NATIONAL COMMISSION FOR SCIENCE AND TECHNOLOGY

(MALAWI)

NATIONAL RESEARCH AGENDA IN ENERGY, INDUSTRY AND ENGINEERING

(2014 – 2019)

`A nation with scientifically and technologically led sustainable growth and development'

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FOREWARD

The Government of Malawi (GoM) recognises the importance of science and technology for national socio-economic development. This is demonstrated by the existing S&T policy framework and the inclusion of Science and Technology as one of the priority areas in the MGDS II (2011-2016) which is an overarching development strategy for Malawi. Increased application of science, technology and innovation is the main route for the creation of additional wealth through increased productivity and competitiveness. Well coordinated research and development is the basis for increasing the stock of knowledge to devise and apply new technologies. The GoM has, therefore, developed this Research Agenda as a policy document that will govern research in the identified priorities areas in energy, industry and engineering covering from 2014 to 2019.

The GoM appreciates the diversity of needs and interests of different stakeholders in research in the areas of energy, industry and engineering. However, stakeholders are expected to take deliberate steps to conduct and support research in the identified priority areas during the implementation of this Research Agenda.

The GoM will also endeavor to channel resources to support research in the set priority areas. A special appeal is however being made to all co-operating partners, Non Government Organisations and private sector to complement government's efforts in supporting research in the identified priority areas.

ACKNOWLEDGEMENTS

The development of the Research Agenda in Energy, Industry and Engineering was a consultative process coordinated by the National Commission for Science and Technology (NCST) through the National Committee on Energy, Industrial and Engineering Sciences (NCEIES). The composition of NCEIES is shown in **Annex 1.**

The NCST would therefore, like to acknowledge the efforts and contributions of all stakeholders, so numerous to mention, towards the development of the research agenda. Special, heartfelt gratitudes are extended to the following organizations and individuals.

The Drafting Committee

The drafting committee was responsible for the analysis of data, prioritization of the research areas, drafting the Research Agenda and also served as an editorial team. The list of members is shown in **Annex 2**.

Stakeholders

Various institutions which were consulted and provided information that assisted in identifying and prioritizing the research areas. Stakeholders also critically reviewed the draft research agenda and their input was duly incorporated into the final document.

NCST Management and Staff

The former Director General (Dr. Henderson M. Chimoyo), the Director General (Mrs. Gift Kadzamira), management and staff of NCST for their input, guidance and support rendered during the development process of the Research Agenda.

Mr Hambani Gausi also deserves thanks for proof reading the document.

ACRONYMS AND ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
EHP	Essential Health Package
GoM	Government of Malawi
HIV	Human Immunodeficiency Virus
ICT	Information and Communication Technology
ERP	Economic Recovery Plan
MGDS	Malawi Growth and Development Strategy
MGDS II	Malawi Growth and Development Strategy II
NES	National Export Strategy
M&E	Monitoring and Evaluation
NCEIES	National Committee on Energy, Industrial and Engineering Sciences
NCST	National Commission for Science and Technology
NGOs	Non Governmental Organisations
NRAEIE	National Research Agenda in Energy, Industry and Engineering
NSTP	National Science and Technology Policy
R&D	Research and Development

1 INTRODUCTION AND BACKGROUND INFORMATION

In Malawi, research and development (R&D) in the fields of energy, industry, engineering and related areas is principally carried out by public R&D institutions which are mainly funded by government. These institutions include University of Malawi (The Polytechnic and Chancellor College), Mzuzu University, Lilongwe University of Agriculture and Natural Resources, Malawi Industrial Research and Technology Development Centre, Malawi Bureau of Standards, and Department of Agriculture Research Services (Chitedze Research Station).

1.1 Challenges Affecting Research and Development Activities

R&D activities in Malawi are however faced with a number of challenges. These challenges have resulted into low levels of R&D output and have adversely affected the socio-economic development of the country. The main challenges affecting R&D activities in Energy, Industry and Engineering include:

1.1.1 Limited Human and Financial Resources

Most of the R&D institutions working in the areas of energy, industry and engineering have inadequate numbers of qualified staff to carry out research as revealed by the high rate of vacant positions which exist in these institutions. Other challenges faced by these institutions include inadequate financial resources for research and training, brain drain of qualified staff and in some cases lack of managements' commitment to promote research and development.

1.1.2 Inadequate Infrastructure Capacity

Most R&D institutions do not have appropriate facilities including laboratories and workshops for carrying out research and development. Where laboratories and workshops exist; they are in poor condition, lack critical research equipment or are old and obsolete. R&D activities require state of the art equipment which is often very expensive and therefore becomes difficult for these institutions to acquire due to limited financial resources.

Information and Communication Technologies (ICTs) such as computers are available in most R&D institutions, however they are inadequate. In addition these institutions have poor internet and intranet connectivity, lack important technical software exacerbated by lack of proper information archiving and sharing within and outside the institutions. Knowledge acquisition is also restricted due to limited access to renowned databases of technical and academic research papers. Consequently researchers are unable to access relevant and up-to-date information on particular areas or subjects.

1.1.3 Low Knowledge Generation and Research and Development Productivity

Knowledge generation and research productivity, technology development and commercialisation of research results in the Energy, Industry and Engineering sectors are very low. This is mainly due to lack of collaboration amongst institutions; inadequate dissemination forums for research results; lack of mechanisms to commercialise research results; lack of systems to incentivize researchers and

research institutions to share research findings and possible research ideas; and lack of adequate laboratory space, equipment and software. As a result, relevant information is not readily available to stakeholders.

1.1.4 Limited Institutional Collaboration and Partnerships

Collaboration and partnerships between the private sector and government, donor community and researchers or research institutions is very limited to facilitate proper implementation of research projects both locally and internationally. This has resulted into different R&D institutions being involved in similar research and development activities. Duplication of efforts and conducting of research on obvious issues have a negative impact on the utilisation of scarce resources, In addition research and development activities undertaken are not necessarily demand driven.

2 RATIONALE

This Research Agenda represents nationally set and agreed priorities in Energy, Industry and Engineering in which research efforts for Malawi will be concentrated over the next five years. The development of R&D priority areas will therefore ensure that;

- Human resource training and development; and infrastructure capacity development efforts in R&D in Energy, Industry and Engineering are geared towards the priority areas;
- Research and development activities are commissioned, conducted and funded with alignment to national priorities;
- Links between research, action and policy are reinforced;
- R&D institutions/ researchers are made aware of the R&D needs of the country; therefore concentrating their efforts in addressing these needs; and
- Collaboration and partnerships between the private sector, government and donor community and researchers or research institutions are enhanced for the implementation of research projects both locally and internationally.

3 POLICY, REGULATORY, AND INSTITUTIONAL FRAMEWORK

R&D priority areas were selected with due consideration to the MGDS II (2011 - 2016); the Science and Technology Act (2003); National Science and Technology Policy (2002); the vision of the government of transforming the country from a predominantly consuming and importing economy to a predominantly producing and exporting economy; and views of relevant stakeholders consulted.

3.1 The Malawi Growth and Development Strategy II (2011 – 2016)

The Malawi Growth and Development Strategy II (MGDS II) is the current overarching development strategy for Malawi. It is an operational medium-term strategy designed to attain Malawi's Vision 2020. The objective of MGDS II is to continue reducing poverty through sustainable growth and infrastructure development following the successful implementation of the MGDS I between 2006 and 2011. The MGDS II identifies nine key priority areas drawn from six themes with the aim of sustaining and accelerating economic development within a short period of time, and with the available resources. The key priority areas are: Agriculture and Food Security; Transport Infrastructure and the Nsanje Inland Port; Energy, Industrial Development, Mining and Tourism; Education, Science and technology; Public Health, Sanitation, Malaria and HIV and AIDS Management; Integrated Rural development; Greenbelt Irrigation and Water Development; Child Development, Youth Development and Empowerment; and Climate Change, Natural resources and Environmental Management.

3.2 The Economic Recovery Plan

During the first year of the implementation of the MGDS II, Malawi faced a number of macroeconomic challenges which included reduced disposable incomes due to poor tobacco revenues, severe scarcity of foreign exchange, and persistent power disruptions. The severe foreign exchange shortages had a negative impact on imports of strategic commodities including fuel and industrial raw materials. Government, therefore, developed the Economic Recovery Plan (ERP) which focused on immediate policy reforms; and short and medium term measures that would bring quick wins to the economy. In the medium term the ERP will ensure that energy generation and supply, transport infrastructure and export diversification are addressed quickly. Tourism, mining, manufacturing, commercial farming, agro-processing and Information Communication Technology (ICT) were identified as the focus areas to assist in generating the desired foreign exchange earnings.

3.3 The Science and Technology Act (2003)

The Science and Technology Act No. 16 of 2003 provides for the advancement of science and technology; the establishment of the National Commission for Science and Technology and the establishment of the Science and Technology Fund amongst others. The S&T Act mandates the National Commission for Science and Technology to:

- Advise Government and other stakeholders on all science and technology matters in order to achieve a science and technology-led development
- Chart out national direction and establish national priorities in science and technology development in relation to socio-economic development needs
- Appraise, review, monitor and evaluate priority research and development programmes, plans and projects of R&D institutions and undertake independently or in collaboration with appropriate person, body or institution surveys and research investigations considered necessary.

3.4 National Science and Technology Policy (NSTP) (2002)

The promulgation of the National Science and Technology Policy (NSTP) underscores the important role Malawi attaches to the development and application of science and technology in socio-economic development of the country. It also recognises that developed countries maintain their leadership positions in socio-economic development mainly due to their strength in scientific and technological capabilities. Developing countries on the other hand are poor mainly due to low productivity caused largely by the low scientific and technological capabilities. They lack ownership of the factors and means of development; hence they acquiesce to positions advanced by donors and other development partners regarding accumulation of national capabilities. In Malawi, this is manifested by lack of competitiveness owing to the lack of change in the structure of the economy.

The National Science and Technology Policy is consistent with other sectoral policies in advocating for the advancement of Science and technology for the socio-economic development of the country through:

- Ensuring adequate and sustained supplies of energy for continued economic growth and development;
- Shifting the country's economy from predominantly consuming and importing to predominantly producing and exporting;
- Ensuring that every Malawian has equitable access to basic needs and services at an affordable cost for sustainable development, social and economic welfare, and prosperity of the people of Malawi;
- Facilitating the increase and overall productivity of the agriculture sector through irrigation and mechanisation amongst others;
- Promoting the efficient utilization and management of natural resources in the context of sustainable development;
- Promoting and developing the construction industry; and
- Providing a coordinated transport environment that fosters a safe and competitive operation of commercially viable, financially sustainable and environmentally friendly transport services and enterprises.

3.5 The National Export Strategy (MNES)

Over the past 10 years exports have grown at a much slower pace than imports creating an unsustainable structural trade deficit that leaves Malawi vulnerable to aid and foreign exchange shocks. The NES provides a clearly prioritised road map for building Malawi's productive base to generate sufficient exports to match the upward pressure on imports. The NES targets to raise exports as a share of imports from 51.5 percent in 2010 to 75.7 percent in 2017 and 93.4 percent in 2022.
Specifically, the NES seeks to:

- Develop three priority clusters namely oil seed products, sugar cane products and manufacturing and also support existing export clusters (tobacco, mining, tea, tourism, services) in which Malawi can compete and that have strong economic spillovers, thus allowing for the diversification of exports; and
- Improve the enabling environment for the productive base such that investment growth may increase in the productive sectors (including domestic and foreign direct investment into the production of competitive goods and services for export) and the enabling sectors (or those necessary to address supply-side constraints, such as energy, finance and transport).

4 GOAL AND OBJECTIVES

The overall goal of the National Research Agenda in Energy, Industry and Engineering is to guide researchers, technologists, policy makers, program implementers, academic institutions, development partners, investors and other stakeholders on R&D priority areas for Malawi in construction, transport, energy, mining, agro-processing, manufacturing, environment, climate change adaptation and mitigation, health and ICT in line with the national development agenda.

The specific objectives of this Research Agenda are to:

- Promote the conduct of research in Energy, Industry and Engineering that is responsive to the socio-economical development of the country;
- Promote multidisciplinary and collaborative research;
- Facilitate the mobilization of resources for the conduct of research that is relevant to local requirements or needs;
- Facilitate the coordination of research in Energy, Industry and Engineering conducted by various stakeholders;
- Promote the strengthening of capacity for conducting research in Malawi; and
- Facilitate the translation of research findings into policy and practice.

5 METHODOLOGY

Stakeholder consultations were carried out through questionnaires and interviews in order to identify R&D priority areas in energy, industry and engineering. The identified R&D priority areas were reviewed in order to come up with research questions. Gap analysis was performed and prioritisation of R&D areas was done. The, draft Research Agenda was then developed and circulated to stakeholders for feedback and validation.

5.1 Stakeholder Consultations

Stakeholder consultations were carried out to get views on research needs and ideas from both those involved in research and those who access and use research knowledge in policy development and practice.

Structured questionnaires were used to identify areas of research and development in energy, industry and engineering that are relevant for the social-economic development of the country. The questionnaires were administered to stakeholders electronically and in hard copies followed by face to face interviews wherever necessary. Stakeholders comprised research and development institutions, universities, government departments, private sector organizations and public institutions amongst others.

5.2 Review of Identified R&D Areas and Formulation of Research Questions

A task team comprising members from the National Committee on Energy, Industry and Engineering Sciences (NCEIES) was put in place to appraise responses from stakeholders consulted. .

The task team accomplished the following:

- Reviewed all submissions and scrutinized the list of R&D areas as identified by stakeholders for consistency and alignment to the MDGS II, the Economic Recovery Plan, the National Science and Technology Policy and the National Export Strategy;
- Consolidated the R&D areas identified by stakeholders; and
- Formulated research questions from the identified R&D areas.

5.3 Prioritisation of R&D Thematic Areas and Activities

Prioritisation of the R&D thematic areas as well as activities within each thematic area was done to ensure that the limited resources (personnel, finance, time, infrastructure etc) should be focused on those issues that are deemed most critical to the socio-economical development of the country and practical to address.

Each of the identified research area was analysed according to a five point criteria as follows:

a. Appropriateness (Should the research be done?)
b. Relevancy (Why should the research be done?)
c. The chance of success (Can the research be done?)
d. Impact of the research outcome (What do the stakeholders benefit from the research?)
e. Level of innovation of the research (How innovative is the research?)

Each of the identified priority areas was scored against the above mentioned criteria on a scale of 0-3 and ranked accordingly. Any research area that scored more than 10 from a maximum score of 15 was prioritized.

5.4 Drafting of the Research Agenda

A team comprising members of the NCEIES drafted the Research Agenda and also served as an editorial team. The list of members is shown in Annex 2.

5.5 Stakeholders Consultation

The draft Research Agenda was circulated electronically to key stakeholders for their input and comments which were later incorporated into the final document.

6 PRIORITY AREAS OF RESEARCH AND DEVELOPMENT IN ENERGY, INDUSTRY AND ENGINEERING

The key R&D priorities identified in the Energy, Industry and Engineering sectors in Malawi, have been organised into 12 thematic areas and include Construction; Transport and Transport Infrastructure; Agro-processing; Manufacturing; Mining; Energy; Environment; Agriculture and Irrigation; Water and Sanitation; Climate Change Adaptation and Mitigation; Health; and Information and Communication Technologies (ICTs).

6.1 Construction

Good housing and other physical infrastructure contributes to economic growth and poverty reduction. It adds to the reduction of the health burden from infectious and parasitic diseases and accidents. It also provides security to both humans and assets and is a large asset base and a source of income. However, the building and construction sector faces a number of challenges such as; effects of natural disasters (earthquakes, flooding, heavy winds etc) on buildings; reliance on imported and/ or expensive building materials; use of environmentally unsustainable building materials; and high energy demands.

6.1.1 Objective

To increase access to decent and sustainable buildings and other physical structures by developing and promoting the use of sustainable construction materials and practices.

6.1.2 Prioritized areas of research and development

- Prediction and assessment of the effects of natural disasters (such as earthquakes, tremors, flooding etc) on buildings and other physical structures including production of geo-hazard zonation maps; and development and promotion of low cost early warning systems;
- Adoption, development, optimisation and promotion of construction materials and practices to minimize impacts of natural disasters (such as earthquake/ tremor, flooding etc);
- Assessment, development and promotion of alternative construction materials (to replace cement; burnt bricks; corrugated iron; wood; etc) and practices that are sustainable and affordable without compromising on quality, durability and safety;

- Assessment, development and promotion of low cost multi-storey structures to maximize on the use of space without compromising on durability and safety; and
- Assessment, development and promotion of low cost and low energy intensity and low greenhouse gas emission processes for production of building materials and construction technologies.

6.2 Transport and Transport Infrastructure

An efficient and sustainable transportation system provides better connectivity to local, regional and international markets and promotes competitiveness of products. A reliable transportation system reduces cost of production and marketing of goods and services through, among other things, reduction in lead times. Furthermore, the provision of high quality and affordable transport improves access to social services such as education, health, markets and communication facilities. Thus investment in the transport system plays a major role in socio-economic development.

Despite notable improvements made to the transport system; there are critical issues that are negatively impacting on the performance of the transport sector, which include: high construction costs; inadequate investment in construction machinery; reliance on imported and expensive vehicles and fuels; congestion of roads especially in urban areas; impact of transport emissions onto the environment; high transport costs; poor condition of most ports; poor condition of most feeder roads especially in rural areas; poor condition of railway infrastructure; ageing fleet of water vessels and a declining airline industry.

6.2.1 Objective

To ensure a safe, affordable, competitive, accessible, high quality and sustainable transport system.

6.2.2 Prioritized areas of research and development

- Assessment, development and promotion of road construction materials;
- Improvement, optimization and management of transport systems (rail, road, water and air) to reduce transportation costs and improve efficiency and competiveness;
- Assessment, adoption, development and promotion of vehicles and hybrids that use alternative fuels such as ethanol, biogas and electricity;
- Improvement of fuel efficiency and development of alternative fuels; and
- Assessment of emissions from the transport sector.

6.3 Agro-processing

Malawi's economy is agro-based and agro-processing has potential to contribute effectively to the country's economic growth. However, most of Malawi's agricultural products are mainly traded as primary commodities partly due to poor and inadequate supportive infrastructure, low level of vocational skills, weak marketing and distribution systems, low levels of technology development and adoption and low investment in agro-processing.

6.3.1 Objective

To ensure upstream integration of key agricultural products in the value chain and increase agro-processed products for both domestic and export markets.

6.3.2 Prioritized areas of research and development

- Assessment, adoption, development, optimisation and promotion of handling, storage and transport systems for perishable products to prolong shelf life;
- Assessment, adoption, development, optimisation and promotion of agro-processing equipment and other technologies to promote value addition of agriculture products for both local and export markets and;
- Assessment, adoption, development, optimisation and promotion of agro-processing technologies to improve productivity and quality in order to promote competitiveness at both local and international markets;

6.4 Manufacturing

The development of industries is an integral part of a nation's economic growth and development. Manufacturing is key to the attainment of the country's aspiration of transforming from predominantly importing and consuming to producing and exporting. Currently, the manufacturing sector contributes about 11 percent to the GDP but has high potential of contributing more. However; Malawi's industry is facing a number of challenges such as low industrialization, poor quality and quantity of raw products/materials, high transport costs and unreliable energy supply (poor supportive infrastructure) leading to low industrial output, narrow industrial base, and low levels of value addition.

6.4.1 Objectives

To promote industrialization, value addition, industrial productivity and efficiency; and to promote the use of modern technologies in manufacturing in order to enhance competitiveness of Malawian products at local and international markets.

6.4.2 Prioritized areas of research and development

- Assessment, adoption, development, optimisation and promotion of metal reuse/ recycle technologies from locally available materials/ waste materials for import substitution, costs reduction and promotion of industrialisation;
- Assessment, adoption, development, optimisation and promotion of plastic production/ reuse technologies from locally available materials/ waste materials for import substitution, reducing costs and promoting industrialisation;
- Assessment, adoption, development, optimisation and promotion of technologies for processing of locally available materials (minerals, wood, clay, limestone, sand etc) for import substitution;
- Assessment, adoption, development, optimisation and promotion of low cost, and low energy/ energy efficient technologies;

- Assessment, adoption, development, optimisation and promotion of alternative fueled vehicles (battery/electric, gas, fuel cells, solar, biofuels, biogas) to petroleum fueled vehicles to reduce the reliance on imported fuels; and contribute to the improvement of the environment and reduction of greenhouse gases;
- Assessment, adoption, development, optimisation and promotion of production/ manufacturing facilities; technologies; and practices for local and international accreditation to promote trade; and
- Adoption, development, optimisation and promotion of process improvement technologies and practices (labour saving technologies, maintenance programmes, use of low cost materials, waste minimisation, process control etc) to improve quality, efficiency and productivity; and reduce production costs hence producing goods and services that are competitive locally and internationally.

6.5 Mining

Malawi has abundant mineral resources that can be exploited. These resources include bauxite, heavy mineral sands, monazite, coal, uranium, precious and semi-precious stones, limestone, niobium, dimension stones and rock aggregates. However, the mining industry is not fully developed and as a result the minerals are not fully exploited. The development of the mining industry therefore, can significantly improve the country's foreign exchange earnings and contribute to economic growth and development.

6.5.1 Objective

To increase countrywide geological mapping, exploration, production, and value addition of mineral resources.

6.5.2 Prioritized areas of research and development

- Assessment, development, optimisation and promotion of low cost technologies and practices for small-scale sustainable mining;
- Preliminary assessment and quantification of mineral resources;
- Development and promotion of sustainable exploitation of mineral resources; and
- Assessment, development, optimisation and promotion of technologies and practices for local processing/ value addition of minerals.

6.6 Energy

A well-developed and efficient energy system is vital for the social-economic development of any country. Access to modern energy services contributes to high economic activity and productivity, high quality of life and encourages new investments across the country particularly in the sectors such as mining and manufacturing. However, the energy sector in Malawi continues to face a number of

challenges. The capacity to generate electricity is inadequate resulting in frequent blackouts and brownouts.

The transport sector in Malawi heavily relies on energy derived from petroleum products which are imported and at times the country experiences shortages of liquid and gas fuels due to logistical and foreign exchange problems. Furthermore, only 7 percent of the population is connected to the national electricity grid and therefore the majority of the population has to rely on biomass fuel for cooking, tobacco curing, lumber extraction and brick burning. However, biomass resources are diminishing and difficult to source due to rapid population growth, climate change and deforestation. In addition, use of traditional cooking methods lead to incomplete combustion of the fuelwood and high levels of indoor air pollution. Therefore there is need to improve supply of electricity, liquid fuels and biomass, promote alternative sources of energy and energy efficiency.

6.6.1 Objective

To improve capacity and efficiency in energy generation, transmission, distribution and utilisation to meet national socio-economic demands sustainably and contribute to improved human health, climate change mitigation and adaption.

6.6.2 Prioritized areas of research and development

6.6.2.1 Non Renewable energy

- Assessment, adoption, development, optimization and promotion of co-combustion (coal combustion and biomass co-combustion etc) technologies for electricity generation and industrial processing;
- Assessment, adoption, development, optimization and promotion of coal conversion technologies for production of diesel fuel;
- Assessment, adoption, development, optimization and promotion of waste plastic conversion technologies for production of fuel oil;
- Assessment, adoption, development, optimization and promotion of coal resources and combustion technologies for electricity generation, industrial processing and household use; and
- Assessment of utilization of nuclear energy.

6.6.2.2 Renewable energy

- Assessment of the effectiveness of the implementation and sustainability of renewable energy projects and systems;
- Assessment of the impacts of biofuels on food security and their social feasibility and sustainability;
- Adoption, development, optimization and promotion of biofuels production and utilisation technologies as alternatives to firewood, charcoal and petroleum fuels;

- Assessment, adoption, development, optimization and promotion of biogas, solid biomass, wood gas and landfill gas production and utilisation technologies for electricity generation, heating, cooking and bio-fertiliser production;
- Adoption, development, optimization and promotion of solar energy (photo-thermal, photovoltaic) technologies for electricity generation, water pumping, process heating, cooking and process drying at all levels (household, community, industrial etc);
- Adoption, development, optimization and promotion of wind power technologies for electricity generation and water pumping to increase and improve energy generation;
- Adoption, development, optimization and promotion of alternative energy sources/ technologies for heating, brick burning and cooking in order to reduce the over dependence on wood fuel and charcoal for both rural and urban communities;
- Adoption, development, optimization and promotion of hybrid energy systems (water/ wind/ solar/ geothermal/ and biomass) and energy technologies to increase and improve energy generation;
- Adoption, development, optimization and promotion of mini and micro hydro power technologies for electricity generation in order to increase and improve energy generation;
- Assessment, adoption, development, optimization and promotion of waste (agricultural, household, industrial, municipal, bagasse, forest etc) to energy technologies for electricity generation and process heating to increase and improve energy generation; and
- Adoption, development, optimization and promotion of geothermal energy production and utilisation technologies for electricity and process heat generation.

6.6.2.3 Energy efficiency and conservation

- Assessment of various energy generation, distribution, and utilization systems and strategies (off grid, communal, grid, regional interconnectivity etc);
- Adoption, development, optimisation and promotion of electrical energy efficiency technologies and practices during production, transmission, distribution and utilisation at all levels (household, transport, agricultural and industrial);
- Adoption, development, optimisation and promotion of energy efficiency technologies and practices for cooking, heating and drying (efficient cookstoves and solar energy) at all levels (household, community and industrial); and
- Adoption, development, optimisation and promotion of fuel efficiency technologies and practices during transportation and utilisation at all levels (household, transport, agricultural and industrial).

6.7 Environment

Natural resources and environment play a significant role in influencing social and economic development in Malawi. Approximately 80 percent of the country's population depends on natural resources for their subsistence and household income. However, increasing population growth coupled with high poverty levels have led to an increase in exploitation of natural resources. Inadequate

alternative livelihoods, unaffordable energy technologies and uncoordinated policies have exacerbated environmental degradation leading to social and economic consequences.

6.7.1 Objective

To ensure sustainable management and utilization of the environment and natural resources through promotion of the development and use of environmentally friendly technologies and practices.

6.7.2 Prioritized areas of research and development

- Development, improvement, optimization and promotion of pollution prevention and control, cleaner production, and resource utilisation technologies and practices;
- Assessment, development, improvement, optimization, and promotion of sustainable waste management (waste management hierarchy: avoidance, reduction, reuse, recycling and disposal) technologies and strategies including resource recovery;
- Assessment of environmental degradation and development, improvement, optimization and promotion of technologies for rehabilitation of the degraded environment and minimisation of environmental degradation;
- Development of methodologies for assessment of trees resources;
- Development and promotion of simple and environmentally sound timber harvesting technologies to minimize workload, occupational accidents, environmental damage and logging and sawmill wastes; and
- Assessment of environmental problems and development of mitigation measures to promote cleaner and greener environment.

6.8 Agriculture and Irrigation

Agriculture is key to food security, economic growth and wealth creation. However, the sector faces a number of challenges such as over dependence on rain-fed farming, failures in technology development and transfer, low absorption of improved technologies, poor support infrastructure, climate change effects, low level of irrigation development, pre-harvest and post-harvest losses, and lack of investment in mechanization.

6.8.1 Objectives

To increase agricultural production and productivity; and to reduce pre-harvest and post-harvest losses.

6.8.2 Prioritized areas of research and development

- Adoption, development, optimisation and promotion of alternative fertilizer technologies using locally available resources to reduce the reliance on imported and expensive chemical fertilizers (through use of organic fertilizers);

- Adoption, development, optimisation and promotion of technologies for loss reduction, improvement of quality, preservation and marketability of crop products;
- Adoption, development, optimisation and promotion of sustainable agricultural waste technologies for resource recovery;
- Assessment, adoption, development, optimisation and promotion of irrigation technologies and practices to increase the efficiency and share of irrigation in the agriculture system;
- Adoption, development, optimisation and promotion of technologies to improve agriculture productivity and production at household and industrial levels; and
- Assessment, adoption, development, optimisation and promotion of farm implements/ equipment for small scale farmers.

6.9 Water and Sanitation

Water is a fundamental catalyst for energy generation, agriculture, health, industrial development, climate change, natural resources and environmental management, health, tourism, fisheries and other socio-economic developments. Improved water supply and sanitation services have a direct impact on lives of communities especially women and children by reducing the burden of water carriage for households and reduction of waterborne and other related diseases. In recent years, access to potable water has improved throughout the country and tremendous progress has been made in achieving universal access to basic sanitation as compared to many other sub-Saharan countries.

Despite these achievements, there are considerable challenges facing the country. These include relatively low access to potable water, low access to running water, aging infrastructure, inadequate maintenance capacity, low access to improved sanitation, inadequate sewer facilities, unsystematic disposal of liquid, solid and other forms of waste, inadequate capacity to manage sewer facilities and inability to separate organic and inorganic components of waste to facilitate composting.

6.9.1 Objective

To improve accessibility to water and improved sanitation facilities through the development and promotion of appropriate technologies with special attention to the needs of the poor, women, children, and other vulnerable/ marginalised groups.

6.9.2 Prioritized areas of research and development

- Assessment, adoption, development, optimization and promotion of water saving and water recycling technologies at household, industrial and agricultural levels;
- Assessment, adoption, development, optimization and promotion of rainwater harvesting technologies for household, industrial and agricultural use;
- Assessment, adoption, development, optimization and promotion of low cost water processing technologies for household, industrial and agricultural use;

- Assessment, adoption, development, optimization and promotion of low cost sustainable wastewater treatment technologies for resource recovery and costs reduction;
- Assessment, adoption, development, optimization and promotion of technologies and practices that can reduce vandalism of water and sanitation infrastructure;
- Assessment, adoption, development, optimization and promotion of low cost sustainable sanitation options, with special attention to the needs of the poor, women, children and other vulnerable/ marginalised groups; and
- Assessment, adoption, development, optimization and promotion of low cost water lifting technologies for household, industrial and agricultural use.

6.10 Climate Change Adaptation and Mitigation

Malawi experiences a number of adverse climatic hazards such as prolonged dry spells, droughts, unpredictable rainfall patterns, floods and increased temperatures. Climate change effects result in loss of human and animal life; compromised water quality leading to diseases such as diarrhoea, cholera and malaria; and infrastructure loss. In addition, effects of climate change have adverse impacts on agriculture, fisheries, wildlife, gender, energy, education, health, and forestry. It is estimated that in 1992 drought reduced the country's maize production by 60 percent of its normal year production bringing about a 10 percent reduction in the country's GDP.

6.10.1 Objective

To enhance resilience of communities to climate change risks and impacts through the development and implementation of appropriate climate change mitigation and adaptation programmes and actions.

6.10.2 Prioritized areas of research and development

- Assessment, adoption, development, optimisation and promotion of carbon sequestration technologies in all sectors to reduce the overall quantities of greenhouse gases released into the atmosphere;
- Assessment, adoption, development, optimisation and promotion of environmentally friendly/ alternative technologies to replace technologies that have large carbon foot-print;
- Assessment of the impact of climate change and natural disasters on the country's overall economy and general livelihood;
- Assessment, adoption, development, optimisation and promotion of measures for mitigation and adaptation of the impact of climate change; and
- Assessment, adoption, development, optimisation and promotion of measures for mitigation and adaptation of natural disasters.

6.11 Health

A health population is necessary for a country to achieve sustainable economic growth and development. Malawi has registered a number of achievements in the health sector such as reduction in infant mortality rate, maternal mortality rate, malaria in-patient case fatality, and HIV prevalence. Despite these achievements, the country still faces a number of challenges including high prevalence of preventable diseases, high mortality rates, high prevalence rate of HIV, limited access to maternal health services, inequitable access and utilization of Essential Health Package (EHP) services, inefficiency of health care system, inadequate supply of essential drugs, and inadequate health infrastructure.

6.11.1 Objective

To contribute towards improved delivery of health services and health delivery technologies thereby attaining a health population for increased productivity and economic growth.

6.11.2 Prioritized areas of research and development

- Assessment, adoption, development and promotion of beneficial technologies and practices for effective and efficient health services delivery with emphasis on rural areas;
- Assessment, adoption, development and promotion of ICT to enhance health services delivery;
- Assessment, adoption, development and promotion of drug/ medicine/ medical equipment manufacturing technologies;
- Assessment of impacts on health of the different technologies (energy, industrial, agriculture, infrastructure etc);
- Assessment, adoption, development and promotion of beneficial technologies for the screening, prevention; diagnosis; and treatment, of both communicable and non-communicable diseases;
- Assessment of levels of exposure to radiation emissions from hospital equipment; and
- Calibration of hospital equipment

6.12 Information and Communication Technology (ICT)

Information is a vital resource for all human kind throughout all stages of life. It is therefore important that information should be made available in a form that is applicable and usable, and at the right time. Use of ICT enhances the production, transportation and provision of information to the general public for human development as well as for making informed decisions. Well developed information and communication technology system, is essential for the development of a country.

Despite notable achievements made in this sector; the sector still faces a number of challenges. These include low usage and adoption of electronic and online services, high communication costs, high printing costs, lack of coordination and collaboration on ICT infrastructure development, intermittent availability of service, low geographic coverage and low local content in terms of provision of information.

6.12.1 Objectives

To increase utilization of ICT products and services with particular attention to rural and underserved communities; and to improve delivery of services.

6.12.2 Prioritized areas of research and development

- Assessment, adoption, development, optimisation and promotion of technologies and practices to increase and improve usage and adoption of ICT in both rural and urban areas;
- Assessment, adoption, development, optimisation and promotion of low cost technologies and practices to increase and improve geographical coverage of ICT services;
- Assessment, adoption, development, optimisation and promotion of technologies and practices to increase and improve usage and adoption of ICT in agriculture, education, marketing, energy, health, natural resource management, disaster management etc; and
- Assessment, adoption, development, optimisation and promotion of technologies and practices to reduce the cost of ICT services and contribute to poverty reduction.

7 IMPLEMENTATION STRATEGIES

It is important that all stakeholders (government, R&D institutions, private sector, NGOs and all interested parties) be actively involved in order for the Research Agenda to be effectively implemented. Some of the strategies put in place for the effective implementation of the Research Agenda are:

- R&D institutions to incorporate the identified R&D priority areas of the Research Agenda in their R&D programmes;
- Funding priority be given to R&D projects in the identified R&D priority areas;
- R&D teams for specific priority areas be formulated comprising researchers from different institutions and different areas of expertise to enhance collaboration and knowledge sharing.

A detailed action plan with budget is shown in **Annex 1**.

8 FINANCING MECHANISM OF THE RESEARCH AGENDA

Financing of research and development in the identified priority areas is critical for the realization of the goal and objectives of this Agenda. Stakeholders are, therefore, urged to support financially or otherwise, research and development which is geared towards addressing priorities outlined in the Agenda. The following financing mechanisms shall be pursued.

8.1 Research Grants Scheme

The NCST through the Science and Technology Fund shall commit direct resources at various levels to support the undertaking of research and development in the identified priority areas.

Researchers and all other stakeholders wanting to undertake research in the identified priority areas shall be encouraged to take advantage of existing national and international research grant schemes which are occasionally advertised. This shall be carried out through the development of R&D proposals which shall be submitted to prospective funders (government, private sector, international organisations, NGOs etc).

8.2 Public and Private Partnerships

Public and private partnerships shall be an important vehicle for nurturing resource mobilization for research in the priority areas. Promotion of partnerships between R&D institutions and private sector/ users of R&D results shall be vital to attract research funds in areas of mutual interest. Efforts in cultivating a culture of corporate social responsibility to support the financing of R&D in the priority areas at various levels shall be promoted.

8.3 Other financing mechanisms

R&D institutions shall make deliberate efforts to:

- Allocate funding for R&D activities in the priority areas.
- Strengthen capabilities in searching, identifying and sharing of information on all potential sources of funds for research and development across the world to enhance access to and use of international research funding possibilities; and
- Engage in activities that will build capacity in proposal writing and research skills that will attract funding.

9 DISSEMINATION OF RESEARCH AND DEVELOPMENT FINDINGS

Researchers shall ensure that R&D results are communicated to a wider audience beyond the research community. Reporting of research and its results shall be the responsibility of every researcher and the research institution. The responsibility may be delegated to either the sponsor or any individual upon mutual agreement. Research and development communication shall entail expressed commitment to publish or disseminate the results within a specified period.

It is incumbent upon research institutions to promote multifaceted and comprehensive research communication to achieve high quality research dissemination. Institutions conducting research shall have a responsibility of disseminating research results to ensure that the results reach end-users. The researchers have a responsibility of publishing and organizing events for dissemination of research results.

All approved research studies shall have a component on dissemination of results and shall be budgeted for. Institutions shall also be required to establish budget lines for dissemination of research results. The NCST shall establish research data banks and repositories and compile annual directories of research in order to facilitate access and availability of research data and information for use by researchers, end-users and other relevant stakeholders.

The NCST shall ensure that research and development information is available for utilization at the national level by policy makers, communities, target populations, researchers and all other relevant stakeholders. It is, therefore, the intention of the National Research Agenda to stimulate interest that will generate research evidence in the identified priority areas.

10 COMMERCIALISATION OF RESEARCH RESULTS

Commercialization will translate the research results into new product and services which can either be exported or substitute imported products and improve existing products and services thereby creating employment, improving production and productivity. As a result this will contribute to the socio-economic development of the country as the economic status of more people will improve as they get employed; foreign exchange requirements for importation of goods and services will be reduced since imported goods and services will be replaced with locally produced goods and services; and foreign

exchange earnings for the country will improve as more goods and services will be exported. In addition by improving production and productivity Malawi will be able to produce goods and services which can effectively compete with those from other countries. It is therefore required to review various models on commercialisation that would be adopted; research projects to incorporate commercialisation of the research results; encourage R&D institutions to have innovation hubs and incubation centres which would take forward any research towards commercialisation; and enhancement of the relevant policies that promote commercialisation (Intellectual Property policy, Innovation Policy etc).

The NCEIES will therefore work with other committees of the Commission (such as the National Committee on Technology Transfer and Commercialization) and other relevant stakeholders to promote the commercialization of research results.

11 MONITORING AND EVALUATION OF THE IMPLEMENTATION OF THE RESEARCH AGENDA

Monitoring is a continuous assessment of project implementation in relation to agreed schedules, use of inputs, infrastructure and services provided by project beneficiaries. Evaluation is a periodic assessment of the relevance, performance efficiency and impact (both expected and unexpected) of the project in relation to stated objectives.

The tracking of the stakeholders' adherence to the Agenda shall be part and parcel of monitoring the implementation of the Agenda. The tracking will be done using tools and indicators as described below. This tracking shall benchmark the review of the Agenda.

11.1 Checklist for Submission of Project Proposals for Registration and Review

All R&D activities carried out shall be registered (both proposals and completed projects) with NCST. Checklists for submission of project proposals for registration with NCST and review by NCEIES shall contain an element of the study addressing any of the priority areas.

11.2 Monitoring and Evaluation (M&E) Reports

The NCEIES shall be supported by NCST in order to undertake inspections and M&E visits to registered R&D activities being conducted The NCEIES shall also be required to produce M&E reports after the visits.

11.3 Progress and Final Reports

The NCEIES shall ensure that progress reports of R&D activities undertaken in the priority areas are produced. Progress and final reports shall be submitted to NCST and R&D institutions that approved the study as per stipulated guidelines and standard operating procedures. At the end of each research study, a final report shall be deposited with the R&D institutions that approved the R&D activity with two copies submitted to NCST.

11.4 Database and Directory of Research and Development Activities

Database and directories of approved/ registered research and development activities carried out in the priority areas shall be compiled using final reports of R&D activities deposited with NCST and R&D institutions.

11.5 Review of the Agenda

This Agenda has a lifespan of five years. Informed by emerging issues in engineering, energy and industry, and the above stated indicators for tracking the stakeholders' adherence to the implementation of the Agenda, there would an evaluation after two years to coincide with the end of the MGDS II followed by a final review of the Agenda after five years.

12 LIST OF SOURCE MATERIALS

Report on Malawi's climate technology transfer and needs assessment under United Nations framework convention on climate change (UNFCCC)-expedited phase II - Environmental Affairs, Department, Ministry of Natural Resources and Environmental Affairs. Lilongwe, Malawi, March 2003

Economic Recovery Plan - Ministry of Economic Planning and Development; Malawi Government, Lilongwe, 2012

The Malawi Growth and Development Strategy II (2011-2016) - Ministry of Finance and Development Planning; Malawi Government, Lilongwe, 2011

The Science and Technology Act (2003)

Research Policy, Focus Areas, Guidelines and Regulations (Third Edition) - Directorate of Research and Postgraduate Studies, Sokoine University of Agriculture, Morogoro, Tanzania. ISBN 978 9987 640 98 0. August, 2010

National Export Strategy (2013 – 2018): Volume 1 - Ministry of Industry and Trade; Malawi Government, Lilongwe, December 2012

The National Science and Technology Policy (2002)

The National Health Research Agenda for Malawi - Ministry of Health, Lilongwe, Malawi, January, 2012

National Energy Policy - Malawi Government, Ministry of Energy and Mining, 2003, Lilongwe

ANNEX 1: List of Member Organisations for the National Committee on Energy, Industrial and Engineering Sciences (NCEIES)

i. University of Malawi (The Polytechnic)

ii. Malawi Industrial Research and Technology Development Centre

iii. Mzuzu University

iv. Malawi Institution of Engineers

v. Malawi Energy Regulatory Authority

vi. Malawi Confederation of Chambers of Commerce and Industry

vii. National Construction Industry Council

viii. Ministry of Energy

ix. Ministry of Transport and Public Infrastructure

x. Technical, Entrepreneurial and Vocational Education and Training Authority

xi. Ministry of Agriculture, Irrigation and Water Development

xii. Malawi Bureau of Standards

xiii. Lilongwe University of Agriculture and Natural Resources

xiv. Department of Agriculture Research Services (Chitedze Research Station)

xv. Department of Science and Technology

xvi. University of Malawi (Chancellor College)

Annex 2: List of Members of the Drafting Committee

i. Dr Moses Chinyama (Chairman)
ii. Mr. Welton Saiwa (Vice Chairman)
iii. Mr. John Taulo
iv. Mr. Emmanuel Mjimapemba
v. Dr. Hendrex Kazembe-Phiri
vi. Mr. Arthur Wengawenga
vii. Mr. Stephen Chalimba
viii. Mr. Macpherson G. Matewere
ix. Mr. Ebony Msikawanthu
x. Mr. Kondwani Thapasila Gondwe
xi. Mr. Joseph Kalowekamo
xii. Mr. Emmanuel Mkoma
xiii. Mr. Rex Kanjedza
xiv. Dr. Patsani Kumambala
xv. Mr. Albright Mchema
xvi. Mr. Victor Luwambala
xvii. Mr. Rodgers Banda
xviii. Mr. Caspah Kamunda
xix. Dr. Christopher Guta
xx. Mr. Chimwemwe Mtegha
xxi. Mr. Fredrick Wazingwa Munthali