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BIOENERGY DEVELOPMENT STRATEGY AND INVESTMENT PLAN FOR THE WEST AFRICAN REGION

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Acronyms

ABPP	Africa Biogas Partnership Programme
AfDB	African Development Bank
AUC	African Union Commission
BEST	Biomass Energy Strategy
CCHP	Combined Cooling Heating and Power
DFI	Development Finance Institution
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
ECOWAS	Economic Community of West African States
ECA	(United Nations) Economic Commission for Africa
GACC	Global Alliance for Clean Cooking (now Clean Cooking Alliance)
GHG	Green House Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German development agency)
IAP	Indoor Air Pollution
ICS	Improved Cookstove
ICC	Improved Charcoal Value Chain
IRENA	International Renewable Energy Agency
NDBP	National Domestic Biogas Program
NGO	Non Governmental Organisation
NPCA	NEPAD Planning and Coordinating Agency
PMU	Programme Management Unit
PPA	Power Purchase Agreement
PPO	Pure Plant Oil
RD&D	Research Development and Demonstration
RECs	Regional Economic Communities
SNV	Netherlands Development Organisation
SSA	Sub Saharan Africa

SVO	Straight Vegetable Oil
UNDP	United National Development Organisation
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
VAT	Value Added Tax
WACCA	West African Clean Cooking Alliance
WHO	World Health Organisation
WG	Working Group

1 Introduction and background

Like other regions of Sub Saharan Africa (SSA), the Economic Community of West African States (ECOWAS) faces many challenges as it strives to reduce poverty and improve the socio-economic well being of its population. One of the key challenges facing economic growth in the region is limited access to modern energy services and growing energy security challenges. The region faces widespread and unsustainable production and use of traditional biomass (firewood and charcoal). About 80% of the primary energy consumption comes from traditional biomass and over 90% of the population use wood and charcoal for domestic cooking. While biomass is an important energy resource in the region, its traditional use has many negatively impacts on ecosystems, health and the climate. For instance, WHO estimated that nearly 600 000 people died of indoor air pollution in Africa in 2012 (WHO, 2015).

However, there is potential for a transition to a more sustainable future, provided appropriate development pathways are identified, nurtured and supported by relevant policy and regulatory frameworks. Developing modern energy supplies, especially in support of rural development and transforming the agricultural sector by adding value to agricultural products and creating markets for rural farmers is a potentially transformative intervention in the region (World Bank, 2015; IRENA, 2015).

Fortunately, the ECOWAS region is endowed with significant biomass resources with which to produce food, fuel and fibre to feed its people and fuel its economic development. Thus, a strategy towards modernising biomass use is widely viewed as an important element of the transition to sustainability in the region. It is therefore important for the region to develop strategies to make this transition a reality and ensure access to modern energy services and improved livelihoods for its communities. These modern bioenergy technologies include more efficient and clean cooking technologies such as improved fuelwood cookstoves, bioethanol cookstoves and biogas systems; clean transport fuels such as bioethanol, biodiesel, biomethane, as well as heat and electricity. Already, some initiatives have been developed, demonstrated or rolled out in several countries in the region either at national level or as isolated projects with varying degrees of success and impact. The main thrust at regional level should be to facilitate the scale up of such technologies across the region to enable significant and widescale impact.

1.1 AUC Bioenergy Programme Background

This ‘Bioenergy Development Strategy and Investment Plan for the Western African Region’ commissioned by the African Union Commission (AUC) - in partnership with the UN Economic Commission for Africa (ECA) and the African Union Development Agency (AUDA-NEPAD) - is part of an on-going programme that supports the design of strategies to modernise the bioenergy in Africa. This programme to modernise the bioenergy sector in Africa has been undertaken through a consultative process spanning several years and involving a cross section of stakeholders and African Union Member States. Since its inception, the Bioenergy programme has developed studies with the aim of supporting African countries to implement policy and regulatory framework for bioenergy that support modernization of the bioenergy sector. Since 2011, the programme has systematically generated several outputs which have contributed towards capacity building and exchange experiences on some of the best practices on the African continent. These outputs have been systematically implemented to build capacity and also exchange experiences on some of the best practices on the African continent as shown in Figure 1. Key achievements of the to-date and include :

a) Policy Options for Bioenergy Energy Development in Africa (2011)
b) Technical and Economic Assessment of Biofuels in Africa (2011)
c) Africa Bioenergy Policy Framework and Guidelines (2013)
d) Seven Case Studies on Regulatory Reforms for Adoption of Biofuels Programmes in Cameroon, Ethiopia, Kenya, Mali, Mauritius, Rwanda, and South Africa (2015)

e) Mainstreaming Gender in Bioenergy Development
f) Localisation of Clean and Renewable Energy Technologies in Africa.

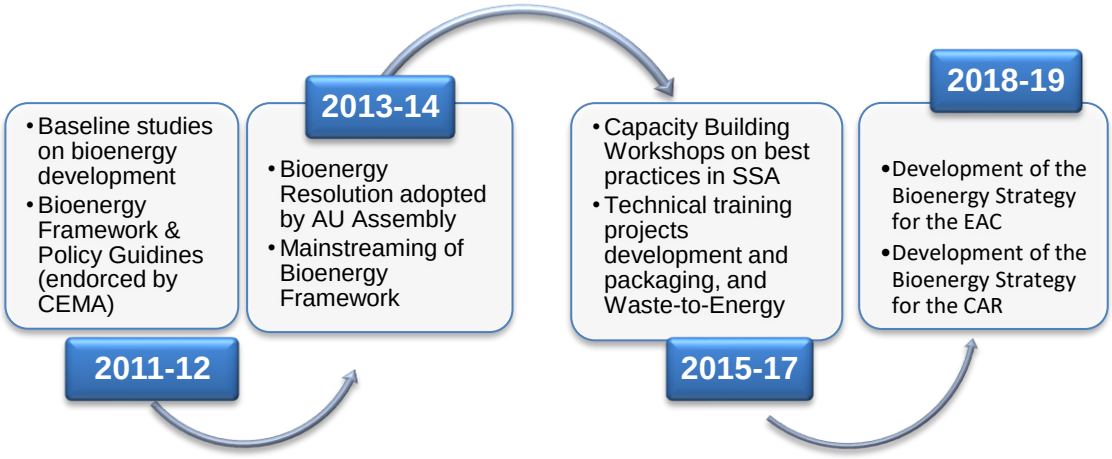

Figure 1: Programme activities to modernize the bioenergy sector in Africa

One of the most important policy guidance outcome of this process has been the development of the African Bioenergy Framework and Policy Guidelines in 2013. The purpose of the Framework is to (a) build consensus on shared framework that inspires and provides guidance to individual countries and regions in developing bioenergy policies and regulations; and (b) enhance awareness among African policymakers and the civil society about the need for more environmentally friendly and socially acceptable bioenergy development policies.

Despite producing important policy, regulatory and investment guides, the bioenergy programme has not yet made significant impact at the national and regional levels through visible policy changes and practical investments. Against this background, building upon the achievements and lessons learnt from implementing the programme, the AUC in partnership with ECA and AUDA-NEPAD as well as the regional centre of excellence in renewable energy and energy efficiency (i.e. ECREEE- the ECOWAS Centre for Renewable Energy and Energy Efficiency) is developing Bioenergy Development Strategies and Investment Plans with associated action plans for each region of Africa (Northern, Western, Central, Eastern and Southern). These bioenergy development strategies and investment plans are expected to lead to the deployment of sustainable regional bioenergy projects that will accelerate the adoption of modern bioenergy technologies, practices that will have positive impacts on modern energy access, local industrial development, job creation and general improvement of local livelihoods and rural economic development.

At the regional level ECREEE has been leading efforts to modernise the bioenergy subsector. As early as 2012, ECREEE collaborated with the Global Bioenergy Partnership (GBEP) and organised a Regional Bioenergy Forum in Bamako, Mali in March 2012 to elaborate and validate the ECOWAS Bioenergy Strategy Framework. The ECOWAS Regional Bioenergy Strategy aims to increase food and energy security in the ECOWAS Region though sustainable production and utilization of bioenergy resources. This Strategy was adopted by the ECOWAS Ministers of Energy at the ECOWAS-Global Forum for Sustainable Energy (GSFE) High Level Energy Forum in Accra, Ghana in October 2012. Also, ECREEE has spearheaded clean cooking in the region through the West Africa Clean Cooking Alliance (WACCA), launched in Accra, Ghana in October 2012 and is being implemented as part of the ECOWAS Bioenergy Strategy. WACCA aims to provide access to clean, efficient, safe and affordable cooking energy in the ECOWAS region. It promotes the use of efficient stoves and alternative fuels such as bioethanol, biogas, briquettes and LPG (Liquefied Petroleum Gas) for cooking and heating.

An important observation made in the region has been the absence or inadequate clear-cut policy on bioenergy in ECOWAS Member States. As a result, bioenergy development follows an ad hoc path in the absence of clear and well-defined direction and leadership. Thus one of the principal components of the Bioenergy Strategy has been the development of a regional bioenergy policy. The ECOWAS Bioenergy Policy was developed from 2016 with the financial support of UNDP and involved a multi-sectoral approach with active participation of key stakeholders. The ECOWAS Bioenergy Policy (EBEP) was finally adopted by the ECOWAS Heads of State and Government in Monrovia in June 2017. This Policy has the vision of transitioning to sustainable production, transformation and use of biomass in order to ensure universal access to modern energy services with a view to creating added value, jobs, increasing food security, mitigating environmental impacts and contributing to the achievement of the overall Sustainable Development Goals. It further promotes the sustainable use of the biomass resources of the region, which include agro-industrial, municipal liquid and solid bio-wastes, which can be utilized for power generation, heating, food preservation and cooking.

1.1.1 Objectives of the AUC Bioenergy Strategy in ECOWAS

The aim of the Bioenergy regional strategy and investment plan for Western Africa region is to provide a guiding framework for creating an enabling environment for accelerating the deployment of modern and improved biomass energy technologies at the regional level while supporting individual national strategies. An upscaling in modern bioenergy technology diffusion in the region is expected in turn to facilitate improved access to modern energy services, improve energy security, encourage local economic activities and development, job creation and improve especially rural livelihoods in the member countries.

This strategy includes elaborate regional action plans and accompanying budgets for the region that will facilitate the domestication of the ECOWAS Bioenergy Policy, taking into account national specific circumstances in each member country. This strategy is a product of and supports the implementation of National Bioenergy Action Plans (NBEAPs) and associated national targets that are based on the regional ECOWAS Bioenergy Policy targets up to 2030. In the process, the regional Bioenergy Strategy will assist to strengthen the implementation of the regional policy while aligning and harmonising regional and national level policies. The strategy is a compilation of interventions that remove the barriers impeding the adoption and diffusion of selected and relevant bioenergy technologies in the region. This bioenergy strategy will promote the mainstreaming of modern /improved bioenergy in the region by ensuring that bioenergy development is integrated into national policy development, and also through capacity building among stakeholders, particularly policy makers, civil society, local private sector and academia. This will be achieved through knowledge generation and sharing, facilitating access to information, and partnerships, as well as via the creation of enabling market environment and supportive policies. Some of the enablers include developing appropriate financial vehicles and supporting private sector participation in delivering modern bioenergy services.

This Bioenergy Development Strategy and Investment Plan for Western Africa is guided by the ECOWAS Bioenergy Policy and the Africa Bioenergy Policy Framework Guidelines, and draws on lessons learnt from previous studies done under the continental bioenergy programme as well as international, continental and regional best practices. The strategy was developed in consultation with key stakeholders in the region, particularly ECREEE – the ECOWAS Centre for Renewable Energy and Energy Efficiency, bioenergy developers, policy makers and other relevant stakeholders.

The ultimate goal of this strategy and investment plan is to promote the sustainable production, supply and use of bioenergy to alleviate energy poverty and support sustainable development in the region. Developing a sustainable bioenergy subsector will assist in diversification of energy services, improving energy access and security, facilitating modern technology development and associated businesses and value chains, improve economic development, support food security and sector sustainability. To support these aims and on the basis of previous studies, success stories in the region and elsewhere globally, and the African Union Bioenergy

Framework and Guideline documents, this strategy provides guidelines on the establishment of harmonised financial, institutional and policy frameworks; and enhancement of the capacity of member countries to identify, formulate and implement sustainable, economically viable and gender sensitive biofuels policies, programmes and projects in support of national and regional sustainable development and poverty reduction strategies.

Apart from the policy and regulatory interventions, the strategy lays out an investment strategy and identifies potential business delivery models, funding sources and financing schemes, institutional framework for roll out based on private sector led market deployment as well as assessment of capacity needs and resource needs. Harmonisation at regional level is a key aspect of the strategy to improve the effectiveness of programme impacts and allow efficient implementation.

The bioenergy strategy is based on specific types of bioenergy resources and corresponding bioenergy conversion platforms that are relevant to the ECOWAS region and target countries of Benin, Burkina Faso, Cabo Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo.

2 Vision and goals of the ECOWAS Bioenergy Strategy and Investment Plan

2.1 Drivers for modern bioenergy

If properly harnessed, modern bioenergy has the capacity to improve energy security by reducing reliance on imported fossil fuels, diversifying the energy mix and tackling the depletion of the biomass resource base. Modern bioenergy can also facilitate economic development and rural economies through income generation along the value chain and improved livelihoods from access to modern energy services. There are also local and global environmental benefits of adopting modern bioenergy. However, there are various challenges that hinder the wide-scale adoption and growth of modern bioenergy industry in the Western Africa region and this includes poor information for planning, lack of an enabling environment, high technology costs, poor access to finance, lack of awareness and lack of access to technical support services. Although these challenges and developmental priorities are common in the region, each country has unique challenges, priorities and technology deployment targets depending on individual member states conditions, existing infrastructure, resource base and markets.

2.1.1 Vision

The Vision of this Bioenergy Strategy and Investment Plan is:

Transition to sustainable production, transformation, trade and utilization of biomass in order to ensure universal access to modern energy services with a view of creating added value, jobs, increasing food security, mitigating environmental impacts and overall sustainable development in ECOWAS

2.1.2 Mission

Create an enabling environment in the ECOWAS region that will unlock the potential of modern and improved biomass energy by removing the institutional, legal, financial, social, environmental and capacity barriers, and thereby facilitate the upscaling and wide diffusion of a modern, sustainable and vibrant bioenergy sector in the region.

2.1.3 Objectives of the Strategy

To create an enabling environment for investment in modern bioenergy and realise this Vision, the short term objectives of this strategy include:

- Mobilise resources and stakeholders to support the development of the bioenergy subsector
- Establish regional coherence and harmonisation in bioenergy policies, regulations and institutions
- Undertake technical and market feasibility studies to increase knowledge and understanding of the bioenergy resources, conversion platforms and markets and thereby improve planning and investment environment
- Develop and periodically update a coordinated biomass resource and market information system
- Identify, develop and enhance human and institutional capacity needs to support modern bioenergy development. This includes training a critical mass of technical and business expertise to support the selected high priority technologies, supported by effective regional and national institutions that will support bioenergy technology roll out programmes
- Raise public awareness and widely disseminate information and knowledge on modern bioenergy to improve diffusion
- Establish Research and Development programmes on modern bioenergy such as research on the use of ethanol and other fuels as domestic cooking fuels
- Develop policy and regulatory instruments to support market transformation of modern bioenergy, including incentives and financing instruments, such as carbon finance in the longer term, establish a regional fund to support the development and implementation of sustainable bioenergy programmes
- Mobilise investment flows into the bioenergy subsector
- Support the sustained investment in modern bioenergy technologies in the region

The **long term** objectives of the Strategy are to:

- Provision of energy services to the poor through improved access to modern energy services. Improved energy access in rural areas allows income generation activities through productive use of energy which lead to improve livelihoods
- Promotion of agro-industrial development and job creation. Development of the modern bioenergy sector is expected to lead to rural development through involving small-scale farmers as direct producers or out-growers enabling them to generate new income, opening up employment opportunities, and thereby alleviating poverty and boosting rural incomes.
- Minimising health risks and addressing gender imbalance. Thousands of people in the region, especially women and children, die each year from respiratory diseases caused by indoor-air pollution from cooking and heating with traditional biomass in inefficient devices. Women and children also spend a great amount of time collecting fire wood at the detriment of their safety, education, or other rewarding activities. Modern bioenergy could greatly reduce health risks and improve gender issues in the rural areas
- Attracting investment in sustainable agriculture and land use. Production and supply of modern bioenergy can have positive impacts in terms of creating markets for rural produce, increased income and tax revenues from a more productive economy. A deliberated move towards the establishment of small-scale processing (refining) units will enable low income groups to generate additional income and help transform the rural sector from subsistence production to agro-processing.
- Improving food security. Bioenergy can bring more investments and modernise the agricultural sector by increasing mechanisation, but taking measures to minimise the impact

on land use, biodiversity, soils, and water resources. Use of slurry from biogas production and nutritive ash (residue of controlled combustion processes or biochar) can greatly improve the soil and increase agriculture yields.

- Improving government budgets, balance of payment and energy security by reducing reliance on imported fossil fuels, saving on foreign exchange and improving balance of payments with consequence impacts on national economies.
- Improve biodiversity, natural resource management and climate change. Sustainable production and use of biomass resources has positive impacts local environment. Environmental benefits can also be derived through reduction in GHG emissions, improved air quality and reduced local pollution. Energy crops can also provide useful ecosystem services while the conversion of waste to energy can reduce the environmental pollution associated with the disposal of these wastes. Stimulating farmers to collect and use agricultural waste, rather than burning it can reduce dependence on the natural forest. Estimates made by ECREEE show that the use of agro-industrial waste coupled with use of efficient devices and systems can potentially save 3 billion tonnes of wood by 2030.

2.1.4 Targeted technologies

Given the resource diversity in the ECOWAS region, the key biomass energy technology that have been prioritised for promotion include the following:

- Clean cooking fuels and improved stoves
- PPO/SVO, biodiesel and bioethanol for diesel oil and gasoline substitution and/or blending
- Domestic, community, institutional and industrial biogas
- Combined Heat and Power (CHP)
- Small-scale biomass gasification
- Biomass for rural electrification (including decentralised electricity generation in agro- and forestry industries)

These priority technologies have been identified as the most appropriate across the region to meet power and fuel needs, but focus at the national level will depend on resource availability and market structure in each country. As presented in the next section, the thrust of the strategy is to ensure by 2030, the region has universal access to clean, safe and affordable cooking energy, where households will switch to LPG as primary cooking fuel and use improved cookstoves (ICS) as main cooking device based on sustainable biomass fuel. This should result in savings of at least 3 billion tonnes of wood by 2030. Also, the region intends to develop biomass to power projects, using biomass residues or dedicated plantations as feedstock. This will include biomass heat and power especially in large-agro industries such as sugar processing companies and forestry companies. Electricity from wood plantations is especially attractive in countries such as Liberia, Guinea and Sierra Leone. Additional bioenergy opportunities exist via the waste to energy route in municipalities, agro-industries and slaughterhouses, where waste streams can be converted into electricity, biogas, pellets, briquettes, etc. Gasification of agricultural residues and other biomass streams also holds potential in the region given the wide availability of these resources and used to generate electricity and heat for various applications in rural areas.

2.1.5 Deployment targets

Targets for bioenergy technology deployment have been modeled using a base year of 2012 and projected to 2030 as outlined in the ECOWAS Biofuels Policy. These targets aim to achieve universal access to clean, safe and affordable cooking energy, bio-based power generation and transport fuel blending with biofuels as shown in Table 1. While these targets are defined for the

regional level, national level activities and interventions will be designed and implemented to ensure that the regional level targets will be achieved.

Table 1: ECOWAS Bioenergy Policy Targets

Bioenergy target by 2030	**Baseline (2012)**	**Target (2030)**
Increase share of efficient charcoal production	17%	100 %
Increase share of population using improved woodfuel cook stoves	29%	100%
Increase LPG penetration in households	8%	26 %
Increase share of population using alternative modern cooking fuels (biogas, bioethanol and LPG)	27%	41 %
Introduce and increase blending ratios for biodiesel and bioethanol as % of fossil fuels consumption in transport	<1%	10%
Increase installed capacity of electricity generation from biomass residues or dedicated biomass plantations to 5% of total installed electricity generation capacity in the region or 13% of installed renewable based electricity generation capacity (MW)	~ 100	2008

2.2 Guiding Principles of the Strategy

The guiding principles for the Bioenergy strategy are based on factors that underlie key successful bioenergy initiatives in Africa as outlined in the Africa Bioenergy Policy Framework and Guidelines. The key principles, which will contribute to the success of the strategy are:

- Subsidiarity: Actions and policies to be conducted at regional level will be those for which regional action can bring added value to national action. Preference should be given to undertaking bioenergy energy initiatives at the most appropriate level and scale that is practical and viable.
- Comparative Advantage: Prioritised bioenergy technology should reflect the country's or region's comparative advantage. There are more chances of successful deployment of a few key appropriate technologies rather than attempts to promote multiple technologies. The Strategy promotes specialisation at sub-national, national, regional and/or sub-regional level, in the development of bioenergy initiatives. Encouraging national and sub-regional institutions to focus on bioenergy resources/technologies where they have comparative advantage provides a sound basis for effective partnerships and regional cooperation.
- Level playing field and subsidies/incentives: Encouraging a level playing field vis-à-vis conventional energy options ensures that any explicit or implicit subsidies and incentives enjoyed by conventional energy forms are either extended to bioenergy or removed altogether for all energy options. Any additional subsidies or incentives channelled to bioenergy should be performance based preferably with an explicit sunset clause designed to encourage competitiveness.
- Sustainability indicators: Bioenergy comes with various socio-economic and environmental sustainability concerns. When implemented properly, bioenergy can be carbon neutral and promote socio-economic development, and this requires adhering to established sound sustainability principles.
- Gender & Equity: It is important to ensure that bioenergy programmes take account of the gender and equity dimensions of socio-economic development, for example, by alleviating women's workload, creating income-generating activities for women, their households and

their communities, ensuring access to quality social services, including healthcare and literacy training.

- Addressing need for both heat, transport fuel and electricity services: Meeting the thermal energy needs of the bulk of the region's population in a sustainable way is especially important given the unsustainable dependency on traditional biomass. However, it is also important to pay adequate attention to non-thermal energy needs such as transport fuels and electricity provision in line with prevailing demand patterns.

3 Bioenergy challenges in West Africa: Status and Challenges

3.1 Regional energy sector overview

The Economic Community of West African States (ECOWAS) is a dynamic and fast growing regional group of fifteen countries, founded in 1975. Its mission is to promote integration in all fields of economic activity. The ECOWAS region population is estimated to be about 377 million people and faces many developmental challenges since 11 of its 15 nations are currently categorized as Least Developed Countries (LDCs). Currently, these nations also belong to the Heavily Indebted Poor Countries (HIPCs), and 12 of them have low human development indicator (HDI) levels and high Poverty rate.

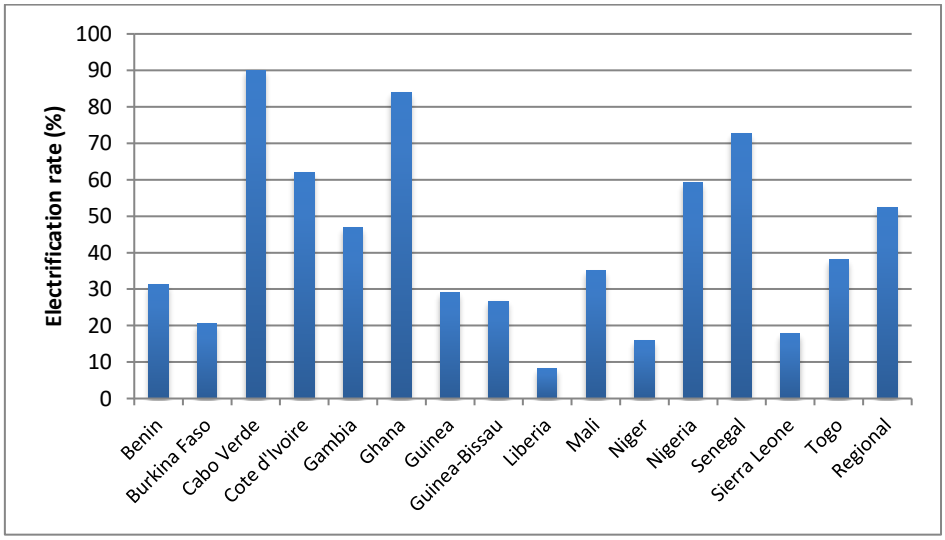

Figure 2: Share of electrified population by country (2017)

One of the key challenges facing the region is improving access to modern energy services to the majority of the population. While rich in energy resources, the ECOWAS region lags in access to modern energy such as electricity, liquid and gaseous fuels, modern cooking options, and mechanical power. Despite a regional electrification access target of 65% by 2020, around half the population is unelectrified and over three-quarters of the ECOWAS inhabitants rely on traditional biomass as their main source of energy as shown in Figure 2 (ECREEE, 2017). Household access to electricity across the region is below 30% and wide gaps exist between the access rates in urban areas and in rural areas and between countries. The electricity networks serve mainly urban centres.

Energy poverty is widespread in the region, especially in rural areas and adversely affects education, nutrition and food security, water and sanitation, health, etc. Its rural population is increasingly facing difficulties to meet their energy needs through gathering or buying woodfuel (wood and charcoal), while the penetration of modern energy services (electricity, biogas, LPG,

ethanol and improved woodfuel stoves) is still low. The region's energy sector struggles with low investment, inadequate infrastructure, and high costs, which are in turn met with low ability to pay by consumers.

The electricity systems in ECOWAS are all facing supply capacity constraints and failing to attract capital investment. In addition, there are inefficiencies and losses in the systems – it is estimated technical and commercial electricity losses in the electricity systems vary between 15% and 40% throughout the ECOWAS region (EEEP, 2013). Increasing fossil fuel import dependency, shortages and fluctuating fossil fuel prices are major concerns of West African countries and require a diversification of sources. In some countries even more than 90% of the electricity generation is satisfied by expensive diesel or heavy fuel. As a result, the increasing and fluctuating oil prices are adversely affecting the economies of ECOWAS oil importing countries.

The region has however, plentiful energy sources – including oil and gas, hydropower, biomass and solar irradiation - most of which have not been fully exploited (Avila et al. 2017). Converting the potential into actual energy is an urgent need of ECOWAS to ensure energy security of the region.

As policy response to the challenges of energy security, energy poverty and climate change, the ECOWAS member states have expressed the necessity to mainstream renewable energy and energy efficiency (RE&EE) into their national policies. However, these efforts can be more successful if developed under a regional framework.

3.1.1 Biomass use in ECOWAS region

Traditional biomass is the dominant energy source in the ECOWAS region contributing almost 80% in the final energy consumption, varying from 60% (Senegal) to over 90% (Niger, Guinea Bissau). Over 90% of the population use traditional biomass for domestic cooking (ECREEE, 2012). This dependence is due to limited choice of fuels, unaffordability of alternatives and abundance of biomass resources (IEA 2014). Modern bioenergy production, supply and use is still limited. As of 2015, about 87% of West Africans had no access to clean cooking and relied on traditional wood fuels for cooking and heating. This is however, an improvement on the 2000 share of over 95% (IEA 2017).

Over the decades, the heavy dependence on wood and traditional charcoal has resulted in a massive depletion of the forest resources, exacerbated by an increasing population, with devastating economic, social and health consequences for the rural populations and the poor. According to FAOSTAT (2013), deforestation in ECOWAS is almost 1 million hectares per year, with severe negative impacts on habitats, biodiversity and ecosystems, as well as desertification and GHGs emissions. The reliance on traditional biomass has resulted in adverse public health impacts including deaths from pneumonia, chronic obstructive pulmonary disorder and lung cancer. It is estimated that about 75% of the region's population is affected by household air pollution from indoor smoke, small particle pollution, carbon monoxide, and nitrogen oxides, mainly from cooking and heating with solid fuels. This results in the annual deaths of an estimated 173,000 people, roughly half of them children. Women, as active agents in biomass management, as the primary household cooks, and as participants in many biomass-intensive processing sectors, are severely impacted by continued traditional biomass use.

Looking ahead, it is projected that the demand for traditional biomass will increase in absolute terms due to rising population and lack of alternative energy sources. West Africa's energy mix is expected to remain the same by 2030 and traditional biomass is projected to continue to be the main energy source (IEA 2017). However, improvements could be achieved, for instance, under the IEA Energy for all Case scenario, but this requires annual investments of up to $78 billion in the energy sector. The share of traditional biomass could then be expected to decline to 62% in 2030. The share of LPG and gas, and electricity could also become more prominent (IEA 2017).

The IEA estimates that bioenergy will still constitute 51% -57% of the primary energy supply in ECOWAS region by 2035 (IEA, 2010). Given that dependency on traditional biomass will remain a challenge into the future, more efficient end-use of traditional biofuels could be a key part of the transition towards sustainable bioenergy supply. This should be coupled with sustainable forest management and efficient biofuel conversion technologies (IRENA, 2014). However, through appropriate strategies and policy interventions, this trajectory could be altered by accelerating the transition to modern energy systems and rapidly transforming the region's rural economies. If such economic transformation is based on shifting the small holder and subsistence farms towards more commercial activities that include modern energy production and use, it could be possible to simultaneously drive low carbon growth and improve the welfare of the poor majority in the region. According to Granoff et al (2014), pursuing low carbon growth and poverty reduction will require a significant structural shift in the economic and social systems, and particularly substantial transformation in energy, food and human habitat systems. Thus an opportunity exists for many SSA countries to leverage potential growth in agricultural systems by improving on farm productivity and income, coupled with clean energy production and use. Modern bioenergy could be at the heart of a rural transformation strategy reduces pressure on national forestry resources and ecosystems, and at the same time creates employment, improves income and opportunities while radically reducing urban migration. There are also opportunities to expand the range of bio-products and enable the development of national bio-based economies that valorise most of the available bio-resources including waste and agro-residues and achieve circular economies in the region. Countries in Western Africa are well positioned to develop and modernise their biomass resource base and enable a transition to sustainability and improved livelihoods for their communities.

3.1.2 State of modern bioenergy in ECOWAS region

Several biomass projects throughout the region produce power for the grid. The Abidjan Municipal Solid Waste-to-Power biogas project provides 3 MW of capacity (Gumbo, 2013). The 42 MW Biovea Biomass Plant, located in Aboisso, Côte d'Ivoire is a registered Clean Development Mechanism (CDM) project that would use woodchips from forestry residues at palm oil plantations to export power to the national grid; commission was planned for June 2013, but the current status remains unclear. In Nigeria, the Ibadan GNEEDER biogas plant (0.5 MW) began operating in 2010, producing power from slaughterhouse waste. Ghana has four small biomass plants with a total installed capacity of 2 MW.

To date, most biomass power production is used for self-generation in industrial plants. In Senegal, a biogas digester at a slaughterhouse in Dakar has a capacity of 1000 m^3/day and can annually produce 876 MWh of electricity to power the slaughterhouse (reducing consumption from the utility by 48%) and 1752 MWh of heat to produce more than 25,550 m^3 of hot water. Several other ECOWAS Member States use biomass for cogeneration: Ghana has 4 MW of biomass co-generation; Nigeria is home to a 5 MW biomass plant that produces power for a cement plant; and Guinea-Bissau has a 150 kW co-generation pilot project using cashew shells. In Côte d'Ivoire, a number of industries use biomass (including sugar bagasse, palm husks, cotton husks, coco, and other agricultural residues) for self-generation, totalling 80 MW of installed capacity.

As momentum behind biomass generation grows, several major projects are under development. In Sierra Leone, the Addax Makeni Bioethanol and Power Plant, financed and under construction as of December 2011, will annually produce 80 million litres of fuel ethanol from sugar cane and 32 MW of electricity from residual bagasse, of which 15 MW will be fed into the national grid. Côte d'Ivoire has shortlisted seven private companies to develop grid-connected biomass plants under a buy-own-operate agreement.

3.1.3 Liquid biofuels production

So far, only a few countries in the region are involved in commercial biofuel production and these include Burkina Faso, Liberia, Mali, Niger, Senegal, and Sierra Leone. Some of these countries have developed specific strategies for biofuels, as well as regulatory frameworks. In the transportation sector, Mali and Ghana have both established mandates for the use of biofuels, while Nigeria has established a 10% ethanol blend and 20% biodiesel target under its national biofuel policy (REN21, 2014). Table 2 shows the bioethanol and biodiesel annual production in 2017 for selected countries in the region. Some countries such as Benin, Cabo Verde, Côte d'Ivoire and Guinea reported zero production.

Table 2: Bioethanol and biodiesel annual production (litres)

Country	Bioethanol	Biodiesel
Liberia	-	8,701
Mali	15,000,000	816,630
Niger	-	27,360
Senegal	500,000	-
Sierra Leone	4,000,000	-

Source: ECREEE, National monitoring reports (2017)

In Mali, production of bioethanol is at the Nsukala plant, which is a sugar plantation and refinery in Segou. In Sierra Leone, the Addax Makeni Bioethanol and Power Plant has an annual production capacity of 85 million litres and 32 MW of electricity from residual bagasse, of which 15 MW will be fed into the national grid (REN21, 2014). It uses sugarcane as primary source and cassava as a secondary source, and exports all the bioethanol it produces. In Senegal, the sugar company Compagnie Sucrière Sénégalaise has an ethanol production capacity of half a million litres per year, of which 200,000 litres are for national use. There is limited activities in the oilseed sector biodiesel production apart from some small-scale units and demonstration projects. Mali and Burkina Faso have the longest record in Jatropha projects. Most of these projects are located at the Southern part of the countries. In these areas there is Jatropha grain processing capacity and a market for the Jatropha oil, mainly used to power Multi-Functional Platforms (MFPs), to produce soap or to be turned into biodiesel on a small scale. Both countries are land-locked and diesel prices are relatively high. The large plantations projects projected for Ghana and Senegal were less successful so far and were not realised, although small experiments are on-going. There is a commercial biodiesel production in Mali with Mali Biodiesel (a private promoter), and a demonstration plant in Burkina Faso with Belwet and Agritech as stakeholders. One key problem is scarcity of the oil seed feedstock on the market and its pricing. The sector is limited to vegetable oil derived from plant species other than jatropha. Private developers produce castor and sunflower biofuels. However, production remains low and is not intended for the national energy sector because the market is underdeveloped.

3.1.4 Modern Biomass Energy Potential in the ECOWAS region

Overall statistics on the availability of biomass resources in ECOWAS are often unreliable (ECREEE, 2012). A basic assessment of the potential for producing bioenergy crops shows divergent potentials for different fuel crops across the region. Based on ECREEE's initial assessment, the potential for producing a number of crops is high in countries such as Benin and Nigeria, while Cabo Verde, Liberia and Sierra Leone appear to show more limited potential (ECREEE, 2012). A more detailed assessment of the potential availability of four newer fuel crops - sweet sorghum, jatropha, cassava, and cashew—was conducted by ECREEE and UNIDO under the "Regional potential assessment of novel bio energy crops in fifteen ECOWAS countries" project, again with widely divergent results by crop (ECREEE et al 2012). As shown in Table 3, countries like Togo and Nigeria already have a very extended agriculture

that encompass a large part of the total arable land that is available while there is very limited arable land area in countries like Cabo Verde.

Table 3: Land area and population statistics in ECOWAS countries

Country	Area (km^2)	Population Density (#/km)	Arable land/ capita (ha)	Potential arable land in use (%)
Benin	112 620	60	0.36	19.3
Burkina Faso	274 200	46	0.35	17.5
Cabo Verde	4 033	101	0.09	nd
Cote d'Ivoire	322 460	52	0.28	14.1
Ghana	239 460	85	0.16	23.6
Guinea	245 857	32	0.26	5.5
Guinea-Bissau	36 120	37	0.10	14.7
Liberia	111 370	30	0.16	6.0
Mali	1 240 000	9	0.18	9.4
Niger	1 267 000	8	0.44	35.1
Nigeria	923 768	141	0.41	49.4
Senegal	196 190	54	0.22	17.7
Sierra Leone	71 740	78	0.29	13.7
The Gambia	11 300	129	0.12	21.9
Togo	56 785	93	0.61	56.6

Table 4 shows the results of the regional energy crop suitability mapping by country and differences in the opportunities in the various countries for specific crops. The results show that Camelina and Crambe are not suited for this region while Cabo Verde is not suited for rain-fed agriculture and therefore energy crop production.

Benin has a good potential for several of the energy crops. Cassava, Cashew and Groundnut are already grown in the country and a number of initiatives have been taken around Jatropha and early stage exploration of Sweet sorghum projects. The southern part of the country is growing oil palm. The country is a net exporter of Cassava products and is well placed to turn a portion of this stream, based on example projects in Nigeria into ethanol.

Table 4: Potential of the selected bio-energy crops in ECOWAS countries

Country	Camelina	Cashew	Cassava	Castor	Crambe	Ground-nut	Jatropha	Sweet Sorghum
Benin								
Burkina Faso								
Cabo Verde								
Ghana								
Guinea								
Guinea Bissau								
Ivory Coast								
Liberia								
Mali								
Niger								
Nigeria								
Senegal								
Sierra Leone								
The Gambia								
Togo								

Key:
Green: great opportunity, Light green: opportunity, Yellow: less opportunity, Orange: limited opportunity, Red: no opportunity

Burkina Faso is like other countries in the Northern part of the region with a rainfall gradient from south to north which makes most of the country suboptimal for production of Cassava and Cashew. Groundnuts and Grain sorghum are grown in the country. Thus optimal production of energy crops like Sweet sorghum will need the significant rainfall only found in the southern part of the country. In the central dryer parts of the country, there is definitively a potential for Castor beans, although very little experience exists with the crop today.

Ghana has already a wide range of existing Bio-energy projects running today with mixed success. The country has good rainfall patterns conducive for most of energy crops. Areas where industrial palm plantations can be grown will not allow competitive production of other crops; on the other hand, the extensive plantation experience in the country can help with the successful introduction of new crops. The presence of sugarcane to ethanol operations can form synergies for the development of sweet sorghum in the country.

Guinea is producing significant quantities of groundnut and cassava but needs these entirely or primarily for food use today. The country is likely too wet for optimal castor production. Sweet Sorghum, especially grown as dedicated energy crops will likely have a clear potential in the country, especially in conjunction with existing ethanol plants operating in the area.

Guinea Bissau has a limited potential for cassava and needs all the production for food purposes. The rainfall patterns in the country are also not conducive for optimal production of Castor Bean or Groundnut. Some groundnut is produced today in specific parts of the country. Dedicated Sweet Sorghum may have potential, although the rainfall patterns may be more conducive for successful sugarcane production. Cashew nuts are the major export crops and the country can develop at least a portion of its bio-energy strategy on the surplus fruit production and conversion technology that can exploit this.

Cote d'Ivoire has the same luxury and challenges like Ghana, in that is has a wide rainfall spectrum and has choices for Bio-energy projects to be developed. The country is probably too wet for Castor cultivation. It is in a very good position to further develop a successful ethanol business on the basis of cassava surpluses, sugarcane and sweet sorghum synergies and cashew fruits.

Liberia is today growing palm plantations due to its high precipitation climate. It is also a relatively high producer of Cassava but needs this entire production for food uses. If in the future cassava productivity can be enhanced this may open further opportunities for bio-energy uses. The climate of the country is too wet for optimal sweet sorghum or castor production.

Mali is like Burkina Faso a country with strong rainfall gradients with a very dry northern part and a southern part conducive for cultivation of several of the selected bio-energy crops. The country is limited in cassava production but has significant efforts in Jatropha project development and has significant groundnut production. In the dryer central areas like in Burkina Faso, castor production has likely some potential and Jatropha projects grown for erosion control will again have limited bio-energy potential. If a sweet grain sorghum strategy can be developed, this could become a significant opportunity for the country.

Niger has the overall limiting factor of relatively low rainfall in the majority of its territory, limiting the potential for crop cultivation overall. Castor can have a clear potential as a crop under these conditions. The country has limited cassava production and needs the entire production for food use. The groundnut production is significant but again food oriented.

Nigeria like Gambia and Ivory Coast has also a very wide rainfall pattern allowing the positioning of all the selected crops in its territory. Sweet sorghum will have a limited potential as bio-energy crops in the northern part of the country limited by precipitation levels. In the south, bio-energy production will continue to be dominated by traditional crops like oil palm and sugarcane.

Senegal has a double gradient system in its agro-climatological zones: from south to north and from west to east. The country has limited cassava production and needs most of that for food purposes. This also applies to groundnuts. In the central part of the country there will be a potential for the development of Castor as a crop. Contrary to what was believed before the potential for Sweet sorghum can probably be restricted to the more southern and south western parts of the country, due to precipitation patterns.

Sierra Leone is located in an area with generally high levels of precipitation and has attracted historically a number of oil palm and sugarcane projects. This climatic pattern is not conducive for the cultivation of castor and cashew. Quantities of groundnut production in the country are also limited and all directed towards food use. The cassava production in Sierra Leone is relatively important but the entire production is currently converted into food products. Sierra Leone can have some potential for the production of Sweet Sorghum as a dedicated energy crop in conjunction with sugarcane to ethanol projects. Especially the areas in the North East of the country adjacent to Guinea would be prime target areas for this opportunity.

The Gambia is similar to Cabo Verde regarding the limited arable land area and is unlikely to have much potential for energy crops. Cassava production is very limited and all produce is directed towards food. Sweet Sorghum has potential as a bio-energy crop though.

Togo also has a relatively diverse rainfall pattern making it suitable for a range of bio-energy crops. There is also relatively high degree of arable land use which might require the development of integrated food and energy farming systems. There are currently successful cooperatives in the production of different food and industrial crops like corn and cotton in Togo.

3.1.5 Initiatives on modernising the bioenergy sector in ECOWAS

As discussed before, the ECOWAS region has challenges with achieving universal modern energy access. It is also struggling with high dependence on fossil fuels and unsustainable use of traditional biomass energy, with adverse impacts on socio-economic outcomes, environment, forest resources, and climate change. Against this background, the ECOWAS Heads of States adopted the ECOWAS Energy Protocol in 2003, which was meant to improve energy efficiency and increased use of renewable resources. This was followed in 2006 with the adoption of the ECOWAS/UEMOA White Paper on access to energy services for populations in rural and peri-urban areas, and all these culminated to the establishment of ECREEE in 2008. ECREEE was established to lead and coordinate efforts at the regional level with a mandate to develop and promote clean, efficient and sustainable energy in the region.

To achieve its mandate, ECREEE has spearheaded a number of initiatives in the region. Of particular interest to the bioenergy subsector, ECREEE organised the Regional Bioenergy Forum in Bamako, Mali in March, 2012 to elaborate and validate the ECOWAS Bioenergy Strategy Framework. The ECOWAS Bioenergy Strategy was adopted by the ECOWAS Ministers of Energy at the ECOWAS-GFSE High Level Energy Forum in Accra, Ghana on the 31st October 2012. This Regional Bioenergy Strategy aims to facilitate the transition from the use of unsustainable and inefficient production, transformation and utilization of bioenergy resources to modern, efficient and sustainable ones.

3.1.5.1 West Africa Clean Cooking Alliance (WACCA)

As part of this Strategy, the West Africa Clean Cooking Alliance (WACCA) initiative was launched in Accra, Ghana on the 29th October 2012. WACCA aims to provide access to clean, efficient, safe and affordable cooking energy in the ECOWAS region. It promotes the use of very efficient stoves and alternative fuels such as bioethanol, biogas, briquettes and LPG (Liquefied Petroleum Gas) for cooking and heating.

3.1.5.2 ECOWAS Regional Bioenergy Policy

One of the principal components of the ECOWAS bioenergy strategy is the formulation of a Regional Bioenergy Policy. The ECOWAS Bioenergy Policy was adopted at the ECOWAS Summit of Heads of States and Governments held in Monrovia, Liberia in June 2017. The ECOWAS Bioenergy Policy is envisaged to strengthen the Renewable Energy and Energy Efficiency policies already adopted which aims to increase access to sustainable energy services.

This policy seeks to promote a modern, sustainable and vibrant bioenergy sector in the region by creating an enabling environment that can unlock the potential by removing the institutional, legal, financial, social, environmental and capacity gaps and barriers. It is aimed at addressing the needs and constraints of the governments, the private sector and the local communities in using existing biomass resources including household, agricultural, fish/sea food, and industrial processing wastes and residues.

3.2 Challenges facing the bioenergy sector

The key challenges affecting adoption and growth of modern bioenergy industry in West African region includes lack of an enabling environment, poor access to finance/affordability, lack of awareness and lack of access to technical support services. Currently, ECOWAS states are at different levels of development and/or implementation of renewable energy and energy efficiency policies and regulations to help address the various barriers to the development through universal access to clean energy in the region. Primary focus across the region has been on developing the electricity sector, with less attention being paid to cooking and heating and the transport sectors.

Barriers hindering the adoption and scale up of modern bioenergy in West Africa can be classified into economic and financial barriers as well as non-financial barriers. Non-financial barriers include inadequate policy and regulatory support, poor and no institutional capacity, limited human resource capacity and skills, technical difficulties, lack of information and awareness, as well as a socio-cultural and behavioural barriers.

3.2.1 Economic and financial barriers

Bioenergy investments, like other renewable energy technology investments require high initial capital investments compared to incumbent technologies, especially in West Africa where most of the technologies have to be imported. This includes supporting infrastructure, such blending and specially designed distribution and storage facilities for biofuels. Even good quality, high tier efficient stoves have to be imported from outside West Africa. Given that the target group of modern bioenergy services is mostly the low income rural and urban households, limited affordability of modern bioenergy technologies is a big challenge for the region.

Imported systems and designs also may not operate optimally, leading to poor performance and consequent poor investment outcomes. Thus some bioenergy technologies may need to be adapted and modified to improve performance under local operating conditions. Also, for widescale replication beyond well-resourced agribusinesses, cheaper designs are needed - that are adapted to the local context.

Also, bioenergy developers and consumers have difficulty in obtaining financing at low interest rates. Financial institutions are generally unfamiliar with lending in this sector and perceive it as risky. The current bank lending rates in the region are exorbitantly high on average above 20%, making borrowing on very costly. In addition, small bioenergy projects have high transaction costs at many stages of the development cycle.

Furthermore, there is limited knowledge on the feasibility of the various bioenergy technologies, which is worsened by poor project packaging capacity within local project developers. There are also limited viable business models for modern bioenergy deployment. This is due to a number of factors including poor feedstock supply, reliance on single income streams, and insufficient financial engagement of project owners resulting in commercially unrealistic models. Even projects that are fully funded by donor grants have encountered viability problems.

3.2.2 Policy and regulatory

Renewable energy technologies are generally supported by policies in their early stages to enable them to be competitive against incumbent fossil technologies. For instance, bioethanol fuel markets have mostly been developed using mandatory fuel blending mandates. Such policies and regulations are currently not well developed in the region. This translates into high risks for investors. Although there is some political commitment to advancing modern bioenergy to solve various national challenges, there is largely a lack of political action to ensure programmes are actually implemented on the ground. For instance, most countries in the region have regulations against unsustainable charcoal production and supply, but in practice, unsustainable charcoal markets are still expanding. For potential public electricity grid connected technologies, replication of investments beyond captive sites requires a supportive framework of government incentives, such as attractive feed-in tariffs and fair access to the grid. These are still missing in most countries in the region.

There is also no motivation to add value to waste as most countries do not enforce environmental regulations and polluters may face no penalties for waste dumping. This makes investment in waste to energy less economically attractive as a waste clean-up technology.

The region also lacks standards for various devices and fuels, which makes quality control and enforcement difficult.

3.2.3 Technical

One of the pre-conditions for successful modern bioenergy investment is to ensure adequate biomass feedstock availability to allow high capacity utilisation of the investment. For biogas systems, availability of livestock manure is a constraint which limits its application in areas with limited livestock or where pastoral grazing is practised. All of the successful biogas projects have sufficient feedstock on-site as a by-product of the developer's own business or an adjacent business with an equity stake. Novel feedstocks (e.g. lignocellulosic materials or dryland plants) may represent a breakthrough in expanding the range of feedstock options in the region – but these require more complex and costly technology. R&D is required to unlock this potential.

For some bioenergy systems, such as anaerobic digestion, sensitivity to feedstock specifications limits the potential feedstock range and supply-side adaptability, and could lead to poor performance and energy output. On the other hand, gasification systems require strict operating parameters adherence to precise manufacturer specifications or high outputs of char, tar and particulate matter may cause cleaning problems, result in engine failure and generate an excess of toxic by-products. Many small-scale gasification systems have failed in the region due to these technical operational difficulties.

3.2.4 Market

Given that most modern bioenergy systems are imported, there is limited access to manufacturer support and spare parts in the region. For biogas to electricity systems, there is only one European biogas technology provider with permanent representation in the whole of Africa, so plant managers must usually be self-contained with their own in-house personnel. Lack of local support and poor access to spare parts is a major challenge for project developers and consumers.

3.2.5 Institutional capacity

Bioenergy is a cross-sectoral issue and requires close coordination between different line ministries and other stakeholders for developing and implementation of technology dissemination strategies. Typically, coordination between relevant ministries and stakeholders on bioenergy issues is insufficient. This can be as simple as the sharing of data to draw up projects or the alignment of strategies. In addition, there is limited institutional capacity to develop new regulations such as integration of renewables into public grid and effecting forward looking and sustainable economic incentives and other instruments.

3.2.6 Human resource and skills

Typically, the region lacks sufficiently trained and experienced human resource to build, operate and maintain modern bioenergy systems. While some isolated projects have trained some artisans and plant operators, the market is not fully developed to ensure continuity in opportunity for the trained personnel, and this expertise is lost over time as the market fails to provide enough business for them. Poor construction of systems and limited operator capacity has led to technical problems such as operating conditions resulting in systems under-performing or breaking down. It is particularly challenging to secure the skills required to operate modern bioenergy systems in rural locations. There is a need to elevate skill levels through training and operational exposure.

3.2.7 Information and Awareness

Although modern bioenergy technologies are generally well known in the region, there are various aspects on investment and market operation that are largely lacking in the region. Project developers and investors lack information on opportunities and the market feasibility of the different potential technologies while policy makers lack information on biomass resource and supply and demand patterns of bioenergy for proper planning. Consumers lack information on performance of technologies and market processes to make informed choices for investing in these technologies.

3.2.8 Socio-cultural and behavioural

Due to technological lock in and other cultural perceptions and habits, the market for modern bioenergy has taken time to develop as end users are reluctant to switch to new devices or energy forms. This reluctance is also linked to lack of information about the benefits of modern bioenergy including health and financial benefits.

3.3 Measures and interventions to address challenges

To address the identified challenges and bottlenecks facing the modernisation of bioenergy, there are various measures that can be implemented in the ECOWAS. These include creating accurate information on the sector, creating an enabling environment for investors and project developers, harmonisation of policies and regulations, getting political commitment and mainstreaming modern bioenergy, availing appropriate finance and risk mitigation, capacity building and skills enhancement, standards setting and enforcement, identifying champions in each country to keep modern bioenergy as top priority. These are briefly describe below:

- Information: There is need to understand the baseline to plan properly, so information provision and mapping of resources is important to assist investors, developers and policy makers

- Enabling environment: The ECOWAS region needs to create an enabling environment to ensure that various bioenergy technologies can be upscaled and this includes putting in place harmonised enabling policies and regulations, and availing appropriate financing packages. Quality and standards are key to ensuring sustained dissemination of technologies.
- Political Action: The bioenergy sector is not prioritized, so there is need for not only political will but political action to move the bioenergy up the attention ladder of decision makers
- Political commitment: There is need for commitment by Partner states in the ECOWAS on the target outcomes. There is also need for ownership of technology deployment programmes, and long term (financial) commitment by each country
- Mainstreaming including gender considerations: Bioenergy needs to be mainstreamed, taken seriously and proactive agenda adopted
- Champions: There is need for champions for bioenergy in the region to ensure bioenergy targets are achieved by sustaining the momentum
- Project Packaging Facility: There is limited capacity in the region for packaging bioenergy investment proposals, thus there is need for capacity building and brokerage to facilitate developers to package bioenergy projects for funding
- Financing: There is need for providing upfront investment solutions. Innovative financing including blended finance appear to be appropriate for the ECOWAS markets. Scaling can be achieved through blended finance as mature markets can only be achieved with large scale public and private investments. Thus, there is need for fund mobilization strategies, identifying sources of finance, addressing modalities for accessing this finance and corresponding conditions as well as identifying the gatekeepers of these initiatives. There is need also to link bioenergy investments to green funding platforms available via climate change mitigation.
- De-risking: There is need for de-risking bioenergy investments
- Business models: Models that involve coalition such as the African biogas platform appear to be making more progress and this could be a way forward. Projects implementation via Public Private Partnerships could be more successful, including the national governments, development partners, lead implementing partners and private sector. Collaboration of practitioners are also vital to create synergies.
- R&D: There is need to adapt and optimise technologies as well as conduct research on alternatives fuels and feedstocks. There is also need for demonstration of technologies to increase awareness and show proof of concept.
- Awareness and information: Bioenergy has attracted negative publicity due to pressure from lobby groups, concerns around sustainability of some programmes and failure of especially Jatropha based biodiesel programme, there is need to educate stakeholders and provide accurate information for decision making.

4 Country Priorities

Based on ECOWAS member states national submissions of priority interventions in the bioenergy subsector, all countries see a great need to upscale the dissemination of improved cookstoves (ICS) and alternative cooking fuels such as LPG. Currently, about 22% of the 340 million total population use efficient cookstoves and about 11% has access to modern and efficient fuel alternatives. By 2030, more than 80% of the total population (400 million people) is expected to use either efficient cookstoves or modern alternative fuels for cooking. About

60% in the population in region is expected to use modern fuels replacing traditional cookstoves. Table 5 shows member states improved cookstove targets for those countries with quantified cookstove objectives.

Furthermore, Burkina Faso and Guinea plan to promote efficient stoves for small enterprises. Burkina Faso is targeting improving efficiency of stoves used for dolo (a traditional beer) production while Guinea aims at increasing the efficiency of smokehouses and brick making.

Benin, Guinea, Senegal and Togo have plans to improve the efficiency of charcoal production, and promote the use of the Casamance kiln charcoal-making process. Guinea targets to disseminate about 3,000 units of efficient charcoal kilns. Guinea, Mali and Senegal also intend to promote sustainable woodfuel supply from forests, for instance through participatory forest management in Senegal. Benin and Côte d'Ivoire plan to establish wood energy plantations. Côte d'Ivoire and Ghana also intend to develop forestry feedstocks for bioenergy production.

Table 5: Improved cookstove and clean cooking fuels targets in ECOWAS member states

Country	Objective
Benin	• 140 000 new HH have access to improved cook stoves • 275 000 HH have access to butane stoves with a 35% subsidy on the tank cost
Burkina Faso	• 540 000 improved cookstoves are produced and used. At least 50% are used in urban and semi-urban areas at a cost of USD 12.1 million
Cabo Verde	• Eliminate three-stone cooking stove (35% of HH still used it) through improved low emission cookstoves by 2025 at the latest. 100t of wood a year are currently taken from forests
Ghana	• 2 million efficient cookstoves are adopted by 2030 at a cost of USD 50 mil • 50% of HH adopt LPG in semi-urban and rural households by 2030 at a cost of USD 6 million
Guinea	• 1 million efficient cookstoves are adopted by 2030. All the targets to reduce wood consumption and improve cookstove efficiency
Liberia	• Distribute 280 543 efficient cookstoves by 2030
Niger	• 100% of urban HH have access to improved cook stoves • 30% of rural HH have access to improved cookstoves
Senegal	• Production and access to 7.6 million improved wood cookstoves and 6.8 million improved charcoal cookstoves

A number of countries also want to promote generation of electricity from biomass, especially using the combined heat and power technology. For example, Senegal targets to build 115 MW of cogeneration capacity in its agro-industry waste to energy programme. Burkina Faso, Liberia and Senegal have plans to generate electricity from biomass but do not specify the type of feedstock. Burkina Faso has budgeted USD 12.5 million for biobased power generation, while Liberia plans to build a 30 MW biomass power plants. Senegal also targets 50 MW biomass plants capacity by 2030.

As shown in Table 6, eight member countries have targets to blend bioethanol with gasoline for transport by 2030, with blending mandates ranging from E2.5 for Niger to E30 for Sierra Leone. Biodiesel is also a priority fuel in the region and the region adopted B5 blending target in 2013 (ECOWAS, 2013). At least ten countries are considering liquid biofuels as an alternative to petroleum fuels and at least seven countries are prioritising biogas. Cabo Verde targets to generate electricity from biodiesel in remote islands, while Mali intends to develop 4 MW solar/ biodiesel hybrid power plants capacity for rural electrification. Niger targets to produce biofuels and biogas for cooking purposes. Transport fuel blending targets for Nigeria are E10 and B20, Liberia B5, Burkina Faso E10 and B5. Gambia, Togo and Guinea target to produce biofuel for transport but are silent on the feedstock of choice. Sierra Leone promotes liquid biofuels production from sugarcane, corn and rice husk.

Biogas is also another priority technology in the region. Member states that have demonstrated interest in developing biogas for cooking include Niger, Guinea and Burkina Faso. Guinea plans

to produce 40 ktoe of butane and biogas annually while Burkina Faso targets to disseminate 75 000 household biogas digesters by 2030. Ghana also plans to build 200 institutional biogas units in high schools and prisons. Senegal targets to disseminate between up to 49,000 household biogas digesters by 2030.

Table 6: Priority technologies by country

Technologies	ICS*	IC*	Biogas	Ethanol	SVO/ Biodiesel	Gasification	LPG/ CCFs	CHP
Benin								
Burkina Faso								
Cabo Verde								
Cote d'Ivoire								
Gambia								
Ghana								
Guinea								
Guinea-Bissau								
Liberia								
Mali								
Niger								
Nigeria								
Senegal								
Sierra Leone								
Togo								

*ICS – Improved Cookstoves; *IC – Improved charcoal

Gasification is another priority bioenergy technology which is considered important in Burkina Faso. The country intents to build twenty 250 kW cotton straw based gasifiers for the production of electricity. In addition, Benin, Côte d'Ivoire and Mali have interests in the production of briquettes from agricultural residues.

5 Elements of the Bioenergy Strategy and Investment Plan

Without significant interventions in the subsector, it is likely that the current dominant dependency on traditional biomass will persist in the Economic Community of West Africa States with many adverse impacts on the socio-economic wellbeing of the poor majority as well broader national economic and environmental impacts. Without interventions to make modernise biomass production and use, and achieve sustainability in the subsector, demand for for traditional biomass is expected to increase in absolute terms due to rising population and lack of alternative energy sources (Smeets et al 2012). Thus it is critical for ECOWAS member states to address this potential fundamental future challenge by adopting and promoting the more efficient end-use of traditional biomass fuels to allow a transition towards sustainable bioenergy production and use. This should be coupled with sustainable forest management and efficient bioenergy conversion technologies (IRENA, 2014).

Sustained efforts at modernising biomass energy production, supply and end use at the regional and national level has potential to accelerate the transition to modern bioenergy systems and rapidly transforming the region's rural economies by shifting the rural farms towards more commercial activities that include modern energy production and use. Modern bioenergy could be at the heart of a rural transformation strategy to reduce pressure on national forestry resources and ecosystems, and at the same time creates employment, improves income and opportunities while radically reducing urban migration. There are also opportunities to expand the range of bio-products and enable the development of national bio-based economies that

valorise most of the available bio-resources including waste and agro-residues and achieve circular economies in the region. This will allow the region to achieve low carbon growth and inclusive green growth, a key development objective of the African Union. Given that most of ECOWAS economies are dominantly agrarian and rural, an opportunity exists for member countries to transform rural economies by improving on farm productivity and income, coupled with clean energy production and use. This has wider economic impacts that will drive sustainable development in the region.

ECOWAS member countries have significant bioenergy potential but this potential varies. Bioenergy crops (such as sugarcane), appear to be attractive feedstocks as large unutilised land areas are still available for cultivation in most countries. However, this potential needs to be carefully evaluated against sustainability considerations. On the other hand, other biomass resources such as forestry and agricultural wastes and residues present a good opportunity to address environmental disposal challenges as well as provide waste to energy. According to IRENA (2017), Africa has potential to produce up to 13.9 EJ of liquid biofuels annually from energy crops and this is sufficient to satisfy the 108 billion litres per year oil demand in Africa's road-transport sector. In addition agro-industrial residues in the region could provide sufficient feedstock for several GW of power generation capacity. Also, the region has substantial potential to harness biogas with millions of households having sufficient dung and water, apart from commercial and industrial scale biogas systems.

The regional bioenergy strategy and investment plan for the West African region has the ultimate objective of accelerating the diffusion of modern bioenergy technologies in the ECOWAS. To facilitate growth of this subsector, there is need to undertake interventions at regional and national level to address the identified barriers so as to create an enabling environment for upscaling the technologies. Regional interventions are described in this section and defined more concretely under the regional action plans for transforming the bioenergy industry-they outline in detail the activities that are included in the regional bioenergy strategy, and corresponding resource requirements and actors involved. Implementation of most activities to transform the biomass energy sector would be at national level – as defined in each National Bioenergy Action Plan. This strategy provide a harmonised approach and outlines the framework at regional level that will support these national activities in each member state to achieve both national and regional bioenergy targets.

5.1 Key Elements of the strategy

The ECOWAS Bioenergy Strategy and Investment Plan seeks to facilitate and promote sustainable domestic and foreign investments in the biomass energy subsector to help address prevalent energy poverty especially in rural and peri-urban populations. Key sustainability considerations are that bioenergy investments should not compromise food security and environment integrity. In implementing the Strategy, priority will be given to promoting local production of components and devices, to enhance the local socio-economic development impacts through creation of added value, employment, alongside food and energy security. An overarching principle of the Strategy is the creation of an enabling environment for market activities by removing market barriers. To allow investment in the bioenergy subsector requires removal of market barriers in the region and in each country. This entails creating an enabling environment for investors and project developers as well as end users. Such enabling conditions include enacting enabling regulations, providing policy incentives, setting requisite institutions and providing access to affordable financing instruments. This Regional Strategy is therefore anchored on the following key elements:

- Resource assessment and planning
- Policy and regulatory development and harmonisation
- Information and knowledge sharing
- Capacity building and technology transfer

- Financing mechanisms and resource mobilization

5.1.1 Resource Assessment and Planning

For effective and efficient planning of bioenergy production and use in the region, resource assessments and market information gathering are critical. Typically, not much is known about the state of bioenergy resources, supply and demand patterns. This is mainly due to limited institutional capacity with national agencies and inadequate funding to implement data collection and analysis. Resource assessments should cover natural resources such as land use, soil and water, environment and ecological systems, climate and weather characteristics. The bioresource comprise of the forestry and agriculture based biomass, and include primary resource, secondary resource and tertiary resources, the latter include waste and residue streams. In addition, other relevant market information such as demographic distribution, infrastructure and supply-demand patterns should be assessed. Thus readily available information on extent and distribution of land availability for energy crops, waste and residues should be available to policy makers, project developers and investors. Components of the resource assessment and market information should include:

a) Resources assessment and mapping covering
   - resource inventory
   - climatic and weather scenarios
   - resource availability and utilisation such as land, water and other environment considerations
   - current resource uses, potential competition and risks
   - Socio-economic context evaluation.

5.1.2 Policy and regulation development and harmonisation

To support the transition to modern bioenergy, review and development of policy and regulatory frameworks have to be developed and adopted by the member states (including targets, regulations, codes and quality standards). This should include harmonisation of regional policies and regulations for technology deployment to assist in create synergies, remove any policy conflicts and allow more efficient diffusion of bioenergy technologies in the member states. Harmonisation of regulations also helps in developing the market in the region as technical standards and certification can be achieved in a cost effective manner and facilitate greater uptake of technologies. Policy and regulatory refinement and harmonisation should take the following into consideration:

- Establishment of a common regional bioenergy vision (this requires political will and an inclusive consultative process for sustainability of initiatives)
- Ensuring there is policy coherence with other sectoral policies (consultation through inter-ministerial task teams and regulatory processes)
- Benchmarking activities on global best practices and experiences
- Consideration and recognition of member states uniqueness and apply subsidiarity principles
- Coordination of implementation strategy and strengthening of related institutions.

5.1.3 Information and Knowledge sharing

Availability of properly packaged and continuously updated market information on biomass energy subsector is critical, but so is awareness raising, education and communication to the process of rolling out modern bioenergy products and services to various market segments such as project developers, investors, feedstock producers, farmers, policy makers and financiers. Key elements of information production and sharing include:

- Identification of knowledge sources

- Establishment of a knowledge management system
- Knowledge management, sharing and transferring (communication tools), creation of a regional bioenergy database and an observatory
- Knowledge review, updating and monitoring.

5.1.4 Capacity building and technology transfer

Lack of and limited institutional capacity and human skills are key barriers to implementing and sustaining modern biomass energy programmes. Thus, education and training to improve knowledge and skills is a necessary pre-requisite for any sustainable bioenergy programme. This capacity is required across the entire industry and value chain. Apart from coordination provided at regional level, it is important to create and capacitate an agency within each government to be the custodian of championing modern bioenergy technology promotion. These institutions need to be capacitated to enable them to fulfil all the functions that will enable the region to achieve its bioenergy deployment targets. It is essential to consider and embed gender aspects in capacity building activities. Capacity building activities should include:

- Increasing awareness among market actors
- Reinforcing existing institutional structures and human skills
- Providing professional and on the job training
- Facilitating knowledge transfer and sharing, and promoting innovation.

5.1.5 Financing mechanisms and resource mobilization

Due to the high upfront costs of modern bioenergy technologies, there is need for developing and implementing innovative and tailored financing mechanisms and schemes especially for rural and peri-urban applications. These include subsidies and subventions, financial guarantee funds, blended finance coupled with finance risk mitigation measures involving both local and international financial institutions. To achieve scale and develop markets, innovative finance is vital for large scale public and private investments. Thus, exploring financing mechanisms and resource mobilisation requires:

- identifying sources of finance and mapping financing schemes suitable for different actors and activities across the bioenergy value chain
- examining modalities for accessing this finance, corresponding conditions, barriers to accessing finance and identifying the gatekeepers of schemes
- explore innovative green financing mechanisms such as climate mitigation related financing mechanisms to support relevant actors from enterprise support to end user finance
- mobilizing local finance institutions, particularly private sources of capital; and
- Coordination of donors.

6 Investment plan and resource mobilization

The planning period of this bioenergy investment plan is over the period 2021-2030 – a 10 year period which is expected to have the following phases:

- An initial 2 years (2021-2023) of preparation (studies, institutional, regulatory and policy changes, human resource training), setting the groundwork, mostly using existing resources, and mobilizing more important funds from various sources;
- A 6-year (2024-2030) implementation phase, where large -scale investments based on the proposed strategy are undertaken to achieve the regional bioenergy strategy objectives.

Both public and private funds will be required to operationalize the strategy. Public funds will be derived from the member states budgets, funded by own or external sources; while private funds will be coming from participating non-state entities such as private firms, farmers and households, and NGOs. Public costs will cover own government expenses (policy and regulatory management and monitoring, capacity building and project management, investment in state infrastructure, public awareness campaigns and grass-root sensitization, etc.) as well as provision of subsidies to participating entities (including private sector). Public subsidies will be necessary to support and catalyse private investments in the framework of public-private partnership schemes, and this can include investment subsidies for producers of biofuels, ICS and Improved charcoal producers.

Private finance will mostly be for the operational components of the strategy directly linked with rolling out of the selected bioenergy technologies. This includes end-user device purchases and equipment manufacturers and energy companies who make large budget investments in energy conversion plants and production facilities.

Below is a description of the detailed activities and estimated budget for implementing the selected priority bioenergy programme aspects and technologies.

6.1 Improved cookstoves (ICS) programme

To reduce pressure on national biomass resources, it is necessary to improve end-use efficiency and increase the functional services per unit of energy consumed – targeting wood fuel stoves (firewood, charcoal, pellets, and briquettes). More efficient technologies have typically high upfront costs and the good quality higher efficiency stoves (e.g. Tier 2 stoves) need to be imported into the region. Subsidies or innovative finance may be required in the initial stages to make the stoves financially competitive against less efficient devices. There is thus need to develop a number of innovative funding mechanisms to make the technologies affordable. After attaining a dissemination of certain critical mass in terms of number of units and assemblers / manufacturers, the industry can become self-sustaining and subsidies can be gradually withdrawn without any adverse effects on continued dissemination of bioenergy technologies. Key requirements for successful deployment of efficient stoves include:

- Ensuring significant stove efficiency improvements (i.e. reduced wood fuel consumption) relative to traditional stoves
- Ensuring quality of stoves meets consumer requirements and tastes (ease of use and durability being of major importance)
- Achieving commercial production at scale (thus, ensuring costs to consumers that are competitive with traditional stoves and/or where reductions in expenditures on fuels provide a very fast payback) and,
- Having distribution and/or installation networks that make purchasing ICS as easy as traditional stoves.

6.1.1 Activities

This activity should result in the availability on the local market of affordable, appropriately designed and good quality efficient stoves that meet the requirements of users. To achieve these outcomes would entail the following:

#	Activity
1	Identify and capacitate national ICS units within each country to coordinate ICS activities
2	Building on existing studies (e.g. GACC), conduct feasibility studies to identify target locations in each country where stove dissemination will achieve higher impact. It is recommended that dissemination efforts target rural areas with moderate to severe fuelwood shortages (especially where a commercial market for fuelwood exists) as well as

	urban and peri-urban low income areas where traditional cooking practices are still prevalent
3	Develop business plans and due diligence assessments for efficient stove businesses. Train supporting entrepreneurs on how to conduct feasibility studies and development of bankable projects
4	Establish a regional Tier 2-4 efficient stove production facility. This activity enables the region to produce good quality efficient stoves at scale based on common quality standards and user needs. The plant would be set up in a member state with relevant infrastructure to support the facility
5	Set up harmonised regional quality standards and quality assurance system so that end users and market operators can identify and make informed procurement decisions
6	Building on existing institutions, establish a regional efficient stove RD&D unit (whose activities include testing of ICS) and working closely with ECREEE Bioenergy PMU and linked to national research institutions as well as to a proposed network of efficient stove practitioners and stakeholders
7	Integrate construction of ICS in the curriculum of vocational education and training and undertake technical capacity building and accreditation of local stove producers and businesses
8	Train producers and businesses in marketing and promotion of efficient stoves
9	Provide access to financial incentives and financing mechanisms (usually micro finance) where necessary and appropriate along the value chain;
10	Conduct public and consumer awareness raising of benefits of efficient stoves (involving the Ministries of Health). Sensitize architects on including provision of ICS in the design of low-costs residential buildings and institutions that cook with biomass

6.1.2 Expected outcomes of intervention

This programme is expected to lead to the increased penetration of ICS in households and institutions supported by a regional and local stove manufacturing industry, efficient value chain and supportive institutional, regulatory and policy framework. Ultimately the wide dissemination of ICS should lead to reduction in fuelwood demand and corresponding reduction in deforestation rates.

6.1.3 Resource requirements

The following financial and human resources as well as equipment will be required to enable the implementation of the action plan.

#	Activity	Financial (USD)	Source of funds	Human resource
1	Capacitate national ICS unit	20,000	National governments, Development partners	Line ministry officials
2	Conduct feasibility studies	300,000	Development partners	Consultants, Line ministry officials
3	Develop business plans	100,000	Development partners	Consultants, private sector
4	Establish regional stove production facility	500,000	Private sector, financial institutions	Private sector, financial institutions
5	Setup harmonised regional standards	50,000	National governments	Consultants
6	Establish regional RD&D unit	500,000	Development partners	Engineers, social scientists, economists
7/8	Train and accredit local stove producers and businesses	200,000	Development partners	ECREEE, Line ministry officials
9	Providing finance (subsidies)	2,000,000	National governments, Development partners	Line ministry officials

10	Conduct public and consumer awareness	60,000	National governments	Line ministry officials

6.2 Clean cooking fuels programme (LPG, biogas, bioethanol)

Clean cooking fuels CCFs such as LPG, biogas and bioethanol offer alternative cooking solutions for households, institutions and industries currently dependent on fuelwood in the region. Implemented properly, CCFs can reduce the burden and cost of firewood collection, preserve woodlands and forests and expand the mix of energy supplies on the market. Biogas can also be used in internal combustion engines to generate electricity and there is already some experience in the region where abattoirs and some factories use production waste as feedstock for biogas production. These initiatives need to be upscaled so that more households, institutions and industry can substitute fossil fuels and fuelwood with a clean source of energy.

6.2.1 Activities

To achieve the widespread biogas production, the following activities are proposed:

#	Activity
1	Identify and capacitate national CCFs units within each country to coordinate CCFs activities and create a network of CCFs supporting agents in every district
2	Building on existing studies, conduct feasibility studies to identify target locations in each country where CCFs dissemination will achieve higher impact. It is recommended that dissemination efforts target rural areas with significant market potential (e.g. areas with livestock population, and with moderate to severe fuelwood shortages). Also identify institutions and industries that have significant organic biomass waste streams (such as abattoirs and fruit factories) that can be viably harnessed for biogas production. In addition, identify municipalities that have significant organic and liquid waste streams.
3	Develop business plans and due diligence assessments for CCFs businesses
4	Set up harmonised regional quality standards and quality assurance system for biogas systems at different scales for consistency of installations on the market
5	Building on existing institutions, establish a regional biogas RD&D unit and working closely with ECREEE Bioenergy PMU and linked to national biogas research institutions
6	Undertake technical capacity building and accreditation of local masons and businesses
7	Conduct demonstration of biogas systems in strategic locations for awareness and proof of concept
8	Providing access to financial incentives and financing mechanisms where necessary and appropriate along the value chain;
9	Conduct public and consumer awareness raising of benefits of biogas and how to access systems, finance and support for installations

6.2.2 Expected outcomes of intervention

CCFs can help reduce indoor air pollution, cut down on fuelwood procurement costs as well as improve quality of life in the region. They can also contribute to significant reduction in energy bills of industry and institutions, making them more competitive and offering better services. There are also benefits from using clean fuels such as biogas - as it also assists in environmental management by adding value to waste and reducing the waste disposal costs for institutions. Slurry is a valuable fertiliser.

6.2.3 Resource requirements

The following financial and human resources as well as equipment will be required to enable the implementation of the action plan.

#	Activity	Financial (USD)	Source of funds	Human resource
1	Capacitate CCFs unit	20,000	National governments, Development partners	Line ministry officials
2	Conduct feasibility studies	300,000	Development partners	Consultants, Line ministry officials
3	Develop business plans	100,000	Development partners	Consultants, private sector
4	Setup harmonised regional standards	60,000	National governments	Consultants
5	Establish regional RD&D unit	500,000	Development partners	Engineers, social scientists, economists
6	Train, and accredit masons	600,000	Development partners	ECREEE, development partners, Line ministry officials
7	Conduct technology demonstrations	600,000	Development partners	Line ministry officials, development partners, NGOs
8	Provide incentives (subsidies)	60,000,000	National governments, Development partners, financial institutions	Private sector, financial institutions
9	Roll out CCFs programme	1,250,000	Private sector,	Private sector, financial institutions
10	Conduct public and consumer awareness	60,000	National governments	Line ministry officials, NGOs

6.3 Biofuels for transport programme

Biofuels have potential to displace fossil fuels in both the transport sector and also at household level. However, to establish a sustainable biofuel programme in the region and in each country requires serious national commitment to ensure there is adequate feedstock mobilisation, supportive institutions, policy and regulations are in place, fuel standards are set and blending and distribution infrastructure is established.

6.3.1 Activities

To promote biofuels production and use in each country for national and regional supply, a number of key activities need to be undertaken as follows:

#	Activity
1	First, there is need to conduct feasibility studies to identify potential for mobilizing adequate feedstock to produce targeted volumes of biofuel (e.g. E10; D5). This includes assessing ongoing activities, current industry production and potential for establishing greenfield plantations and (for instance) new non annexed distilleries for expanded ethanol production. Land identification and zoning is critical in that process as well as accounting for socio economic and environmental sustainability criteria. Identify specific business cases for investment development.
2	Establish supportive institutional, policy and regulatory framework for promoting biofuel implementation including harmonized regional blending mandate (E10/D5)
3	Identify and capacitate national biofuel units to coordinate biofuel programme supported by an inter ministerial task force and other key stakeholders such as private sector and R&D
4	Set up harmonised regional quality standards and quality assurance system for biofuel production, supply and use
5	Develop business plans and due diligence assessments for biofuel production for

	identified ventures
6	Undertake technical capacity building and accreditation of local businesses along the value chain
7	Providing access to financial incentives and financing mechanisms where necessary and appropriate along the value chain;
8	Conduct public and consumer awareness raising of benefits of biofuel and de mystify biofuel use in vehicles
9	Establish feedstock production facilities. Feedstocks should be selected appropriately depending on each country's conditions
10	Establish biofuel conversion facilities
11	Establish biofuel blending and distribution facilities. For countries that want to adopt more ambitious blending levels (e.g. Burkina Faso plans E10 and B5), the strategy should offer flexibility to allow different levels of fuel blending

6.3.2 Expected outcomes of intervention

Building on existing agro-industries or establishing greenfield facilities, this programme is expected to establish large scale biofuel production in the region (in selected countries where there is potential and interest) and substitute 5-10% of fossil fuels for transport. This has fiscal implications for countries that import petroleum fuels and can lead to various other socio-economic and environmental benefits in the region.

6.3.3 Resource requirements

The following financial and human resources as well as equipment will be required to enable the implementation of the action plan.

#	Activity	Financial (USD)	Source of funds	Human resource
1	Conduct feasibility studies	12,000,000	Development partners	Consultants, Line ministry officials
2	Setup harmonised regional institutional, policy regulatory framework	240,000	National governments	Consultants, R&D entities, Line ministry officials
3	Capacitate biofuels units	20,000	National governments, Development partners	Line ministry officials
4	Set up harmonised regional quality standards	180,000	National governments	Consultants, R&D entities, Line ministry officials
5	Develop business plans	100,000	Development partners	Consultants, private sector
6	Train, and accredit local value chain	600,000	Development partners	ECREEE, development partners, Line ministry officials
7	Providing incentives (subsidies)	240,000,000	National governments, Development partners, financial institutions	Private sector, financial institutions
8	Conduct public and consumer awareness	60,000	National governments	Line ministry officials, NGOs
9	Establish feedstock	120,000,000	Private sector, financial institutions	Private sector, financial institutions
10	Establish processing	600,000,000	Private sector, financial institutions	Private sector, financial institutions
11	Establish distribution	240,000,000	Private sector, financial institutions	Private sector, financial institutions

6.4 Biobased combined heat and power generation programme

Combined heat and power production via direct combustion of agricultural residues or forestry waste is an established and well-proven method. It is largely based on mature direct combustion boiler and steam turbine systems (EC, 2013). CHP technologies or combined cooling heat and power (CCHP), have better efficiencies, lower fuel consumption and better CO_2 emissions profiles than heat and electricity production individually – but in the ECOWAS region, heat applications and market are normally unavailable. This technology is therefore useful in many agro-processing facilities where both heat and electricity are required for various food processing applications. There is wide experience of using CHP systems in the sugar industry where, cogeneration of process heat for sugar processing and electricity (use in the mill and also for export to the public grid) has been in existence for decades. The success and application of this technology varies between countries in the ECOWAS and efforts still continue to roll out the technology.

6.4.1 Activities

Promotion of CHP or cogeneration in the region will build on existing initiatives and this will vary from country to country. Some countries already have relevant institutions, policies and regulations to support the further expansion of cogeneration and these countries would require additional push in the form of financial incentives or capacity to upscale activities. The following activities are important for supporting the growth of cogeneration in the region:

#	Activity
1	Building on existing studies, conduct detailed biomass resources assessment to identify clusters of biomass feedstocks in various agro industries and municipal waste
2	Building on existing studies, conduct feasibility studies to identify viability of cogeneration in identified agro industries. From this analysis, identify specific business cases for investment support.
3	Establish harmonized regional supportive institutional, policy and regulatory framework for promoting cogeneration. Depending on state of power sector, review electricity regulations to allow private participation in the power market. This includes introducing feed in tariffs and other incentives such as net metering.
4	Develop harmonized and standardised power purchase agreements between national utilities and independent power producers. Develop and implement a model to calculate and set tariffs in a transparent and sustainable way. CHP installations must be standardised to allow for interconnection to the national grid
5	Strengthen national institutions by equipping national utility with appropriate tools and software to deliver on duties, including capacity to model and implement pricing mechanisms / electricity tariffs.
6	Providing access to finance and financing mechanisms where necessary for project developers

6.4.2 Resource requirements

The following financial and human resources as well as equipment will be required to enable the implementation of the action plan.

#	Activity	Financial (USD)	Source of funds	Human resource
1	Conduct resource studies	120,000	Development partners	Consultants, Line ministry officials
2	Conduct feasibility studies	360,000	Development partners	Consultants, Line ministry officials
3	Setup harmonised	240,000	National governments	Consultants, R&D

	regional institutional, policy regulatory framework			entities, Line ministry officials
4	Set up harmonised regional PPAs	60,000	National governments	Consultants, R&D entities, Line ministry officials
5	Build national institutional capacity	600,000	Development partners	ECREEE, development partners, Line ministry officials
7	Providing incentives (subsidies)	60,000,000	National governments, Development partners, financial institutions	Private sector, financial institutions
10	Establish plants	1,200,000,000	Private sector, financial institutions	Private sector, financial institutions
11	Establish distribution networks	60,000,000	Private sector, financial institutions	Private sector, financial institutions

6.5 Improved charcoal value chain (ICC) system

Charcoal production is illegal in many ECOWAS countries but its trade remains a large part of the ECOWAS economies. Its production is unorganised and unsustainable, charcoal production has a worse impact on the environment compared to firewood collection as live trees and shrubs are cut down to make charcoal using very low-efficient kilns, while firewood is collected via pruning, and deadwood. Between 30 to 50% of the heat value of wood is lost during conversion to charcoal. This leads to massive waste of the biomass feedstock, hence accelerating the rate of deforestation. It may be more efficient to use firewood where transport distances are short and transport costs are low. Most charcoal is produced by individual farmers and their families. Few charcoal producers cooperate with one another on an organised basis. This makes it difficult for producers to add value to their production and to introduce measures to make charcoal production sustainable. It is therefore important that charcoal production be improved significantly to reduce the rate of deforestation through the introduction of improved charcoal kilns and efficient organisation of the value chain.

6.5.1 Activities

The promotion of improved charcoal value chain system (ICC) will entail several key actions along the value chain including the designing appropriate charcoal kilns, training and organising charcoal producers, standardisation and quality control supported by appropriate regulatory and policy framework. Also, the activities need to include promotion of commercial woodlots through agriculture and forestry authorities. Cultivation of fast-growing plants (e.g. bamboo) which can be used as feedstock for charcoal production should also be promoted. Rural communities should also be sensitised to plant trees for firewood and charcoal production, as part of agroforestry, live fencing or dedicated woodlots.

#	Activity
1	Identify and capacitate national ICC units within each country to coordinate ICC activities
2	Awareness raising on adverse impacts of inefficient charcoal production
3	Develop and train communities on sustainable management and harvesting of forest
4	Develop and train communities on alternative feedstock for charcoal production
5	Formalise marketing of charcoal by establishing charcoal marketing centres in rural and urban areas
6	Rationalise and develop supportive fees and taxes along the charcoal value chain (including simplifying licencing and registration of transporters)

7	Formalise and protect wholesalers and retailers them from illegal dealers
8	Design of efficient and mobile charcoal kilns for regional dissemination – R&D institutions in the region can be tasked with developing technology
9	Conduct efficient kiln demonstrations in every country in key charcoal production areas to raise awareness of the technology and show proof of concept
10	Set up harmonised regional quality standards and quality assurance system so that end users can identify and make informed procurement decisions
11	Train, register and accredit charcoal producers in every district
12	Provide incentives for adoption of efficient charcoal kilns
13	Establish national efficient kiln production facilities. This activity enables the countries to produce good quality efficient kilns at scale based on common quality standards and user needs.
14	Introduce efficient kilns
15	Promote efficient charcoal stoves (similar to ICS)
16	Enforce efficient charcoal production (through NGOs and local authorities and national charcoal task force – due to rampant corruption, there is need for independent monitoring of inefficient charcoal production at local level)

6.5.2 Expected outcomes of intervention

Wide scale establishment of ICC systems is expected to lead to significant reduction in deforestation rates and bring corresponding ecosystem services benefits. An organised and more efficient charcoal production sector will also lead to more sustainability in the sector, and improved community relations as current activities are largely considered illegal.

6.5.3 Resource requirements

The following financial and human resources as well as equipment will be required to enable the implementation of the action plan.

#	Activity	Financial (USD)	Source of funds	Human resource
1	Capacitate national ICC unit	20,000	National governments, Development partners	Line ministry officials
2	Raise awareness	60,000	National governments	Line ministry officials
3	Develop sustainable forest management and harvesting	600,000	National governments, Development partners	Line ministry officials, NGOs
4	Develop alternative charcoal feedstock	600,000	National governments, Development partners	Line ministry officials, NGOs
5	Formalise marketing of charcoal	600,000	National governments, Development partners	Line ministry officials
6	Rationalise fees and taxes along the charcoal value chain	1,200,000	National governments, Development partners	Line ministry officials
7	Formalise and protect wholesalers and retailers	360,000	National governments, Development partners	Line ministry officials
8	Design of efficient and mobile charcoal kilns	350,000	Development partners	R&D entities, engineering consultants
9	Conduct efficient kiln demonstrations	120,000	Development partners	Line ministry officials
10	Setup harmonised regional standards	60,000	National governments	Consultants
11	Train, register and accredit charcoal producers	600,000	Development partners	ECREEE, Line ministry officials
12	Providing incentives (subsidies)	500,000	National governments, Development partners	Line ministry officials

13	Establish kiln production facilities	1,250,000	Private sector, financial institutions	Private sector, financial institutions
14	Market improved charcoal systems	60,000	Private sector, National governments	Private sector, Line ministry officials, NGOs
15	Promote efficient charcoal stoves (similar to ICS)	1,200,000	Private sector, National governments	Private sector, Line ministry officials, NGOs
16	Enforce efficient charcoal production	600,000	National governments, Development partners	Line ministry officials NGOs

6.6 Biomass gasification programme

This programme aims to promote smalls scale gasification in the region. Biomass gasification for off grid applications involves production of gaseous fuel called producer gas used in a gas engines, or modified gasoline and diesel internal combustion engines for electricity generation. Producer gas can also be used to produce steam which is then expanded on a steam reciprocating internal engine to produce electricity. Besides providing electricity to isolated areas in rural areas and associated benefits, it creates additional employment for feedstock providers who are mostly small and medium scale farmers. The challenge for biomass gasification implementation is lack of awareness for sensitizing policy makers and financial providers on the potential of the technology, and innovative financing mechanism aimed at leveraging the relatively higher electricity generating costs compared to other traditional energy supply systems.

6.6.1 Activities

To achieve the widespread gasification production, the following activities are proposed:

#	Activity
1	Identify and capacitate national gasification units within each country to coordinate gasification activities
2	Building on existing studies, conduct feasibility studies to identify target locations in each country where gasification dissemination will achieve higher impact
3	Develop business plans and due diligence assessments for gasification businesses
4	Set up harmonised regional quality standards and quality assurance system for gasification systems
5	Building on existing institutions, establish a regional gasification RD&D unit and working closely with ECREEE Bioenergy PMU and linked to national research institutions
6	Undertake technical capacity building and accreditation of local artisans and businesses
7	Conduct demonstration of gasification systems in strategic locations for awareness and proof of concept
8	Providing access to financial incentives and financing mechanisms where necessary and appropriate along the value chain;
9	Conduct public and consumer awareness raising of benefits of gasification and how to access systems, finance and support for installations

6.6.2 Expected outcomes of intervention

Producer gas can used in internal combustion engines for electricity generation but also can be used for thermal applications directly. This is useful for providing off grid electricity and creates employment rural farmers.

6.6.3 Resource requirements

The following financial and human resources as well as equipment will be required to enable the implementation of the action plan.

#	Activity	Financial (USD)	Source of funds	Human resource
1	Capacitate gasification unit	20,000	National governments, Development partners	Line ministry officials
2	Conduct feasibility studies	300,000	Development partners	Consultants, Line ministry officials
3	Develop business plans	100,000	Development partners	Consultants, private sector
4	Setup harmonised regional standards	60,000	National governments	Consultants
5	Establish regional RD&D unit	500,000	Development partners	Engineers, social scientists, economists
6	Train, and accredit artisans	600,000	Development partners	ECREEE, development partners, Line ministry officials
7	Conduct technology demonstrations	600,000	Development partners	Line ministry officials, development partners, NGOs
8	Provide incentives (subsidies)	60,000,000	National governments, Development partners, financial institutions	Private sector, financial institutions
9	Roll out gasification programme	1,250,000	Private sector,	Private sector, financial institutions
10	Conduct public and consumer awareness	60,000	National governments	Line ministry officials, NGOs

6.7 Financing the investment plan

Financing for the investment plan could come from a variety of sources. Member states governments are expected to provide some funds from the national budget and from taxation receipts, but funding for some aspects can be motivated for technical assistance from development partners, and green funds where applicable. As key market players, the private sector is expected to use available market financing vehicles to invest in the selected technologies.

6.8 Financing modalities

6.8.1 Public finance

There are various public finance institutions that provide public capital to support both public and private sector projects as well as policies and programmes including sustainable bioenergy. Some of these institutions have specific mandates to support renewable energy investments and these include:

International financial institutions: including global and regional multilateral development banks that provide funds, financing instruments and risk mitigation instruments. They use their own capital (raised on initial capital provided by government donors) or act on behalf of multiple government donors. Examples include the World Bank Group, the African Development Bank (AfDB), the European Investment Bank (EIB), the European Bank for Reconstruction and Development (EBRD), the Islamic Development Bank, the West African Development Bank (BOAD).

Development Finance Institutions (DFIs): include most of the above international financial institutions and also encompass bilateral development agencies, such as the AFD (the French Development Agency), KfW (the German Development Bank) and JICA (the Japanese International Cooperation Agency). These provide bilateral finance (typically from one developed country to several developing countries). They also include national development banks and government funding agencies that provide finance within their own individual countries.

Local financial institutions: both public and private finance institutions with a main presence in the domestic market. They could be large or very small in terms of managed capital.

Export credit agencies: these are public agencies and entities supplying government-backed loans, guarantees and insurance to corporations from their home country aiming to do business overseas in developing countries and emerging markets. Most industrialised economies have export credit agencies to promote exports and imports. An example is Afreximbank

Climate finance institutions: these include international climate funds and intermediary institutions created by multiple government donors to channel public funds from developed countries to support clean technology projects in developing countries. Among the most prominent climate finance institutions supporting renewable energy deployment are the Global Environment Facility (GEF), the Climate Investment Funds (CIFs) and the Green Climate Fund (GCF). Often functioning as implementing agencies for climate funds, DFIs also channel a large share of public climate finance to developing countries.

6.8.2 Risk mitigation

There is a perception of high risk in the development and financing of renewable energy projects in Africa, especially bioenergy projects. Project risks include political and regulatory risks; counterparty, grid and transmission link risks; currency, liquidity and refinancing risks; as well as resource risks, which is particularly significant for bioenergy.

Thus, access to effective risk mitigation instruments is critical to mobilising private investment. Public finance institutions can make important contributions by providing private investors with risk mitigation instruments. These include guarantees, currency hedging instruments and liquidity reserve facilities. They help mobilise private capital while reducing the capital requirements of the public finance institution. Available risk mitigation include:

Guarantee instruments

Guarantee instruments can improve the structure and quality of bioenergy investment by addressing various risks, making projects more attractive to private investors. Guarantees supporting bioenergy investments issued by public entities such as governments and international finance institutions address political, policy, credit, and currency risks. Available guarantees include:

- government guarantees – in this case governments provide guarantees to mitigate currency, regulatory and power off-taker risk. These guarantees are typically issued by the ministry of finance
- political risk insurance – important for unstable countries for risk such as civil unrest, currency inconvertibility and transfer restriction, breach of contract, and expropriation. Political risk insurance can be obtained from institutions such as the Multilateral investment Guarantee
- partial risk guarantee – is also used to cover political risk over and beyond the political risk insurance
- partial credit guarantee – can be used to cover debt service default and is offered by IFC. `

In addition to guarantees, currency risk mitigation instruments can also be used to protect investments from fluctuations/depreciation in local currency. Such instruments include providing tariffs denominated in USD or factoring in currency movements in the tariff formula.

Other instruments include currency hedging, currency risk guarantee and local currency lending. These instruments can be factored in during project development to enable financial closure of proposed investments.

6.8.3 Support for project preparation

It is important for the region to create a unit that supports early-stage project development initiatives and a corresponding pipeline of projects for investment. Support for project preparation through capacity building, brokerage and dedicated grants is critical in West Africa given the limited capacity on project development in the region. Support should also be provided for preparing feasibility studies or project proposals for project sponsors applying for loans. A Programme Management Unit housed in ECREEE can assist in developing tools and assisting project developers in this regard. This will enable project developers to write high quality project proposals through proper preparation of written project documentation and business proposals.

7 Implementation Strategy

7.1 Regional and national level institutional framework

Implementation of the regional bioenergy strategy and investment plan will be at two levels, at regional and national level. There are some key activities that are envisaged at regional level such as policy harmonisation and some capacity building, but the bulk of activities will be undertaken at national level. The strategy will be facilitated and coordinated at regional level through ECREEE and the ECOWAS Secretariat. A Bioenergy Programme Management Unit (PMU) is proposed to coordinate the activities within ECREEE and is to work closely with the ECOWAS Secretariat. This regional level coordination will facilitate joint political commitment and takes advantage of established mechanisms for regional cooperation and decision making. It can also allow for achieving economies of scale for implementing and mobilising resources. In addition, regional coordination allows for synergy and cross learning opportunities.

7.1.1 The Bioenergy Programme Management Unit (PMU)

The PMU is to be established within the ECREEE and will provide support to the Partner States on key activities proposed in the strategy. Most activities will primarily be implemented at the national level while the PMU's role will be that of a catalyst and facilitator. It will also foster cooperation and collaborative efforts across the member states, facilitate knowledge and information sharing including:

- Regional institutional, policy and regulatory harmonisation
- Capacity building and training at national and regional level
- Strategy Implementation support: One of the key roles that the PMU is expected to play is to support project development and assisting member states with packaging of projects for funding
- Strategic coordination and programme management: including promotion of exchanges and dissemination of best practices (knowledge management).

Through a designated Energy Programme Officer, the proposed PMU will provide coordinating, assisting implementation, monitoring and communicating the progress of the regional and national activities in close collaboration with the ECOWAS Secretariat. The latter will link bioenergy activities to the broader ECOWAS energy programmes and political structures such as the ECOWAS Energy Committee and other Ministerial bodies. At the country level, the

PMU will coordinate with Partner States through the ministry of energy and proposed bioenergy national focal points of the working groups. The PMU's budget is estimated to be 5% overhead of the regional programme activity budget.

7.1.2 National level institutional setup

For effective implementation of the strategy, strong and committed teams (Thematic working groups) will need to be established at national level. These working groups are expected to be broad based (but relevant to specific technologies such as biogas, ethanol, etc.) to provide wide consultations and mainstreaming. The national working groups drawn from the key stakeholders will be coordinated by a designated national bioenergy Focal Point, a senior officer within the ministry in charge of energy and the overall champion of bioenergy in each country. The bioenergy Focal Point will provide strategic, policy, and institutional guidance for the strategy implementation. The person will guide the national working groups and ensure coordinated implementation of the strategy at national level. In addition, the focal point will be the link with the regional PMU.

National thematic working groups

The thematic bioenergy working groups (WGs) comprise of technical officers in key government institutions, private sector and NGOs with interest in bioenergy access, working under the coordination of the energy ministry Focal Point. These thematic working groups will vary in composition depending on country priorities and institutional framework in each country. A thematic champion will be selected to oversee the promotion of individual (thematic) aspects/technologies of each national bioenergy strategy. The working groups will meet regularly and approve national work plans, budgets and monitor progress.

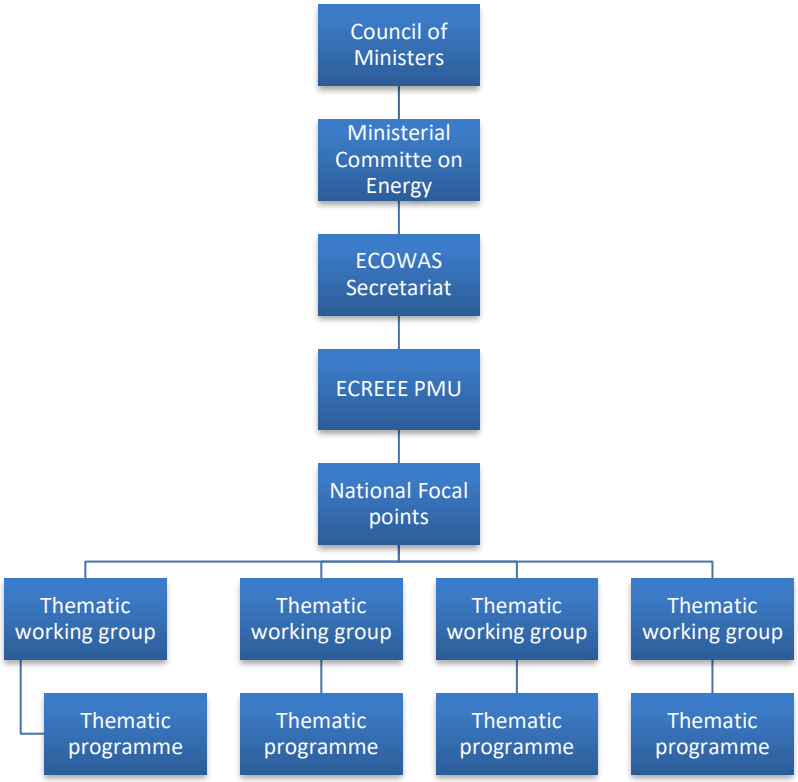

Figure 3: Regional institutional framework to support bioenergy strategy implementation

7.2 Implementation of national programmes

Implementation of the selected programme areas at national level will be undertaken under the institutional set up and within the timeline as shown in the following tables.

7.2.1 Improved cookstoves programme

#	Activity	Responsible institution	Timeline
1	Capacitate national ICS unit	Ministries of Energy, Focal Point	Year 1
2	Conduct feasibility studies	PMU, Focal Points, WG, Line ministry officials, Private sector – project developers, Academia	Year 1-2
3	Develop business plans	PMU, Focal Points, WG, Line ministry officials, Private sector – project developers	Year 2
4	Establish regional stove production facility	PMU, Focal Points, Private sector	Year 3-4
5	Setup harmonised regional standards	PMU, Focal Points, WG, Line ministry officials	Year 2
6	Establish regional RD&D unit	PMU, Focal Points, WG, Line ministry officials, R&D institutes	Year 2
7/8	Train and accredit local stove producers and businesses	PMU, Focal Points, WG, Line ministry officials, NGOs	Year 4
9	Provide finance (subsidies)	PMU, Focal Points, Ministry of Finance, Financial institutions, development partners	Year 3-+
10	Conduct public and consumer awareness	PMU, Focal Points, Line ministry officials, NGOs	Year 2-+

7.2.2 Clean Cooking fuels promotion programme

#	Activity	Responsible institution	Timeline
1	Capacitate CCFs unit	Ministries of Energy, Focal Point	Year 1
2	Conduct feasibility studies	PMU, Focal Points, WG, Line ministry officials, Private sector, Academia	Year 1-2
3	Develop business plans	PMU, Focal Points, WG, Line ministry officials, Private sector – project developers	Year 2
4	Setup harmonised regional standards	PMU, Focal Points, WG, Line ministry officials	Year 2-3
5	Establish regional RD&D unit	PMU, Focal Points, WG, Line ministry officials, R&D institutes	Year 2
6	Train, and accredit artisans	PMU, Focal Points, WG, Line ministry officials, NGOs, development partners	Year 2
7	Conduct CCF demonstrations	PMU, Focal Points, WG, Line ministry officials, NGOs, development partners	Year 3
8	Provide incentives (subsidies)	PMU, Focal Points, Ministry of Finance, Financial institutions, development partners	Year 3-+
9	Roll out CCFs programme	PMU, Focal Points, Private sector	Year 3-+
10	Conduct public and consumer awareness	PMU, Focal Points, Line ministry officials, NGOs	Year 2-+

7.2.3 Biofuel for transport programme

#	Activity	Responsible institution	Timeline
1	Conduct feasibility studies	PMU, Focal Points, WG, Line ministry	Year 1

		officials, Private sector, Sugar estates, Oil companies, Academia	
2	Setup harmonised regional institutional, policy regulatory framework	PMU, Focal Points, WG, Line ministry officials, Private sector, Sugar estates, Oil companies, Academia	Year 1
3	Capacitate biofuels units	Ministries of Energy, Focal Point	Year 1
4	Set up harmonised regional quality standards	PMU, Focal Points, WG, Line ministry officials, Private sector, Sugar estates, Oil companies, Academia, R&D entities	Year 1-2
5	Develop business plans	PMU, Focal Points, WG, Line ministry officials, Private sector, Sugar estates, Oil companies, Academia	Year 2
6	Train, and accredit local value chain	PMU, Focal Points, WG, Line ministry officials, NGOs, development partners	Year 3-4
7	Provide incentives (subsidies)	PMU, Focal Points, Ministry of Finance, Financial institutions, development partners	Year 3-+
8	Conduct public and consumer awareness	PMU, Focal Points, Line ministry officials, NGOs	Year 3-+
9	Establish feedstock	Focal Points, WG, Line ministry officials, Private sector, Sugar estates	Year 4-+
10	Establish processing	Focal Points, WG, Line ministry officials, Private sector, Sugar estates	Year 4-+
11	Establish distribution	Focal Points, WG, Line ministry officials, Private sector, Oil companies	Year 5-+

7.2.4 Combined heat and power programme

#	Activity	Responsible institution	Timeline
1	Conduct resource studies	PMU, Focal Points, WG, Line ministry officials, Private sector, Agro-industries, Academia	Year 1
2	Conduct feasibility studies	PMU, Focal Points, WG, Line ministry officials, Private sector, Agro-industries, Academia	Year 1-2
3	Setup harmonised regional institutional, policy regulatory framework	PMU, Focal Points, WG, Line ministry officials, Private sector, Agro-industries, Electricity utilities, Academia	Year 2
4	Set up harmonised regional PPAs	PMU, Focal Points, WG, Line ministry officials, Private sector, Agro-industries, Electricity utilities, Academia	Year 2
5	Build national institutional capacity	PMU, Focal Points, WG, Line ministry officials, Private sector, Agro-industries, Electricity utilities, development partners	Year 2-3
7	Provide incentives (subsidies)	PMU, Focal Points, Ministry of Finance, Financial institutions, development partners	Year 3-+
10	Establish plants	Focal Points, WG, Line ministry officials, Private sector, Agro-industries, Electricity utilities, development partners	Year 3-+
11	Establish distribution networks	Focal Points, Line ministry officials, Private sector, Agro-industries, Electricity utilities	Year 4-+

7.2.5 Improved charcoal value chain system

#	Activity	Responsible institution	Timeline
1	Capacitate national ICC unit	Ministries of Energy, Focal Point	Year 1
2	Raise awareness	PMU, Focal Points, Line ministry officials, NGOs	Year 1-+
3	Develop sustainable forest	PMU, Focal Points, WG, Line ministry	Year 1-+

	management and harvesting	officials, NGOs, R&D institutes	
4	Develop alternative charcoal feedstock	PMU, Focal Points, WG, Line ministry officials, NGOs, R&D institutes	Year 1-+
5	Formalise marketing of charcoal	PMU, Focal Points, WG, Line ministry officials, R&D institutes	Year 2-3
6	Rationalise fees and taxes along the charcoal value chain	PMU, Focal Points, WG, Line ministry officials, R&D institutes	Year 2-3
7	Formalise and protect wholesalers and retailers	PMU, Focal Points, WG, Line ministry officials, R&D institutes	Year 2-3
8	Design of efficient and mobile charcoal kilns	PMU, Focal Points, WG, Line ministry officials, R&D institutes	Year 1-2
9	Conduct efficient kiln demonstrations	PMU, Focal Points, WG, Line ministry officials, R&D institutes, NGOs	Year 2-3
10	Setup harmonised regional standards	PMU, Focal Points, WG, Line ministry officials	Year 2
11	Train, register and accredit charcoal producers	PMU, Focal Points, WG, Line ministry officials, NGOs	Year 3
12	Providing incentives (subsidies)	PMU, Focal Points, Ministry of Finance, Financial institutions, development partners	Year 3-+
13	Establish kiln production facilities	PMU, Focal Points, Private sector	Year 4
14	Market ICC	PMU, Focal Points, Line ministry officials, NGOs	Year 4-+
15	Promote efficient charcoal stoves	PMU, Focal Points, Line ministry officials, NGOs, private sector	Year 2+
16	Enforce efficient charcoal production	Line ministry officials, Forestry, Local government, NGOs	Year 5-+

7.2.6 Gasification programme

#	Activity	Responsible institution	Timeline
1	Capacitate gasification unit	Ministries of Energy, Focal Point	Year 1
2	Conduct feasibility studies	PMU, Focal Points, WG, Line ministry officials, Private sector, Academia	Year 1-2
3	Develop business plans	PMU, Focal Points, WG, Line ministry officials, Private sector – project developers	Year 2
4	Setup harmonised regional standards	PMU, Focal Points, WG, Line ministry officials	Year 2-3
5	Establish regional RD&D unit	PMU, Focal Points, WG, Line ministry officials, R&D institutes	Year 2
6	Train, and accredit artisans	PMU, Focal Points, WG, Line ministry officials, NGOs, development partners	Year 2
7	Conduct gasification demonstrations	PMU, Focal Points, WG, Line ministry officials, NGOs, development partners	Year 3
8	Provide incentives (subsidies)	PMU, Focal Points, Ministry of Finance, Financial institutions, development partners	Year 3-+
9	Roll out gsification programme	PMU, Focal Points, Private sector	Year 3-+
10	Conduct public and consumer awareness	PMU, Focal Points, Line ministry officials, NGOs	Year 2-+

8 Monitoring and evaluation

It is important to monitor the implementation of the bioenergy technology roadmap and rate of deployment of modern bioenergy technologies in each country and region, and to assess if strategy needs to be adjusted given the experiences gained through its implementation. Thus there is need to establish indicators that capture the roadmap's impact and provide governments

with quantitative and qualitative information about the roadmap's successes and shortcomings. These data can then be used to improve policy settings, tweak targets, or adjust institutional frameworks if needed. Monitoring will be a continuous process, with tracking and monitoring occurring on a regular basis, as shown in Figure 4. This process also requires significant data collection efforts and needs to be budgeted for in the overall programme activities.

Figure 4: Monitoring and evaluation of strategy implementation

Indicators can be grouped by type (i.e. technology, financial, policy and sustainability) as well as qualitative and quantitative metrics to allow measurement of progress against the specific strategy milestones.

8.1 Bioenergy technology deployment

For bioenergy technology deployment, the indicators measure the number of bioenergy projects implemented as units of technologies rolled out, capacity installed or energy produced.

Table 7: Indicators for bioenergy technology deployment

Programme activity	Indicator
1. Information system	Availability of installed and functional database, relevant information readily accessible to decision makers
2. ICS	Number of ICS disseminated, percentage of population using ICS
3. ICC	Number of established woodlots, Number of improved charcoal kilns disseminated, Percentage of charcoal produced by improved kilns
4. Biogas	Number of installed and functional biogas systems, reduction of fuelwood use
5. Biofuel	Amount of biofuel feedstock produced per year (tonnes), amount of biofuel produced per year (litres), percentage of petroleum substituted in national energy mix
6. CHP	New bioenergy capacity installed for electricity generation (MW), Share of bioenergy (percentage) in the total installed power capacity

8.2 Socio-economic indicators

Socio-economic indicators include the expected improvement in end users energy use experience and other national economic benefits of using modern bioenergy

Table 8: Socio-economic indicators

Programme activity	Indicator
1. Information system	Availability of readily accessible information for decision makers, better national planning and investment decisions made
2. ICS	Reduced IAP, improved health, reduce burden on women, reduced energy bill

3. ICC	Reduced deforestation, improved woodfuel resource, improved charcoal value chain efficiency, improved charcoal income
4. Biogas	Reduced IAP, improved health, reduce burden on women, reduced energy bill
5. Biofuel	Reduced energy import bill, local job creation, improved rural economy, diversification of agro industries
6. CHP	Reduced energy import bill, local job creation, improved rural economy, improved electricity access, diversification of agro industries

8.3 Policy and processes

The strategy involves various policy and regulatory changes and their establishment paves the way for creating a conducive environment for upscaling the selected technologies. These changes are common to most of the technologies and include the following:

- Improvements to policy and regulatory framework for bioenergy including number of useful new institutions created, or institutions reformed, number of new support policy measures adopted, number of standards developed and adopted, improvement in quality control and quality of installations and products
- Effectiveness of stakeholder consultation including number of stakeholder workshops organised
- Effectiveness of awareness raising/campaigns organized e.g. number of stakeholders reached by communication campaigns; qualitative assessment of stakeholder acceptance
- Success of measures being taken to address various barriers (e.g. number of trained installers, number of certified and accredited artisans)
- Improvements to the bioenergy permitting procedures e.g. average time to market of bioenergy projects (by type, taking into account permitting procedures)
- Support available to project developers along the biomass supply chain, e.g. duration and success rate within the permitting process
- Compliance with non-mandatory regulatory measures (e.g. biofuels blending targets; bioenergy targets)

Table 9: Policy and processes indicators

Programme activity	Indicator
1. Information system	Functional information system set up successfully, data collected and captured and available for use, relevant officials trained
2. ICS	ICS standards developed and adopted
3. ICC	Improved charcoal kiln standards developed and adopted
4. Biogas	Biogas standards developed and adopted
5. Biofuel	Biofuel mandate adopted and implemented
6. CHP	Standardised PPAs adopted, net metering adopted, electricity sector regulations changed to allow independent power producers, etc.

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