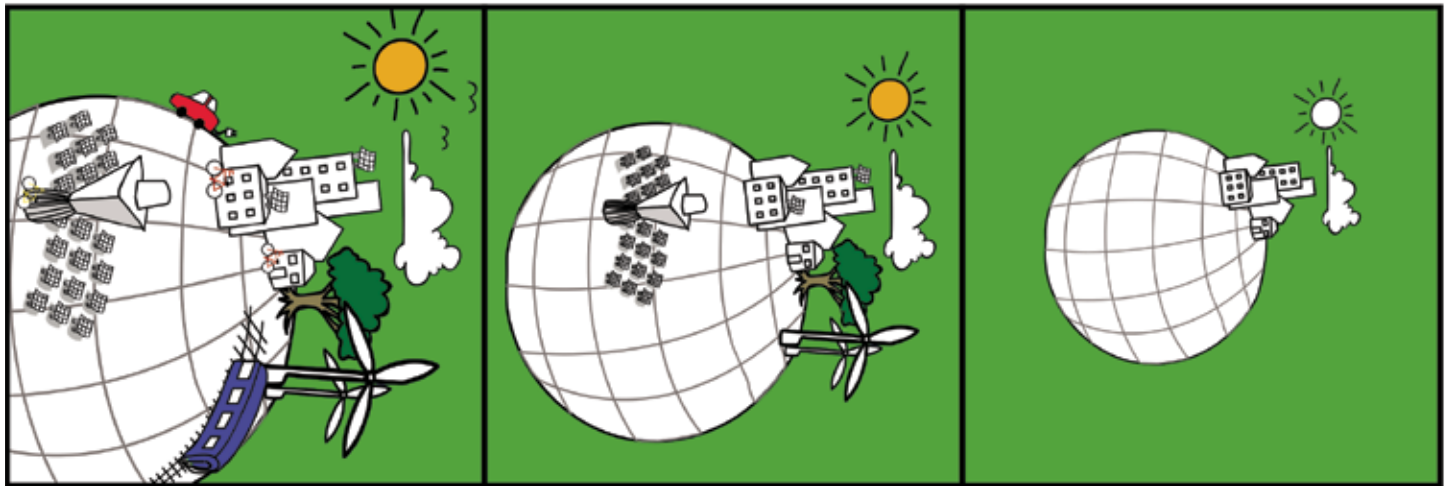
BOA NGUVU:

AN AFRICAN SUSTAINABLE ENERGY COUNTRY



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ACRONYMS

AEEP	Africa Energy Partnership
CBO	Community based organisations
CDM	Clean Development Mechanism
COMESA	Common Market for Eastern and Southern Africa
CPV	Concentrated Photovoltaic
CSP	Concentrated Solar Power
DNI	Direct normal irradiance
EAPP	East Africa Power Pool
ECOWAS	Economic Community of West African States
EDF	Energy Development Fund
EIS	Energy Information System
EJ	Exa Joule = 1million TJ (*see* annex energy units)
EU	European Union
FIT	Feed in Tariff
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GVEP	Global Village Energy partnership
IEA	International Energy Agency
LPG	Liquefied petroleum gas
LTWP	Lake Turkana Wind Power
MDG	Millennium Development Goal
NAMREP	Namibian Renewable Energy Program
NGO	Non Governmental Organisation
ODA	Official Development Assistance
R&D	Research and Development
RAPP	Regional Africa Power Pool
REDD	Reducing Emissions from Deforestation and Forest Degradation
RES	Renewable Energy Sources
RESP	Renewable Energy Supply Plan
RET	Renewable Energy Technologies
SE4ALL	Sustainable energy for all
SLG	Local Management Structure (Structure Locale de Gestion)
SWH	Solar Water Heater
SSA	sub Saharan Africa Pool
TJ	Tera Joule (see annex energy units)
Toe	Tons oil equivalent
TPES	Total Primary Energy Supply
UN	United Nations
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value Added Tax
WWF	World Wide Fund for Nature previously World Wildlife Fund

EXECUTIVE SUMMARY

Sustainable energy is starting to move to the core of energy policy in Africa. There is a growing realisation amongst African policy makers that with deforestation, escalating oil and gas prices, and global measures to mitigate climate change, purely traditional biomass and fossil fuel based development paths are no longer viable.

In fact, across Africa a wide range of sustainable energy solutions have already been implemented and, in most instances, are working sustainably and effectively. The opportunity therefore exists for each country to learn from these solutions which exist already somewhere in the continent and bring them all together for implementation at national level, according to the specific energy resource endowments.

This report offers the example of the Republic of Boa Nguvu. Boa Nguvu has defined an Energy Strategy 2030, to transition to a sustainable energy based country. In other words, Boa Nguvu has gathered the "Best of Africa" when it comes to sustainable energy practices.

The report describes the path chosen by Boa Nguvu in achieving a sustainable energy future, with the expectation that it will inspire other African countries to address their related challenges. It shows how to achieve the transition in a poor country from an energy mix dominated by fossil fuels and traditional biomass to renewable energy including sustainable biomass as the main sources supplying most of the energy needs of all sectors. Although this is a fictional case, it is based on the real situations in sub-Saharan Africa.

This path includes several steps towards a sustainable energy future:

An **Energy Diagnosis** involving key stakeholders is a key pre-requisite to ensure that the complexity of energy systems are well understood, that the options for a sustainable energy future are a result of democratic process based on fact and that the needs of particularly poor and vulnerable people are fully taken into consideration.

The diagnosis informed a National Consultation Process, organised in needs assessment workshops, a civil society consultation workshop, and a high-level workshop. The consultation process outcomes, together with the diagnosis, served as direct input to the country's energy Strategy 2030 with its Objectives and a Plan of Action.

The **Objectives** of the **2030 Strategy** provided the overarching guidance for the development of the Plan of Action. Realistic objectives have been set to ensure the progress and monitoring of the Action Plan, some of which are summarised below.

- By 2030 there will be universal, affordable, reliable and sustainable energy access in both, urban and rural areas. Access to sustainable energy is a key contributor to human welfare.
- By 2030 the share of imported petroleum products will be halved and almost all electricity will be supplied from renewable energy sources to improve the country's energy security.
- By 2020, a target of 100% of improved kilns and stoves will be achieved.
- By 2030, at least 85% of the total primary energy will be supplied from sustainable biomass and other renewable energy sources and 95% of electricity will be generated from renewable energy
- By 2030, all biomass from energy will be derived from sustainable biomass resources and benefitting rural communities. Hydro power plants will include a thorough environmental impact assessment carried out and monitored by independent institutions.

The **Plan of Action** is composed of three components: managing **demand for energy**, transforming the **supply of energy** and securing **mechanisms for implementation**.

Energy efficiency and energy demand management, but also behavioural and societal changes are at the core of the action plan that should help the country achieve its objectives. The action plan looks at the development of an energy-aware culture; the use of energy efficient

equipment, services and buildings; and urban planning and transport. Biomass will remain an important energy source to meet energy household demand by 2030. Therefore, a dedicated **biomass action plan** for Boa Nguvu has been developed encompassing both the demand and the supply side.

The renewable energy supply strategy is focused on increasing dramatically the share of renewable electricity in the energy mix, including international electricity trade, and the promotion of sustainable modern biomass.

Implementation mechanisms should turn the strategy into concrete achievements, galvanising private and public sector forces. Although financial mechanisms are crucial for the implementation of the action plan, institutional set up, capacity building and the development of local manufacturing facilities and a workforce are also essential to ensure the economic and social development of the Boa Nguvu Economy.

With the combination of political will, participatory planning and concerted action including international partners, Boa Nguvu is well on its way towards a sustainable energy sector. However, international energy and climate policies in the large economies of Europe, the Americas and Asia have far-reaching consequences for poor people and will facilitate or disrupt the country's progress towards its goals.

“Boa Nguvu”, a country in sub-Saharan Africa, has been created to explore how various successful sustainable energy efforts can be combined in one country to provide energy access for all. It is hoped that this report will serve as a source of inspiration for energy stake-holders in the sub-continent.

Boa Nguvu: An African Sustainable Energy Country

1 INTRODUCTION

"Boa Nguvu", a country in sub-Saharan Africa, has been created to explore how various successful sustainable energy efforts can be combined in one country to provide energy access for all. It is hoped that this report will serve as a source of inspiration for energy stakeholders in the sub-continent.

Context

African Energy Ministries are overwhelmed with ambitious policy documents and reports on renewable energy pilot projects that have not been scaled up. This report examines what can happen once there is a catalyst that galvanises the political will to implement a comprehensive sustainable energy programme based on existing and proven policies and options. The political and economic conditions described for Boa Nguvu are similar to those faced by today's policy makers and the report is an invitation to all energy stakeholders to consider the wisdom of implementing such a programme before the current unsustainable practices give rise to a critical situation.

Sub-Saharan Africa is well placed to embrace an energy future with minimal use of fossil fuels. It has a vast endowment of potential in solar, wind, geo-thermal, hydro, bioenergy and other renewable energy resources which largely remain untapped. In wide geographical zones there are opportunities to implement clean technology infrastructures. Expanding access to sustainable, affordable and clean energy is crucial to the long term economic and social development of the sub-continent.

It is heavily reliant upon traditional and often non sustainable biomass for basic energy needs such as cooking and space heating and a high proportion of the population has no access to electricity. Sub-Saharan Africa has the lowest rates of electrification and access to modern fuels in the world, at 26% and 21%, respectively (UNDP/WHO, 2009). Progress in access to modern cooking fuels since 1990 has been negligible.

Respiratory diseases and livelihood crises are just some of the problems currently endured by the majority of households. Closing the rural energy access gap in sub-Saharan Africa is likely to be one of the key global development priorities and challenges of the next 20 years.

Fossil energy has not provided adequate solutions. A decade of soaring oil prices has threatened development efforts in countries whose attempts to industrialise and expand services have left them heavily dependent on fossil fuels. For instance, in the search for short term solutions to energy shortages, diesel sets have gained a huge share of peak power supply all over the continent. Vital public and private financial resources are diverted towards imported fossil fuels. Oil import bills in sub-Saharan Africa increased by $2bn in 2010, more than one third higher than the increase in Official Development Assistance (IEA, 2011a).

Tackling energy poverty has a profound impact on poverty as a whole. Energy poverty can be defined as the lack of sufficient choice that would give access to adequate, affordable, effective and environmentally sustainable energy services that could support economic and human development. Energy supplies water and fuels agricultural output, health, education, job creation and environmental sustainability. It is therefore a key input to achieving most of the Millennium Development Goals.

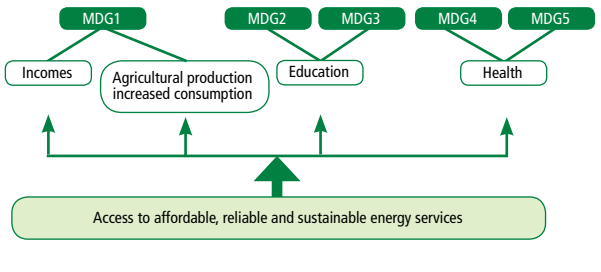


Figure 1: Access to affordable, reliable and sustainable energy services
Source: ECOWAS UEMOA, 2005

Fortunately, sustainable, renewable energy options abound for cities and rural areas – making available lighting and other energy services, including improved cooking solutions and providing new jobs in the African economy.

This report highlights energy options which simultaneously break energy dependence and widen energy access, thereby accelerating the development of sub-Saharan Africa: Boa Nguvu, an African Sustainable Energy Country, offers an analysis of how a given country in sub-Saharan Africa can reach and exceed the UN Sustainable Energy for all 2030 targets:

- Ensuring universal access to modern energy services.
- Doubling the rate of improvement in energy efficiency.
- Doubling the share of sustainable renewable energy in the global energy mix.

The fictional Boa Nguvu Sustainable Energy Strategy and Plan of Action are based on real examples from the continent or, exceptionally, from other regions of the South. They will show that the UN targets, particularly for renewable energy, can be surpassed if the potential resources typically available are well mobilised. The strategy delivers, through a democratically mandated action plan, a reliable and sustainable energy system in which, for example, 85% of the total primary energy is supplied from sustainable biomass and other renewable energy sources and 95% of electricity is generated from renewable sources and grid interconnections with neighbouring countries are strengthened (Table 6, Boa Nguvu 2030 energy balance).

What ignited change in Boa Nguvu?

Boa Nguvu has had to respond to major budget deficit problems due to high global oil prices since 2008. The Boa Nguvu energy sector had an existing strategy which was adopted in 2000. However the strategy had several gaps. There was no consultation with the key stakeholders such as other ministries, civil society, the private sector, local authorities and communities. Although renewable energy and energy security were specified, neither targets nor a timeframe were set towards reaching the strategy goals. Furthermore, the resources (mainly human and financial) were not addressed. As a result, it failed to become a point of reference for the stakeholders, donors, civil society or other ministries. In fact even the Ministry of Energy was not assessing its overall performance against the strategy.

The need to regain the lost momentum in energy reform was further underlined in 2009 as major public unrest occurred in urban areas over the rising costs of both electricity and charcoal. The Boa Nguvu government reacted by a major ministerial reshuffle. The new Minister of Energy, with full presidential backing, was given responsibility to address this issue which threatened the survival of the entire sitting government. She responded by setting up a multi-stakeholder committee representing major biomass energy interest groups, including forest user groups. This committee is mobilising civil society groups to participate in the expanding energy reform and address the unsustainable biomass exploitation which was the root cause of the unrest.

In 2010 the President of Boa Nguvu commissioned a technical team in the Ministry of Energy to conduct a thorough documentation of the energy sector according to globally recognised standards. This included assessments of current capacity and a review of the potential of all energy sources. This information was then tabled in the National Energy Consultation which ran for

12 months and was concluded in March 2012. The consultation input was used as a basis to flesh out the country's strategic objectives, a Sustainable Energy Action Plan between now and 2030 and implementation mechanisms. Throughout the process, international cooperation was considered as a vital element to achieve the country's objectives.

The main elements of the process are as follows:

- Energy diagnosis and resources assessment
- National consultation process
- Strategy objectives
- Action plan
  - ➜ Energy demand
  - ➜ Energy supply
  - ➜ Implementation mechanisms

The Republic of Boa Nguvu: Key economic and social characteristics

Boa Nguvu is a country in the eastern part of Africa with a population of approximately 15 million, growing at the rate of 1.4% per year. Boa Nguvu has a mixed parliamentary democracy and presidential system with vibrant civil society institutions. As such, the country is starting to develop a good reputation in the region and with the international community. Delegations of international private sector investors have visited recently and are already signing partnership agreements in agriculture, mining, and telecommunications. However it is one of the poorest countries in Africa, classified as a Least Developed Country with a per capita income in 2010 of US$750. The weakness of the energy infrastructure is a key concern for investors in productive sectors.

The main source of export revenue is copper but Boa Nguvu's mining industry is small compared with other producers in Africa, generating one billion Euro turnover in 2010. Recently oil reserves have been discovered, with production coming on stream in 2010 and expected to generate significant export revenue, peaking at 0.8 billion Euros annually based upon current prices. Cash crop production is dominated by sugar: production in 2010 stood at 200,000 metric tonnes, generating 50 million Euro of gross export revenue.

Small-scale agriculture is the backbone of the economy, providing the main source of livelihood, with the biomass energy sector being an important contributor to the income of poor households across the country. There is high demand for agricultural land, with a predominance of small plots, owing to subdivision. Large natural forests predominate in the north-west of the country in a low lying area with low population density because of the prevalence of tropical diseases for humans and livestock.

The capital city and the copper region are the only two main urban centres of Boa Nguvu, which in the last ten years have rapidly expanded without the corresponding public investment in basic infrastructure, schools and hospitals, leading to the emergence of large unplanned informal settlements.

Broader issues

In terms of developing its energy sector, Boa Nguvu has to tackle two broader issues in the national economy, which have been constraints to progress to date:

- Poor infrastructure (network for electricity: transport and distribution, but also roads and railways). For example the copper industry generates its own electricity from fossil fuels due to the unreliable supply from the national grid, with high costs affecting the revenue from the industry.
- High dependence on bilateral and multilateral donors that contributed 50% of the government budget in 2010. The mining and sugar industries are developed and controlled by international companies, with little benefit to the national economy and infrastructure.

- The national private sector is weak and suffers from insufficient development of financial institutions and policies that would guarantee a sound investment environment. To date, the conditions for attracting the long-term investment of international financial capital required for innovative infrastructure projects have been lacking. The financial barriers faced by large scale renewable energy projects are similar to those currently being faced by large project such as the Lake Turkana Wind Power project in Kenya, which will provide valuable lessons for other countries on how to overcome these barriers.

Lake Turkana wind project

Location and justification

The Lake Turkana Wind Power Project is located in north-western Kenya, near Lake Turkana, a relatively desolate spot without any transmission line networks. The winds sweeping the area moves consistently at 11 metres per second making this an ideal area for wind turbines.

The Kenyan government is seeking to reduce its reliance on imported energy and fossil fuel, while ensuring a reliable supply of electricity based on clean low-cost energy. According to the government's projections through 2029, Kenya will need additional installed electric energy capacity of 2,396MW by 2020 and 7,539MW by 2029. To meet these needs, the country will have to import nearly half the energy for 2020 and more than one-quarter for 2029.

The government included the Lake Turkana Wind Power Project into its power development plan, issued an independent power producer license and negotiated the costs of the electricity that it generates. In addition to reliable, inexpensive electricity in rural areas, the project will also provide access to carbon credits under the Gold Standard scheme, making it possible to use ICT, to light schools and electrify health centres, and ultimately create new jobs.

The project

The project includes building 365 wind turbines, reinforcing 200km of roads and bridges and adding an estimated 426km of transmission lines to connect and supply power to the national electric grid at an optimal point. The reliable, continuous clean power will add an additional 30% to Kenya's current total installed power. The project is forecast to reduce carbon emissions by 16 million tons during its 20-year lifespan.

The wind park will be generating 300MW when it is fully commissioned. Projected costs are approximately €459 million. According to Lake Turkana Wind Power, the wind park will deliver electricity at a rate ~60% cheaper than thermal power plants. The African Development Bank, the lead broker, will facilitate the entire debt tranche through the African Financing Partnership facility. In April 2013 a €115 million AfDB loan tranche was released after the Spanish government agreed to provide concessional funding for the 428km transmission line to connect the power to the national grid.

Although the Spanish investment will mitigate this, the project requires financial risk guarantees, which the World Bank is reluctant to provide, given the uncertainly that all the electricity will be consumed. An alternative suggested by the WB is that the project should be brought on line, in phases, over ten years to keep up with the expected increase in demand.

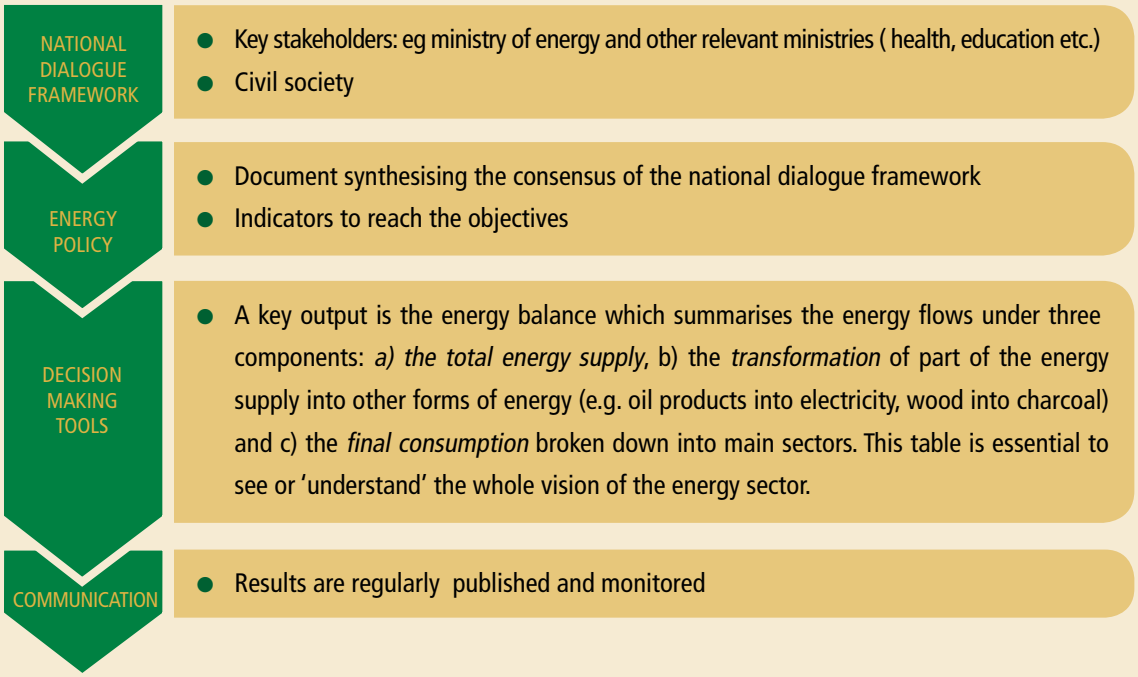
Source: AfDB (2012); Wind Power Monthly (2012); Renewable Energy Focus.com (30 April 2013); Lake Turkana Wind Power (2013)

2 ENERGY DIAGNOSIS AND RESOURCES ASSESSMENT

As a preparatory stage for the development of the Boa Nguvu 2030 Strategy and Action Plan, the government commenced a diagnosis of the energy sector in 2010. The whole process has been piloted by the Ministry of Energy and Environment with support from international African experts in the framework of a partnership between the country and the international Institute for Energy. Other ministries covering finance, economic planning and rural development, industry and infrastructure, and social affairs were closely involved as key stakeholders. During the process expertise has been gained by Ministry staff, which has raised awareness of the importance of an Energy Information System requiring dedicated expertise and regular updating to make it sustainable.

Energy Information System and energy accountability

The Energy Information System (EIS) is a decision making tool for African Energy Ministries. It has been promoted by the EU Intelligent Energy programme and the "Organisation Internationale de la Francophonie". It provides an in-depth sector analysis and energy indicators, allowing for the design, monitoring, and assessment of energy policy. The EIS also offers a national dialogue framework for energy sector stakeholders, thereby enhancing the transparency of the energy sector. EIS is therefore a communication tool for energy sector stakeholders. The following diagram summarises the steps from the national dialogue framework till the dissemination of the results



2.1 SUMMARY OF THE ENERGY SECTOR DIAGNOSIS

The current state of the Boa Nguvu energy sector is as follows:

2.1.1 Access to energy

- Traditional and fossil energy forms have failed to provide sustainable and reliable energy to Boa Nguvu's people. Few have access to electricity and a majority depends on unsustainably harvested biomass. Power stations are old, inefficient and use expensive heavy fuel. Biomass is produced, transformed and used in a very inefficient way leading to deforestation around the capital and the copper zone, the main consumption centres for charcoal. Electricity prices are increasing due to dependence on imported petroleum products.
- At the household level, access to modern forms of energy is low and marked by great disparities between urban and rural areas for electricity. Access to electricity is about 10% in rural areas. Even if the urban electrification rate is approximately 65%, towns and cities are marred by frequent power outages and by illegal connections. The precarious nature of illegal access is illustrated in the box on the next page. For the wealthy households and for medium and large businesses this is overcome by running diesel generators which are contributing to the inefficient use of imported petroleum products. For cooking, charcoal is the main source of energy in the capital and large cities, whereas firewood is the main source of energy in rural areas. Liquefied petroleum gas (LPG) for cooking is barely used and is limited to the capital and the mining zone.

Illegal connections and lighting in Nairobi, Kenya

Otieno Kagellois is a resident of Kibera. He says "I think I am one of the many lucky slum dwellers who enjoy "stolen" electricity. To get it, a gang of generally 4 to 6 men, usually in the dead of the night, climb up the electricity pole lines and attach a thick cable to the live wire. They then descend the cable to the ground below, where it transports the electricity to the nearby Kibera slum. Anyone who wants electricity has only then to contact one of these gangs and they join you, using thin wires plus an earth connection. I use the electricity for lighting and to power a radio and television and charge my mobile phone.

Source: Practical Action, 2011

2.1.2 Energy mix

- There is a predominance of traditional and often non-sustainable biomass (wood and charcoal) in the structure of primary production, transformation and final energy consumption, particularly for the household sector (Table 1).
- Apart from large hydro, other renewable energy sources, mainly solar PV, modern biomass and geothermal are marginal in the power generation mix. The country is endowed with significant renewable energy sources which, however, require a comprehensive survey to assess the full potential and significant investment to tap this potential.
- Biomass is harvested at unsustainable levels, causing deforestation. Rural communities are not benefitting because most of the revenues from forest resources are transferred to urban middlemen who control the bulk of production, processing and transport of bio energy.
- Large hydro power plants have been built without thorough environmental or social assessment and mitigation options. Stakeholders were not consulted. This top-down approach has been particularly detrimental to the livelihoods of the affected rural communities.

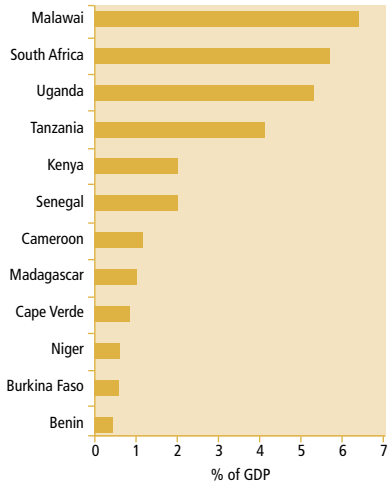
2.1.3 Energy security

- Although progress has been made to expand investment in domestic electricity generation, transmission and distribution, the situation is critical as Boa Nguvu must import power from a region where the supply is insufficient. Increases in the import prices of electricity are expected to continue in the short term, given the prevailing electricity shortage in the region and the historic lack of investments in electricity generation to meet both national demand and exports. In the absence of investments and reforms, this will impact negatively on electricity prices for all households and businesses. The heavy reliance on hydro power increases energy insecurity because of the sharp variations of rainfall over the years which make electricity supply planning more challenging.
- The country is part of the Regional African Power Pool (RAPP). Within the Power Pool, new interconnections with neighbouring countries are being planned. Interconnection will increase the efficiency of the power sector and the use of renewable energy (e.g. Lake Turkana Wind) in the region. The RAPP will be a hub for regional electricity exchange. It is expected to increase energy security in the region, but its impact on rural electrification and poverty may be negligible unless grid extension to poor and rural areas is incorporated.
- Oil has recently been discovered and exploited. All oil production is exported but a mini refinery is being considered. Based on the current level of exports, calculations show that the life expectancy of the proved reserves is approximately 20 years.

2.1.4 Energy Supply

- The whole energy system is inefficient (for instance, high losses in the power sector, inefficient transformation of biomass). Reforms are required to put energy utility companies on a commercial basis and, at the same time, importing of energy equipment needs to be facilitated by reform of tariffs and duties.

- At country level, the diagnosis reveals a high dependence on imported petroleum products to meet the needs of the transport and power sectors and household kerosene needs. Furthermore, with some annual fluctuations linked to rainfall levels affecting the hydro sector, approximately 24% of the electricity is imported (net imports) from neighbouring countries, thanks to two interconnectors.
- Security of energy supply is also a major concern for larger and smaller companies (bakery, carpentry etc), who are facing additional costs due to a non reliable electricity supply.



In some countries, the impact of power cuts is above 4% of GDP. Many enterprises invest in backup generators which bear high costs of production per kWh in addition to the greenhouse gas emissions. It has been estimated that back-up generators account for about 17% of the total installed capacity in West Africa.

Figure 2: Non reliable electricity supply and impact on GDP in selected sub Saharan Africa. (AFD/World Bank, 2010)

2.1.5 Energy Demand

The energy sector diagnosis was refined to better understand the pressing needs in terms of energy demand management in Boa Nguvu. Sectoral Energy Assessment surveys helped identifying energy saving opportunities and potentials. Some of the major findings include:

- Biomass accounts for approximately 82% of the Total Primary Energy Supply and 62% of the total final consumption. Traditional biomass use is a health and environmental hazard when it is used with inappropriate equipment. It affects women and children most. The overall efficiency of the whole biomass chain is very low, which offers room for important energy savings. For these reasons, the biomass sector is one of the priorities for the government. It is part of the philosophy of providing a safe and sustainable energy for all.
- Lighting is inefficient in both the public and private sectors. Incandescent light bulbs are still widely used, as well as kerosene. Other consumer appliances show very low levels of efficiency.
- The building and industry sectors are characterised by poor performance in terms of energy efficiency, due to the use of inefficient equipment, lack of regulation and low purchasing power of a large portion of the Boa Nguvu population. A lack of information is another important factor that is hindering the penetration of efficient options in these sectors.
- There is a large margin for improvement in the industrial sector. Efficiency savings can be scheduled in the short, medium and long term, according to the level of investment in new equipment required
- The transport sector is hugely inefficient and creates acute pollution problems in the main cities. It is characterised by the lack of both city planning and a good public transport system.
- The electricity sector suffers from heavy grid losses (above 20%, where international standards are less than 10%) due to the outdated transport and distribution infrastructure. Furthermore, in informal settlement areas, most households access electricity through illegal connections, which increase the distribution losses whilst dramatically impacting upon the profitability of the national utility. Thermal power stations are old and their overall efficiency is lower than 30%.
- With regard to biomass energy, almost all charcoal is produced from traditional kilns with an average rate of 12%, e.g. more than eight kilograms of wood are needed to produce one kilogram of charcoal. Improved kilns and semi industrial kilns with up to 25% efficiency are available and have been experimentally proven. However additional investment is still a constraint to many charcoal makers.
- The inefficiency also characterises households that are using traditional stoves with an average conversion rate of 14%, compared to 30 to 40% for improved stoves. There are a few retailers

of improved stoves. However, charcoal is still affordable for the poor and the absence of a comprehensive biomass regulation strategy is thwarting the dissemination of improved stoves. As a result, within a 60km radius of the capital, forests have disappeared.

2.1.6 Institutional set-up

- At the institutional level, a parastatal rural electrification agency has been created but, as yet, there are no financial mechanisms to transfer financial resources to implement the rural electrification strategy. The electricity subsector suffers from a lack of leadership and coordination. Moreover, the utility aims to prioritise more affluent customer groups which exclude most of the rural population. With less than 10% of the rural population having access to electricity, a clear need exists for a new institutional approach to rural electrification.
- Despite the existence of an energy planning unit within the Ministry of Energy and Environment, energy planning is hindered by the lack of coherent series of data particularly for biomass energy. For other sectors (electricity, oil), although data exist, they are not collected and processed by the energy planning unit on a regular basis. This is due to the low level of expertise and staff, combined with the absence of any baseline data against which to monitor progress on indicators such as energy access.
- The current utility sector comprises a set of parastatal monopolies whose mounting annual losses are a growing burden on the annual budgets for government expenditure.

2.1.7 Private and financial sector involvement

- There is little private sector involvement in renewable energy and access to energy because of a non-conducive investment environment. Investor interest in Boa Nguvu is currently concentrated on large centralised schemes, such as hydro power plants. Smaller rural projects are considered risky and often bear high transaction costs. A re-balancing of strategy effort is required, to deliver decentralised solutions that go hand-in-hand with expanded and reformed utility services.
- For poor households in Boa Nguvu to afford modern energy sources, initial capital costs have to be mitigated. To attract the “up-front” private investments into the renewable energy sector, the opportunities need to be packaged into a programme and clarity offered about what risk is involved. Currently, the implementation of renewable energy schemes in Boa Nguvu is fragmentary, composed of isolated NGO pilot schemes with finite grant based investment.

2.1.8 Capacity building

- A complete overhaul of the educational system is required to put Boa Nguvu on a sustainable energy path.
- Sustainability topics (e.g. behaviour, energy efficiency) have not yet been introduced into the national curriculum, to create awareness and prepare the ground for new energy options within the populations as a whole.
- Vocational and university level technical training is very limited. In a recent survey it was found that there are only 200 qualified engineers exercising their profession in the public and private sectors of Boa Nguvu, leaving a wide gap to be filled by international technical cooperation. Many qualified technicians have migrated and need to be encouraged to return to Boa Nguvu to participate in the development of the energy sector.
- In the private sector, human resources are currently under-qualified for the challenges ahead and it will require major in-house training programmes to raise capacity levels.

2.1.9 Policies

- There is no support scheme for renewable energy or for access to energy.
- Electricity generation and consumption is subsidised without differentiating between poor and rich people. Despite these subsidies, electricity costs to the final consumer are still quite high (15 US cents per kWh). These subsidies are a major constraint to efficiency efforts and renewable energy deployment, as they keep the running costs of fossil fuels based power plants and electricity consumption artificially low.
- Prior to 2010, there were no sustainability criteria embedded into energy sector policy making, and no policy guidelines in important areas of the national energy mix such as electricity generation, charcoal production and no indicators on emissions and efficiency in the transport sector.

In summary Boa Nguvu must mobilise national and regional investments to realise incremental gains in efficiency and sustainability within its energy system. The diagnosis highlights the fact that there are quick wins in the field of energy efficiency combined with the longer term demands in terms of technical human resource development.

2.2 KEY ENERGY BALANCE FINDINGS FROM THE DIAGNOSIS

Further to the diagnosis, fundamental data have been gathered and processed (energy balance and key indicators). A common and recognised methodology is crucial for international comparison. Boa Nguvu has therefore adopted a methodology similar to that used by many African countries as well as by the International Energy Agency (see box Energy Information System above).

A summarised analysis as well as the energy balance of the country is presented below.

Table 1: Boa Nguvu simplified energy balance in 2010 (ktoe)

SUPPLY and CONSUMPTION	Crude oil	Oil Products	Biomass and agro residues	Charcoal	Hydro	Geothermal/ solar	Electricity	Total
Production	1200	0	13000		300	10		14510
Imports	0	2500	0				120	2620
Exports	-1200	0	0				-20	-1220
a-T PES	**0**	**2500**	**13000**	**0**	**300**	**10**	**100**	**15910**
Electricity Plants	0	-250	-50		-300	-10	410*	-200
Wood transformation			-7000	900				-6100
Losses							-90	-90
b. Final consumption		**2250**	**5950**	**900**	**0**	**0**	**420**	**9520**
Industry	**0**	400	150	100			150	800
Transport	**0**	1600	0					1600
Buildings	0	250	5800	800			270	7120

* 300ktoe from hydro, 10ktoe from geothermal and solar, 85ktoe from oil products, 15ktoe from biomass (mainly bagasse)

2.2.1 Primary energy supply

Biomass

The total primary **energy** supply **(TPES)** is dominated by traditional biomass which accounts for approximately 82% of the TPES. The whole biomass chain is characterised by very low energy efficiency, both for processing wood into charcoal and at the level of the end users, most of whom are equipped with traditional stoves.

Out of a production of 13,000ktoe of **primary biomass** (wood and residues), 5,800ktoe is wood used by households, mainly for cooking and heating and 150 ktoe by small scale industries such as brick making. A further 7,000ktoe of wood was transformed into charcoal producing 900ktoe of charcoal. This ratio (12.8%) is low due to the inefficiency of the equipment (traditional kilns) used during the transformation process. The remaining of the primary biomass production (50ktoe) is bagasse and other agro-waste used to generate electricity mainly for the sugar cane industry.

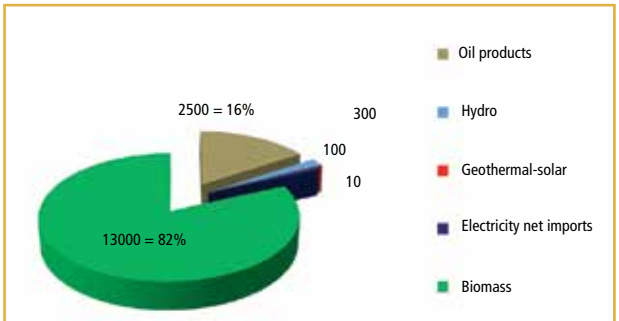


Figure 3: Total primary energy supply (TPES)

Crude oil and oil products

Boa Nguvu has a modest amount of oil reserves. As Boa Nguvu does not have a refinery, the current annual production of 1,200 thousand tons oil equivalent (1,200ktoe) is exported and the entire consumption of oil products (2,500ktoe) is imported from various countries on the basis of short term contracts. Out of this total, 250ktoe are used by the utilities for electricity generation. The remaining imported oil products are split between transport, industry and the buildings sectors,

Electricity from direct sources and imports

According to the convention for energy balances methodology, hydro, wind, solar and geothermal are included under the total primary energy supply. In 2010, the Boa Nguvu utilities generated 300ktoe from hydro power and 10ktoe from geothermal and solar. Net electricity imports reached 100ktoe.

2.2.2 Transformation

This component of the simplified energy balance presents the flow of energy converted into other energy vectors. In the case of Boa Nguvu, 85ktoe of electricity are generated from 250ktoe of petroleum products and 15ktoe of agro-residues. The total electricity generated in 2010 (including hydro and geothermal/ solar: 310ktoe) was therefore 410ktoe.

With respect to biomass, 900ktoe of charcoal are produced by processing 7,000ktoe of wood which shows the low inefficiency of the technologies used for charcoal making.

2.2.3 Total final consumption (TFC)

Biomass (charcoal and firewood) and petroleum products account for the bulk of final consumption. Petroleum products are mainly used by the transport sector. Kerosene is mainly devoted to lighting for rural households. **Liquefied petroleum gas** (LPG) use is negligible. When net imports are included (100 ktoe), the total electricity supply available amounts to 510ktoe. To calculate the electricity available for the final consumption, losses (90ktoe) must be deducted which gives 420 ktoe available for the final consumption, split between industry and buildings sector (Tables: Energy Balance and Electricity Balance).

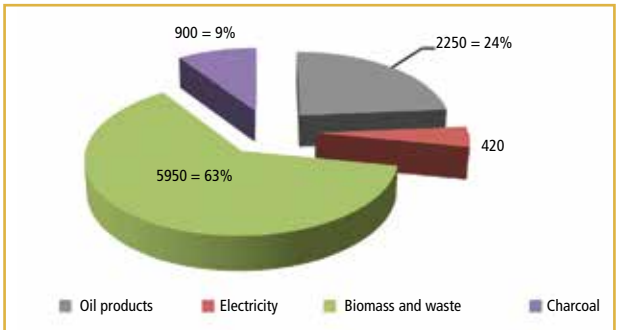


Figure 4: Breakdown of final energy consumption (ktoe and %)

2.3 KEY POWER SECTOR FINDINGS FROM THE DIAGNOSIS

The power sector operates two thermal power plants with an installed capacity of 250MW from which output is delivered to the grid. In addition there are 15 diesel generators for small towns for local grids with a total capacity of 30MW. With regard to renewable energy the total installed hydro capacity is estimated at 450MW, split between 5 sites. Other renewable energy sources are still marginal and limited to geothermal (15MW), solar PV (5MW) and agro residues (35MW) from the sugar cane industry. All the plants, apart from the solar infrastructure and the biomass electricity facilities are owned by the utility which has a monopoly in electricity production, transport and distribution. However, given the frequent power cuts, there are also small diesel generators, which are privately owned by entrepreneurs and wealthy people but mainly in the capital. These diesel generators are only used as a backup, given their high production costs.

Table 2: Power plant installed capacity (2010)

Power plants	Installed capacity (MW)	Capacity share (%)
Fossil (fuel and diesel)	280	36
Hydro	450	57
Geothermal/solar	20	3
Biomass	35	4
Total	**785**	**100**

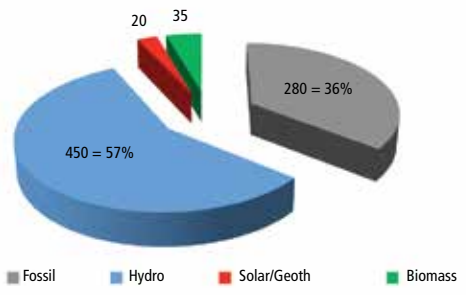


Figure 5: Structure of power plants in 2010 (MW)

Generation, losses, electricity trade and domestic supply

Although hydro power accounts for 57% of the total installed capacity, its contribution to electricity generation is as high as 73% (figure 5) as electricity production from fossil power plants is limited to meet the peak demand due to their high production costs. Hydro power is used as base load, which means it is used on permanent basis apart from scheduled maintenance work or unexpected breakdown, but output might also be limited by climatic conditions.

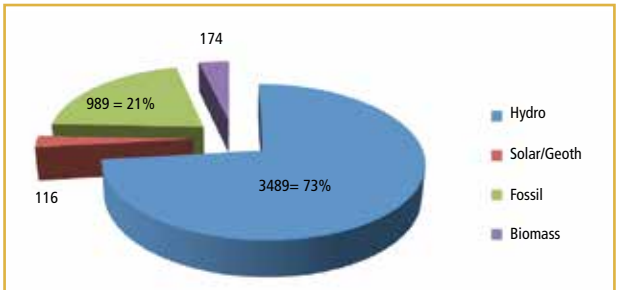


Figure 6: Breakdown of total electricity supply excluding losses in 2010 (GWh and %)

The installed capacity is however not sufficient to meet the demand and net imports (imports minus exports) from neighbouring countries accounted in 2010 for approximately 24% of the electricity supply available for the final consumption (electricity balance table 3). The imports are also justified by lower tariffs from neighbouring countries due to electricity surplus from hydro power.

Table 3: Energy balance of the electricity sector in 2010 (based on Boa Nguvu energy balance)

	Production	**Share (%)**
Production from:	*Unit: GWh*	%
- hydro	3489	73
- Solar/geothermal	116	2
- fossil fuels	989	21
- biomass	174	4
Total Production	**4768**	**100**
Imports	1396	
Exports	-233	
Losses	**-1046**	
Available for final consumption	**4885**	

2.4 KEY TRANSPORT SECTOR FINDINGS

In Boa Nguvu, the transport sector accounts for 71% of the total final consumption of the oil products (figure 6) and is having an important impact on the deficit of the balance of trade.

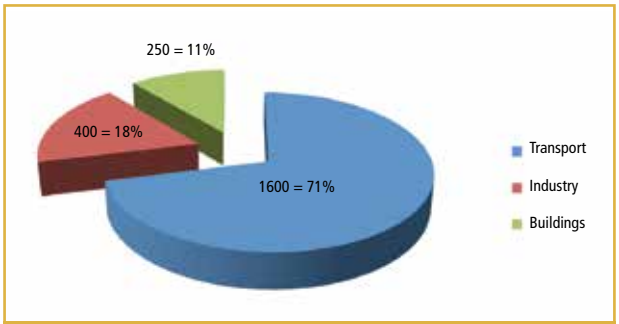


Figure 7: Share of transport in the total final consumption of oil products (ktoe and %)

Currently more than 90% of the vehicles are over 15 years old. This has an impact on the energy consumption and GHG but also on the balance of trade due to the imports of vehicles parts. Compared with cars, collective transport (buses or rail) is most efficient, least environmentally-harmful and contribute to save energy, reduce pollution, and GHG.

The transport system is dominated by roads. The railway system with 750km of tracks and the fluvial transport are marginal and very inefficient.

2.5 KEY BUILDINGS SECTOR FINDINGS

The 4th IPCC Assessment Report concluded that by 2030 cities and towns may house around 60% of the world's projected 8.2 billion people as the trend to increased urbanisation continues (UNDP, 2007). By 2030 over 80% of the projected increase in energy demand will come from cities in non-OECD countries. Boa Nguvu is characterised by a similar trend with currently high demographic growth particularly in urban areas and increased challenges to meet, on a sustainable basis, energy needs for urban but also rural population. The Boa Nguvu building sector is very inefficient with almost all households, commercial and public buildings equipped with incandescent bulbs for lighting and very low efficiency energy appliances.

Cooking, which accounts for the bulk of the household energy consumption, is characterised by the use of traditional stoves, with low energy efficiency, which has an impact on the sustainability of forests resources and also on indoor air pollution and the share of expenditures devoted for energy for cooking particularly in urban areas. Charcoal consumption over the recent past has been increasing at a rate close to the rate of urban growth of 5% per annum. In rural areas given the very low rate of electrification, kerosene is widely used for lighting which contributes to increasing the deficit of the balance of trade and energy insecurity without providing a good quality of service to rural end users.

2.6 KEY INDUSTRY SECTOR FINDINGS

The industry sector currently consumes 800ktoe of energy annually, half of which is directly derived from fossil fuels. The mining and ancillary engineering sector have dealt with irregular electricity supply by installing diesel generators, but the productivity of small and medium enterprises which cannot afford the generators and fuel are badly affected by power outages.

This consumption of fossil fuels can be reduced by a combination of efficiency measures and switching renewable energy. Between 5 to 10% of energy savings require very simple changes: for example changing operational shift patterns and encouraging power saving behaviour. In this category the payback period might be as low as 6 months. The next 20% to 25% of savings require relatively small changes, such as improvement in insulation, overall maintenance and change of some spare parts. The payback period lies between several months to 5 years. The following 30% to 50% of savings require major repairs, changes of equipment, better and more efficient processes. The payback period can extend from 3 to 10 years.

The prospects for renewable energy in the Boa Nguvu mining sector are illustrated by the changes currently taking place in the South African Mining Sector: China's Jinka Solar announced that it will build a PV installation with South Africa's Solea Renewables at a chromium mine in Limpopo province (Jinka Solar Holding Company, Press Release 31 August 2012).

2.7 SURVEY OF ENERGY POTENTIAL

Mapping renewable energy (small and large hydro, biomass and waste etc.) and fossil resources is paramount to designing the optimal energy mix by 2030. Not all this potential is usable. The socio-economic and environmental aspects are needed to refine the potential assessment. However, this information enabled Boa Nguvu to start a discussion about the best technologies for its energy mix and where to deploy them.

2.7.1 Renewable energy sources

Solar and wind

For wind and solar potential assessments, the Boa Nguvu energy ministry partnered with IRENA, and used its global solar and wind atlas (www.irena.org). As a result, the Boa Nguvu high level atlas sparked the investigation of renewable energy potentials, before initiating detailed national assessments and building human capacities. It has reduced the country's financial risk of investigating technical potentials further and shows the high level of solar and wind potential for investors.

Based on this high-level the energy ministry conducted some further analysis, identifying the best locations for wind and solar, with tables and maps. The aim was to identify suitable zones for renewable energy parks.

Table 4: Boa Nguvu solar potential

	Coastal area	Central	South	Other Regions
Area (%)	10	50	15	25
Average yearly hours of sun	2500	3000	3500	2000
Average yearly insulation (kWh/m2/year)	1800	2000	2800	1700

The measurements show that solar potential offers sufficient opportunities for decentralised and large solar power plants. In fact, the Boa Nguvu energy ministry was inspired by a mapping project in Madagascar and has calculated, based on its solar atlas and future electricity demand projections, that land-based and roof mounted solar PV panels could satisfy the country's entire electricity consumption, now and until 2050, while requiring less than one per cent of the territory's land. Since solar PV energy will not deliver all of the country's electricity in the future and many of the panels will be on roofs, the land use will be much less than one per cent.

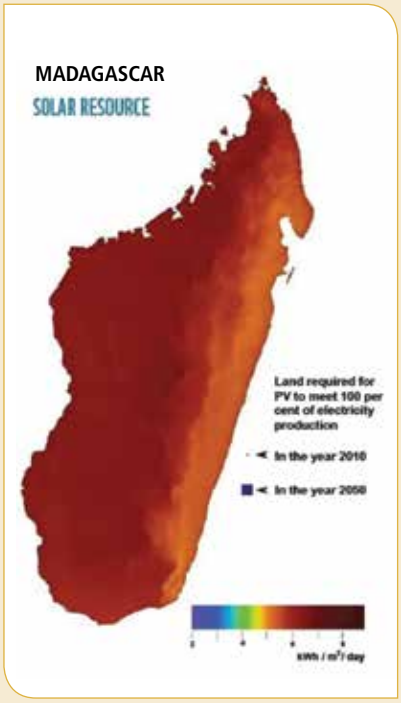
Madagascar solar atlas

Renewable energy requires land. But just how much?

WWF and First Solar have created a solar atlas that illustrates some answers about solar photovoltaic electricity in seven different regions. One of these regions is Madagascar.

Overall, the solar resource in Madagascar is very strong, with over two-thirds of the island having an annual average global irradiation greater than 6kWh/m2/day. Even on the rainy side of Madagascar, annual global irradiation is greater than 5kWh/m2/day.

Four and a half square kilometres of solar panels would generate enough electricity to meet Madagascar's total current electricity generation. Because population and per capita electricity consumption are expected to rise in the coming decades, 780 square kilometres of land dedicated to solar production would be required to meet 100% of Madagascar's total electricity needs in 2050. Concentrated into one location, this land would represent a square of about 28 kilometres on each side. The solar map shows land needed for 2010 generation (red square) as well as land use needed to meet electricity demand in 2050 (blue square). More info can be found on www.panda.org/solaratlas.



The energy ministry used the recently published Tunisian wind atlas as an example of identifying the best wind potentials. This Atlas required using wind-measuring instruments for a period of a year, at heights of 20 and 40 metres, in 17 different sites in the country, besides the use of the statistics collected by the Institut National de Météorologie. Boa Nguvu wind energy measurements show good potential, particularly along the coast, average speed of between 6 and 7m/s which is very suitable for wind farms. At least four good sites with a respective potential of 55MW, 100MW, 125MW and 200MW have been identified.

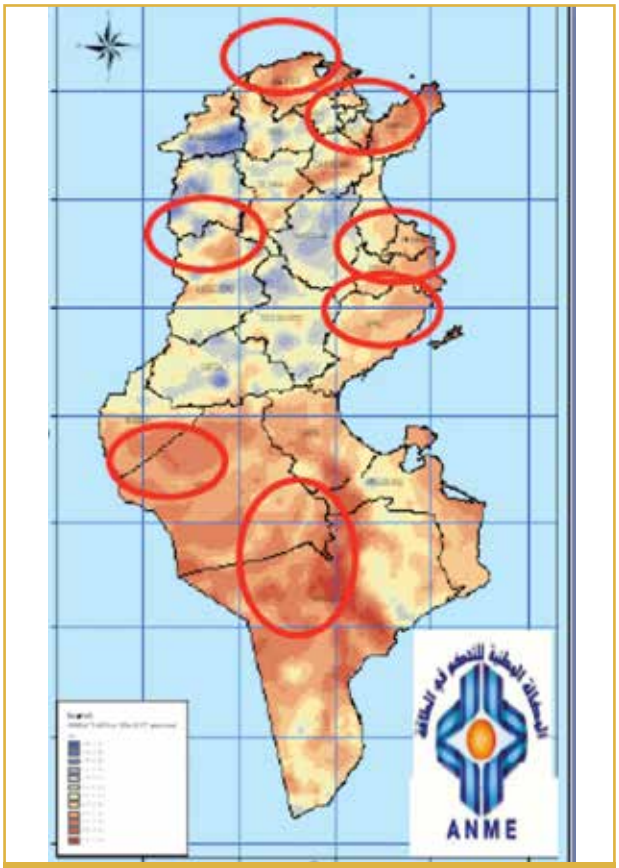


Figure 9: Tunisia wind atlas

Hydro power

The technical hydro potential has been assessed, with the support of a leading international company in the field of hydro power assessment and development. This potential has been estimated at 5,000MW, of which just 9% is currently exploited.

Detailed feasibility studies have been carried out and 2,000MW of economic potential have been identified, comprising six sites between 50MW and 500MW. This potential should be assessed further, based on social and environmental criteria, including impact assessment studies. Furthermore, more than 300 micro and small hydro sites (5kW to 1,000kW) have been identified, most of them close to small villages in rural areas.

Geothermal

The energy ministry, in cooperation with the Boa Nguvu Electricity Company, the state utility, has estimated geothermal resources at 400MW of which only 15MW are currently exploited. Most of the potential can be mobilised with reasonable costs if the initial capital is secured and financial risks to the private sector of failed drilling mitigated. Boa Nguvu is working with the EU-Africa Infrastructure Trust Fund to further explore the potentials and attract private sector investments.

Geothermal Risk Mitigation Fund, Eastern Africa

The EU-Africa Infrastructure Trust Fund (ITF) is the main financial instrument for financing regional infrastructure projects in Africa. The Trust Fund blends grants from the Commission and member states with long-term financing from European financial institutions and the ADB. The GRMF contains 20m Euro from Germany and 30m Euro mobilised by the EU-Africa Infrastructure Trust Fund. A key feature is reducing barriers for capital investments by helping to offset the high risk of unsuccessful exploratory geothermal drilling, and so help public and private investors for the construction of geothermal power plants.

ITF grants are used for:

- Financial support for drilling of exploration wells at the most promising geothermal prospects, to assist developers secure finance for subsequent exploration or appraisal wells.
- Surface studies to determine the optimal location of exploration wells at the most promising geothermal prospects.
- The development of a regional geothermal database of prospects in the region.
- Pre-application training workshops for developers.
- Support to AUC for management of the project.

Source: EU-Africa Infrastructure Trust Fund, 2013

Biomass

Boa Nguvu forests are a major source of household energy needs. According to the FAO, the total forest area in 2010 accounted for 3.5 million hectares, approximately 20% of the total land area of the country.

Forest area:	3.5 million hectares
% of land area	20%
Yield	150t/ha
Potential	525 million tons

This is significant potential, although not all the forest area is suitable for energy purposes. Further studies are required to determine more accurately the economic and sustainable potential.

In addition, agriculture residues (mainly bagasse) and animal waste offer a potential for energy generation. This will be mainly middle-scale power plants for the sugar cane industry, and small biogas units for households in the case of animal waste. It must be stressed that the mobilisation of animal waste for large scale energy generation is not a priority as it is scattered and its collection might be costly. However, there are opportunities for larger biogas units for small enterprises, when animal wastes are concentrated, such as slaughter houses, poultry farms etc.

2.7.2 Fossil fuels

Oil has been discovered recently, with proved reserves estimated at 20 million tons. According to the current rate of production of 1,200ktoe/year, the life expectancy is estimated at approximately 17 years. All the production is currently exported and all petroleum products are therefore imported. Debate about the development of a refinery is currently ongoing in the Boa Nguvu parliament. According to some preliminary research carried out during the 1990s, there are no other fossil resources such as coal, natural gas and uranium.

3 CONSULTATION PROCESS

The diagnosis informed the national consultation process. Three types of workshops were held with the participation of politicians, policy makers, government, private sector, civil society and community based organisations (CBOs), and the international community. The first six workshops with CBOs, local governments and civil society served to gather input for the policy makers and decision makers. The high level workshop served directly as input to the strategy.

- **Needs Assessment Workshops** – five workshops were held in different parts of the country. Each workshop ensured the participation of representatives from regional CBOs (e.g. farmers, small businesses, women's associations) and local governments. The purpose of these workshops was to assess their local energy needs and local capacities to related operation and maintenance of energy schemes, their views about the capacity for the poor to pay for services, and about safety and efficient use of energy.
- **One Civil Society Consultation workshop** – this gathered the participation of a wide range of stakeholders from across the country, government officers from the relevant sectors, private enterprise, NGOs, and representatives of regional (district) governments, religious groups, etc. The purpose of this workshop was to understand their views regarding the role of energy, the government commitment to energy access for all, and the scope for partnership during the implementation phase.
- **One High Level Workshop** with the participation of Ministers and Vice-Ministers of Energy, Environment, Food and Agriculture, Transport and Industry; top executives from electricity utilities, the Regional Power Pool delegates put forward by civil society and the small enterprise sector, the banking sector, university and research centres, and development cooperation partners. The purpose of this workshop was to define the policy principles that will guide the strategy within the framework of a sustainable energy programme. The discussions were based on the recommendations of the previous workshops. Some of these recommendations are listed below.

The above process conforms to models for best practice in multi-stakeholder policy making, and there are various countries that have made some strides towards such consultative energy policy making, Morocco being a good recent example in Africa.

Example of Energy Policy Consultation – Morocco

Morocco organised national energy conferences in November 2006, bringing together the sector's main stakeholders (administrators, energy companies and federations, consumers) during thematic workshops (security, sustainable development, competition and investment) and plenary sessions. This event under the patronage of the prime minister provided an opportunity for a wide ranging assessment of the situation, issues and options as regards energy policy. In 2008 and in follow up to this work, the government commissioned a strategy paper and signed an energy cooperation agreement with the EU including, in particular, establishing a twinning system between European and Moroccan administrators covering a wide range of areas addressed by the conferences (statistics and forecasts, security and investment programming).

Source: WWF, 2010

RECOMMENDATIONS ON THE KEY AREAS OF STRATEGY FORMULATION

The central focus of the stakeholder assessment was a dialogue on the UN Sustainable Energy for All targets, but, during the consultation, civil society organisations pushed very strongly for an ambition for Boa Nguvu to go further and become the African leader in renewable energy solutions. The following recommendations were made:

- The stakeholders mandated the government to develop the energy sector to the greatest possible extent on the basis of energy efficiency and on renewable natural resources of the country and the region. Energy will be generated from large, small and micro hydro, from both thermal and solar photovoltaic including concentrated solar systems, from wind, geothermal and biomass. Sustainability criteria should accompany the development and deployment of these technologies.
- Public bodies at all levels have key roles to play (WWF, 2011a):
  - ➜ Creation of the correct framework for enabling the energy transition, e.g. mandating performance standards in all demand sectors, prioritising a fair access to sustainable energy for all, levelling the playing field for all energy sources and providing appropriate incentives at various levels for the deployment of energy access and renewable energy technologies.
  - ➜ Investment in large infrastructure, particularly the public transport and power grids infrastructure, and early stage R&D projects, to ensure continued innovation, both in demand and supply.
- Private actors, both consumers and companies, are also required to engage by:
  - ➜ Operating under a long-term perspective, resulting in the adoption of best practices in energy efficiency.
  - ➜ Channelling investments into the most efficient and renewable energy options.
- It was agreed that training and empowerment will be crucial to ensure sustainable and long lasting energy access for all. Communities, especially in remote areas, should be capacitated to operate their energy systems with maintenance systems that allow them to operate autonomously except in cases of major breakdown.
- Private sector involvement is important. Participants observed the need for a stable and predictable policy environment which can be a strong enabling factor for attracting private sector investments. Ghana was highlighted as an example of a developing country that developed and has consistently implemented energy access, for the last 15 years, in spite of changes in governments. As a result, the current access to basic energy is between 70% and 80%.

- Policy makers shall also consider the improvement of energy efficiency through legislation, for instance, through the banning of energy inefficient products such as incandescent light bulbs or second hand household appliances such as fridges.
- Access to finance and innovative payment methods (e.g. mobile phones) should be considered.
- Quality control and assurance of renewable energy and energy efficiency equipment should give people and companies confidence in these products. Too many products have failed in the past.
- Biomass, both sustainable wood and processing agricultural residues into modern forms of energy such as biogas, heat and electricity will be a key innovative component of the Sustainable Energy strategy.
- Biomass energy, particularly biofuels, will be developed in a cautious manner according to international best practice and integrated with food production in the agricultural sector.
- High levels of regional cooperation will be sought to maximise integration and ensure access to regional renewable electricity supplies.
- Non-Governmental Organisations argued for 15% of future oil revenues to be channelled into renewable energy project financing. The government representatives in the process agreed to submit this proposal to parliament for further debate.
- Civil society organisations (CSOs) can play an independent oversight and verification role. They can also function as policy innovators and watchdogs for social and environmental safeguards, organisers of community participation, capacity builders at local level and promoters of transparency and accountability.

The results of the energy diagnosis, the survey of sustainable energy potentials and the consultation have been combined to develop strategic objectives, an action plan for energy demand and supply, implementation mechanisms and an international cooperation strategy.

4 OBJECTIVES OF THE 2030 SUSTAINABLE ENERGY STRATEGY

The objectives of the 2030 strategy fall under **an overall strategy to guarantee universal, affordable, reliable and sustainable energy access in both urban and rural areas, most of which will be renewable** and, to some extent, local and hence not exposed to international fluctuating energy commodity prices. All factors of sustainable energy production will be mobilised for an economically optimal combination of centralised and decentralised energy solutions. Special attention will be given to decentralised off-grid solutions in remote rural areas that have historically been neglected in national development planning in general and energy planning in particular.

4.1 ENERGY ACCESS AND SECURITY OF ENERGY SUPPLY

Objectives:

- Sustainable energy access for all by 2030, through centralised and decentralised means.
- Power cuts which were common and which are negatively affecting households and small entrepreneurs, will become marginal by 2020 thanks to the significant deployment of renewable energy sources.
- By 2030, imported petroleum products will remain stable despite a sharp increase in the population during the period, which translates into a significant reduction of the fossil fuel consumption per capita. This will be achieved by electricity generation from renewable energy sources (RES), the substitution of kerosene, used for lighting mainly in rural areas, by renewable electricity and significant changes such as efficiency measures and the promotion of affordable and efficient public transport.
- The international electricity trade with neighbouring countries will be balanced and limited to meeting the peak demand in the respective countries. Cross-border trading will be in renewable energies, optimising their use in the region.
- All biomass will be supplied from sustainable sources and there will be at least a fivefold increase in other renewable electricity (hydro, solar, wind and geothermal). Approximately 12% of the fuels for transport will be derived from renewable energy sources, mainly renewable electricity and biofuels, with a focus on biofuels for trucks and buses, and electricity for trains, cars and motorbikes. However this target will be linked to the compliance with sustainability criteria in the bio energy sector and can be revised upwards.

4.2 ENERGY EFFICIENCY

Objectives:

- In the building sector, the efficiency of lighting will be improved by a factor of four by 2030.
- Building efficiency will be improved in existing private and public sectors buildings by 30% and in new buildings by 50% by 2030 (all new buildings will comply with stringent energy

efficiency measures such as design, energy efficient equipment etc.).

- Inefficient energy appliances will be removed from the market progressively, between 2013 and 2016. All households in urban and rural areas using biomass will be equipped with improved stoves by 2020
- There will be 100% improved kilns for charcoal production by 2020. The average rate of carbonisation will reach 30% from 12% in 2010.
- By 2020, 80% of the journeys for professional purposes will be by public transport with an objective of a 25% reduction of the energy intensity in the transport sector.
- Transmission and distribution losses, including illegal connections, in the electricity sector will be dramatically reduced to come in line with international standards.
- By 2030, due to the progressive implementation of efficiency measures, the industrial sector will have switched completely to energy efficient equipment and practices.

4.3 PREDOMINANCE OF RENEWABLE ENERGY IN THE ENERGY MIX

Objectives:

- By 2030, at least 85% of the total primary energy will be supplied from sustainable biomass and other renewable energy sources. The key challenge will be to ensure that biomass production comes from sustainable feedstocks.
- By 2030, at least 95% of the electricity will be generated from renewable energy.
- By 2030, universal access to sustainable energy and electricity for the people of Boa Nguvu with a focus on renewable decentralised production
- By 2030, all biomass is harvested from sustainable sources (natural forests, plantations and agro-residues).
- The per capita fossil consumption of the buildings, transport and industrial sectors will substantially decrease by 2030. In the transport sector, biofuels and renewable electricity will be introduced.

4.4 SUSTAINABLE USE OF NATURAL RESOURCES

Objectives:

- By 2030, biomass demand for fuel, wood and charcoal should have stabilised at current levels and all supply should come from sustainable sources. Deforestation will be halted and a regeneration process will ensure that biomass is harvested sustainably. This will be achieved by a combination of efficiency measures as well as supply chain measures, including sustainable plantations and natural forests management.
- By 2030, 12% of transport fuels will come from biofuels and renewable electricity.
- By 2030, 85MW of electricity production capacity will be based on agro-wastes such as bagasse.
- All new large and medium scale (over 5MW) energy projects will be subject to environmental and social impact assessments carried out and monitored by independent institutions. Smaller plants (between a half and five megawatts) should follow environmental guidelines and submit an environmental statement to the Ministry of Environment before the project implementation.
- Water catchment areas will be subject to strategic impact assessments.
- Protected areas will include limitations for large energy parks.
- Go-zones (established with all the preconditions to favour business start ups, as opposed to the usual no-go and red tape) and dedicated renewable energy parks will be identified and opened to private company projects, based on a thorough renewable energy potential assessment.
- Sustainability schemes will be in place for hydropower and biomass by 2015.

The energy sector diagnosis has enabled Boa Nguvu stakeholders to highlight the key problems and to define realistic objectives for a better energy future. The next sections will detail how the country is planning to achieve these objectives. These “action plans” have been inspired by several successful initiatives in Africa and elsewhere.

5 ENERGY DEMAND ACTION PLAN

The government of Boa Nguvu has set ambitious energy demand objectives. Energy efficiency and energy demand management, but also behavioural and societal changes are at the core of the action plan that should help the country achieve its objectives. The action plan has been designed with short term (by 2016), mid-term (by 2020) and long term interventions (by 2030) in close cooperation with the Ministry of Housing and the Ministry of Economy for all fiscal issues. A more detailed explanation of implementation mechanisms for the action plan is given in Chapter 7.

5.1 CULTURAL AND SOCIAL CONTEXT, EDUCATION AND EMPOWERMENT: THE DEVELOPMENT OF AN ENERGY-AWARE CULTURE

Empowerment, education and behaviour are important factors in the success of any energy demand management policy. Energy efficient technologies need to be available and affordable but the way we use these technologies will play a major role in their impact. Energy efficiency and renewable energy programmes in Boa Nguvu have focussed not only on supplying the right technologies, but also on:

- Developing an "energy saving" culture from the primary school stage. This fundamental action, as part of a wider environmental awareness raising approach, has facilitated the integration and development of more environmental behaviour and profiles and helped to disseminate a culture of low consumption.
- Encouraging gender-sensitive local empowerment to turn efficiency into local opportunities. Some technologies, such as efficient stoves, can be manufactured locally (See Goma efficient stove project).
- Promoting the culture of energy efficiency with positive examples (see Madagascar example below). According to the International Energy Agency (2006), the energy consumed to supply lighting entails greenhouse gas emissions of an impressive 1,900Mt of CO2 per year. In 2009, EU countries started to phase out incandescent light bulbs. In 2005, South Africa launched a national campaign to replace 43 million incandescent light bulbs. The lighting sector has evolved greatly thanks to the implementation of policies to ban inefficient bulbs. This can impact countries dramatically where such regulations have not yet been adopted. Indeed, the massive flow of cheap inefficient bulbs in the market could affect the healthy development of the energy sector.
- Setting up a coordination unit involving key sectors and stakeholders. Novel measures are now in place as a result of the coordination unit. For example new housing developments will include basic social infrastructure (schools, health centres and shops) to reduce time spent on transport and improve the efficiency of the education system by making a better allocation of the time of young children.

Efficient electric lighting in Madagascar

In Madagascar, the electrification rate is about 25%. Residential consumption represents 30% of the total electricity generated by JIRAMA (The national power company). Besides, lighting accounts for 10% to 20% of households' electricity bill. 40% of the electricity generated comes from thermal power plants which are fuelled with heavy fuel and diesel; thereby resulting in high production costs and a high selling price. Each year nearly 100 million US dollars of fuel are imported.

The project's goal is to enable the emergence of a good quality and affordable efficient lighting market in Madagascar; thus promoting energy saving. The main objectives are:

- Stimulation of the market by distributing 776,500 compact fluorescent lamps (CFLs) among households in 8 towns in Madagascar.
- Regulation of the lighting market by promoting the adoption of a national framework and regulation that favours good quality and an affordable efficient lighting market in the country.

This would have several benefits for Malagasy society:

Economic

- Reduction of 19MW of the electricity peak power call;
- A yearly saving of 10 million US dollars for the national electricity company on fuel and other inputs;
- More available power: no load shedding, more households having access to electricity;
- Growth of a good quality lighting market.

Environmental

- 776,500 incandescent lamps not used anymore;
- About 72,000T of CO2 emission reduction in seven years.

Social

- Approximately 200,000 households using good quality CFLs;
- At least 7% saving on electricity bills for households.

MOUs have been established between WWF, JIRAMA, the Ministry of Energy and the TELMA Foundation. The CFLs will be purchased by JIRAMA through World Bank funding. JIRAMA ensures the network quality, facilitates the implementation and participates in impacts monitoring. WWF's responsibilities include coordination, fundraising and contracts management. The TELMA Foundation is responsible for the logistics, transport, storage, distribution and collection of the lamps at their shops. The Ministry of Energy facilitates tax issues, and work on the regulation and standardization of the lighting market.

A feasibility study was conducted, followed by a baseline study in the eight targeted cities (Diego, Nosy Be, Mahajanga, Toliara, Antananarivo, Antsirabe, Fianarantsoa and Toamasina) and in the pilot city (Ambositra).

A pilot operation was implemented in the city of Ambositra from 6 October 2011 to the 21 October 2011. Six thousand one hundred CFLs, offered by Philips Corporation, were distributed. The average decrease in household electricity bill was about 10% and JIRAMA savings are estimated at 7 million Ariary for the months of November and December 2011. The population of Ambositra was enthusiastic and receptive to the project. The CFLs were quickly adopted, sparking a craze and bringing awareness to both the economic and ecological impact of lighting behaviour. Media and direct sensitisation have also significantly improved the public understanding of the concept of energy saving.

The distribution of the 776,500 CFLs started in July 2013. It is expected that the project will use Gold Standard VER carbon credit to fund the implementation of the regulation of the lighting market and the recycling of the CFLs.

5.2 SUPPLY OF EFFICIENT APPLIANCES, EQUIPMENT, BUILDINGS AND SERVICES

5.2.1 Efficient equipment and services

An energy labelling programme will be put in place for all relevant household energy appliances (such as cooking stoves, refrigerators, air conditioners, light bulbs, cars, washing machines) by 2016. This will enable consumers to make the right choices.

Energy efficiency standards will be established for most relevant electricity consuming appliances by 2016 with a regular review based on technological progress. This will lead to a progressive elimination of inefficient products. Three direct objectives have been put forward:

- A ban on the import and production of all incandescent light bulbs and halogen lamps by 2015 will be enforced. The ban, in combination with promotional activities around LED lighting and compact fluorescent light bulbs, will improve lighting efficiency by a factor of four. A programme for the recovery of used low consumption lamps has been put in place to reduce and minimise the impact on the environment.
- A ban on import of second hand refrigerators by 2015.
- A ban on imports of vehicles over five years old by 2016 and a ban on all vehicle imports over 3 years old by 2020.

To limit counterfeited products and ensure that only efficient products are commercialised, an independent centre for testing the energy performance and quality of domestic appliances (refrigerators, stoves etc.) has been set up.

The national and local supervisory authorities have contributed to the creation of ESCOs (energy service companies specialised in energy efficiency and solar water heaters), in particular thanks to an appropriate incentive based regulatory framework (in particular by authorising administrations to contract/take out an energy performance contract "EPC" over several years).

Energy Efficiency Awards will be organised every year to encourage energy producers, marketers and end-users.

There will be a ban on inefficient cooking stoves by 2020. This will more than double stove efficiency. Large-scale training programmes have been planned to assist stove manufacturers in the production of more efficient stoves that will comply with national quality standards. Those programmes will run over four years, from 2014 until 2018. They will be built on lessons from projects such as the one at Goma, DRC where WWF is training local businesses to build and sell cheap, culturally appropriate stoves that halve the amount of charcoal needed, so helping protect the sensitive forest environment. It is also helping landowners start sustainable tree plantations for charcoal, to help meet Goma's needs.

Mass Uptake of Improved Stoves, Goma, Democratic Republic of the Congo

(Ashden Award 2013
www.ashden.org/int_awards)

The *Improved Stoves* project contributes to the overall objective of the World Wide Fund for Nature's 'Environmental Programme around Virunga' (WWF/PEVi) to fight poverty and support local development in order to reduce threats to the Virunga National Park. The *Improved Stoves* project was started in May 2008 together with women associations, who became the producers of efficient stoves.

Continued ➜

Since then it has been through a number of phases to overcome the barriers to production and widespread usage of improved stoves in Goma.

The acceleration of production and sales since 2010 was driven by several initiatives at the program level:

- A market study, which concentrated efforts on the best model - Only one model of improved stove, the Jiko Nguvu Nyeusi, was produced and promoted
- Large rotating capital was made available to associations so that they could have the quality raw material in sufficient quantity to meet demand.
- An intensive information campaign conducted on the radio for several months succeeded in informing a broad segment of the population of the city about the efficiency of the stoves and the existence of outlets, spread throughout the city.
- Redeployment of outlets of improved stoves to strategic locations in the city which boosted sales to customers who previously did not know where to obtain them.

Since 2009, more and more manufacturers in the city of Goma have abandoned the manufacture of the traditional stove in favour of the improved Jiko Nguvu Nyeusi. It is in this context that the program has also provided training to improve the quality of their production. An impact study showed the following results to date:

Six out of ten households in Goma are currently using an improved stove. In 2008, the proportion was one out of ten. Three quarters of households using an improved stove use the Jiko Nguvu Nyeusi model, using half as much charcoal as the model that was most prevalent in Goma in 2008, reducing consumption of charcoal by over 20%, corresponding to 13,250 tons of charcoal a year. If 80% of the charcoal comes from Virunga National Park, 10,604 tons of charcoal from the park is saved by the use of this improved stove. It can be estimated that nearly 2,544ha of natural forests have been saved in 2012 through the project. This same saving of charcoal enabled half of the population of the city to halve its fuel expenses, which corresponds to over US$6.6 million to be put to other uses in the local economy.

5.2.2 Buildings: a transition to sustainability and performance

The building initiatives will mainly target the larger cities in the country, where a large amount of energy is wasted in air conditioning, bad lighting practices and water heating.

A building code, based on energy performance certification programmes, will enter into force in 2015 for all new and refurbished public buildings and private buildings of a size over 500 square metres. Common sense measures based, for example, on the solar orientation of buildings and dominant wind directions, combined with good thermal and phonic insulation (with natural and local products) should make it possible to achieve this at the lowest cost.

Thermal rehabilitation programmes, accompanied by flexible financial mechanisms (third-party financing and EPCs proposed by the ESCOs), will facilitate this thermal and energy rehabilitation.

Compulsory energy audits (benefiting from a tax credit of 30 to 50%) for tertiary buildings, combined with programme contracts (subsidies of 20 to 40%) for the implementation of energy saving measures identified by the audit, will help achieve energy and water savings.

An independent energy labelling programme of public buildings and private buildings larger than 500 square meters (similar to the appliance labelling) will create transparency on the estate market and will enable the public sector to lead by example.

Further to the adoption of the Green Building Regulations on the use of the solar water heating systems to supply hot water, all hotels with more than 20 beds must be equipped with solar water heaters by 2020.

5.2.3 Energy efficiency in the industrial and service sectors

Charcoal production is very inefficient with very low rates of conversion from firewood to charcoal (about 12%). This comes in addition to the current very low penetration of improved stoves. By 2030, the average rate of carbonisation will reach 40%, thanks to a massive dissemination of improved kilns and training programmes for charcoal producers.

Mandatory energy audits will be carried out, every five years by 2015, for establishments consuming more than 300toe per year. For SMEs, 20% of the costs of the energy audits will be subsidised.

Industrial facilities with energy consumption over 1,000toe per year will have to have an energy manager among the employees.

Capacity building programmes will be organised for experts and companies to perform energy audits in industrial and commercial companies and implement energy efficient systems.

Technical assistance will be provided in examining and implementing energy efficiency measures and renewable energy options at the level of industrial processes and installations (boilers, compressed air engines, cold production, solar drying solar heating etc.).

Industrial motors will be part of the product categories targeted by the energy efficiency standards initiative described above.

Prior, obligatory consultation, (evaluation of a project's energy efficiency by an approved certification body and authorisation by the Energy Agency) for all new industrial projects consuming more than 600toe per year will be required.

5.3 URBAN PLANNING AND TRANSPORT

Africa is experiencing a rapid rate of urbanisation. AUN Habitat and ICLEI report (2009) estimates that by 2050, 62% of the population of the continent will live in urban areas. In Africa, urban areas are responsible for the bulk of energy consumption due to higher income in urban households and the concentration of services (administration, hotels etc.). Urban planning has an important impact on energy consumption and green-house gas emissions. Boa Nguvu has devised a city

City sustainable energy plan

UN Habitat's planning guide uses a 10-step process as a framework for city planning. This is of course not a linear process (see diagram below for a more dynamic view of the process)

1. Designate a lead office and find a champion
2. Establish partnerships
3. Find the 'hooks' in the vision, goals, and policies of your city
4. Conduct an energy and greenhouse gas (GHG) emissions audit of your city / local authority
5. Analyse your information and develop a draft plan
6. Build public and internal support
7. Finalise the plan
8. Implement and finance the plan
9. Monitor and evaluate the plan
10. Publicise and communicate the benefits.

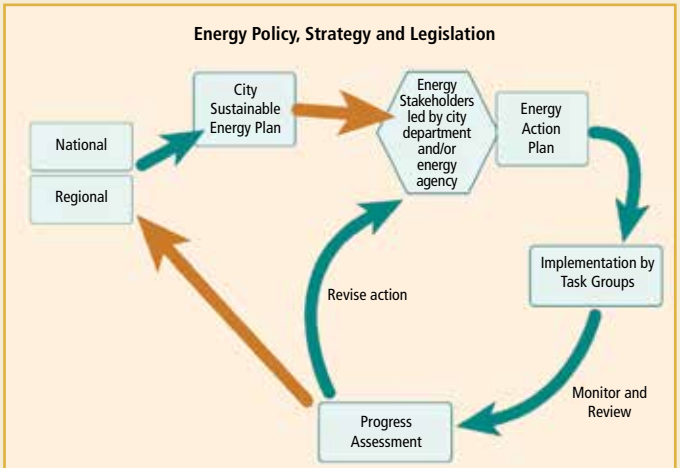


Figure 10: City sustainable energy plan (UN Habitat an ICLEI, 2009)

Source: UNEP, 2009

plan based on the recommendations of the UN Habitat Local Governments for Sustainability.

Some of the outcomes of this process can be found below:

In the field of transport, Boa Nguvu wants to shift the paradigm of urban planning from promoting the individual car. This includes legislation and regulatory measures (zoning) regarding land use. Commuting on an almost daily basis with individual cars increases congestion, fuel consumption and ultimately GHG. This also has an impact on the urban environment and the quality of life, with increased time devoted to commuting. In parallel with the improvement of public transport, disincentives were set in the capital city of Boa Nguvu, for instance:

- Privately-owned and public utility vehicles are designated one day off, every week between Monday and Friday, for a 12-hour period on specific routes. The last digit of the plate number determines the day-off schedule
- Removal of curb-side parking and free parking

At the level of the Ministry of Planning and in close coordination with other ministries, a decision has been taken to develop efficient and affordable public transport with buses, trains, tramways for the two metropolitan areas of Boa Nguvu – the capital and the copper producing zone. The network has been conceived to reach commuters who currently make use of individual means of transport.

Dedicated pathways for bicycles, together with a zero VAT policy for bicycles, to increase the share of low or zero carbon means of transport. This type of measure will also ensure that poor and low income people are not penalised by the implementation of the urban planning and transport policy.

In the longer term, a coordination mechanism has been set up to ensure that town planning and urban design include energy efficient measures for example, traffic management plans taking into account energy efficiency.

It is planned to restore the 750km of existing railway track outside of the cities, build approximately 1,000km of new railway track by 2030 and promote a modern fluvial transport system for goods and services.

An interesting example of a sustainable transport plan can be found in the city of Bogotá.

Promotion of public transport

The problem

The Colombian capital Bogotá suffered from heavy traffic congestion, no rail, no formal bus system and no plan for change. The use of private cars was a major cause of congestion and air pollution. Approximately 95% of road space was used by private cars, which transported only 19% of the population.

By the end of the 1990s, a new Bus Rapid Transit (BRT) system, named TransMilenio was designed. It was launched in 2000 with the first phase comprising 40km of exclusive busways, 57 bus stations, and 305km of roads for feeder buses.

The strategy

One important factor in the success of TransMelinio has been the city government's strong leadership with careful design and planning. Under this leadership, Bogotá was transformed into a leading model for innovative, efficient and accessible transportation networks worldwide. This leadership has combined with the mobilisation of necessary funds, state-of-the-art technologies adopted to run the system, the establishment of a good management company, a sound investment in infrastructure and an efficient single fare pricing system.

Achievements and impact

By 2015, TransMilenio will have 22 lines and 6,000 articulated buses providing five million trips per day. In addition to exclusive busways, the City of Bogotá has 230km of bike lanes with plans to increase this to 350km of expanded sidewalks and a 17km pedestrian zone. Among the travel demand management measures instituted, private cars

Continued ➜

are forbidden to operate in Bogotá central business district during the morning and evening peak. Parking fees were increased by 100% and fuel taxes were increased by 20%. A key promotion measure is 'car-free day' held once a year on a weekday and car-free Sundays on particular roads.

The TransMilenio public transport system has become the first mass transit system in the world to be considered a clean development mechanism (CDM) in accordance with the Kyoto Protocol. This means that it is officially accepted that the TransMilenio system reduces the emission of greenhouse gases because of its greater efficiency in transporting passengers and due to the partial substitution of private means of transport by high quality public services. It could also be applied to similar transport systems in other countries.

5.4 DEMAND DIMENSION OF BIOMASS CHAIN: STABILISING WOOD CONSUMPTION

The Boa Nguvu rural population is highly dependent on biomass resources to meet its basic energy needs. Almost 80% of rural households cook with firewood, which causes serious respiratory and eye diseases, especially for women and children. Surveys carried out by the Ministry of Energy and international organisations show that biogas is a sound option for improving access to safe and reliable cooking fuel at a domestic scale for many areas of Boa Nguvu that are endowed with good potential. The biogas production and dissemination plan will be linked to a wider international initiative. Biogas will be mainly used for cooking and lighting which will improve the quality of life in rural areas that have a very low rate of access to modern energy services. Boa Nguvu has set an ambitious target of an average of 100,000 biogas units for the period 2012-2025. The programme involves establishing and supporting small businesses that will produce, commercialise and sell subsidised biogas plants under a program managed by the Ministry of Energy, with the involvement of micro credit institutions, NGOs, and manufacturers.

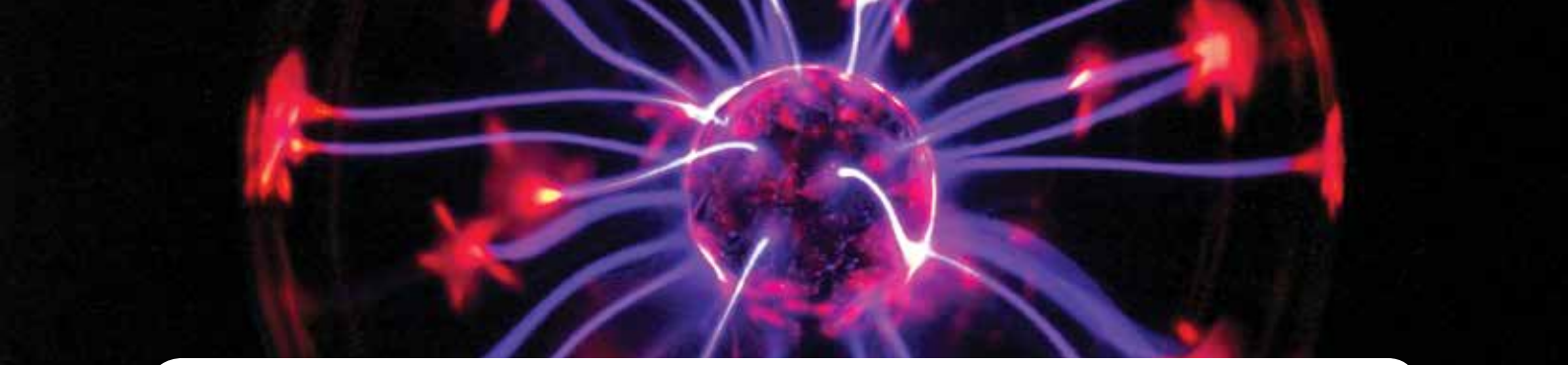
Despite the demographic growth, wood production will be maintained at the same level by 2025 and will remain stable until 2030. Charcoal production will increase considerably as a result of the introduction of efficient energy technologies. With the same amount of wood as in 2010, charcoal production will reach 2.8 million toe in 2030, which is more than a threefold increase. Furthermore, charcoal dust will be systematically collected and recycled. This is also the case for sugar cane residues (bagasse),mainly used to meet part of electricity needs of the sugar cane industry and landfill gas, with 50MW of additional capacity.

Characteristics	Traditional Kilns	Improved Kilns	Semi-industrial Kilns	Industrial Kilns
Conversion Technology				
Efficiency	8–12%	12–18%	18–24%	>24%
Emissions (in g per kg charcoal produced)	CO_2: 450 - 550 CH_4: ~700 CO: 450 - 650	→		CO_2: ~ 400 CH_4: ~50 CO: ~160

Figure 11: Potential for energy efficiency improvement. *Source: World Bank, 2011*

It is expected that the combined measures on efficient stoves and kilns will stabilise wood consumption, despite a growing population. Even taking into account a population increase, with these productivity gains, the sustainability of forest resources can be secured.

Results	Energy efficiency of carbonisation	Agro waste recycling
2010	Wood for charcoal production: 7 million toe Charcoal production : 0.9 million toe Average yield: 13% Improved stoves dissemination: 20,000	Very marginal
2030	Wood for charcoal production: 7 million toe : Charcoal production 2.8 million toe Average yield : 40% All stoves will comply with efficiency standards by 2020. Improved stoves dissemination: 1 million out of which: 80% in urban areas and 20% in rural areas	Bagasse recycled adding 30MW electricity capacity 100,000 biogas units for rural households by 2025.



6 ENERGY SUPPLY ACTION PLAN

A two-pronged strategy has been designed to increase the share of renewable energy. The strategy is focused on increasing dramatically the share of renewable electricity in the energy mix, including international electricity trade, and the promotion of sustainable modern biomass. Biomass will remain an important energy source to meet energy household demand by 2030. While alternatives to biomass will be researched, tested and disseminated, the country needs to secure its forests and foresee for the needs of its people. A more detailed explanation of implementation mechanisms for the action plan is given in Chapter 7.

6.1 ON-GRID AND OFF-GRID RENEWABLE ELECTRICITY

By 2030, large scale, sustainable and cost effective renewable energy resources will be deployed in combination with decentralised solar PV and other technologies for remote and small villages. Not all communities will be connected to the grid. Grid expansion is expensive and is not a prerequisite for people to access electricity. Alternatives that will be pursued are a mix of micro-grids and individual renewable energy systems.

6.1.1 The energy mix

Table 6: Deployment of RES for electricity generation: 2010-2030 (cumulative MW)

	2010	2017	2022	2030
Large and medium hydro	450	450	650	1200
Small and micro hydro		5	10	250
Wind		10	60	350
Geothermal	15	30	80	350
Concentrated Solar Power (CSP)			25	200
Concentrated solar PV (CPV) farms		20	60	200
Solar PV farms		20	100	150
Decentralised PV (off grid and micro grid)	5	30	80	350
Biomass residue (landfill, bagasse etc.)	35	35	50	85
Fossil	280	350	350	350
Total installed capacity (MW)	785	950	1465	3485
% RE	64	63	76	90

6.1.2 Hydro

Despite the use of sustainability criteria, large hydro does have significant environmental and social impacts. There is also a high risk of relying on one single technology that is drought sensitive. The country has experienced droughts in the previous years and the hydropower plants have produced significantly less power than the installed capacity. A total reliance on hydro power will be at the expense of energy security as hydro power already accounted for 73% of the electricity produced in the country in 2010. Hydro power stations are important, however, as they are used, to a certain extent, to compensate for the variability of other renewable electricity sources like wind or PV.

For these reasons, the government decided to limit hydro power from national watercourses to less than 50% of the country's total power capacity.

Large and medium plants will account for the lion's share with 1200MW installed by 2030. Approximately 350 small and micro hydro power plants will be built, with an average capacity of 714kW per unit or a total of 250MW of small hydro by 2030. All the villages connected with micro hydro were previously deprived of a reliable electricity supply. Most of the schemes were off-grid and were therefore contributing to increasing the rate of rural electrification.

For all villages, micro hydro is contributing to jobs creation, particularly during the implementation phase. Furthermore, from an economic perspective, micro hydro is most effective, compared with diesel, given the high costs of this fuel and the transportation cost to remote villages. Rwanda has recognised these benefits and intends to maximise its micro hydro potential as the following example demonstrates.

Micro hydro power in Rwanda

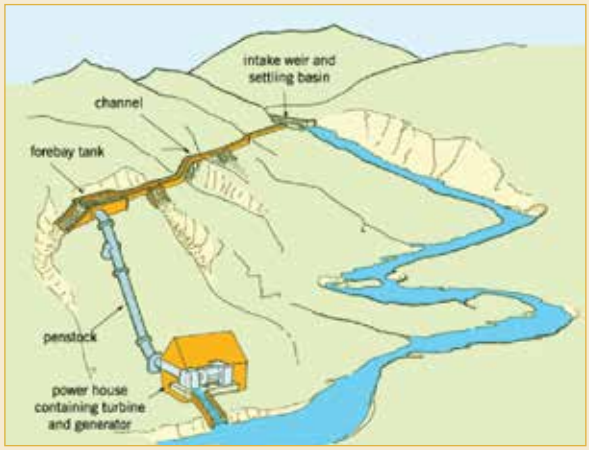
Problem and options

Firewood remains the main source of energy in Rwanda particularly in rural areas. Off-grid renewable solutions are increasingly acknowledged to be the cheapest and most sustainable options for rural areas in much of the developing world," according to REN21, a renewable energy policy network (REN21, 2011).

Strategy

Rwanda has highlighted expanding electricity access and private sector investment in electricity generation as areas of high priority. Unlike traditional power stations that use fossil fuels or large hydro power plants, micro-hydro power has practically no effect on the environment because it does not depend on dams to store and direct water.

As part of the initiative undertaken by the Global Village Energy partnership (GVEP), a micro hydro plant was launched in 2012. Located around 50km from Kigali in the northern region of Rwanda, the Musarara micro hydro-



power plant was constructed under the expertise of the Global Village Energy partnership (GVEP), to stimulate job for small-scale developers by helping them access finance in the energy sector. It will generate 438KW of power to around 2000 residents and its neighbouring development infrastructures including hospital and health centres. Within its intervention in Rwanda, GVEP emphasises working hand-in-hand with local entrepreneurs and advising them on how to raise finance as a way of developing long term and trusted business relationships between local people and local businesses (Africa Science Technology and Innovation News, 3 July 2012).

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Other projects

Furthermore, under the "Private Sector Participation in Micro-Hydro Development Project in Rwanda", four newly registered Rwandan companies are each constructing a micro-hydro electricity plant (100–500kW) and building a low-voltage distribution grid. These companies financed their plants through their own equity and debt, with support from the PSP Hydro project. This support comprised a subsidy of 30–50% of investment costs, technical and business development assistance, project monitoring and financial controlling. Three key messages: (1) institutional arrangements rather than technical quality determine the success of such projects; (2) truly sustainable rural electrification through micro-hydro development demands a high level of local participation at all levels and throughout all project phases, not just after plant commissioning; and (3) real impact and sustainability can be obtained through close collaboration of local private and financial sector firms requiring only limited external funds. In short, micro-hydro projects can and will be taken up by local investors as a business if the conditions are right.

Source: Pigath and van der Plas, 2009. Illustration: Practical Action, 2013

6.1.3 Wind

Wind energy in areas with good sites is a very cost effective option. The Boa Nguvu energy diagnosis shows that there was no installed wind capacity in 2010. To ensure a progressive contribution of Boa Nguvu suppliers of services and equipment and develop national expertise, only 10MW will be installed by 2017. This capacity will, however, dramatically increase and reach 350MW by 2030 with a combination of off-grid and grid connected wind farms.

6.1.4 Geothermal

Boa Nguvu is endowed with significant geothermal potential and has already a 15MW installed capacity. Geothermal, unlike wind or solar, can be considered as a non-variable source of energy that increases the reliability of the whole system. Most of the potential will be tapped and the installed capacity will reach 350 MW by 2030.

6.1.5 Solar

The total solar (PV and CSP) capacity by 2030 will be as high as 900MW, outstripping fossil fuel installed capacity.

350MW of off-grid PV will support access to electricity in rural areas. It is a reliable and relatively low maintenance technology. The PV target will be revised upwards if costs decrease further and better electricity storage opportunities arise. Besides solar home systems, solar lanterns particularly for poor people will also play an important contribution in providing modern lighting.

Larger solar parks are planned from 2017 onwards.

Given the Boa Nguvu solar potential, the technology progress, the market development of solar PV and, as a result, the decrease in investment cost, **150MW of solar PV farms** will be deployed.

The introduction by 2017 of concentrated solar PV pilots in locations with high direct solar irradiation is envisaged, given the decreasing prices of this technology, **200MW of concentrated solar PV** (CPV) farms will be deployed by 2030.

In Boa Nguvu, CSP technologies will be introduced only in 2022 with a 25MW semi commercial power plant. Further deployment will be subject to a thorough environmental impact and economic assessment and another 200MW plant is planned for 2030. The largest CSP will be implemented during the last phase of the energy development plan to benefit from the costs reduction of the equipment due to the economies of scale, to ensure a proper technology transfer, increased opportunities for local industries and job creation.

A main advantage of thermal concentrated solar power (CSP) plants is that they can be equipped with a heat storage system in order to generate electricity even when the sky is cloudy or after sunset. This signifi-

cantly increases the CSP capacity factor, compared with solar photovoltaics and, more importantly, enables the production of dispatchable electricity, which can facilitate both grid integration and economic competitiveness. CSP can fill in that gap in the evening when the peak demand for electricity occurs, thus reducing the need to build new fossil power plants for those peak periods. Storage does raise the price of a CSP plant, but when storage is added to a CSP plant, it increases the value of its electricity, both its energy value and its capacity value. However a cautious approach will be developed for CSP, given the currently higher capital costs and the potential water need for cooling the steam turbines, if dry cooling is not used.

In CPV, the concentrated sunlight is converted directly to electricity via photovoltaic cells.

Both CSP and CPV work better in locations with high direct normal irradiance (DNI), while conventional PV technologies can use diffuse or scattered irradiance as well.

Figure 12: Concentrated PV. *Source: ecofriend.com, 2013*

CSP technologies use mirrors to reflect and concentrate sunlight onto receivers that collect the sun's heat. This thermal energy can then be used to drive a steam turbine that produces electricity for utilities.

Figure 13: CSP. Source: Solar Energy Development Programmatic, 2013

Solar lanterns as part of the solution for modern lighting

About 600 million people, and more than 10 million micro-enterprises, across Africa have no access to electricity. They use inefficient and costly fuel-based lighting sources such as kerosene lamps, which greatly limit their socio-economic activities.

The Lighting Africa program works with off-grid lighting products or systems that are stand-alone, rechargeable and can be installed, assembled and used easily without requiring assistance from a technician. These products are affordable, typically costing less than US$100, some retailing at US$10 or less.

Modern off-grid lighting products have three key components:

- electricity source, most commonly a small 1-5W solar panel;
- a modern rechargeable battery, increasingly lithium -ion; and
- a modern lantern or lamp, usually with an LED (light emitting diode) bulb.

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These lighting products come in many forms. The batteries and solar panel may be built into the lamp, or any one of the components can be separate modules that are easily connected to each other using the 'do-it-yourself' plug-and-play technology.

During the day, the solar panel is placed directly in the sun to generate electricity that recharges the battery. At night, the electricity is available to power the lamp. Other modern off-grid lighting products on the African market are dynamo-powered, with the batteries charged by electricity that is mechanically generated through hand or foot pedalling.

Source: World Bank and International Finance Corporation, 2013

6.1.6 Biomass

Biomass is an important component of the Boa Nguvu energy mix with over 80% of the total primary energy supply. While the conversion processes and use of biomass will change, biomass will remain an important energy source. As far as electricity is concerned, the total installed capacity will reach at least 85MW by 2030, mainly derived from the transformation of the residues of the sugar cane industry, based on co-generation technology and landfill gas.

6.1.7 Regional cooperation strengthening interconnection with neighbouring countries

In 2010, Boa Nguvu was a net importer of electricity from neighbouring countries. This was owing to a lack of electricity production capacity in the country but also to cheap hydro electricity available for export from neighbouring countries. The objective of Boa Nguvu is to strengthen interconnections with neighbouring countries and to become a key stakeholder in the regional power pool. Power pools are based on an integrated master plan approach in order to reduce power supply costs. They have several advantages and, generally speaking, they have a good return on investment. They contribute to significantly reducing capital investment and operating costs through improved coordination among power utilities, optimising generation resources with large units and improving power system.

To be an active stakeholder in the power pool as an importer and exporter, Boa Nguvu has taken the following steps

- adequate generating capacity and infrastructure to meet the requirements of the pool;
- legal framework for cross-border electricity exchanges (agreement on prices and modalities for electricity trade).
- regional regulation and mechanism for conflict resolution.

By 2030, electricity trade with neighbouring countries will double, with the implementation of two 220kV interconnectors. Although electricity trade with neighbouring countries will increase dramatically, the net electricity and fossil fuel imports will be marginal compared with 2010, thanks to the generation of renewable electricity during the period 2010-2030.

Regional power pool

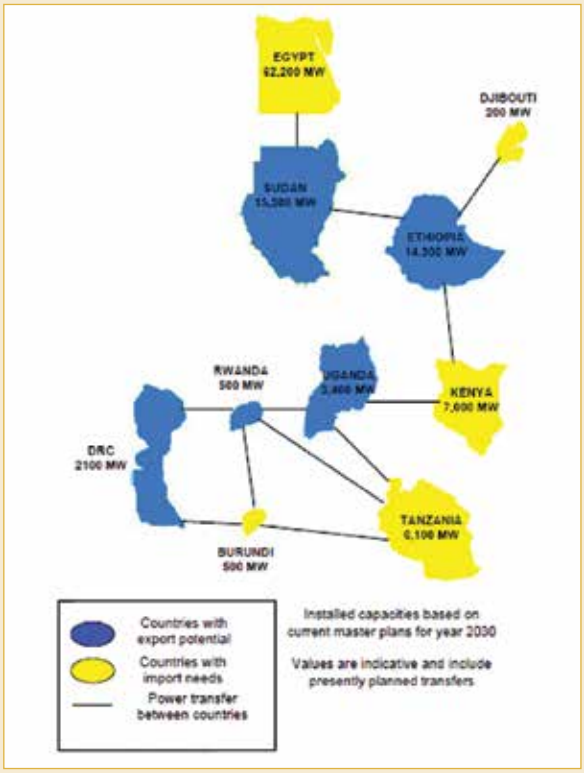
The East Africa Power Pool (EAPP) was set up in 2005 as a specialised institution under COMESA (Common Market for Eastern and Southern Africa).

The main purpose of EAPP is "to provide to the eastern Africa region affordable and reliable electricity, by pooling together all available electrical energy resources in the region in a coordinated manner, in order to increase the access rate to electricity by the population of the region and promote regional integration". There will be mutual assistance among the members in case of failure in their respective power systems.

Under the Inter-governmental Memorandum of Understanding (MOU), signed in February 2005, participating countries have committed amongst others to:

- optimise the usage of energy resources available by working out regional investment schemes in power generation, transmission and distribution, taking into account socio-economic factors
- reduce electricity cost in the region by using power system interconnections and increasing power exchanges between the countries,

A regulatory framework is under preparation. The establishment of a Regional Market Operator and an Independent Regulator is expected. The following table gives an illustration of the potential resources and interconnections within the EAPP by 2030.



Source: SNC Lavalllin, 2010

6.1.8 Electricity supply summary

As a result of the strategy, by 2030 electricity generation will be derived mainly from renewable energy sources. The capacity from fossil fuels will be limited to just 10% of the total installed capacity, compared with 36% in 2010.

Although the share of renewable energy seems high from a technical perspective and may cause problems to the reliability of the system because of the unexpected fluctuations of the renewable output, this risk is limited, given the relatively high share of sources that can adapt their production (to a certain extent) to the need: large hydro, geothermal, CSP with storage and biomass electricity for which the output is not subject to sudden fluctuations. In fact only 700MW (wind, PV, CPV) of the grid-connected electricity capacity is variable. Furthermore, Boa Nguvu has strengthened the interconnections with neighbouring countries to increase the overall energy security of the country and to limit the use of fossil fuel plants that account for less than 10% of the total capacity and even a much lower proportion of electricity generation as they are used as a reserve to cope with exceptional circumstances.

Energy may be stored in hydropower reservoirs, either through the balancing of natural inflows with generation-determined outflows, or through pumps that use electricity in off-peak hours to refill the reservoir. All hydropower infrastructure has potentially significant environmental and social impacts. Attention must be paid to downstream flows, as peaking operations

can impact on natural habitats and human use of rivers. Through smart choices for locations, designs and operating regimes, such impacts can be avoided, minimised, mitigated or compensated, in accordance with existing internationally agreed sustainability criteria.

6.2 SUSTAINABLE BIOENERGY ACTION PLAN

Bioenergy is at the heart of the Boa Nguvu 2030 strategy due to its high share in meeting the energy needs particularly for households, its impact on the livelihood of poor people but also due to the threat to the resource itself when it is not managed sustainably. Sustainable bioenergy supply chains, combined with an efficient use, should enable Boa Nguvu to stabilise biomass consumption and regenerate its forests. Biomass used to generate bioenergy will not only encompass forest resources but also other feedstock such as agro residues, landfill waste, charcoal dust etc. Forest management and plantations, waste and residues recycling and biofuels for transport are the three key areas of the biomass supply action plan. Given the potential conflict of interest of biomass with other key issues such as biodiversity, rural development etc., Boa Nguvu will be adopting ambitious legally binding sustainability criteria for bioenergy, covering production and use.

6.2.1 Natural forest management and plantations

Natural forests are under significant pressure, especially around the rapidly expanding urban centres. Unsustainable fuelwood and charcoal production is a key driver of deforestation and forest degradation. Experiences in sub Saharan Africa show that fast growing tree plantations and, particularly, natural forest management based on participatory approaches have proved successful on a large scale. Nguvu is planning to follow Niger's example to better protect natural forests and to improve biomass production.

Natural forest management for the rural wood energy market

Natural forest management has proved to be a success when institutional and regulatory measures as well as technical measures are devised. In the Sahel, Niger has been pioneering this approach and has introduced major innovations over the past ten years to natural forest management, ranging from forestry co-operative operating systems, to the wood energy rural markets for which particular legislation has been enacted in the 1990s. Since 1989 the Environment Directorate, supported by the Energy II project, has been implementing the Domestic Energy Strategy (DES) with the following objectives:

- improve the commercial value of trees.
- empower the urban and rural populations and meet their needs.
- create revenues.
- sustain management of wood resources.

Key achievements

- Publication of the "Wood Master Plan to Supply Towns" as a planning tool for wood harvesting, based on multi-disciplinary studies incorporating the evaluation of the resource and its generation rate.
- Adoption and implementation of a new tax system for wood energy, in line with the objectives of decentralisation. This encourages the local communities to take on real responsibility through a tax-raising system at source (by the village representatives) and sharing-out this tax between the Treasury, local authorities and rural communities. Niger was the first country in the region to have implemented a policy. Through this tax-raising system and the incentives offered to traders to take supplies to the rural markets and purchase wood cut by local loggers (and no longer their own wage-earning loggers), the financial flows between the towns and the countryside have been drastically changed, making it possible to set an economic development dynamic, springing from the villages themselves and no longer brought about by external financial support.

Continued ➜

- Design of new management techniques for Sahelian-type forest formations.

Procedures and Impact

A thorough survey has been conducted by the Inter-governmental Committee to Control Drought in the Sahel (CILSS) on natural forest management and its impact. A key outcome is the creation of sustainable forest exploitation and commercialisation with the creation of rural wood energy markets managed by local communities. This is summarised in the following table.

Selection of zones to be developed	Prior establishment of development plan to supply urban zones in wood energy. Agreed selection of the priority zones, upon proposal by local populations and after verification of resources and social cohesion
Stages of the implementation of participatory forest development	**6 stages:** 1: Information and sensitisation of rural populations on rural markets, formulation and submission of applications to the Department of Forestry for the creation of a market by villages. 2: Verification of required conditions and validation of the village application. 3: Socio-economic and biophysical diagnosis of the land; socio-economic survey, demarcation of the zone and inventory, elaboration of the development and management plan. 4: Feedback, finalisation and adoption of development plan with the stakeholders: communities, NGO, forest technical services. 5: Support in setting up the local management structure (SLG): training, and elaboration of procedures, preparation of the approval application. 6: Making the rural market official: Handing over by the Department of Forestry of transport vouchers to the SLG and official launching of the market activities. The overall duration of the process is between 1 and 2 years.
Breakdown of income tax and operating revenue	Breakdown according to the origin of the wood. Income shared between: a) State budget, b) local authorities and c) local communities.
Level of development	170 rural markets and 620,000ha as of end 2002.
Regulation framework	1992 Ordinance on the organisation of the exploitation, trade and transportation of wood energy; Rural Code orientation text; New Forestry Code
Poverty control	Significant improvement of incomes in villages: US$0.5 million (2 million CFA / year / village) on average and around US$50,000 (200,000 CFA / year / village) of locally rebated fiscal receipts. Implementation of numerous community investments.

Source: CILSS, 2004; FAO, 2000

Besides forest management, plantations can contribute to increasing the share of sustainable biomass in the energy mix. However, given the scale of investment, community involvement is crucial to reduce the costs and ensure successful implementation. For plantations, Boa Nguvu is looking at Madagascar as the country that has experimented with plantations in dry areas.

Wood energy plantations in Madagascar

Situation and problem

The South West region of Madagascar has a hot, dry climate with slow forest regeneration and a high vulnerability to over exploitation. The forest production potential has been estimated at 64,000t per year, well below the annual consumption. Only for the local city of Toliara, the annual consumption is in excess of 288.000t. Wood energy supply comes from illegal harvesting from natural forests. Poverty has increased and many households resort to charcoal production either as primary or secondary activity, to improve their livelihood, which accelerates forest degradation given the inefficiency of the modes of production.

Strategy

To address the problem, within the framework of the Environmental Program III, a three pronged "Strategy for Sustainable supply of firewood of Toliara" which accounts almost half a million people has been designed.

- Rational exploitation of existing forests for wood energy
- Increase of plantations resources devoted to wood energy
- Forest zoning defining areas for wood energy production

Achievements, impact and lessons

Three plantation campaigns were carried out between 2008 and 2011. Despite previous failures, there was an increase in planters' participation and in planted areas.

The 3 plantation campaigns between 2008 and 2011 involved 860 planters forming 34 groupings. The approach taken allows the planters to own and exploit agro-forestry areas previously inappropriate for cultivation. Further social cohesion and a feeling of ownership of forest resources have resulted in less bushfires. Based on simplified economics there will be potential benefits from plantations when they reach their maturity.

Lessons learnt

- In the beginning, getting key stakeholder participation was difficult due to low awareness on their part.
- The choice of target groups was not always adequate during the first campaign.
- Insufficient organisation and sensitisation of planters led to mixed results during the first campaign.
- It is therefore important from the outset to design an appropriate social organisation of key stakeholders involved in the plantation.
- At regional level, land tenure security of areas devoted to planters should be addressed.

It is important to ensure the follow-up of plantations by communities and strengthen their capacity. Over the 3 campaigns just 865ha was completed, compared with 30,000ha needed to ensure the sustainable supply in wood energy of Toliara.

Source: WWF, 2011a

How to ensure that plantations deliver on their sustainability promise

WWF's New Generation Plantations concept envisages forest plantations that maintain ecosystem integrity, protect high conservation values and are developed through effective stakeholder participation, while contributing to economic growth and employment. The New Generation Plantations project collects knowledge and good practices in plantation forestry in order to promote better plantation management by sharing this information. The New Generation Plantations project speaks for a better understanding of the role that plantations can play in the future, as features of healthy, diverse and multi-functional forest landscapes, compatible with biodiversity conservation and human needs.

For more info: www.newgenerationplantations.com/

6.2.2 Bio energy from waste and residues

Waste-to-energy offers an important potential for the reduction of landfills, for income generating activities and to supply fuels for electricity and household energy. The action plan includes a systematic recovery of wastes from landfill, charcoal dust and agro waste, mainly from the sugar dust industry, within sustainable limits (i.e. leaving sufficient organic matter in the fields).

Landfill management

An approximately 20MW capacity will be developed from 10 sites located in the capital and the copper zone cities. A detailed feasibility study will be carried out to select the technologies taking into consideration environmental, social and financial parameters

Landfill-to-electricity project using CDM: Durban, South Africa

Current situation

The project consists of an enhanced collection of landfill gas at two landfill sites of the Municipality of Durban and the use of the recovered gas to produce electricity to be fed into the municipal grid and replace electricity that the municipal electric company is currently buying from other suppliers. The Mariannhill landfill is an active landfill site which has received approximately 850,000 tonnes of waste. The Mariannhill landfill was officially designated a Nature Conservancy site in late 2002. It is the only landfill in South Africa granted such a status. The second landfill site, La Mercy, is an old landfill, already closed and far away from residential areas. It used to receive 350 tonnes of waste per day and has about 1 million tonnes of waste in place.

Objective

This project is composed of two complementary components:

- Collection, flaring, and combustion of landfill gas, thus converting its methane content into CO_2 and reducing its greenhouse gas effect; and,
- Generation and supply of electricity to the regional grid, thus displacing electricity generation from thermal (mainly coal) power plants.

Impact and achievement

By displacing electricity from the grid, the project reduces emissions related to coal-fired power production which include sulphur oxides, nitrogen oxides, and particulates. It also reduces the adverse impacts related to the transportation of coal and coal mining. Near the landfill sites the project improves the air quality by further reducing the amount of landfill gas released into the atmosphere and thus reducing the risk of neighbouring residents' exposure to odour.

Since the registration of the project in 2004, the Mariannhill site has installed a one megawatt electricity generation capacity instead of the initially planned half a megawatt, while the La Mercy landfill site, due to operational difficulties, was decommissioned in June 2009.

Source: UNFCC, 2012

Agro residues and charcoal dust

Sugar cane is a major agricultural crop in many sub-Saharan Africa countries. In Boa Ngovu, 30MW of capacity by 2030, to meet the needs of the sugar cane industry and, to a lesser extent, to export electricity to the grid when there is a surplus.

A systematic recovery of charcoal dust from retailers and wholesalers will provide an additional output of 210,000 tonnes of charcoal, thereby reducing the pressure on forest resources. Charcoal dust is mixed with molasses or other natural binders to make briquettes, either manually or using simple or complex mechanical devices. Furthermore, there are positive significant social and environmental impacts. The product has benefits because it directly displaces charcoal from forest resources and avoids the dispersion of charcoal dust in the air. Charcoal dust recycling is also a source of generation of hundreds of jobs for poor people. Furthermore, other agro waste such as sawdust is recovered and processed to manufacture briquettes for cooking needs. (UNESCO-UNEVOC, 2006)

Waste to energy for income generation: briquettes manufacturing

Start up

In response to the growing mountain of saw dust and coffee husks residues in Kigali, a local company ENEDOM (Energie Domestique) purchased a briquetting machine from Dev-Tech in India with Funds from UNDP and the Swiss Embassy. The equipment was installed by Indian engineers in April 2000. Tests were carried out on 2 tons of municipal solid waste (MSW), which proved successful when mixed with 10% to 15% of either sawdust or coffee husks. On the basis of these trials, ENEDOM looked for partners to expand the business and in July 2002 formed a joint partnership with TTT in the US.

Pilot marketing

The marketing of briquettes has been highly successful and demand is outstripping current supply. The main market is formed by institutions and is as follows:

- Prison department: 650 tons
- Kigali Institute of Education: 50 tons
- UNHCR 50 tons
- Gitagata Rehab Centre for Army Children 50 tons

One of the problems for ENEDOM has been maintaining a consistent supply and customers have had to frequently switch between wood and briquettes, depending upon the availability of briquettes.

User feedback

- Briquettes are a good substitute for wood as they burn with a small flame and with less smoke.
- Clean and convenient to handle, do not require chopping.
- Fit entirely inside cooking stoves so that doors can be closed.
- Cook slower and last longer than wood, Produce less heat than wood and are not suitable for high power operations such as frying chips.
- Difficult to ignite.

Comparative costs

The use of briquettes indicate a potential saving of 30% by weight and a cost saving of 15.3% as compared to wood typically bought for use in restaurants and institutional kitchens.

Fuel	Wood	Briquettes
Actual Energy (MJ)	22	20
Fuel CV (MJ/kg)	12.05	15.4
KG	1.8	1.3
Fuel Saved %	0	30
Fuel Cost Frw*	29.09	35.00
Actual Cost	53	45
Cost Saved %	0	15.3

Continued ➜

Lessons learnt

- In comparison with wood, briquettes are clean and easy to use because they do not require chopping or splitting unlike wood. They are also easy to store and keep dry.
- At current retail prices, the energy cost of briquettes is around 15% cheaper than for wood. Users also report that there are significant savings because wood requires special labour for cutting, splitting and drying.
- With production costs at 23Frw/kg and a selling price of 35Frw/kg, the pilot briquetting process is profitable.
- With further innovation and increased productivity there is plenty of scope to reduce production costs, leading to greater profit margins and/or lower selling prices.

Source: Young and Khennas, 2003

** Rwandan franc.*

6.2.3 Biofuels and electricity for transport

Boa Nguvu is highly dependent on petroleum product imports for the transport sector. There is a strong rationale to reduce the share of oil in the transport sector with the penetration of biofuels and transport electrification. While the government is committed to electrification, it prefers to wait a few more years to learn from other countries' efforts, in the US, Europe, China and other countries. Right now, the country is determined to replace a share of its oil with biofuels. An advantage of liquid biofuels is their relative compatibility with existing vehicles, liquid fuel infrastructure and ease of blending with petroleum-derived fuels. Boa Nguvu is also prioritising biofuels produced by small farmers on marginal land in association with other crops.

12% of biofuels and electric transport will contribute to the transport energy mix by 2030.

However, a significant shift from the current pattern of consumption requires a massive land use change. During the last decade, several initiatives have been developed to address the environmental and socio-economic impacts associated with the production of biofuels and biofuel feedstocks. The Ministries of Energy, Environment and Agriculture of Boa Nguvu have been following very closely the biofuels issue which is indeed very sensitive given the social, environmental and economic conflicts. The Roundtable on Sustainable Biofuels standards (see below) will be made mandatory in the country. In order to ensure a smooth process towards sustainability Boa Nguvu is looking at a Malagasy type initiative.

Madagascar Sustainable Biofuels Platform

The Sustainable Biofuels Platform was created in December 2009, at the initiative of different ministries and state institutions, all partners of WWF and UNDP's "Sustainable Biofuel Production Promotion" project. Several stakeholders have joined the platform since then, with the aim of ensuring the sustainability of biofuel investments.

One of the platform's main objectives is a sound biofuels supply chain regulation. Its stakeholders have made strong efforts to ensure the inclusion of sustainability principles and criteria, for instance regarding food security, land use and forest protection, in the new regulation. The Platform has fed this process with a Strategic Study of the Biofuels Supply Chain Development.

The Platform's decree proposal is under discussion at the Ministries of Agriculture, Energy, Hydrocarbons, Environment and Forest and Land Use Planning, which are all directly concerned with biofuels.

Source: WWF, 2013

Sustainability criteria

Impact assessment	Biofuel operations shall undertake an impact assessment process to assess impacts and risks and ensure sustainability through the development of effective and efficient implementation, mitigation, monitoring and evaluation plans
Greenhouse gas emissions	Calculated over the whole chain, biofuels shall contribute to climate change mitigation by significantly reducing lifecycle GHG emissions as compared to fossil fuels.
Competition with food or other local applications	The production of biomass for energy must not endanger the food supply and other local applications (such as for medicines or building materials). Reporting on changes in land use in the region and in prices for food and land is of great importance here.
Biodiversity	Biomass production must not affect protected or vulnerable biodiversity and will, where possible, have to strengthen biodiversity. Often local laws and regulations have already been drafted on international agreements about biodiversity. Vulnerable areas and areas with a high value for biodiversity must be spared, where possible restoration of biodiversity is desirable
Environment	In the production and processing of biomass, the quality of soil, surface and ground water and air must be retained or even increased.
Human and labour rights	Biofuel operations shall not violate human rights or labour rights, and shall promote decent work and the well-being of workers.
Prosperity	The production of biomass must contribute towards local prosperity, especially for the smallholders and the local population in general.
Rural and social development	In regions of poverty, bio energy shall contribute to the social and economic development of local, rural and indigenous people and communities.

Source: Roundtable on Sustainable Biofuels, 2013

6.2.4 Sustainability Criteria

After an evaluation of the key initiatives on criteria for sustainable bioenergy development, among them the "Roundtable on Sustainable Biofuels", an international multi stakeholder initiative established in 2006, Boa Nguvu has defined eight principles and criteria to be considered before the deployment of bioenergy and large scale biofuels programmes including feedstock production, processing and biofuel transportation and distribution. The principles and criteria encompass emissions, economic social, environmental and legal issues.

By following the guidelines, Boa Nguvu will be able to dramatically limit the fuel conflicts, thanks to strong land-use planning and the alignment of bioenergy production capacity with efficiency increases in agriculture.

6.3 SUMMARY OF KEY FINDINGS OF THE 2030 BOA NGUVU ENERGY SECTOR

As a result of the strategy, the sustainability of the Boa Nguvu energy sector will be considerably strengthened by 2030 due to a reduction of electricity imports from neighbouring countries, a much higher share of sustainable renewable energy in the energy mix of the country and a significant increase of energy efficiency for the production, transformation and use of energy. Furthermore, the livelihood of poor and middle income people will improve with access to efficient and modern energy services mainly from renewable energy sources including biomass. The 2030 energy balance summarises the key results and conclusions and highlights the progress compared with the 2010 situation of reference (see table 6).

Table 6: Boa Nguvu 2030 energy balance (ktoe)

2030 Supply and Consumption	Crude oil	Oil producers	Biomass-agro resid.	Biogas	Biofuel	Charcoal	Hydro	Geoth.	Solar electricity	Wind	Electricity	Total
production	200	0	13460				967	237	193	79		15136
imports	0	2532									200	2732
exports	-200	0									-200	-400
TPES	**0**	**2532**	**13460**		**0**	**0**	**967**	**237**	**193**	**79**	**0**	**17468**
electricity plants		-132	-64				-967	-237	-193	-79	1580	-92
wood transformation			-7000			2800						-4200
biomass to liquid fuel			-300		100							-200
Biomass to biogas			-160	54								-106
losses											-158	-158
Final consumption	**0**	**2400**	**5936**	**54**	**100**	**2800**	**0**	**0**	**0**	**0**	**1422**	**17712**
industry		400	400			600					522	1922
transport		1700			100						100	1900
buildings		300	5536	54		2200					800	8890

Compared with 2010, the **total primary energy supply** (TPES) has increased by approximately **10%.** However, the **final energy consumption** has increased by **34%,** due mainly to a more efficient use of primary energy and the deployment of renewable energy such as solar wind and geothermal electricity, biofuels and biogas. For instance, charcoal energy efficiency in 2030 is estimated at 40%, which allows the production of 2,800ktoe of charcoal instead of the 900ktoe in 2010 with the same amount of primary energy. With respect to fossil fuels, despite the important demographic growth, imports will only marginally increase.

Renewable energy accounts for 86% of the total primary energy supply. A key outcome, compared with that of 2010, is that biomass is exploited on a sustainable basis and participatory forest management is the current practice for all Boa Nguvu forests.

Approximately 97% of electricity is generated from renewable energy sources and losses account for just 10%, which is in line with good technical management practices. Furthermore, electricity consumption per capita has considerably increased due to the deployment of renewable energy sources, despite population growth.

7 MECHANISMS FOR IMPLEMENTING THE ACTION PLAN

Although financial mechanisms are crucial for the implementation of the action plan, institutional set up, capacity building and the development of local manufacturing facilities are also essential, to ensure the economic and social development of the Boa Nguvu Economy. The action plan also has to be governed by overarching sustainability mechanisms.

7.1 ENVIRONMENTAL AND SOCIAL SUSTAINABILITY MECHANISMS

All sources of energy have impacts on the climate, the environment and on people. Renewable energy sources' impacts are, in general, much smaller than impacts from nuclear and fossil fuels.

Nevertheless, it is important to keep these impacts in mind and to ensure negative impacts are minimised while positive impacts are maximised. Within the renewable energy family, bioenergy and hydropower very often have more impact than wind or solar. Several tools and mechanisms can help in achieving this goal.

Environmental Impact Assessments and their effective enforcement, together with the sustainability assessments of policies, are the governments' first tools. Next to these instruments, there are several other tools that can be included in policies or adhered to by the private sector. WWF has been an active participant in the development of most of these tools.

The Roundtable on Sustainable Biofuels (RSB) has developed sustainability criteria and a certification scheme for biofuels.

The International Hydropower Association has developed the Hydropower Sustainability Assessment Protocol.

Sustainability guidelines for wind parks have been proposed by many institutions, including the European Commission.

WWF and First Solar have published a solar atlas (www.panda.org/solaratlas), showing that, at the country scale, solar PV does not use a lot of land, even if disseminated at a huge scale. At the local level, the report provides guidelines for solar PV parks.

WWF is leading the development of sustainability criteria for geothermal energy in the Philippines. While there are not yet sustainability criteria for all renewable energy projects, the Gold Standard for carbon projects (www.cdmgoldstandard.org) provides a useful sustainability matrix to assess all kinds of renewable energy projects.

Boa Nguvu has developed an energy sustainability strategy that goes beyond climate or social sustainability. This strategy includes broader strategic impact assessments of energy projects and effective environmental impact assessment legislation, but also provides clear rules and criteria for the development of renewable energy, to which companies shall adhere. The voluntary mechanisms highlighted above have served as a source of inspiration for the writing of the rules, and as a useful tool for companies that are subject to these rules.

7.2 INSTITUTIONAL FRAMEWORK

Before the national consultation

The institutional set up was characterised by a dichotomy between the biomass sector and the conventional sector (oil and gas, power). Despite accounting for more than 80% of the total primary energy supply, the traditional biomass sector was not represented within the Ministry of Energy. Energy planning was limited to the conventional sector. The Ministry of Forests was in charge of the bioenergy sector but there was little coordination with the Ministry of Energy. Furthermore renewable energy and energy efficiency were not taken into consideration. The chart below summarises the past structure of the Ministry of Energy.

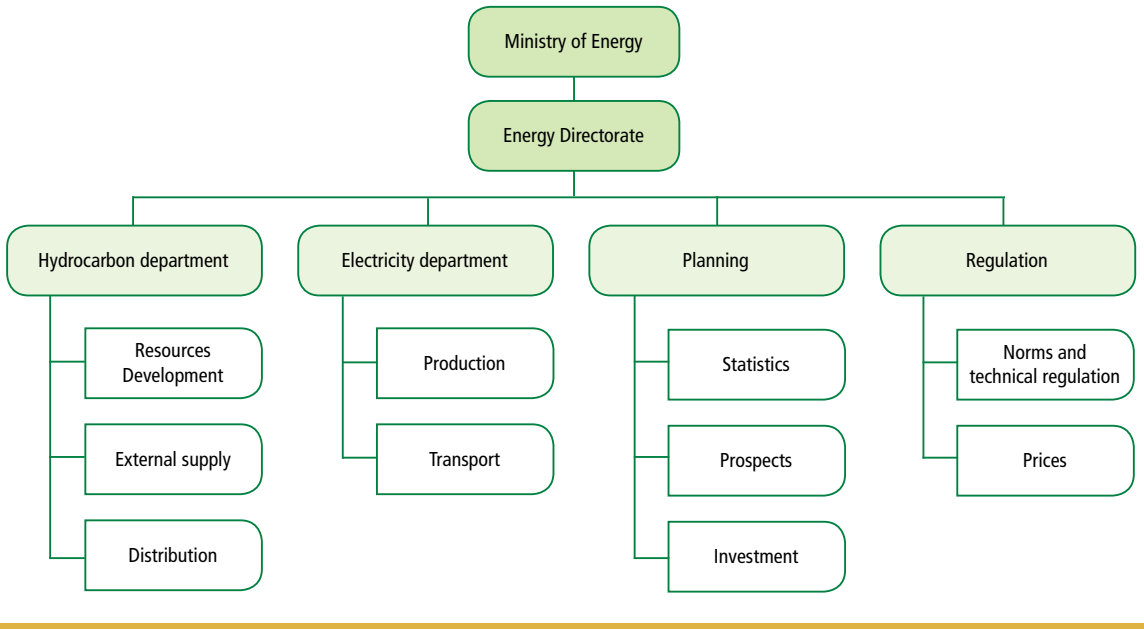


Figure 14: Old structure of the Ministry of Energy

After the consultation

The new structure reflects stakeholders' recommendations to implement the 2030 strategy with a new department dealing with sustainable energy (access to energy, renewable energy and energy efficiency). The energy information system is institutionalised and strengthened to provide comprehensive and detailed information to carry out analysis of the current situation, and modelling for the scenario strategies at the 2030 horizon.

Furthermore, some changes will be carried out to ensure the implementation of the access to energy and sustainable energy targets.

- An Access to Energy, Renewable Energy and Energy Efficiency Agency will be created by 2015, incorporating a dedicated department for enforcement of energy efficiency measures.
- To limit counterfeited products and ensure that only efficient products are commercialised, an independent centre will be established for testing the energy performance and quality of all equipment and appliances (solar panels, refrigerators, stoves, solar lanterns etc.).
- A co-ordination unit for sustainable energy, involving key sectors and stakeholders, will be set up. This will enable novel measures, for example new housing developments will include basic social infrastructure (schools, health centres and shops) to reduce time spent on transport and improve the efficiency of the education system by making a better allocation of the time of young children.
- An Energy Efficiency & Conservation Professional Association will be created.

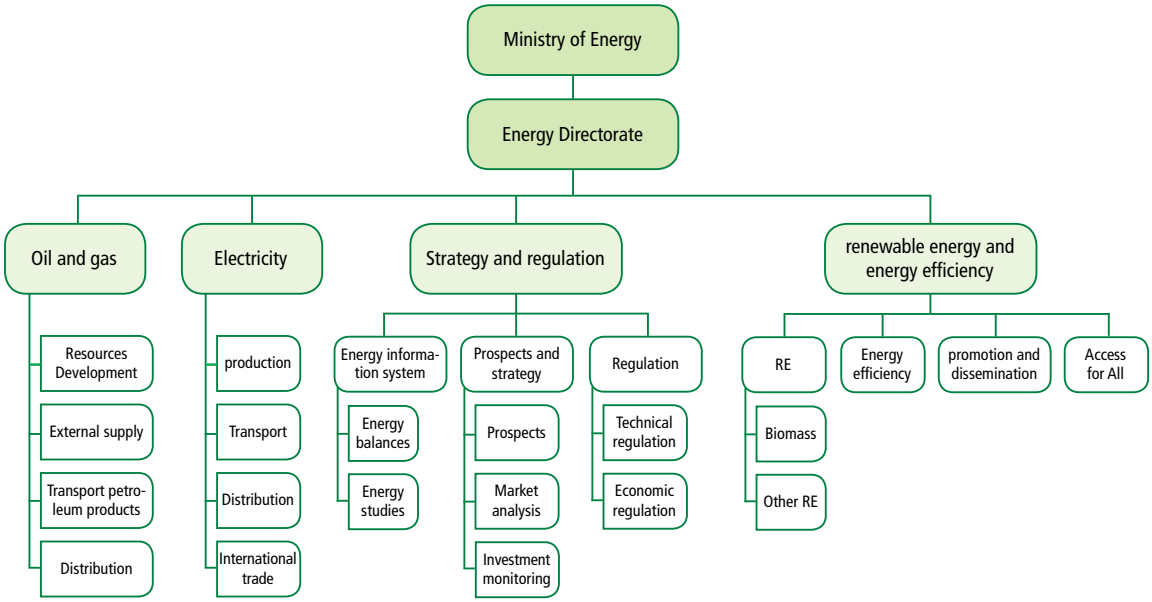


Figure 15: New structure of the ministry of energy

7.3 FINANCIAL MECHANISMS

The investment costs for energy efficiency and renewable energy, whether at the small household scale (e.g. efficient stoves, efficient light bulbs) or at the large scale (e.g. refurbishing buildings or developing large wind parks) are still often higher than their polluting alternative and the benefits are often spread over time. They are also less known by the traditional banking system, making access to funds challenging. In addition, energy tariff distortions and subsidies often don't favour efficiency and renewables. Furthermore, the approach between centralised and decentralised options is very often different in terms of scale, beneficiaries and technology options. Although some barriers might be common, some are specific to rural areas and decentralised renewable energy.

Boa Nguvu will put in place a range of specially adapted, tailored financial and regulatory mechanisms for energy efficiency and renewable energy financing, combining several types of measures.

- Until their final ban, taxes will be increased on incandescent and halogen lamps, whereas taxes on energy efficient bulbs taxes have been considerably reduced.
- Import duty and value added tax (VAT) will be progressively reduced for renewable energy equipment from 20% in 2010, to 10% in 2020 and 5% by 2030.
- The existing road tax will now be based on vehicle fuel consumption and CO2 emissions.
- Subsidies on retail fuels (gasoline, LPG) will be eliminated by 2015. Financial savings will be directed towards public transport companies to increase efficiency and reduce costs.
- Highly efficient components for industrial/commercial imported equipment will be "duty free" for 5 years and there will be targeted tax credits for investments in low consumption labelled equipment.
- To promote local manufacturing of energy efficient equipment, there will be tax relief on profits generated for 5 years.
- Loans with low interest rates (at least 2% below commercial rates) will be made available to small and medium enterprises
- Subsidies of up to 20% of initial investment are provided to investors in renewable energy and energy efficient equipment. Subsidies will be progressively phased out between 2015 and 2022.
- An Energy development fund (EDF) for the deployment of renewable energy and energy efficiency will be created. Apart from the financial allocation from the state budget, 10% of the

For instance, the Ministry of Energy of Boa Nguvu will be following a model (PROSOL) similar to that developed in Tunisia to promote solar water heaters (SWH). The main features of this financing scheme are:

- A bank loan mechanism for domestic consumers to purchase SWHs, paid back through the electricity bill.
- A capital cost subsidy provided by the Tunisian government, up to 100 Dinars (57€) per m^2.
- A series of accompanying measures have been developed, which include supply-side-control quality system set up, awareness raising campaign and capacity building.

Figure 16: PROSOL. Source: UNEP, no date

value of oil exports will be devoted to this fund. Based on a cautious approach ($90/bl and 10% contribution) EDF will generate approximately US$76 million per year. This fund will be inspired by the Renewable Revolving Energy Fund from Namibia.

- The government will work very closely with the private large electricity consumers (companies) in the copper industry, to switch to renewables, for instance through special fiscal incentives.
- Inefficient product exclusions will decrease total costs (appliance and electricity purchase) to the consumer but will increase upfront costs. Those will be compensated by special support programmes.
- Tailored financial mechanisms such as feed-in tariffs (FIT) calls for tender for renewable energy capacity and social tariffs will be developed for the deployment of renewable energy on a large scale for grid connected consumers and for the rural population. FIT will be introduced by 2015. It is a financial mechanism where long-term purchase contracts are offered to renewable energy producers at a fixed price per kWh. For potential financiers, FITs can considerably reduce the risk in investing in renewable energy projects. The disadvantages associated with the costs of renewable energy sources are compensated for by providing an above-market price premium, which enhances the profitability of projects and returns on investment.

Feed-in tariff in Kenya

Mechanism

The Government of Kenya recognised that renewable energy sources have potential for income and employment generation in addition to contributing to the supply and diversification of electricity generation sources. Experiences worldwide show that feed-in tariff (FIT) is a powerful instrument to promote renewable energy. In 2008, the Kenyan government started the implementation of a FIT scheme to accelerate the expansion of renewable energy. The energy sources covered by the scheme included hydro, wind and biomass. Power purchase agreements were set up with predetermined prices for each of the energy sources for a specified installed capacity and over a time span of 15 years.

In January 2010, the FIT scheme was revised to include solar and geothermal sources. In addition, the time span of the contracts was extended to 20 years, and the prices were increased.

Continued ➜

	Wind	Hydro	Biomass	Solar	Geothermal
FIT 2008	Maximum of US$0.09 per kWh up to 50MW capacity	Maximum of US$0.06 to 0.12 per kWh for 0.05 MW to 10MW capacity	Maximum of US$0.045 to 0.07 up to 40MW capacity		
Revised FIT 2010	Maximum of US$0.12 per kWh for 0.5 to 100MW capacity	Maximum of US$0.06 to 0.12 per kWh for 0.5MW to 10MW capacity	Maximum of US$0.06 to 0.08 per kWh for 0.5 to 100MW capacity	Maximum Of US$0.20 per kWh for 0.5 to 10MW capacity	Maximum of US$0.085 per kWh up to 70MW capacity

Impact

The FIT scheme will encourage an estimated additional energy generation capacity of 1,300 MW. This represents a significant increase in Kenya's energy generation capabilities, more than doubling the present capacity (Kenyan Ministry of Energy, 2010), allowing access to electricity for a larger part of the total population and reducing energy poverty. Certain renewable energy options most notably biomass, wind and hydro have already become financially superior to diesel based generation.

Source: UNEP, 2012

- To **increase energy access of the rural population**, the following measures have been put in place by the Boa Nguvu utility:
  - Bill payment will be seasonal and aligned with income from agriculture.
  - Payment of connections fees will be split over three instalments instead of one instalment.
  - A social tariff (lifeline tariff) is set for low income people. Lifeline tariffs are frequently adopted by electricity utilities in Africa and elsewhere. They are designed to provide a subsidy to low income households on the assumption that low income households will tend to consume less electricity than higher income households. In Boa Nguvu, the price of the first 100kWh/month will be sold at three cents/kWh. The difference between the production cost and the social tariff will be covered through a transfer from the oil revenue facility.

Renewable Revolving energy fund

The Namibian Renewable Energy Program (NAMREP) developed a loan financing scheme "Solar Revolving Fund" (SRF) as a financing model and assisted in its implementation. The fund was tasked to finance 100 systems in each financial year by careful selection of applications, so that the scheme benefits citizens throughout the 13 regions in Namibia. It is evidenced that, at the end-of the-project, this was achieved.

The project contracted two commercial financing institutions, Bank Windhoek and First National Bank (FNB) to provide financing for the renewable energy products for the duration of NAMREP programme through a regulation driven mechanism of the Ministry of Mines and Energy (MME)`s SRF. The major commercial financial institutions in the country involved with the financing of commercial and domestic property loan schemes are targeting previously disadvantaged groups and farmers living in remote areas that have no access to grid-connectivity.

Source: Namibia, Ministry of Mines and Energy, 2006

7.4 CAPACITY BUILDING

Design and Implementation Skills

Not having a skilled labour force is a major hindrance to design and implement renewable energy projects. The following capacities are needed and recommended to be built within the first five years.

A Capacity Building Task Force for a period of five years to guide the policies and strategies for the creation of the national capacity on sustainable energy. After this period the government and stakeholders will review and decide whether extension is needed. The task force will also liaise with the international cooperation and other sources of funding and capacity providers.

A National Information Centre will collect climate and energy source information and advise on processes according to the requirements of the energy sector. The centre will be run by a small group of specialists trained abroad in different climate and energy source subjects. This centre will install and operate instruments and equipment to register the information needed. The centre will be equipped with software and hardware for the processing of the information.

Highly skilled experts: An in-house capacity of specialised professionals in the subjects of electrical and electronic engineering, mechanical engineering, civil engineering, environment, regulations, energy economists, and statisticians will be created. These professionals will be trained abroad in the five first years. It is expected that with the new regulatory framework, large scale schemes will be implemented by the private sector. Therefore the role of these highly skilled people will be supervision, monitoring, contracting, setting tariffs and technical standards and ensuring the sustainability and affordability of energy services. Small scale energy services in rural areas (especially those that are isolated), will require a strong partnership between the government and the private sector, small scale manufacturers, designers, installers, trainers, etc.

Operation and maintenance skills

Two types of skills are required:

- Skills to operate and maintain large energy equipment (energy generation systems, high and medium voltage transmission lines, transformation centres, etc). A Training Centre for the formation of highly skilled technicians for operation and maintenance will be set up. This centre will be run by a local university in agreement with the utilities and the Ministry of Energy. A programme of apprenticeships will be put in place in order to form operators and managers for large energy systems. These apprenticeships will be run in coordination with the utilities and using their facilities.
- Skills to operate and maintain small scale energy systems around the country (rural electrification schemes, cooking stoves, and other energy generation devices). The government will choose three technical education centres across the country. It will provide them with the equipment to operate as training centres of technicians for the operation and for maintenance of small scale energy systems. These centres will run short term courses for these sorts of trainees. Owners/managers of small scale energy systems will choose and send the trainees to these centres. The task force with the support of experts and the government will develop the appropriate syllabus and teaching materials. Lecturers of these courses will initially receive training abroad.

Capacity Building for Decentralised Schemes

The design and implementation of energy schemes require several steps, from needs assessments to completion of the installation and commissioning of the systems. It is difficult to have specialists for each step or for each subject. Instead, good practice shows that one individual can be specialised in the design and implementation of a system from start to end. Therefore a training programme on design and implementation of small scale renewable energy systems will be set up. This programme will train experts on small hydropower plants, small wind systems, solar PV systems, cooking stoves, solar water heating systems, biogas systems, etc. The experts will be encouraged to establish local consultancies.

The Task Force, in cooperation with the different energy businesses and national universities, will run a range of courses. All training courses will include in

CAPACITY BUILDING – THE BAREFOOT COLLEGE MODEL

The Barefoot College's mission is to provide basic services and solutions to problems in rural communities, with the objective of making them self-sufficient and sustainable. Barefoot College has significant experience in India at delivering rural development and renewable energy solutions at scale. One of the Barefoot College's most successful programmes is the "Barefoot Solar engineers".

The Barefoot College offers an original and highly effective model to equip the villages with sustainable solar photovoltaic power. Local women are selected to become solar engineers ("Master Trainers") and are sent to Tilonia in Rajasthan, India for a six months training. Upon return, they are equipped with solar systems and are able to effectively electrify their villages and maintain the systems over time. Knowledge is transferred to the community and the costs of solar electrification are kept low. Equipment may be sponsored or paid back by the community, depending on the communities' ability to pay back. The Barefoot College methodology is described in detail at: www.barefootcollege.org/solution/solar-electrification/solar-lighting/.

The concept has been so successful that women from around Africa have attended the training. African governments have become interested in the approach, which places the rural poor at the centre of a sustainable energy revolution. Five governments have agreed to support the creation of a Barefoot College in their country, with financial support from the Government of India and technical support from the Barefoot College in Tilonia. These countries are Tanzania, Senegal, Burkina Faso, Ethiopia and Benin.

Postscript: The WWF – **Barefoot College partnership** is an initiative that creates a concrete link between poor communities and national or international policy. It can provide great examples of sustainable rural energy with special environmental, social and cultural considerations. It can feed national and international policy discussions about access to energy and the role of empowerment to the marginalised and poor.

WWF's goal is to promote the Barefoot College model and to actively use it in its climate, energy and conservation activities. The ultimate objective is to have independent "Barefoot College" institutes promoted by governments in every country where poor people gain from access to training and education. A first common project has been initiated in Madagascar.

depth theory required and practical work. Past experiences show that a course to prepare small hydropower specialists requires four to six weeks and some months or even years of practice alongside experts in the field. For solar PV, solar water heating, wind systems the training is generally less two to three weeks, plus practical work.

In parallel to these courses targeting literate people, the Barefoot College approach will be supported by the government and applied widely in rural areas, for the poorest communities. Here, poor, illiterate people will be at the centre of the energy revolution.

7.5 INDUSTRIAL DEVELOPMENT

Local manufacturing of renewable energy and efficient appliances is a major opportunity for job creation and is key to the deployment of renewable energy and energy efficiency equipment. The following steps will be taken.

Manufacturing of equipment and spare parts

Large and medium scale equipment and systems will continue using equipment manufactured abroad. Similarly the implementation of large systems will rely mainly on external expertise. Small scale equipment will be manufactured to a large extent in the country, and design, installation and commissioning of small scale energy systems will be carried out by national experts.

Manufacturing small scale equipment

By 2020, Boa Nguvu will have the national capacity to assemble, operate and maintain the following equipment:

- hydropower systems up to one MW,
- wind systems up to 10kW, wind pumps for livestock and drinking water and wind generators,
- solar water heating, solar dryers, solar cookers,
- installation and maintenance of decentralised solar PV systems
- household size bio-digesters.

The task force will lead the arrangement of technology transfer programmes through north-south and south-south cooperation. The number of manufacturer companies will be defined, considering the size of the market, potential investments in the energy sector, especially in rural energy (rural electrification cooking stoves and others). Technology transfer programmes will be coupled with the participation of local universities and research centres; this will allow the creation of linkages within small scale equipment manufacturers and universities.

7.6 DEVELOPMENT CO-OPERATION MODALITIES

The systemic challenges to delivering universal energy access in the context of global climate and energy security challenges can only be resolved starting with political will and subsequent concerted action from international partners. This will help distribute energy resources more equitably. International energy and climate policies in the large economies of Europe, the Americas and Asia have far-reaching consequences for poor people.

Decentralised technologies such as improved cooking stoves, stand-alone power devices and mini-grids driven by wind, solar, hydro and bioenergy technologies are often the least costly options to reach the un-served when the density of demand is low.

Investor interest is, however, concentrated more on large centralised schemes, such as hydro power plants. Smaller rural projects are seen as risky and often bear high transaction costs. A re-balancing of effort is required with strategies to deliver decentralised solutions going hand in hand with expanded and reformed utility services.

Bilateral and Multilateral donors will therefore need to allocate significant proportions of their energy sector budgets for Africa towards improved cooking stoves programmes and decentralised electricity systems as well as large power plants fed from renewable energy sources. Other development institutions with large energy sector budgets should take a similar approach to financing energy access for the poor.

Most poor households in Africa could afford modern energy sources, if initial capital costs could be mitigated. To attract private investments into the renewable energy sector in Africa the opportunities need to be large scale or scaled up, and offer clarity

on the level of risk involved. A financial mechanism is required that can aggregate projects, rate investment opportunities and create clusters of projects into tradeable securities. Progressive pension funds and sovereign wealth funds can be encouraged to come forward to pilot these investments. There are signs that Africa already is moving to create the right climate for both public and private investment. The important role for **civil society partners** is therefore to maintain pressure on the donors, during the current Sustainable Energy For All (SEFA) policy momentum, to maintain a balanced portfolio and not to over-emphasise the centralised infrastructure or biofuels components, which would leave the rural communities of Africa in danger of being excluded yet again from access to sustainable energy.

There are various different initiatives currently underway to support sustainable energy strategies in Sub-Saharan Africa. A government like Boa Nguvu will need flexibility in order to adapt to different modalities in order to maximise the in-flow of relevant financial and technical partnerships. Relevant examples are grant finance, commercialisation and payment by results.

Grant Finance

A country like Boa Nguvu can expect both technical and financial support from the EU for a Sustainable Energy 2030 Roadmap. The exact wording of the EU's Agenda for Change is as follows:

*In **energy**, the EU should offer technology and expertise as well as development funding, and should focus on three main challenges: price volatility and energy security; climate change, including access to low carbon technologies; and access to secure, affordable, clean and sustainable energy services* (Brussels, 13.10.2011 COM(2011) 637 final).

An example of EU cooperation at work is the **ECOWAS Renewable Energy Policy**, developed under the Regional Renewable Energy Policy in West Africa Project. The policy is developed with technical assistance from the EUEI-PDF, employing consultants for Innovation, Energy and Development. It is co-funded by the Renewable Energy Cooperation Programme. The project aims at the elaboration of the ECOWAS Renewable Energy Policy and its implementation through targeted national follow up activities. The regional policy is a first step towards aligning the regional and national government's energy policies, legislative and regulatory procedures in a systematic approach.

Source: ECOWAS, 2012

Commercialisation

USAID appears to be taking a different approach by offering facilitation for direct commercialisation of renewable energy opportunities in a country like Boa Nguvu by private sector companies. A country like Boa Nguvu can package its promising start-up bio energy businesses to USAID, which can facilitate them by providing multiple rounds of coaching and guidance before presenting them to investors.

Payment by results

As part of its contribution to the Energy Partnership it established in October 2011, Norway is to enter into three bilateral agreements to scale up access to sustainable energy in Ethiopia's rural areas, replace kerosene lamps with solar alternatives in Kenya, and support Liberia's development of a strategic energy and climate plan, with a major emphasis on 'payment by results'. Payment by results is relatively untested in the energy and development space. It is attractive to donor countries because it enables them to better justify the use of taxpayers' money for international development by showing a clear linkage between inputs and results. All this is not without challenges and risks for a country like Boa Nguvu: there is the challenge of pre-financing which means prioritising resources in current budgeting for reimbursement against results. But it is also attractive because it enables the country to determine how best to deliver the pre-agreed results, as opposed to implementing a program specified by the donor partner (in some cases, the key enabling factor may be implementation of a new law rather than additional funding).

CONCLUDING SUMMARY: KEY POINTS AND TIMELINE TO 2030

In the last five years, Boa Nguvu has been hit by a dual crisis of rising prices of imported and domestic energy. The global oil price has been rising steadily and, domestically, the charcoal market has spiked due to reduced production and higher transportation costs. The country reacted with the development of a bold strategy and action plan. **Fundamental to the Sustainable Energy Strategy 2030 is the political will to make challenging choices and prioritise public policy and investment in the energy sector.** Boa Nguvu has an opportunity to make these investments, with crude oil revenue and with high copper prices expected in the coming decade. It will be vital to maintain this national consensus in the first five to ten years of the strategy period before the benefits are fully realised from the new renewable energy sources coming on stream.

In order to rise out of this crisis and find the path of sustainability and prosperity, while catering to the needs of a rapidly growing population, the Sustainable Energy Strategy 2030 contemplates a carefully sequenced series of measures.

The first practical step is to invest in enhanced capacity for energy information, planning, civil society participation and packaging of investment opportunities. This is the process that Boa Nguvu has been going through in the last three years.

As the renovation of infrastructure and rehabilitation of natural resources requires a ten to fifteen year timeframe for the benefits to be felt, immediate short term measures are required to reduce the immediate supply bottlenecks by introducing energy efficiency gains. Hence:

By **2016** inefficient energy appliances will be phased out.

By **2020** there will be 100% coverage of improved stoves and improved kilns in the biomass sector.

By **2025**, due the thorough realignment of incentive and opportunities in the natural forest and plantations sector, the supply of biomass will become fully sustainable.

The programme for renewable energy infrastructure has started immediately and will register very rapid increases in production from 2017 onwards. From the current base of 785MW the combination of wind, solar, geothermal, hydro, and biomass for the generation of electricity will reach 1,465MW of output in **2022** and 3,485MW in **2030**.

The contribution of renewable energy to the total supply will reach 86% in 2030, while petroleum products consumption will remain static in **2030**.

These measures are embedded in an ongoing and cumulative process of capacity building, both of the engineers and planners and of the population as a whole, to bring about behaviour change in younger generations, in consumers, of rural producers and of society as a whole, especially in terms of the **"up-front" investment** required at all levels, from the mega solar energy park to the household stove, in order to be able to travel down the sustainable energy path and guarantee prosperity and development for future generations.

ANNEXES

Energy units

The internationally recognised units that cover almost all of the measurements of fuel and energy quantities are the cubic metre, tonne (metric ton) and joule. They are derived from the metre, kilogramme and second, included in the Système International d'Unités (SI) and they serve as an international basis for science, technology and commerce. These are the SI units. However, over many years other units have been used.

The SI unit of energy is the joule (J). Many other units for energy are in use for the practical expression of energy quantities, partly for historical reasons and partly because the small size of the joule demands the use of unfamiliar (for non-scientists) decimal prefixes. As a result, the international organisations have used units for energy of a size appropriate for expressing national fuel supplies and related to the commodities in use. Historically the ton of coal equivalent was used but, with the ascendance of oil, this has been largely replaced by the tonne of oil equivalent (toe) defined as 41.868 gigajoules. Many national balances use this unit but the terajoule is increasingly used in accordance with the recommendations by the International Standards Organisation (ISO).

There are several definitions of the calorie in use. The conversion equivalent between the calorie and the joule given here is the International Steam Table (IT) value which is defined to be 4.1868 joules. Similarly, the internationally agreed value for the British thermal unit (Btu) is now 1 055.06 joules. The Btu is the basis for the quad (1015 Btu) and the therm (105 Btu).

Conversion equivalent between units of energy

To: / From:	TJ multiplied by:	Gcal	Mtoe	MBtu	GWh
Terajoule (TJ)	1	238.8	2.388×10^{-5}	947.8	0.2778
Gigacalorie	4.1868×10^{-3}	1	10^{-7}	3.968	1.163×10^{-3}
Mtoe*	4.1868×10^{4}	10^{7}	1	3.968×10^{7}	11630
Million Btu	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
Gigawatt-hour	3.6	860	8.6×10^{-5}	3412	1

**Millions tonnes of oil equivalent*

Source: IEA, 2005

8 GLOSSARY

Biofuels

Biofuel refers to liquid and gaseous fuels produced from biomass – organic matter derived from plants or animals. There is considerable debate on how to classify biofuels. Biofuels are commonly divided into first-, second- and third-generation biofuels, but the same fuel might be classified differently depending on whether technology maturity, GHG emission balance or the feedstock is used to guide the distinction.

Conventional biofuel technologies include well-established processes that are already producing biofuels on a commercial scale. These biofuels, commonly referred to as first-generation, include sugar- and starch-based ethanol, oil-crop based biodiesel and straight vegetable oil, as well as biogas derived through anaerobic digestion. Typical feedstocks used in these processes include sugarcane and sugar beet, starch-bearing grains like corn and wheat, oil crops like rape (canola), soybean and oil palm, and in some cases animal fats and used cooking oils.

Advanced biofuel technologies are conversion technologies which are still in the research and development (R&D), pilot or demonstration phase, commonly referred to as second- or third-generation.

Source: Adapted from IEA, 2011b

Hydro power

The most common way to harness water power is by using a turbine which is turned by water moving in a controlled manner. It is a technology that has been used throughout the world, by a diverse range of societies and cultures, for many centuries. Large dams hold water which can be used to provide energy for industry and grid electrification systems. Smaller systems can provide energy to remote regions without the need to build dams. The following table gives a typology of hydro power schemes according to their size

- Large: more than 100MW, usually feeding into a large electricity grid
- Medium: 15–100MW, usually feeding a grid
- Small: 1–15MW, usually feeding into a grid
- Mini: above 100kW, but below one megawatt; either stand-alone schemes or more often feeding into the grid
- Micro: from 5kW up to 100kW; usually providing power for a small community or rural industry in remote areas away from the grid
- Pico: from a few hundred watts up to 5kW; for domestic use including small-scale agro-processing activities such as threshing, hulling and milling, for battery-charging stations, and for poultry rearing and incubators.

Source: Practical Action, Technical brief: http://practicalaction.org/docs/technical_information_service/micro_hydro_power.pdf

Concentrated Solar Power (CSP):

The general principle of a CSP plant entails using mirrors to concentrate the sun's rays on a heat transfer fluid that circulates and transfers its heat to a thermodynamic fluid that vaporises. This vapour drives a turbine to generate electricity.

There are four main types of plant – the most widespread are parabolic trough plants (50-300MW), solar power towers (10-50MW), Fresnel reflector strip plants (prototypes) and the (10-25kW) Stirling dish system plants dimensioned to meet isolated production needs.

Some plants are equipped with storage systems enabling unused, surplus energy to be stored in the form of heat in molten salt or some other phase changing material. The plant can then draw on the stored heat to generate electricity continuously i.e. during cloudy periods and after sunset.

Source: adapted from: The state of renewable energies in Europe, 11th Eur Observer Report.

Energy Balances

The presentation of energy statistics expressed in natural units in the form of commodity balances between the supply and use of the energy commodities provides a check on the completeness of the data and a simple means of assembling the main statistics of each commodity so that key data are easily obtained. However, because fuels are mainly bought for their heat-raising properties and can be converted into different fuel products, it is also helpful to present the supply and use data in energy units. The format adopted is termed the **energy balance** and allows users to see the fuel conversion efficiencies and the relative importance of the different fuel supplies in their contribution to the economy.

The energy balance is also the natural starting point for the construction of various indicators of energy consumption (for example consumption per capita or per unit of GDP) and of energy efficiency. The statistician also uses the energy balance as a high-level check on the data accuracy as apparent energy gains in conversion processes or large losses indicate data problems.

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