The EU can play a supportive role in upgrading the means of development by enlarging and enhancing the energy access, namely in rural areas, and by supporting the improvement of capacities in the deployment of innovative technologies in the field;
2. Sub-Saharan Africa can become a strong partner in energy production, as well as a market to export innovative technologies and capitalising on research investments of EU institutions and businesses by providing new markets for EU actors.

Against this background, the objective of this study is to generate the information needed to enable the formulation of a clear answer to the question whether and how to launch a research and innovation programme related to SSA energy needs and RE potential, that would be equitable and beneficial for both the EU and the Sub-Saharan region, in the area of renewable energy.

Methodology and approach

The study consists of 8 tasks, which build on each other and which have all been carried out in order to reach the aims of the study. This Final Report presents the key findings regarding the Tasks 1 to 8. It is built up from four different building blocks:

- *Building block 1: Regional scoping*: two Scoping reports have been produced in the period February – April 2014 with the aim to understand the global picture with regard to RE potential across the region. A report has been made for South Africa and Other Sub-Saharan Africa – as the situation in the two parts of the region is quite different. These reports have been complemented by an assessment of RE potential in 14 selected countries to a sample including about 150 organisations: universities, research centres, government agencies, NGOs, and a few private businesses;
- *Building block 2: Thematic research*: 7 Renewable Energy Technology (RET) reports have been produced in the period May – July 2014 on biomass, hydropower, solar, wind, geothermal, ocean energy and grids. They have been carried out according to a harmonised research format and structure, assessing current and future penetration, drivers and barriers, research needs, and existing research supply;
- *Building block 3: Field visits and regional workshops*: a total of 9 field visits and three regional workshops have been held in the period October – November 2014. Country visits were made to Burkina Faso, South Africa, Namibia, Botswana, Mozambique, Mauritius, Ethiopia, Kenya and Uganda. Regional workshops with leading academics, government officials, energy operators, private sector representatives and NGOs were held in West Africa (Ouagadougou, Burkina Faso), South Africa (Johannesburg) and East Africa (Addis Ababa, Ethiopia);

- *Building block 4: Matching with EU needs* – research needs identified in the SSA region have subsequently been matched with EU needs through the development of research fiches and reviewed during a validation workshop in Brussels (February 2015), in the presence of industry associations, leading academics, government representatives and NGOs.

Results and findings

Substantial potential for future renewable penetration in SSA

Even though the current penetration of renewable energy in the SSA region is limited, apart from bioenergy and hydro, the future potential is substantial.

Bioenergy (in particular traditional fuels) will remain the most important source of energy for a majority of SSA countries over the next decades. The main changes will come from afforestation and diversification of resources: biomass-energy will be produced not only from firewood and charcoal, but also from agro-industries' biomass residues, biofuels and biogas from agricultural and urban waste. There is substantial potential to more efficiently use these resources for households (improved cook stoves). Collective and domestic biodigesters are tested in several pilot projects in Mozambique, Mauritius, Uganda, Ethiopia, Ghana, etc. Substantial potential exists for the further use of waste – e.g from industries using biomass, such as sugar cane factories, bakeries or tea industries. Research in the region is focusing on cellulosic biomass (wood and straw residues), non-food crops, organic part of urban waste, etc. There is also significant potential in SSA for scaling up a market-based cogeneration model as a supplier of rural electrification and industrial services. Liquid biofuels could play a more important role in the fuel mix of SSA countries, for transport, industrial use and for power generation and cooking, particularly in areas with significant rainfall. With the support of international donors, a great number of projects are on the way and show the interest for these technologies.

The cost competitiveness and maturity level of **hydropower** has made this technology a leading RET in SSA, with a current capacity of 24 000 MW. In many countries the potential sites for large hydropower plants have been tapped, but there is still a very significant potential, especially at the small/mini/micro scales. When assessing the possible hydropower capacity by 2040, the total is estimated to be nearly 60 000 MW.

Solar power offers a variety of opportunities. Solar home systems are now moving from a development-aid supported market to a commercial business activity with many manufacturers providing products designed for African customers. The market for hybrid PV-diesel systems is slowly growing in some countries, mainly thanks to development aid. In Mali the market is growing fast because of a strong government will. Considering current trends and announced projects, it is aimed for that in a couple of years the annual market for large multi-megawatt PV power plants in SSA will cross 0.5 GWp per year. The market for solar water heaters in SSA is mainly concentrated in South Africa, and the same applies to concentrated solar power (CSP) where South Africa is strongly committed to.

Wind energy offers potential particularly in Southern and Eastern Africa. A number of projects are currently being constructed (954 MW across the region) or in concept phase (765 MW). Provided that 80 % of projects currently being in development phase are completed with the proposed capacity, a further 760 MW power will be generated - a 118 % increase of the current capacity (644 MW).

Africa's **geothermal power** potential is concentrated in the Rift Valley countries and the theoretical potential is estimated as high as 15 000 MW, though more conservative and realistic, estimates are between 7-9 000 MW. The commercially viable potential is estimated at 3-5 000 MW. Only around 200 MW of this potential has been developed for electricity generation. Major investments are now taking place in Kenya. Geothermal potential has also been identified in Ethiopia, Djibouti, Rwanda, Tanzania and Uganda.

The outlook for **ocean energy** in SSA is that in the coming years more and more devices will be put in the water for long-term testing. By 2020 the first real power plants should be in the water to provide a first understanding of the real costs until 2025. By 2030 the deployment should be ready.

A need to focus on countries with basic policy framework conditions in place

The IEA Medium-term Renewable Energy Market Report 2014 [1] reiterates that renewable energy investments can only grow if policy frameworks are in place – which is often not yet the case. This report corroborates with these findings and has demonstrated that the large-scale uptake of renewable energy requires an advanced policy framework (accompanied by a stable investment climate) which needs to be developed consistently over a longer period of time. It requires ownership unbundling and sector regulation in the power sector; the removal of hidden subsidies for power generation from fossil sources and appropriate Feed-in tariffs; an assessment of RE potentials and subsequently defined planning approach for RE deployment, and suitable instruments for the promotion and support of RE technologies including a set of financial incentives. It also requires the cooperation of a whole range of actors, including policy makers, energy regulators, municipalities, foreign and domestic investors as well as access to public and private financing. As demonstrated by the presentation of policy initiatives in South Africa, the development of renewable energy requires above all political will to reform the energy sector and to create appropriate structures and financing channels. It is indeed the government's role to push forward the necessary regulatory reforms and the promotion of RE. We consider the following countries to be most advanced in their regions: Ghana, Mali, Cape Verde (West Africa), Cameroon (Central Africa) Kenya, Ethiopia, Uganda (East Africa), South Africa, Mauritius, Mozambique and Namibia (Southern Africa).

Take into account the limited but growing R&I capacities in Renewable energy

While many SSA countries share similar characteristics and face similar challenges, there are also wide disparities, South Africa being most advanced. Although carried out in several places, basic research in renewable energy is rather rare in the SSA region – and most activities focus on **technology conversion and "frugal" innovation.** A large part of R&I activities revolves around domestic and rural energy needs (e.g. off-grid electrification, efficient cooking, efficient lighting). Offering low-tech, low-cost solutions to poor and remote communities is crucial. Due to the focus on the adaptation of RE technologies to the local capacities and needs, the outreach of most SSA-based R&I activities remains limited to a local audience. African scientists and researchers are not well represented in the international arena: they have few publications, few patent applications, and demonstrate only limited participation in international conferences. The legal protection of patents is limited across the SSA region as well, and its enforcement is often problematic.

However, Africa is also characterised by its dynamics of change. While enrolment in tertiary education in SSA is dramatically lower than in any other part of the world, it also has the fastest growth rate. And if the number of players actively involved in RE remains small, with energy now recognised as a major instrument for economic development, several universities and research centres were created in recent years. All these changes will undoubtedly contribute to dramatically improve R&I capacities in SSA in the coming years.

[1] IEA (2014) "Medium-Term Renewalbe Energy Market Report" See http://www.iea.org/Textbase/npsum/MTrenew2014SUM.pdf

Build on the interest of existing R&I players: improvement of living conditions

The main focus of existing R&I players is **energy access in view of improving living conditions**. Hence, most activities revolve around domestic energies, small-scale applications and biomass management. A lot is done to adapt existing technologies to local materials, to local markets, according to the principles of "frugal innovation". Many SSA players have the required capacity to work on high impact, high visibility research projects in these fields; cooperation with European research institutions is already in place.

However, the **outreach of most R&I activities conducted in SSA is very limited**: few publications, few patents applications. As mentioned, African researchers and inventors lack visibility at the global level. It seems sometimes that, due to lack of efficient capitalisation and dissemination mechanisms, the wheel keeps being reinvented over and over. On a positive note, the structures that could help improving the visibility are already in place: namely, international cooperation networks and Africa-based scientific journals.

RET needs in the SSA region: technology conversion and 'frugal' innovation

The overview of RET specific needs confirms the overall importance of applied research, demonstration and testing (including plans for new or improved products, processes or services) rather than basic research. Key terms are 'technology conversion' and 'frugal' innovation. These actions should however be developed together with private sector players, who need to invest in the development of business models that are adapted to the SSA needs.

Access to resource mapping is key, and there is a strong interest in learning about the impacts of renewable energy technology – thus confirming the commitment to R&I actors to contribute to the improvement of living conditions. There appears ample scope for **mobility initiatives**, however these need to be carefully positioned within the broader brain drain forces that are exerted over the region. Within this context it would be worthwhile to explore how the role of South Africa as a knowledge hub can be exploited – e.g. cooperation programmes which would include EU actors, South African actors and other SSA actors – thus producing mobility solutions that could be more effective than mainstream solutions.

In addition to the above RET-specific needs, we have identified a number of **transversal R&I needs** that deserve separate coverage. These are power control technologies, smart meters, energy limiters and storage solutions. Progress in each of these domains can substantially improve conditions for the take-up of RE technologies in the SSA region.

Sustainable renewable energy development needs to be accompanied by rigorous Impact assessment

Renewable energy in itself is not necessarily positive or negative for the economy, society or environment. Much depends on how and where renewable energy technology projects will be designed, built, operated and financed. Clearly, positive impacts can be strengthened and negative impacts can be dampened by a thorough project preparation, solid business models, engagement of local expertise and population, etc.

Impact analysis is therefore called for – not only by international donors and renewable energy experts but equally so by local SSA stakeholders. Such analysis of impacts is especially important in the SSA region where many citizens and stakeholders are not well-placed to engage, and where such impacts can be unprecedented in size and scope if not well-thought through. Indeed, the development of RE projects requires such assessments as part of feasibility studies, project preparation and site selection, especially as impacts can be so different depending on the

specificities of the projects. The EU – as global leader in sustainable development practices – has a reputation to keep up in this area and can position itself clearly from other global players active in the region.

However, information about these impacts in the specific context of the SSA region is limited and it proves difficult to work with long term baseline scenarios in the context of SSA and to formulate assumptions. When thinking through **economic impacts**, it could well be that limited progress in the RE field to date has to do with vested market interests and structures: there are substantial economic interests related to the fossil fuel economy – both in legal as well as illegal parts of the economy – and many of these players are not particularly keen to give up their positions for the sake of renewable energy. Thus, renewable energy roll-out can also be seen as a powerful instrument to produce structural economic change, to break energy monopolies and to bring more transparency and competition to markets. Depending on the type of technology, the scale of roll-out and the ability to build up local competences, renewable energy can generate substantial **employment** – even though employment losses in traditional fuel economy may need to be accounted for as well. Also important are **health as well as educational effects**, as well as broader social and gender aspects. Renewable energy deployment can also produce powerful **environmental gains**, mostly related to the reduction of fossil fuels usage. However, substantial differences exist between RE technologies, and care should be taken in promoting those with unforeseen and unexpected detrimental effects, including use of valuable **land and water**. Overall, small-scale projects are favourable over large-scale, because this allows for more flexibility when mitigating detrimental effects, especially so in the field of hydropower.

Engage with regional cooperation structures that work

Across the SSA region, various regional cooperation initiatives exist, and some are more effective and advanced than others. Clearly, there are strong differences in institutional set-up between the sub-regions and it is important to take note of this variation. Across the SSA region, the **African Union Commission** provides the strategic framework for pan-African socio-economic development (NEPAD), and Research and Development (Science and Technology) is considered crucial to inform policy making. Three **Regional Renewable Energy Centres** exist in the region and these are considered promising. The ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) is by far the most developed – as it is in place since 2010 and at an already advanced stage in its programme implementation including in the field of R&I activities. The other two regional centres for the development of renewable energy and energy efficiency (EACREEE and SACREEE) are not yet operational. In Southern Africa, the SADC plays a key role in the regional cooperation as well. The **South African government** is committed to investments in Science and Technology as well. Across the region, several institutes and universities are currently working towards **networks of excellence.** The **Regional Power Pools** are less well-placed to coordinate renewable energy research development, but are crucial for promoting cross-border grid connectivity – especially important for accommodating large-scale hydropower plants.

International cooperation: a challenge to prevent overlap, fragmentation and demonstrate the value added of true partnership

Promoting Renewable Energy in SSA is becoming a major objective, if not the priority, of most IFIs including the World Bank, AFdB and EU (DEVCO and EIB). There is a multitude of initiatives, with still some overlapping in spite of the coordination efforts at local level. In itself, there are plenty of financial resources available from the World Bank, the EIB and others.

Needs related to energy programming, identifications of projects, policy reform, institutional development and capacity building are pretty well covered (even with some overlapping). Funds are available to finance RE pilot projects with the following main constraints:

- The private sector is still reluctant to invest in RE;
- Knowledge of RE potential, technologies or success stories is not widely diffused. This creates doubts on the advantages of investing in RE projects, especially from the private sector, the energy utilities and the public authorities;
- There is a lack of good private sector project proposals and a limited local capacity in making pre/feasibility studies;
- Even if not perfect, cooperation is developing. For example, AFD/KFW and EIB are frequently associated in the funding of SSA RE projects;
- Financial resources for feasibility studies are unknown or information about them is confusing.

However, the focus of most international cooperation initiatives in the area of renewable energy is currently on hard investment. At the same time, 'soft' actions (often taken by the EU) are often not targeted to the renewable energy sector. This leaves **substantial room for additional initiatives which focus on EU-SSA research cooperation and capacity building in the area of renewable energy**.

Identification of areas of potential common interest between SSA and the EU

A package is presented through two complementary angles: RET-specific research cooperation (13 research themes) and transversal research cooperation (7 themes). For each of the resulting themes, the following information is provided: 1) Identification of SSA needs for Research and Cooperation; 2) Justification/background information; 3) Scope of possible research and cooperation; 4) Benefits/Impacts for SSA; 5) Benefits/Impacts for Europe; and 6) Possible Cooperation Forms.

Table 0.1 Overview of areas of potential common interest between SSA and EU

RET specific themes	Transversal themes
Project development assistance for Small scale PV	A Strategic and coordinated approach to Resource mapping
Promoting R&I in Solar heating and cooling	Impact assessment of RE deployment
R&I in Concentrated Solar Power	Reinforcing SSA Research infrastructures
Improved charcoal production	Supporting innovative SMEs
Socio-economic study on improved cook stoves	Quality infrastructure and testing centres
Innovative use of Solid Biofuels	Dynamic Energy Supply Modelling
Exploit Biogas potential from agro-industries	Smart Hybrid Minigrids
Assess Urban Waste-to-energy potential	
Assessment of Bioenenergy Value Chains	
Sustainable Small-Scale Hydro	
Applied Research for Geothermal Energy	
Technical Network on Advanced Bioenergy	

Recommendations for EU-SSA cooperation

All research themes are worth pursuing…

An initial assessment has been carried out by applying five criteria to these themes: 1) Development potential of the RE technology based on the technical potential; 2) SSA capacity; 3) Energy access; 4) EU interest; and 5) Public spending and market failure. A first assessment shows that all research themes identified have positive scores on several of the criteria identified. Although there is some variation, none of the themes presented has a poor score which would allow it to be ignored for further assessment.

Towards a menu of research cooperation

The assessment of research themes suggests there is no 'one size fits all'. Instead, the variety of themes suggested requires a tailor-made approach, where a menu of instruments could be deployed:

- Axis 1: Dedicated SSA capacity building (e.g. dedicated H2020 Network actions);
- Axis 2: Enhanced mobility of researchers (e.g. Marie Sklodowska-Curie);
- Axis 3: Dedicated EU-SSA research cooperation (e.g. dedicated H2020 Africa call);
- Axis 4: Mainstream research cooperation (e.g. H2020 Calls for proposals);
- Axis 5: Targeted EU development cooperation (e.g. DEVCO, including EU-ACP cooperation);
- Axis 6: Targeted bilateral cooperation (in targeted areas).

Towards a staged research cooperation

Evidently, the right sequencing of these research themes is crucial. We recommend that the initial focus is on dedicated SSA capacity building (including enhanced mobility of researchers), accompanied by selected participation in mainstream research cooperation (e.g. in CSP) and targeted EU development and bilateral cooperation in complementary areas. In the medium-term, dedicated EU-SSA research cooperation (e.g. a H2020 Africa call) could focus on bioenergy. Such an initiative would need to build on e.g. a Technical network on Bioenergy. In the longer term, this would strengthen the potential of the SSA-region to participate in mainstream research cooperation as well.

Key success factors

An efficient programme to support long-lasting scientific cooperation in RE should activate several levers in a coordinated manner: joint research projects but also joint publications, communications, conferences; student and researcher exchange programmes; professional networks; capacity building; etc. These various actions call for different instruments, so coordination among these instruments towards a shared goal is a key success factor.

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