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AFRICAN ENERGY RESEARCH AND INNOVATION NETWORK: BUSINESS PLAN

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Executive Summary

This document is a response to the Terms of Reference (ToR) of the NEPAD Office of Science and Technology (OST) of 29 September 2006.

The OST sought the support of the Council for Scientific and Industrial Research (CSIR) to develop a comprehensive flagship programme of work on energy as highlighted by the African Ministerial Council on Science and Technology (AMCOST). The CSIR was instructed to:

- Prepare a draft programme of work with clearly articulated project goals and objectives, activities and their milestones, implementation strategies, time-frames, and budgets;
- Convene or organize an electronic dialogue among a small group of international experts to review the draft programme of work and provide specific comments;
- Identify and recommend 10-15 African regional and national institutes that may be involved in implementing the programme of work;
- Revise and finalize the draft programme of work based on comments from the experts; and
- Present the programme of work to the Steering Committee of AMCOST.

The OST provided overall guidance to the CSIR to develop this draft programme of work that reflects the vision and needs of AMCOST.

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1. Background

The New Partnership for Africa's Development (NEPAD), adopted at the OAU Heads of Summit in Lusaka, Zambia, in July 2001, recognizes the important role that energy plays in the development process of African countries; not only as a domestic necessity, but also as a factor of production whose cost directly affects prices of goods and services, and the competitiveness of enterprises. In this regard, NEPAD has identified actions that need to be taken to address the critical barriers to universal access to energy in Africa[1]. The challenge with NEPAD's energy initiative is to develop fully the energy resources of the continent in order to deliver affordable energy services to the various economic and social sectors[2].

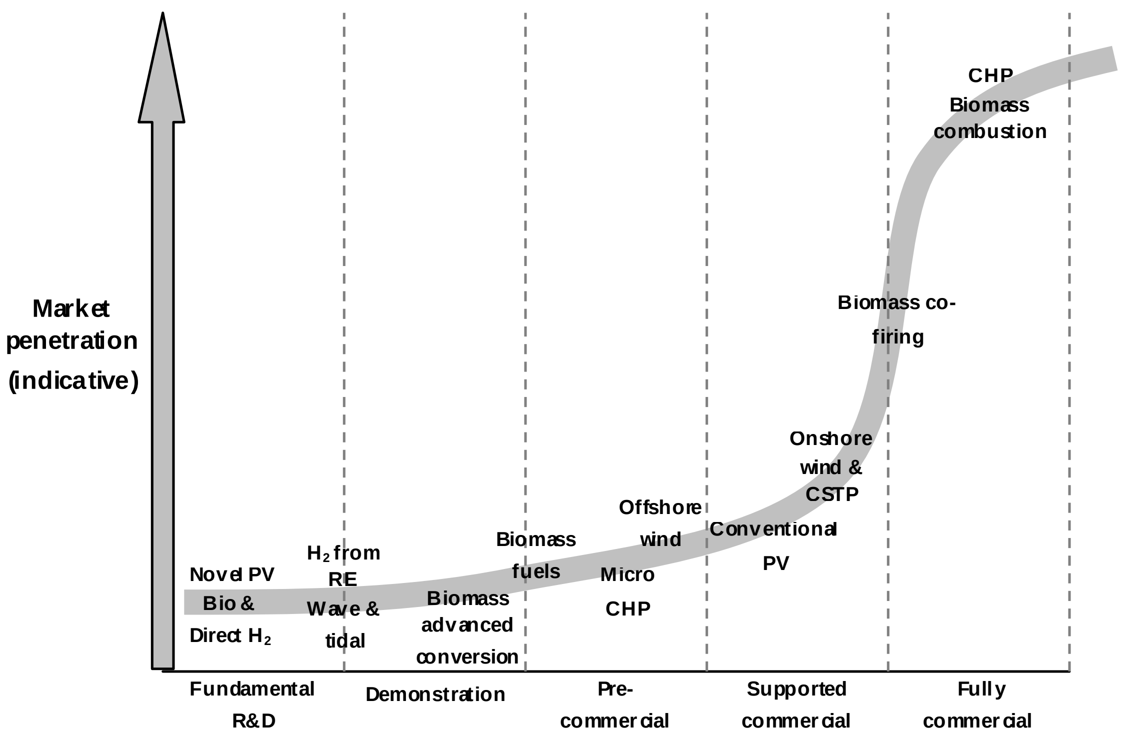

Figure 1. The international commercial maturity of new and renewable energy technologies relative to market penetration (adopted from Foxon et al.[3])

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1 Operationalizing the NEPAD Energy Initiative: Workshop for African energy experts, June 2-4, 2003, Dakar, Senegal.

2 A summary of NEPAD Action Plans. Online <http://www.nepad.org/2005/files/documents/41.pdf>.

3 Foxon TJ, Gross R, Chase A, Howes J, Arnall A, Anderson D. UK innovation systems for new and renewable energy technologies: Drivers, barriers and systems failures. Energy Policy 2005; 33: 2123-2137.

Meeting the NEPAD energy goals will require investments in scientific research and technological innovation. The research priorities have been highlighted in terms of alternative and environment-friendly energy sources, and associated energy policy[4] (see Figure 1 for the perceived international maturity of different technologies). In terms of the latter, it has been stressed that there is an urgent need for the development and adoption of a coherent energy policy and strategy at continental level. The lack of a common African institutional framework is a major handicap for developing and implementing regional energy integration[1]. Table 1 provides an example of the difference in policy emphasis and associated research support and efforts.

Table 1. Rural energy policies in sub-Saharan Africa[5]

Country	Dedicated rural energy/renewables policy	Coverage of rural energy/renewables in main energy policy
Botswana	None	• Emphasis on solar energy development
Eritrea		• Broad support for the development of renewables without specific targets or interventions
Ethiopia		• Broad support for harnessing of renewables, with no specific targets or interventions
South Africa		• Specific policies on biomass sub-sector • Specific support for harnessing of renewables, with no specific targets or interventions
Zambia		• Specific policies on biomass sub-sector • Specific support to awareness creation of other RETs
Zimbabwe		• Specific policies on biomass sub-sector • Broad support for the economic harnessing of other renewables

The first NEPAD Ministerial Conference on Science and Technology has subsequently identified thrusts for a comprehensive African programme for energy research and technology development, which is dedicated to the building of sustainable energy base on the continent. These thrusts are:

- Information on and knowledge of existing appropriate energy technologies;
- R&D to develop new alternative energy technologies; and
- Commercialisation and/or access of/to energy technologies.

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4 Kimenyi MS. Research and development in the south: The case of non-francophone sub-Saharan Africa. Background paper commissioned by the International Development Research Centre, 2003.

5 Karekezi S, Kithyoma W. Renewables and rural energy in sub-Saharan Africa. In: Mapako M, Mbewe A (eds.) Renewables and energy for rural development in sub-Saharan Africa. African Energy Policy Research Network, London: Zed Books Ltd.; 2004, 30.

The overall objective of this programme is to enlarge Africa's energy security through the generation and application of scientific knowledge and related technological innovations. Its specific goals are to:

- Increase rural and urban access to environmentally-sound energy sources and technologies;
- Improve energy efficiency; and
- Increase or enlarge the range of energy sources and technologies for household and commercial uses.

In general the project aims to address the requirements of Agenda 21 pertaining to environmental sound technologies (ESTs) [6]:

"*There is a need for favourable access to and transfer of environmentally sound technologies, in particular to developing countries, through supportive measures that promote technology cooperation and that should enable transfer of necessary technological know-how as well as building up of economic, technical, and managerial capabilities for the efficient use and further development of transferred technology. Technology cooperation involves joint efforts by enterprises and Governments, both suppliers of technology and its recipients. Therefore, such cooperation entails an iterative process involving government, the private sector, and research and development facilities to ensure the best possible results from transfer of technology. Successful long-term partnerships in technology cooperation necessarily require continuing systematic training and capacity-building at all levels over an extended period of time*".

In essence the comprehensive African programme for energy research and technology development strives to render ESTs more affordable to all economic and social sectors through collaborative inter-country partnerships that address regional issues to minimise barriers and systems failures, whilst also contributing to global issues such as climate change. The goals of the programme will be achieved through specific projects that intend to accumulate and disseminate information pertaining to ESTs (see Figure 2). During the next three to five years, the projects described in the following sections will form the core activities of the flagship programme to which different R&D institutes, councils and universities must contribute.

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6 "*Environmentally sound technologies protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes*".

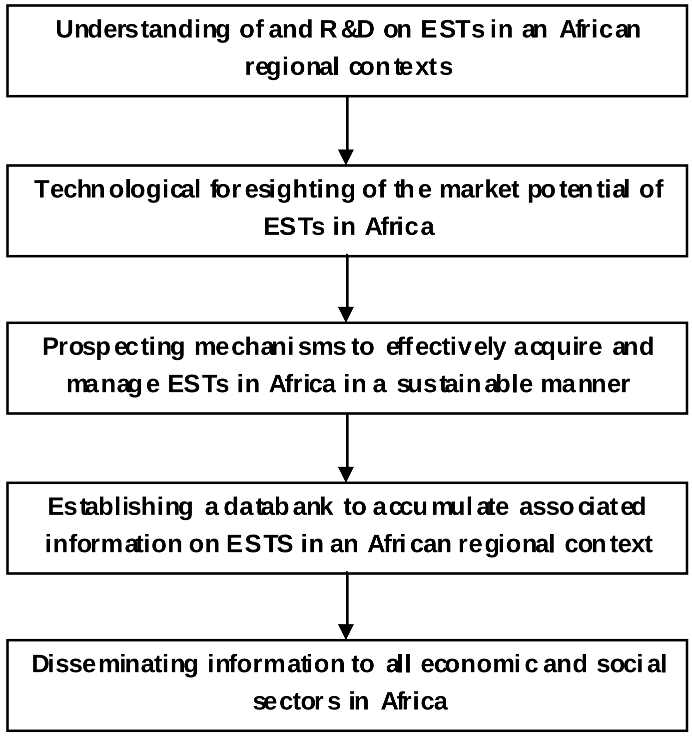

Figure 2. Intend process of the programme to accumulate and disseminate information pertaining to ESTs

1.1. Project 1: African Databank of Energy Research and Technologies

In terms of Project 1, there are currently many research institutions and regional research bodies across the continent fulfilling the role of repository of cutting-edge energy R&D on the continent. The proposed programme will focus on coordinating these R&D efforts and ensure that lessons learnt are shared across the continent in a much-needed structured medium. Furthermore, to improve Africa's access to and use of environmentally sound energy sources and technologies, a continental databank or information base must be created. This will be done through a comprehensive energy technology assessment and foresight exercise. The exercise will cover such aspects as status of energy research and innovation, specific national and common African energy needs, global trends in energy research and technologies, impacts of different energy technologies, and the nature of market/costs of various types of technologies.

Relevant competent national authorities in African countries supported by African experts and international partners will conduct the study. Specific activities and actions to be taken will include the following:

- Integration of diverse efforts, e.g. EU, ADB, GEF, etc.

- Sharing of lessons learnt and experiences between countries and regions.
- Role of energy in poverty reduction and impacts on Millennium Development Goals.

1.2. Project 2: Research on and development of bio-energy technologies and other renewable energy sources

The production of energy in Africa and other parts of the world is increasingly being determined by environmental, in addition to social, economic and technical, factors. International and local concerns over global warming and climate change have given more impetus to research on renewable sources of energy. A large share of the continent's energy needs will need to be met from renewable sources in addition to conventional sources (see Table 2).

This project area will aim at enlarging the range of renewable energy technologies. Its emphasis will be on sustainable use of the continent's biomass (see Table 2) through ESTs. The project will build capacity for combined heat and power production (CHP) based on local resources. In collaboration with international partners, designated African centres will conduct R&D on the following:

- Fluidised bed gasification of biomass or recovered fuels;
- Integrated harvesting techniques for forest-derived fuels;
- Pyrolysis to generate liquid fuels; and
- Conventional production of biofuels.

It is recognised that the other renewable technologies, as shown in Table 2, also require attention in the future; these R&D areas and themes will be identified based on technical workshops to be conducted by designated centres. Energy carriers and conversion technologies such as hydrogen and fuel cells will be explored with the aim of building the capacity of the continent to participate in related international R&D programmes. A definite challenge is to bring together different initiatives across the continent.

Table 2 indicates that research in renewable energy extends from resource to conversion. It makes no sense to research wind energy technologies in a country, for example, if the wind resource is poor (the wind strength is low and intermittent). Appendix A summarises the state of knowledge of the renewable resources on the continent.

Table 2. Classification of energy R&D requirements

Category	Type	Resource	Generation	Distribution/storage	Conversion	Cross-cutting
Fossil	oil	Reserves, availability, extraction	Combustion heat	Road tanker, pipeline, shipping	IC engines, turbines	Energy efficiency: • Residential; • Commercial; • Industrial. Safety Regulatory frameworks Off-grid issues
	coal			Road, rail, shipping	Rankine cycle with boiler, IGCC	
	gas			Bottles, pipeline, shipping	Combined cycle, OCGT	
Nuclear		Fuel processing, enrichment	Nuclear heat: PWR, HTR, FBR		Rankine cycle, Brayton cycle	
Renewable	Solar	Insolation mapping	photo-voltaic effect: PV	Use at source	PV cells	
			Solar heat: Thermal power generation (concentrated), water heaters	Heat stored in thermal oil & molten salts	Rankine cycle, Brayton cycle	
	Wind	Wind mapping	Mechanical motion	Use at source	horiz. & vert. Axis turbines	
	Hydro	Rainfall, terrain		Dams, rivers/waterfalls, pumped storage	Kaplan, Francis & Pelton turbines	
	Ocean	Wave, tide and current mapping		Use at source	Wave, current & tidal devices	
	Biomass	Climate, rainfall, soil	Combustion heat: gasification, pyrolysis	Steam or electricity reticulation Use at source, reticulation or distribution	Rankine cycle	
	Geo-thermal	Geological mapping	Geothermal heat	Use at source	Rankine cycle	
	Municipal wastes	Arisings, quantity and composition, geographically	Combustion heat	Use at source, or transport over short distances	Rankine cycle	
Carriers	Electricity	Installed capacity	Mech. motion to electric generator	Electric grid, no current feasible storage	Electric motor, induction heater, appliances	
	Hydrogen	Water, hydrocarbons	Electrolysis (H_2O), stripping, production of methane	Pressurised bottles, Cryogenic, pipelines	Fuel cell, gas turbine, IC engine	

Shaded area indicates the R&D focus of the SEB flagship programme

1.3. Coordination of the projects

The above and related projects will be further developed and implemented by a proposed African Energy Research and Innovation (AERI) Network. The AERI Network will be configured as a network of designated centres of excellence in scientific research and technological innovation in energy.

2. Frameworks for the projects identified by the Consolidated Plan of Action

2.1. Project 1: African Databank of Energy Research and Technologies

2.1.1. Required tasks

The major issues at the outset revolve around collecting enough information on what already exists to avoid duplication and to formulate a strategy for tapping into whatever data exists. Subsequently, the objectives of the project will be to develop an up to date, relevant and user-friendly African energy R&D database and make it accessible to stakeholders. Some of the data categories that will be captured include:

- R&D centres by county, their energy specialisation, and primary language used;
- R&D programmes (past, present and planned) and related documents, e.g. published reports, theses and dissertations, journal articles, books, etc.; and
- Specific research projects and associated data (if in the public domain).

Key design issues for the database include:

- How data is acquired and verified;
- Choice of software, which will be a compromise between simplicity, reliability, compatibility, flexibility and costs, e.g. licences;
- Information dissemination strategy that accommodates stakeholders in countries with low access to the internet, i.e. not only online access; and
- Financial sustainability issues, e.g. membership fees and fees for specific services.

Figure 3 provides a framework of what the database will consist of.

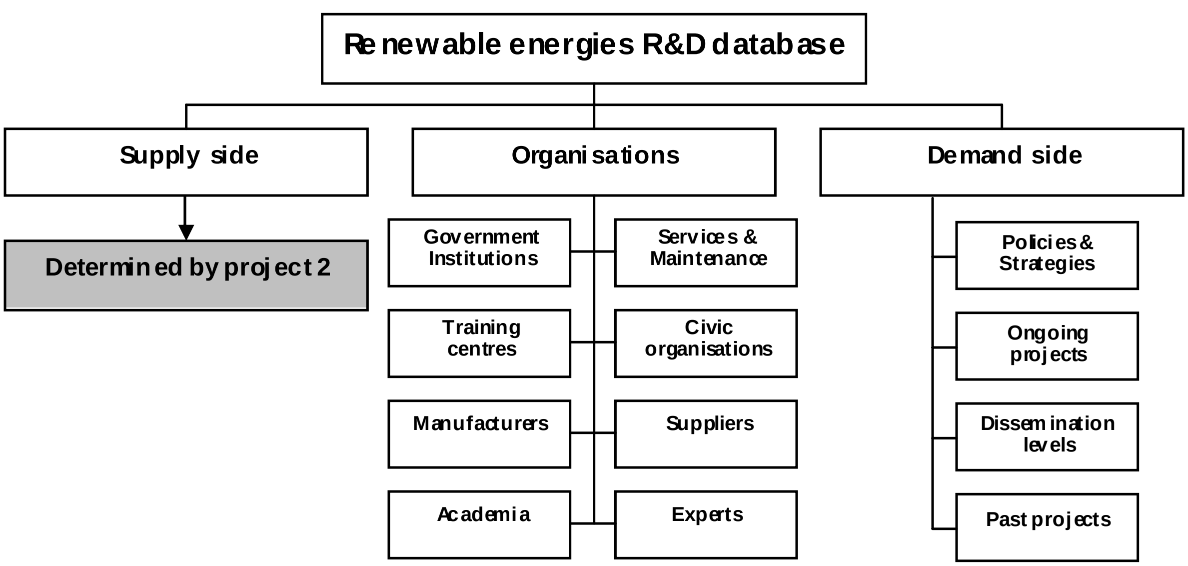

Figure 3. Framework for the African database on renewable energy R&D

2.1.2. Capable African institutions with capacity

The African Energy Policy Research Network (AFREPREN[7]) has done much work in this regard, which can be used as basis for the project. However, participating institutions will be identified, based on the returned completed questionnaire (see Appendix B).

2.1.3. Budget

This section will be completed, based on the electronic dialogue with the identified capable African institutions.

2.2. Project 2: Research on and development of bio-energy technologies and other renewable energy sources

The overall framework of R&D for this project is summarised in Figure 4.

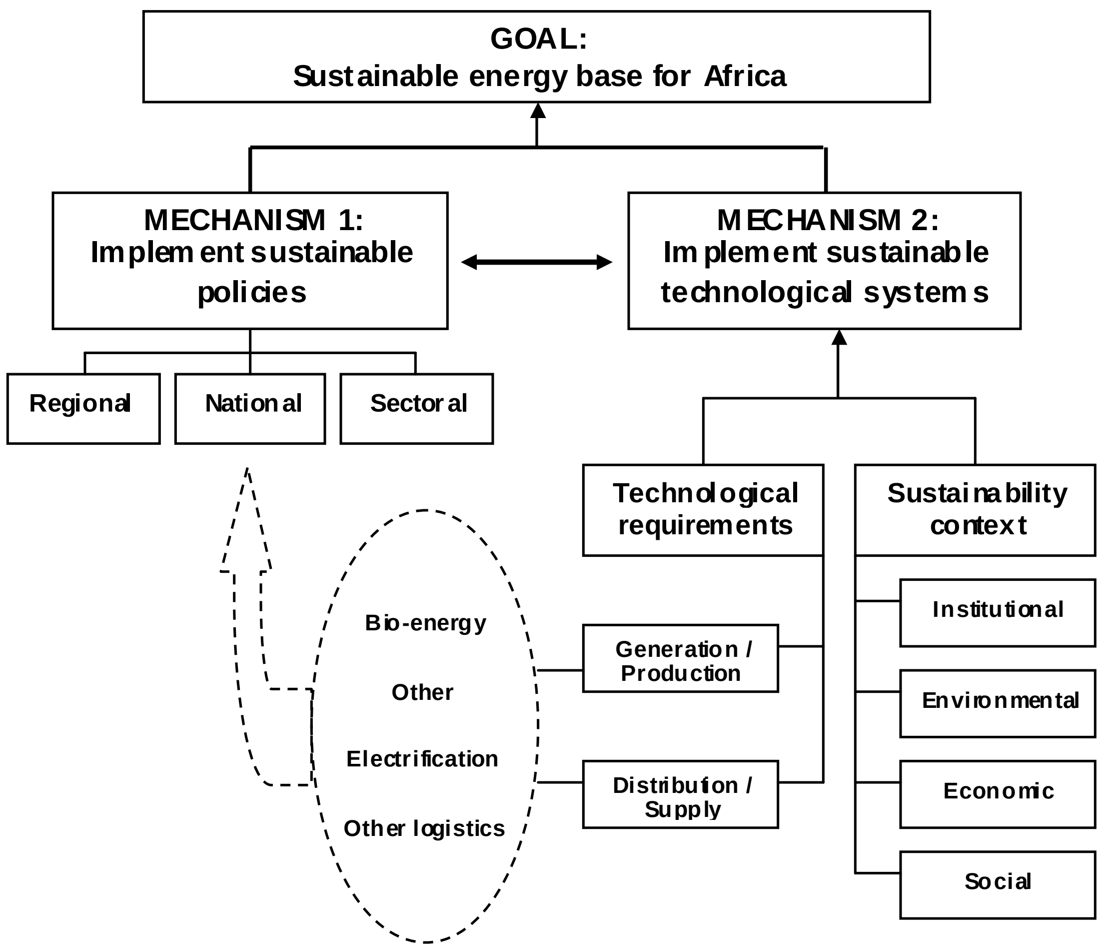

Figure 4. Overall framework for energy-related R&D

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7 http://www.afrepren.org

The bulk of the R&D will focus on Mechanism 2 of the framework, i.e. the implementation of sustainable technological systems, although, as is indicated in Figure 4, some research is called for to ensure sound sectoral, national and regional policies to support such technological systems. The specific R&D requirements for the four bio-energy technological systems are summarised in sections 2.2.1 to 2.2.4. In general, technology management R&D is required for each life cycle phase within the technological systems, i.e. from feedstock provisioning to energy conversion (see Figure 5):

- Technology assessment and roadmapping for specific contexts to direct ongoing R&D activities;
- Modifications required for technology improvements and deployment in specific contexts, e.g. efficiency, safety, operability, etc.;
- Logistics modelling and planning and associated techno-economic feasibility for specific locations;
- Technology (and knowledge) transfer, diffusion and adoption procedures; and
- Post-implementation management and business models and procedures.

In all instances the internal and external influences of inputs to and outputs form the technological systems under evaluation must be considered (see Figure 5).

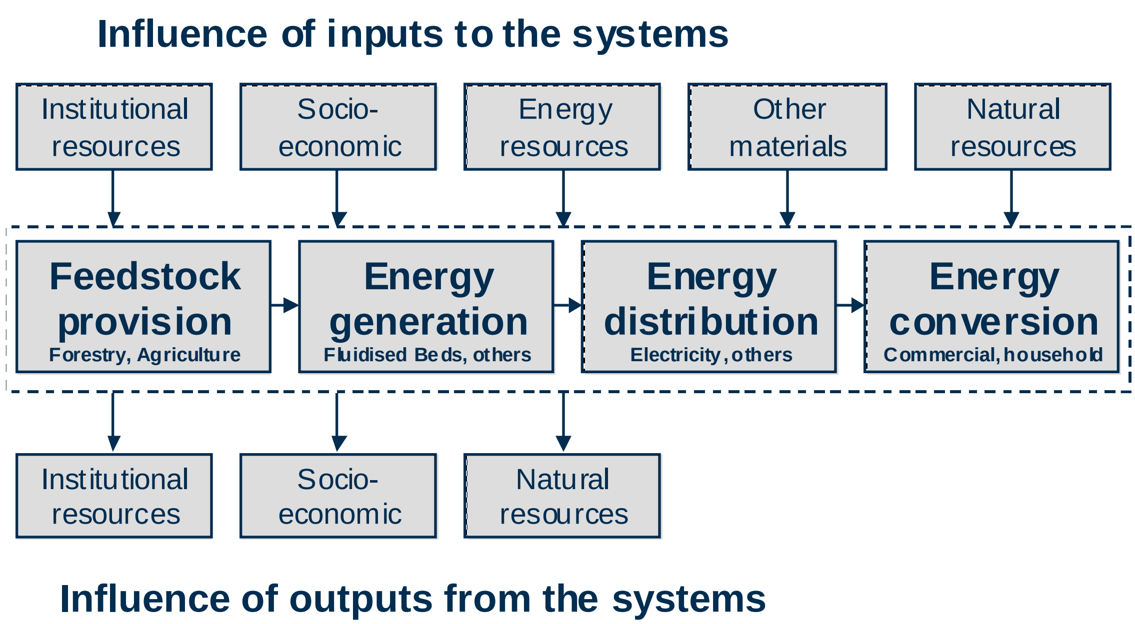

Figure 5. Life cycle phases within the technological systems

In line with the goals of the flagship programme, and especially from a sustainability perspective, research is required in the context of urban and rural deployment, and on small- and large-scale technological systems in urban and rural areas as is shown in Figure 6.

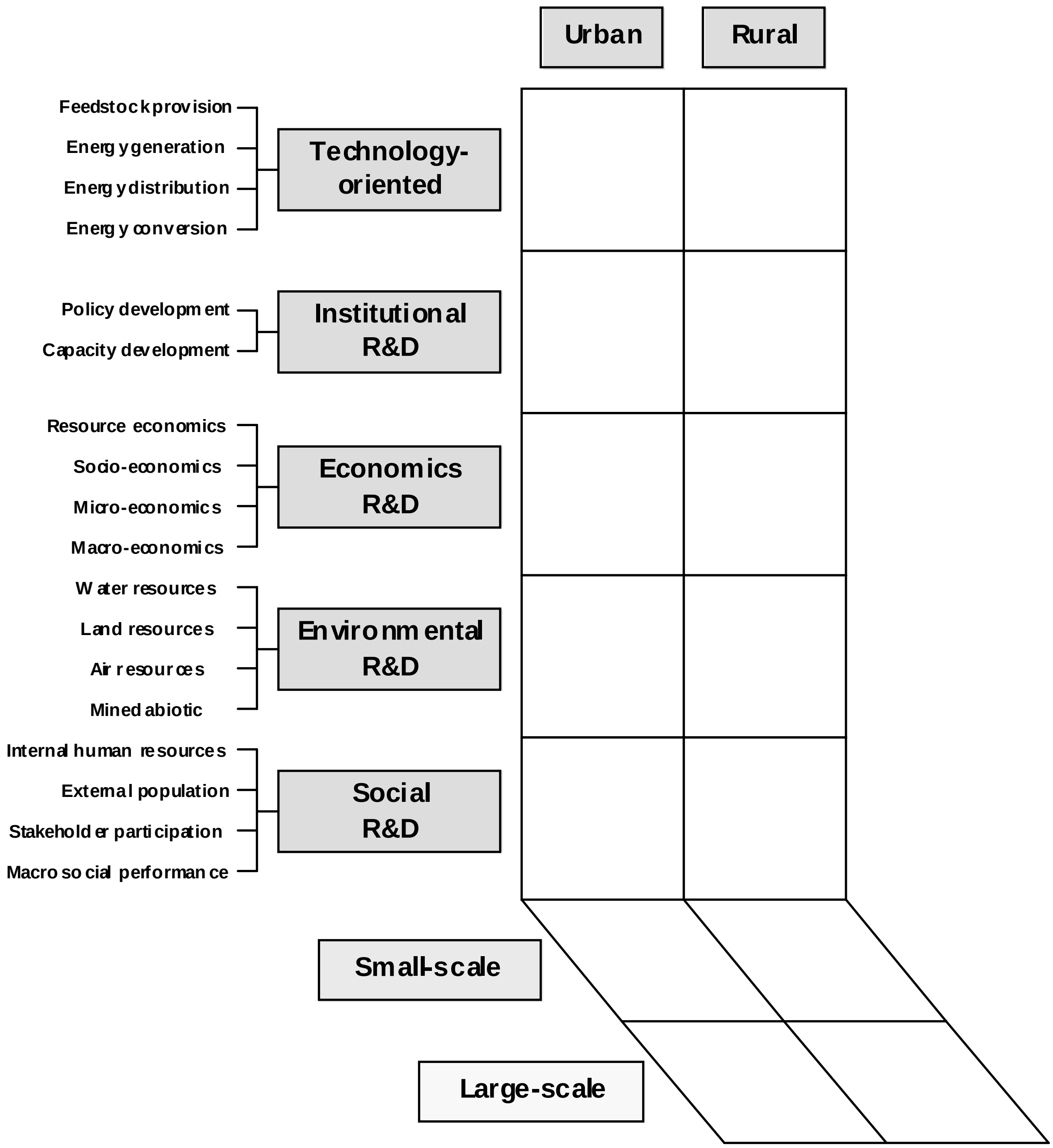

Figure 6. Matrix of required R&D for the four technological systems

In terms of the sustainability of ESTs, research must be initiated on institutional, economic, environmental and social aspects in addition to technology-specific R&D (see sections 2.2.1 to 2.2.4). The sub-components of the research are summarised in Figure 6.

2.2.1. Fluidised bed gasification of biomass or recovered fuel

It is envisaged that the following research areas must be addressed:

- Establish the R&D and demonstrations in this field by means of a thorough literature review and a quantitative survey-type research methodology.
  - Identify the research institutions globally who are active in the field.
- Assessment of what "energy crops" are currently being exploited or investigated.
  - The issue of genetically modified crops needs to be addressed.
  - Matching of types of biomass suitable for gasification, which are generally fast-growing crops such as grasses, with regional climatic and soil conditions.
- Matching of resources (or potential resources) with communities and industry requirements.
  - Assessment of needs, e.g. can the gas be used directly for cooking, heating etc., or would some or all of the gas need to be converted to electricity?
- Socio-economic studies to gauge, for example, the level of job creation that will be achieved.

The above relate predominantly to small-scale applications. However, large-scale applications should also be considered, for example a large central gasifier receiving fuel from surrounding areas or communities. This large gasifier could utilise biomass (either grown as an energy crop or recovered form agricultural activities) or municipal solid waste.

Performance criteria common to both small- and large-scale applications, which require investigation, are:

- System efficiency, i.e. conversion of energy in biomass to useful energy.
  - As a sub-set, the carbon efficiency of the particular biomass.
- "Operability", in terms of ease of operation, inherent safety ("failsafe"), stability, availability, technical risks, etc.
- Environmental performance of the system, with respect to emissions of particulate and gaseous pollutants (for example NH_3, which would result in NO_x after combustion), land conversion, soil and water contamination due to agricultural practices, indoor air pollution on the demand side, etc.

These could be used as criteria to assess the performance of currently available technological systems or as design criteria for new systems. The real key to visibility and adoption of biomass gasification is demonstration. It is generally only the operation of a technology "in the field" that reveals the true obstacles to adoption, and provides data upon which decisions can be made about the potential of the technology.

2.2.2. Integrated harvesting techniques for forest fuels

It is envisaged that the following research areas must be addressed:

- Conduct a review of studies already completed. Studies/audits have been undertaken in South Africa, but it is unknown if similar studies have been undertaken elsewhere in Africa.
- Establish the potential (or conversely the waste) associated with plantation and harvesting techniques.
- Establish the labour involved, and overall cost associated with harvesting.
- Establish if there is a match between arisings and utilisation. This may involve techno-economic studies.
- Socio-economic studies to gauge, for example, the level of job creation that will be achieved.

This research should be done in close collaboration with the gasification and pyrolysis research mentioned above and below, as the utilisation technology and harvesting techniques are inter-linked.

It is recommended that the opportunity be used to ensure that this research is used to not only optimise the recovery of biomass from forestry, but also to increase the sustainability of the forestry itself.

2.2.3. Pyrolysis to generate liquid biofuels

Pyrolysis is the thermal degradation of organic material, e.g. biomass waste, in the absence of air to produce char, pyrolysis oil and syngas, for example the conversion of wood to charcoal. Proponents of pyrolysis claim that it has significant advantages over combustion (incineration) and gasification, in that it can produce a range of products. However, critics say that pyrolysis is still unproven above demonstration scale and that the economics have not yet been shown to be superior to conventional systems.

Therefore, all of the research questions asked off gasification (section 2.2.1) are applicable to pyrolysis too. However, the issue of emissions and hazardous by-products, particularly of small plants in remote locations, needs to be well addressed and may have large cost implications. In addition it needs to be determined, perhaps on a case-by-case basis, if the advantage of pyrolysis (the ability to produce solid, liquid and gaseous products) is indeed advantageous. The risks of an unproven technology should be considered if the advantage over combustion or gasification is marginal.

2.2.4. Conventional production of biofuels

The two specific biofuels, and related issues, that must be researched in the African context are:

- Bio-ethanol:
  - o Fermentation, ethanol separation, value of by-products, blending with petrol; and
- Biodiesel:
  - o Extraction yield, value of by-products, transesterification, blending with diesel.

The conventional first generation technologies are "off the shelf" (see Figure 7), but some modifications may be required if different crops are used. Figure 8 summarises that areas that need further R&D under this theme. Of particular importance are:

- The suitability of crops based on yield/ha and overall economic viability.
  - o Yield improvement is a very important as is the issue of food versus crops, which needs attention in terms of economic substitution.
- Value and markets of by-products, particularly when soya is considered.
- Change in biodiversity, which is closely linked with change in land use.
- Availability of and impact on water resources in the region.

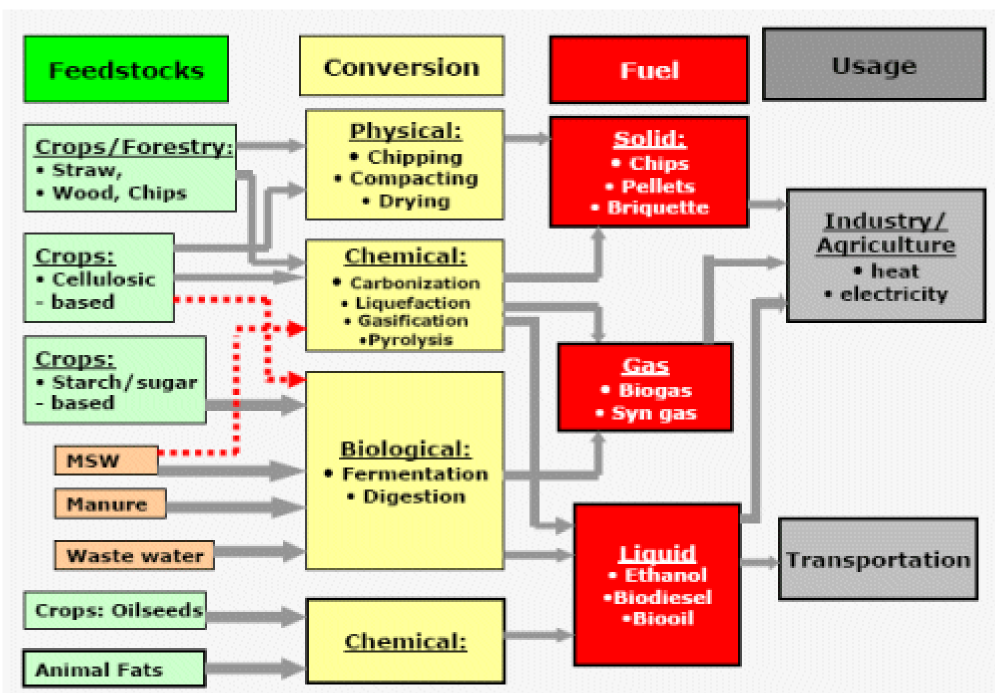

Figure 7. Overview of biofuels production, processing and use

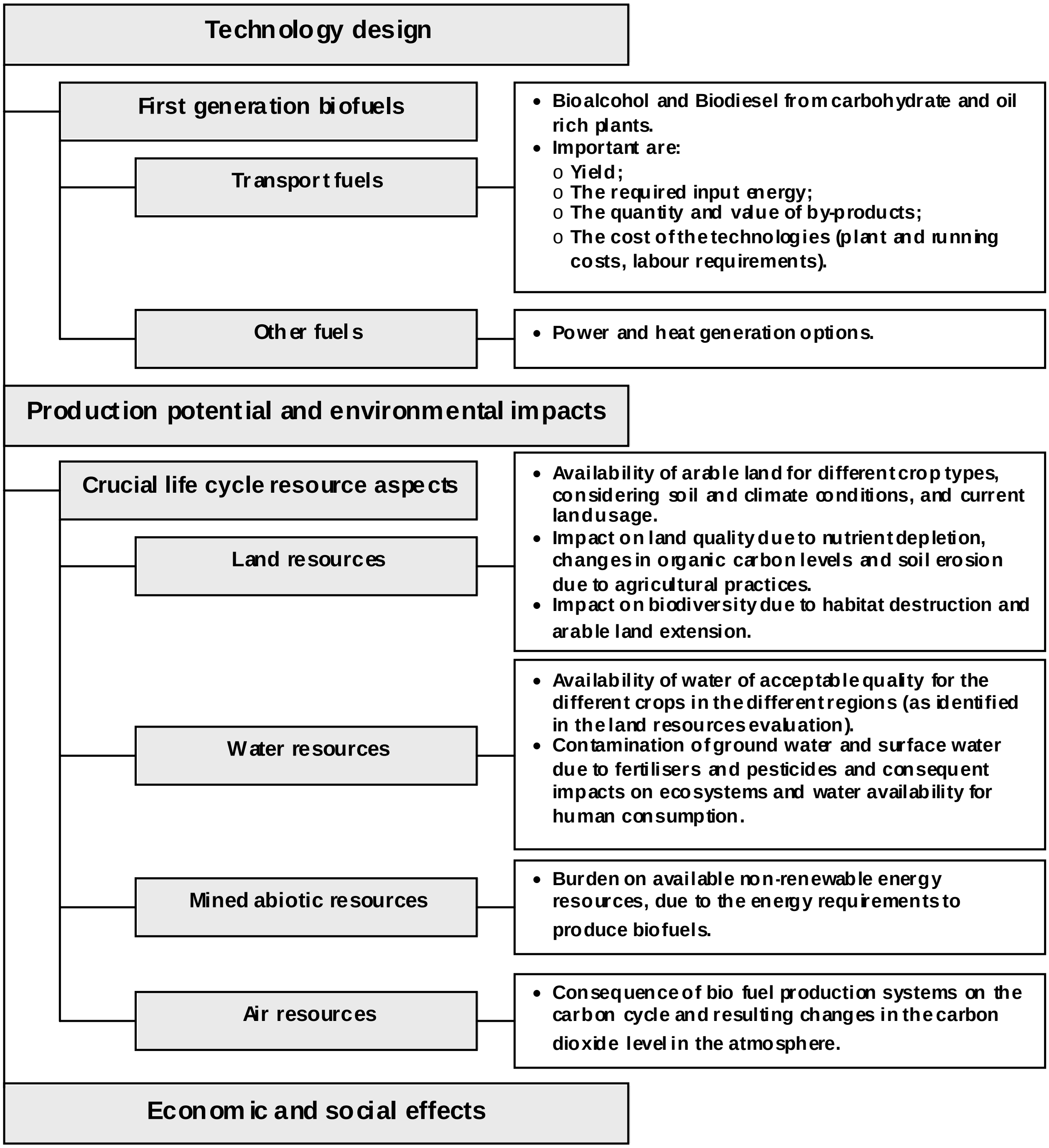

Figure 8. R&D areas related to biofuels

With respect to economic and social effects (in Figure 8), issues that need to be investigated include:

- Effects on availability of food products;
  - o Partial substitution of food products with fuel products and the effect on food price levels;

- Effects on import of fossil fuels;
  - o Partial replacement of fossil fuel with biofuels and effect on balance of payment (macro economics);
- Effect on import of other products;
  - o Import replacement possibilities of animal feed, e.g. soya cake, products for the chemical industry, e.g. glycerol, increased import of methanol etc.;
- International competitiveness;
  - o Comparison of production prices for ethanol from sugarcane in Brazil with African production from, e.g. maize. Cost comparisons of raw materials and by products;
  - o Potential interregional import/export of biodiesel from fertile tropical regions with cost advantages;
  - o Potential for CDM (Clean Development Mechanism) projects;
- Effects on employment;
  - o Direct employment from large industry in agriculture and processing operations;
  - o Direct employment through integrating small scale farming and pre-processing by SMMEs;
  - o Employment in upstream services and downstream products;
  - o Opportunities to link small farming and pre-processing businesses into industry;
- Effects on the second economy;
  - o The potential of biofuels to fulfill the energy needs of the 2nd economy;
- Effects on resources values;
  - o Perceived value changes in the natural resource-base of Africa;
- Government interventions;
  - o Renewable energy goals in place in Africa compared to EU, USA, Brazil and India;
  - o The possibility of legislating compulsory inclusion levels for biofuels;
  - o Tax reductions and subsidies, i.e. quantify required tax reductions and subsidies; and
  - o Evaluate need for import duties to protect African production.

2.2.5. Criteria to prioritise research for the sub-areas

Criteria need to be established to prioritise the research for the sub-areas in terms of budget allocation. Possible criteria include:

- The relevance of the work;
  - o How does the work assist in meeting the objectives of the flagship programme?
  - o How relevant is the work to the broader objectives of NEPAD and the NEPAD strategy, including the transformation of the S&T base?

- The probability of success, potential for impact and contribution to the S&T output of NEPAD;
    - What is the track record of the project leader and the project team?
    - What is the potential for uptake by the intended user community?
    - What is the potential of the project to build new networks within the research community and improve the S&T human capital base of the African continent?
    - How many publications or platform patents could result from the project?
- The S&T merit of the proposal;
    - Is the proposed research original and will it lead to strong S&T growth on the African continent?
    - Is it multi-disciplinary and will it lead to the advancement of knowledge within its field?
- The duration of the project, milestones, investment required per milestone, the deliverables and project budget;
    - Are these clearly specified in the proposal (especially the first years of the project)?
    - Is there value for money in the proposal and is the research question clearly stated?

Further research is required to refine the criteria and establish protocols for the selection of projects within budget constraints.

2.2.6. Capable African institutions with capacity

A plethora of R&D is conducted on fluidised bed technology across the continent, the majority by chemical and process engineering faculty at universities, many in collaboration with research groups outside Africa. Private and semi-private institutions are also actively investigating clean-coal and biomass fluidised bed technologies, most notably the CSIR, Eskom and Sasol, all based in South Africa, but with activities in other African countries. Similarly, the recent surge in conventional biofuel production has sparked R&D in the east, central and southern regions of the continent. In contrast very little structured R&D has been undertaken on the continent into formal integrated harvesting techniques and biomass pyrolysis technologies, although international networks exist that facilitate R&D in these fields. However, the details of this section will be completed, based on the returned completed questionnaire (see Appendix B).

2.2.7. Budget

This section will be completed, based on the electronic dialogue with the identified capable African institutions.

Appendix A: State of knowledge on renewable technologies on the African continent

Solar

Figure 9 displays the amount of solar radiation in the *least* sunny month of the year. The African solar resource can be seen to be is extensive in the North and South.

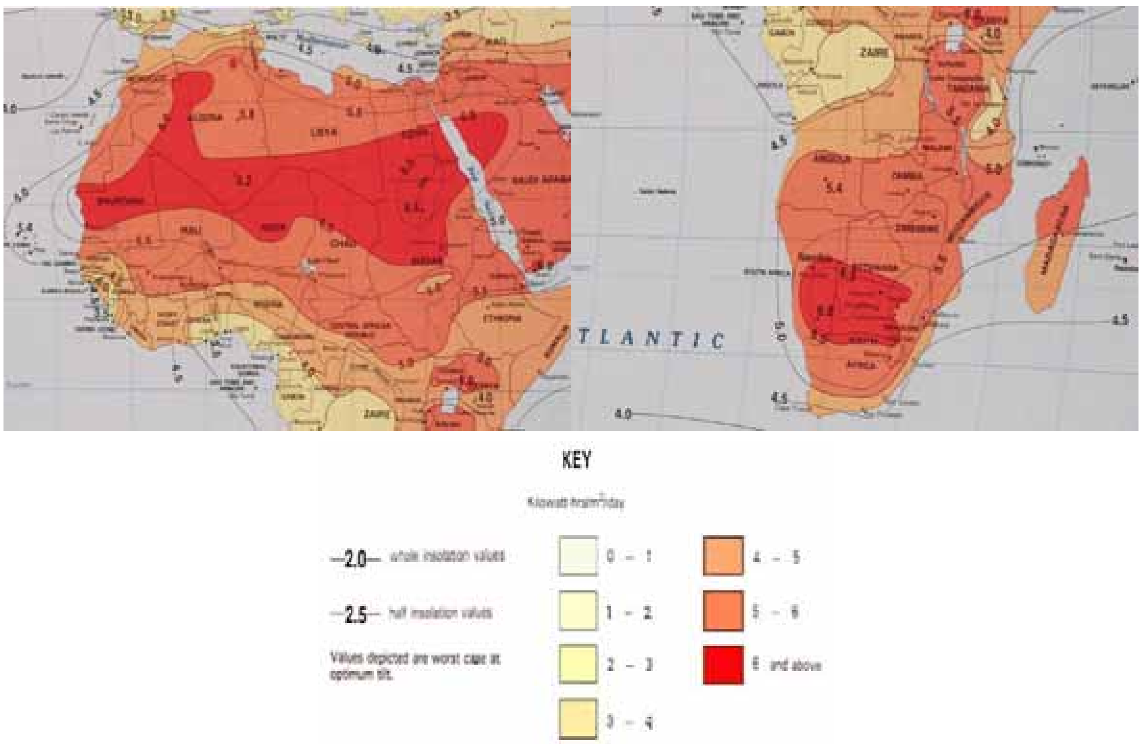

Figure 9. Solar resource in least sunny month of year (Solar Genix)

The World Bank is of the opinion that solar-thermal generated electricity shows the highest potential for cost reductions of all the renewable energy technologies for bulk power generation. Solar-thermal technologies generate electricity using *heat* received from (mostly concentrated) solar radiation, as opposed to photovoltaic technologies, which use solar *light*.

Given the extent of the African resource, it should come as no surprise that the Global Environment Facility has been supporting the development of solar power stations in Morocco and Egypt, or that the South African utility Eskom has completed a final scooping report for an Environmental Impact Assessment for a 100MW solar power station in Upington in the Northern Cape. The full EIA is still pending.

Significant European attention is being devoted to the possibility of importing solar-generated electricity from North Africa to Europe. This would have the benefit of reducing harmful greenhouse gas emissions and provide income for African states.

Solar power is also applicable in the off-grid situation. Solar home systems (SHS), comprising photovoltaic (PV) arrays and batteries, are being implemented in rural areas in a number of African countries. Although PV is more expensive than other technologies, it's stand-alone capability avoids the need for expensive electricity reticulation in dispersed, low-density communities. PV has been used together with wind power in mini-grids in South Africa.

Solar water heating is the cheapest solar technology available, and reduces electricity capacity required for grid-connected homes and fuel in off-grid homes.

Wind

Jargsdorf (2004), in a comparative evaluation of 21 wind data sets from 9 African countries, states that there is no African country with a sufficient wind energy database. This leads decision makers to make use of meteorological data such as that of the World Meteorological Organisation (see Figure 12), and conclude that the African wind resource, in the main, is not great. He goes on to state that as a result the wind potential is being underestimated in all African countries, and that there exist several African countries with a wind potential exceeding that of most European countries.

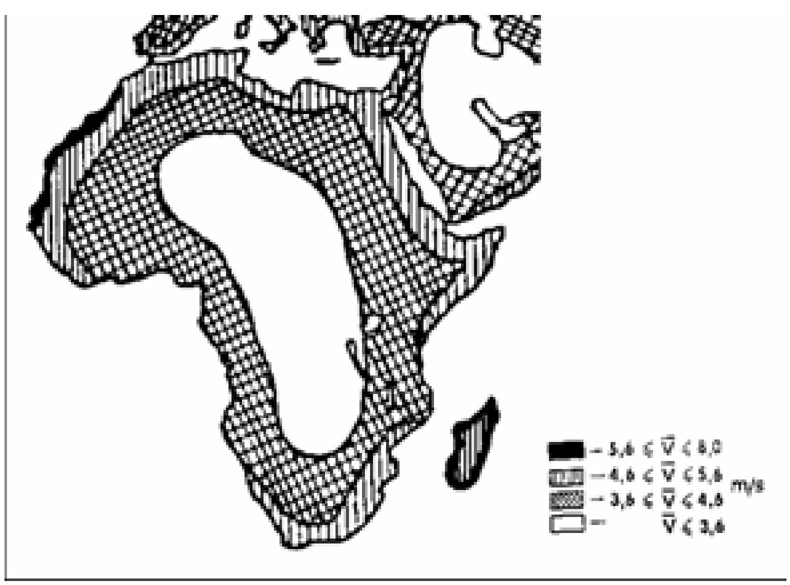

Figure 12. Wind regimes of Africa according to WMO (Jargsdorf, 2004)

The countries with feasible wind regimes are therefore given in three priority regimes.

1st priority:

- North Africa (best in Africa): Morocco, Algeria, Tunisia, Libya, Egypt and possibly Sudan.

2nd priority:

- Southern Africa (not as good as North Africa): South Africa, Namibia, Mozambique, Botswana, Lesotho and possibly Madagascar.

3rd Priority (promising sites):

- East Africa: Somalia, Eritrea, Kenya, Tanzania, Ethiopia.
- West Africa: Mauritania, Senegal, Guinea-Bissau, Guinea-Conakry, possibly Ghana, Benin, Ivory Coast.

Ocean

Energy can be harvested from the ocean in three mechanisms: tidal movement, wave action, and ocean current. A fourth option, OTEC, which makes use of temperature differences between deep water and surface water, has not moved beyond conceptual stage.

Figure 13 shows wave energy intensity in Kw/m of coastline. It can be seen that the best sites appear to be South Africa, the Horn of Africa, Morocco/Spanish Sahara and Madagascar. Ocean current strength is good off the Eastern Cape region of South Africa.

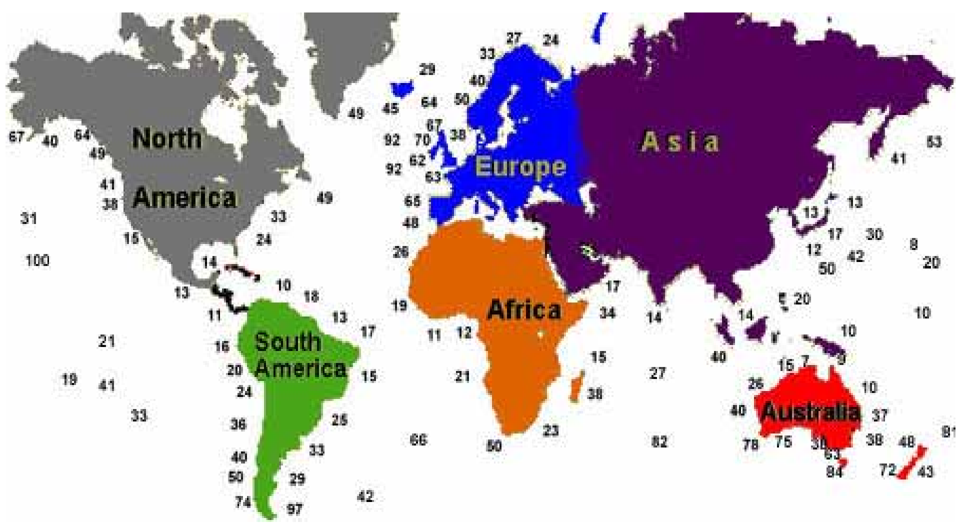

Figure 13. Wave power intensity around the world

Microhydro

The Central African region with its high rainfall is particularly suited to microhydro power generation (see Figure 14). Figure 15 shows the Southern African situation.

Figure 14. The African climate

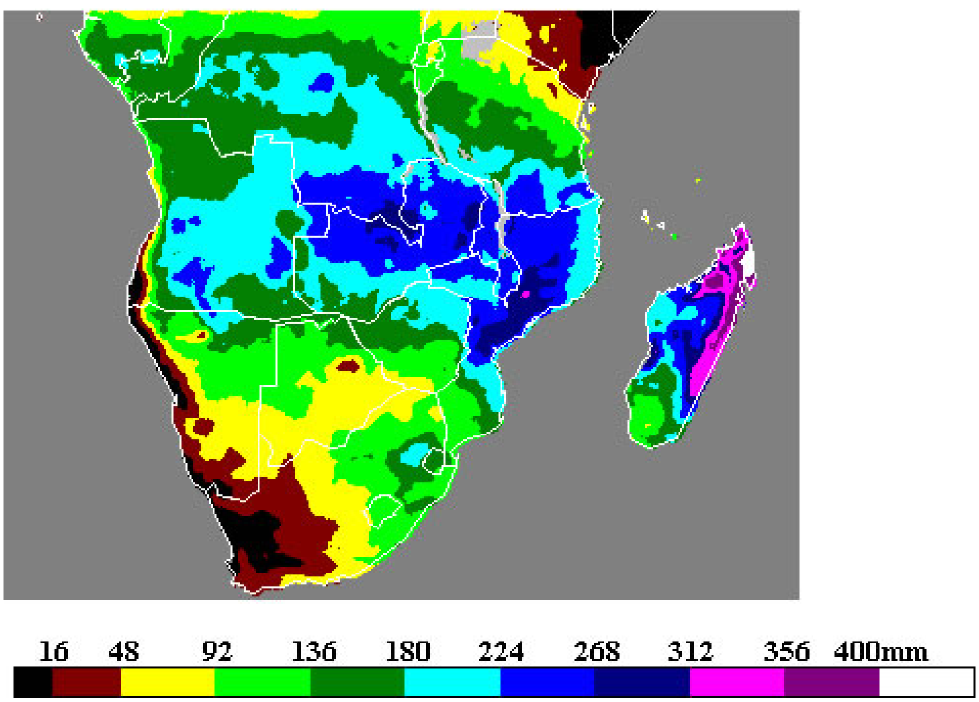

Figure 15. Rainfall in Southern Africa: January (month of highest rainfall for most of the region)

Geothermal

The potential for geothermal energy generation is greatest in east and horn of Africa, most notably within the Kenya rift (see Figure 16). It is estimated that a technical potential to generate over 600 MW currently exists (Mbuthi and Yuko, 2005).

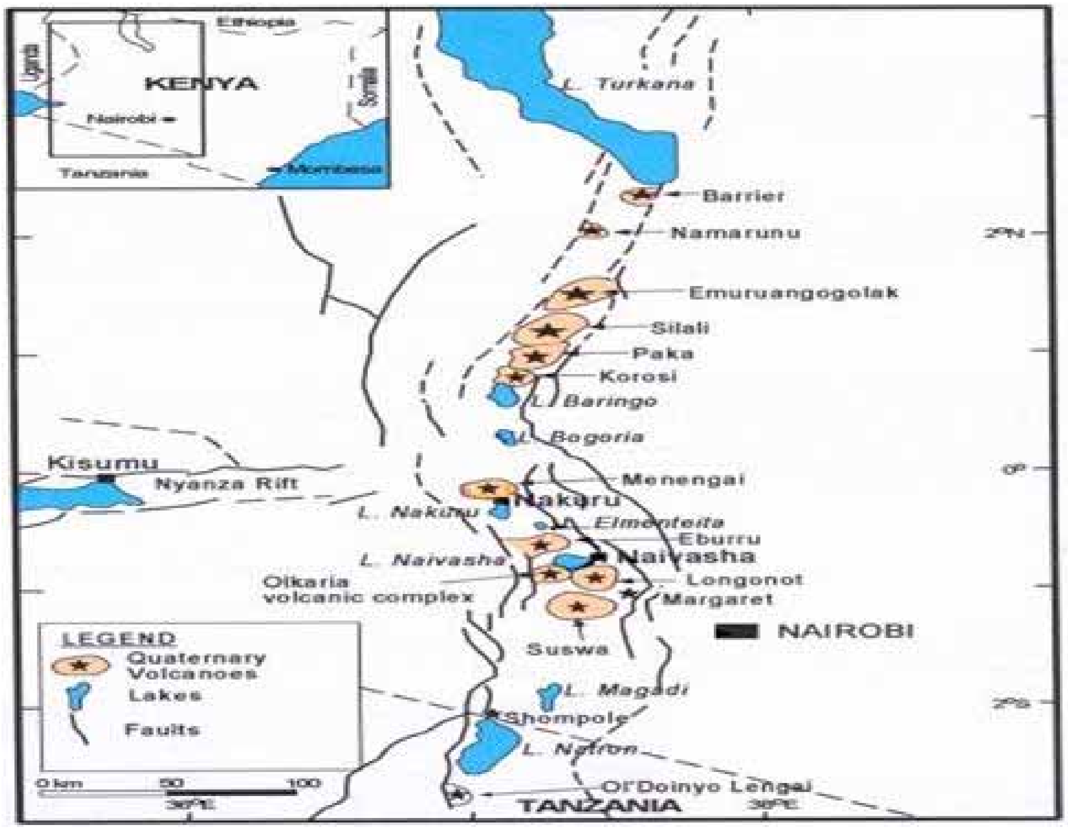

Figure 16. Location of geothermal areas within the Kenyan Rift Valley (Kenya Ministry of Energy)

Appendix B: Questionnaire to determine the capacity and capability of African institutions

This questionnaire is based on the NEPAD Office of Science and Technology's 'criteria and guidelines for establishing African networks of centres of excellence in science and technology'. Accordingly the following the following key features should be considered:

(a) *Institutional identity*—an identifiable formal or informal organization with specific values, norms and rules;
(b) *Existence of and ability to build and sustain a critical mass* of internationally or regionally (African) reputable or recognized scientists and/or engineers, technicians, and technology innovators;
(c) *An identifiable governance structure* with a clear mechanism(s) and hierarchy for making decisions;
(d) *Demonstrated role(s) to contribute to human development* by new adding knowledge to global science or generating specific products in a national or international economic system;
(e) *A reasonable measure of stability* of operating conditions and funding over a specified period of time;
(f) *Organizational dynamism* in terms of ability to adjust to and influence the external environment or demonstrated ability of an organizational to renew itself and grow even during hostile external conditions;
(g) *Institutional articulation* largely judged by the organizations networking capabilities i.e. ability to forge and sustain productive partnerships with other institutions; and
(h) *Relevance* an institution's or network's mission, programmes and outputs to sustainable development goals set by country and/or the international community.

Centres of excellence may take the following forms:

(a) Multidisciplinary teams of individuals from different institutions either formal or informal. The teams are assembled to solve specific problems. These are largely networks of problem-solvers and innovators.
(b) Networks of existing institutions whose facilities, expertise and structured get linked together to implement specific programmes.
(c) Single centres such as a university department or institute.

Questionnaire: Baseline Energy R&D Information

1. Name of Centre of Excellence:

2. Type of Centre of Excellence: Indicate with a cross (multiples allowed):

Type of CoE	
Government department	
Science Council	
Higher Education	
Consultant	
NGO	
Company in private sector	
Government owned company	
Other (Specify)	

3. Location:

4. Contact Person:

5. Contact number:

6. Email:

Research Information

7. Type of energy R&D: Indicate percentages:

Research Type	% Of resources allocated
Basic research Applied research	
Field research	
Development	
Demonstration	
Policy research	
Other	

8. Energy Sector Category: Indicate percentages:

Energy Sector	% Of resources allocated
Primary energy exploration, resource assessment	

Extraction, mining and primary supply	
Energy conversion	
Transport of energy	
End use	
Storage	
Cross cutting issue such as policy, modelling/forecasting, etc.	

9. Energy carrier (where applicable): Indicate percentages:

Type of Energy Carrier	**% Of resources allocated**
Coal	
Oil	
Gas	
Electricity Nuclear	
Renewable (please specify)	
Hydrogen	

10. Demand sector (where applicable): Indicate percentages:

Sector	**% of resources allocated**
Industry	
Commerce	
Mining	
Economic households	
Sub-economic households	
Agriculture	
Transport	

11. Cross cutting (where applicable): Indicate with a cross:

Issue	
Physical environment Health & safety	
Energy efficiency	
Human resource development	
Energy statistics	
Information and planning	
Energy economic relationships CDM Opportunities	
Other (Specify)	

12. Main outputs of Research:

____
____
____
____
____

13. Outline the focus areas in your energy R&D programme and % of resources allocated per focus area:

____
____
____
____
____
____

14. Drivers for the energy research programme (Reasons for undertaking research):

____
____
____

15. Alignment of energy R&D programme with national energy policy, priorities or legislation:

Yes	
No	
To some extent	
No clear national energy priority	

16. Comment:

____
____

17. Total R&D resources budgeted (person-years) for the current year:

____

Total energy R&D resources budgeted (person-years) for the current year:

____

18. Total energy R&D expenditure for the current year (US$):
____

19. Total external energy R&D funding (US$) for the current year:
____

20. Source of energy R&D funding: Indicate % split:

Funding Organisation	%
Government department	
NGO	
Company in private sector	
Science Council	
Self-Funded	
Aid organisation	
Higher Education	
Other	

21. Are there related national or global trends in energy R&D that you are aware of? If so, please give a brief description and state the name and location of the organisation?
____
____
____
____

22. Additional comments?
____
____

Human Resource Information

23. Average R&D Experience of Key Researchers/Project leaders in the energy field: Indicate number of persons for each category:

R&D Experience (Years)	Number of Persons
5 yrs or less	
5-10 yrs	
10-20 yrs	
> 20 yrs	

24. Disciplines of Key Researchers: Indicate the numbers of individuals within each discipline:

Disciplines	**Numbers of Key Researchers**
Engineer	
Chemist	
Physicist	
Environmental Scientist	
Mathematician	
Social Scientist Botanist	
Zoologist	
Economist	
Geologist	
Other (specify)	

25. Participation of external persons/bodies within your R&D programme: (Indicate organisation and number of persons for the current year):

Name of Organisation	**Number of people**

26. Energy R&D Human Resources within your organisation:

Qualification	**Male**	**Female**
N.diploma		
M-Tech		
BTech		
B-degree		
M-degree		
PhD Research assistants		
Technical assistants		
Other		

27. Development of Energy R&D Human Resources of your staff:

Enrolled for further studies	Male	Female	Of these how many are previously disadvantaged individuals
N.diploma			
M-tech			
B-Tech			
B-degree			
M-degree			
PhD			
Research assistants			
Technical assistants			
Other			

28. Please indicate the % funding for further studies:

Type of Funding	%
Funded by individual	
Company in private sector	
Company in public sector	
University	
Government department	
Other government body (NRF) Other (Specify)	

29. Indicate Number of employees that are studying full-time or part-time in an energy R&D related discipline:

Institution	No. of students	
	Full-time	Part-time
University		
Technikon		
Technical College		
Overseas Institution		
Other (Specify)		

30. Additional comments pertaining to the outlined key features of CoEs:

____