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Module 1

Overview of renewable energy and energy efficiency

Advance copy

SUSTAINABLE ENERGY REGULATION AND POLICYMAKING FOR AFRICA

CONTENTS

1. MODULE OBJECTIVES

1.1. Module overview

This is an introductory module for the training package and provides a brief overview of energy sector in Africa and a summary of the status of renewable energy and energy efficiency in Africa (a more detailed review appears in module 2). It then explains why African countries should promote renewable energy and energy efficiency.

The module explains how renewable energy systems and energy efficiency technologies can assist Africa to address the energy challenges facing many countries in the region. Key challenges include energy supply insecurity arising from high oil prices; recurrent drought-related hydropower crises; inability to provide adequate access to modern services for the region's poor; and, adverse local, regional and global environmental impacts of excessive reliance on conventional energy systems.

The final section of the module presents key terminologies, references as well as websites used.

1.2. Module aims

The aims of the present module are listed below.

- Provide an overview of the energy sector in Africa;
- Highlight the potential benefits/contribution of renewables to the African energy sector and explain why Africa should promote renewable energy;
- Highlight the potential benefits/contribution of energy efficiency to the African energy sector and explain why Africa should promote energy efficiency.

1.3. Module learning outcomes

The present module attempts to achieve the following learning outcomes:

- Enhanced understanding/awareness of the potential benefits/contribution of renewables to the African energy sector;
- Enhanced understanding/awareness of the potential benefits/contribution of energy efficiency to the African energy sector.

2. INTRODUCTION

Renewable energy and energy efficiency options have been identified as important for the development of the sub-Saharan African energy sector. However, these options have not yet attracted a significant level of investment or policy commitment. As a result, they are not widely disseminated in the region.

This module presents key reasons why energy sector decision-makers in Africa should promote renewables and energy efficiency options.

Before delving into the rationale for sustainable energy promotion in Africa, the next section of this module will first provide an overview of the energy sector in Africa.

3. STATUS OF RENEWABLE ENERGY AND ENERGY EFFICIENCY IN AFRICA

3.1. Brief overview of the African energy sector

Africa produces less than 10 per cent of the total world's primary energy supply (IEA, 2005). Energy production in Africa is not evenly spread across the continent. For example, in 2003 Africa produced 11 per cent of the world's crude oil, 85 per cent of which originated from only four countries: Nigeria, Algeria, Libya and Egypt. Similarly, about 5 per cent of the world's coal production is from Africa. South Africa, on its own, accounts for 97 per cent of Africa's total coal production (IEA, 2005). Table 1 shows energy production in Africa by source.

Table 1. Production of energy (by source) in Africa (2003)

Type	Amount (Mtoe)	Percentage
Solar/wind	0.058	0.01
Geothermal	0.680	0.06
Nuclear	3.300	0.30
Hydro	7.300	0.66
Petroleum products	128.560	11.69
Gas	129.890	11.81
Coal	139.010	12.64
Biomass*	272.100	24.74
Crude oil	418.780	38.08
Total	**1,099.678**	**100.00**

Source: IEA, 2005.

*Biomass refers to combustible renewables mainly fuelwood, charcoal and agro-residues.

With the exception of South Africa, on a per capita basis, sub-Saharan Africa is the lowest consumer of modern forms of energy (e.g. petroleum, electricity, coal and new renewables) in the world (IEA, 2005). This is demonstrated by the following figure, which compares electricity consumption per capita of sub-Saharan Africa to the rest of the world:

Figure I. **Electricity consumption per capita (kWh/capita) by regions of the world in 2000**

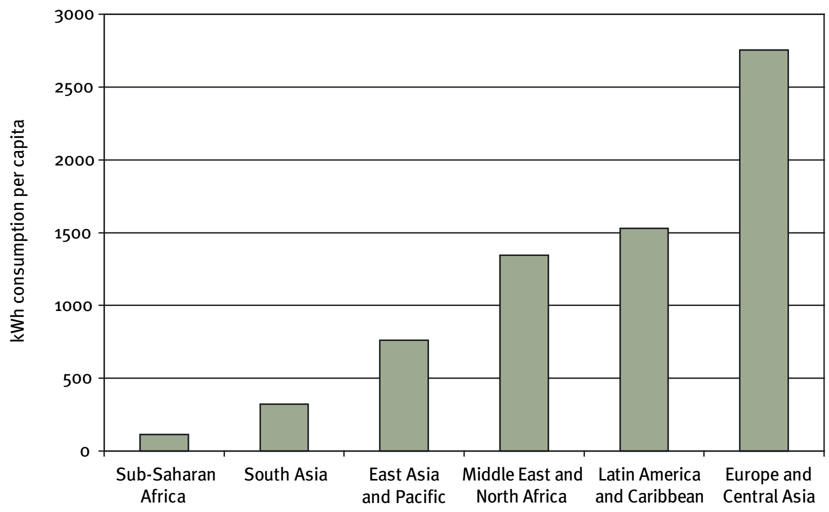
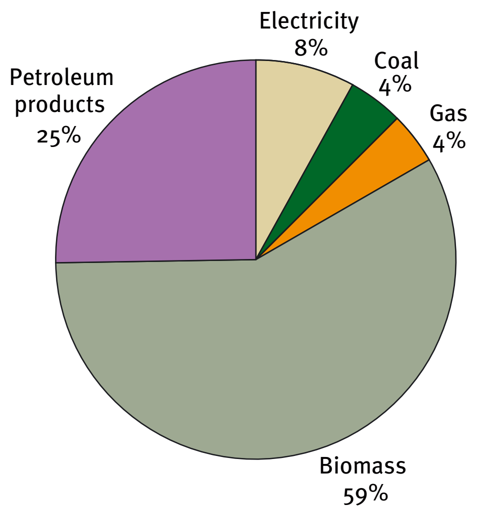


Figure II. **Energy consumption in Africa by source (2002)**



Source: IEA, 2005.

The region's low consumption of modern energy is largely due to continued heavy reliance on traditional biomass fuels coupled with underdeveloped modern energy subsectors especially petroleum and electricity. For example, until the late 1980s, only seven countries had an installed capacity exceeding 1 GW, the size of a single large power plant in USA. By 2001, the number of countries with over

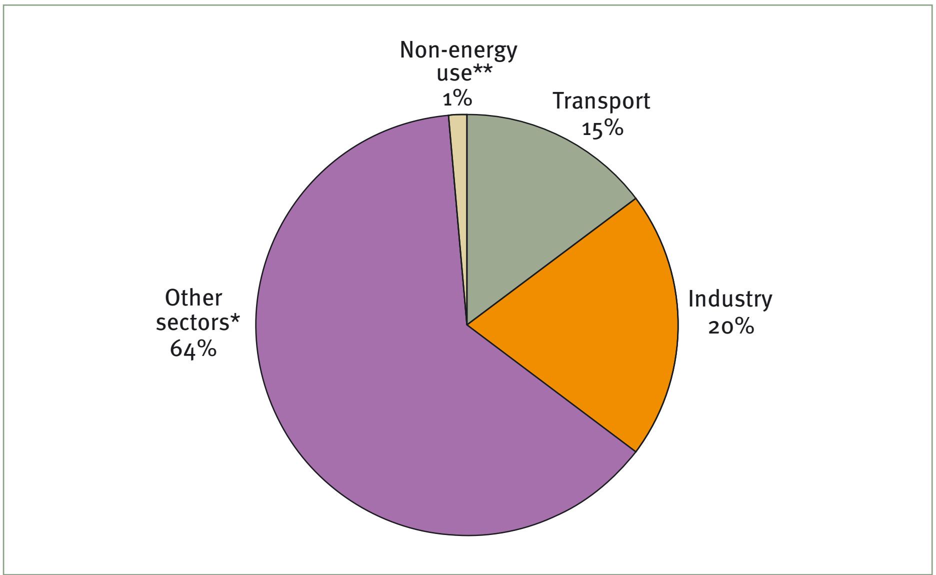
1 GW of installed capacity increased to only 12 (World Bank, 2003a) out of over 50 African countries.

Reliance on traditional biomass energy is particularly high in sub-Saharan Africa, accounting in some countries for up to 95 per cent of the total national energy consumption. Even in Nigeria, a major oil producer, an estimated 91 per cent of the household energy needs are met using biomass (Karekezi et al., 2002). Figure II shows energy consumption in Africa by source.

With the exception of a few oil-producing countries such as Angola, Cameroon, Egypt, Libyan Arab Jamahiriya, Nigeria and Tunisia, most African countries import petroleum either in the form of crude oil or its refined products. In these countries, petroleum imports can account for as much as 50 per cent of the country's export earnings, making it difficult to implement sound economic and environmental policies (IEA, 2003).

In overall terms, the industrial sector constitutes 20 per cent of total energy consumption; transport 15 per cent; while other sectors (i.e. agriculture, commercial, public services and household) account for more than 60 per cent of total energy consumption. Non-energy use accounts for about 1 per cent of the total energy consumption (see figure III).

Figure III. **Sectoral energy consumption in Africa (2002)**



Source: IEA, 2005.

*Other sectors include agriculture, commercial and public services and residential.

**Non-energy use covers the use of other petroleum products to produce white spirit, paraffin, waxes, lubricants and bitumen. The term also includes the non-energy use of coal. It assumes that the use of each of these products is exclusively non-energy.

3.2. Brief overview of renewable energy and energy efficiency in Africa

Africa has a vast range of new and renewable energy resources with significant potential. Although the number of renewable energy resources in the region are unevenly distributed, some of the resources are widely available.

For example, solar energy is perhaps the most widespread renewable energy resource in Africa. A large number of African countries have daily solar radiation ranging between 4 and 6 kWh/m2—a significant energy resource. Biomass is another widespread renewable resource and also the most commonly used in sub-Saharan Africa. It accounts for the bulk of most African countries' total national energy supply—in some countries as high as 95 per cent.

Wind energy is another renewable energy resource that is gradually gaining popularity. However, many sub-Saharan African countries are characterized by low wind speeds, particularly those which are near the equator and landlocked. This largely limits the potential for using wind energy for electricity generation to countries with a coastline (there are some exceptions such as Chad which, although landlocked, has good wind potential in some parts of the country). Nevertheless, even under low wind regimes, there exists opportunities for wind energy applications such as water pumping for potable water and irrigation.

Africa is well endowed with geothermal energy as a result of the formation of the Great Rift Valley. Using the prevailing technology, the region has the potential to generate 9,000 MW of electrical energy (BCSE, 2003 and Simiyu, 2006) from hot water/steam based electricity generation. However, to date, only 127 MW has been exploited in Kenya, and less than 2 MW in Ethiopia (KENGEN, 2003; Wolde-Ghiorgis, 2003). The limited exploitation of the resource is partially due to the significant upfront cost and specialized expertise required. The potential of geothermal energy is even greater than the aforementioned estimate when direct thermal use of geothermal energy is taken into account (Simiyu, 2006).

Africa has substantial hydropower energy resources, with potential estimated to be more than 3,140 TWh of technically exploitable hydropower. Eastern, Southern, Central and parts of Western Africa have many permanent rivers and streams providing excellent opportunities for hydropower development. While large-scale hydropower development is becoming a challenge due to environmental and socio-economic concerns, small hydropower development continues to be an attractive resource especially in remote areas of Africa.

While there are a few successful efforts to promote renewables in Africa, energy efficiency programmes have registered less than encouraging results. Efficiency programmes are largely absent in most countries although the potential gains from energy efficiency are enormous. In Kenya for example, it is estimated that between 10-30 per cent of the primary energy input is wasted (IEEN, 2002). Plans are, however, underway to initiate energy efficiency programmes in some countries in the region (e.g. Kenya). Most of these initiatives are donor-funded mainly by GEF, UNDP, REEEP, UNIDO, AfDB and the World Bank.

The industrial subsector is one of the three major energy-consuming subsectors in the sub-Saharan African region (the other two are transport and residential). It accounts for a quarter of the total commercial energy demand—the bulk of it in the form of electricity and imported oil. The region's industrial base is expected to expand in the not-too-distant future and a critical requirement for this transformation is adequate energy services for industry.

Although sub-Saharan Africa has enough energy resources to meet the requirements of any plausible future industrial development scenario, the present pattern of energy consumption is far from efficient. In most countries in the region, the present pattern of energy utilization is sub-optimal and industrial energy use, in particular, is very inefficient. These inefficiencies constitute a large drain on many of the economies in the region and have adverse impacts on:

- The cost of energy supply;
- The prices of goods and services;
- The environment.

Given the significant renewable energy potential in the region, opportunities exist for exploiting renewable energy technologies that also have energy efficiency attributes such as bagasse-based cogeneration, solar water heaters and geothermal combined heat/power plants. For example, it is estimated that one of the largest consumers of domestic electricity is water heating. This typically accounts for about 30-40 per cent of electricity bills of certain categories of household consumers (Energy Management News, 1999). Solar water heaters provide an excellent opportunity for reducing the amount of electricity used for water heating, and simultaneously reduce the two peaks in electricity demand (morning and evening). Solar water heater projects have been launched in Morocco with an aim of initially installing 80,000 m^2 of solar water collectors (REPP, 2002). An Egyptian electricity utility is also providing incentives for domestic consumers who install solar water heaters. Tunisia has recently launched a utility-based solar water heater programme that is expected to lead to the wider use of solar heaters.

At the industrial level, solar water heaters can be useful in pre-heating water for use in boilers, therefore reducing the amount of electricity or fossil fuels needed to heat the water to produce process steam. This could yield significant savings in energy intensive industries.

Bagasse-based cogeneration also provides an opportunity for energy efficiency. A significant part of cogeneration initiatives is aimed at increasing the efficiency of factory energy use to free up more electricity for export to the grid. It is estimated that modest capital investments combined with judicious equipment selection, increased efficiency in the sugar manufacturing process (to reduce energy use) and proper planning could yield a 13-fold increase in the amount of electricity produced by sugar factories and sold to the national grid (Baguant, 1992).

Combined heat and power geothermal energy plants can also be considered as efficiency technologies. The heat part of a geothermal plant (which has not been widely exploited in the region) could be used for several uses, namely:

- Heating greenhouses—tried in Kenya for flower farming;
- Heating fish ponds—currently practised in parts of Asia;
- Water and space heating—done in parts of the developed world.

To conclude, the trend depicted in the foregoing discussion indicating under-exploited renewable energy and underdeveloped energy efficiency in the region can be traced back to national energy policies. While most sub-Saharan African countries now have dedicated energy policy documents articulating the objectives for the energy sector, they tend to mainly concentrate on conventional energy systems at the expense of renewables and energy efficiency. Although the overall objective of the national energy policies is to increase the provision of modern energy services to the bulk of the population, renewables and energy efficiency technologies are usually not among the priority options.

There appears to be lack of policy implementation plans for renewables and energy efficiency such as those developed for conventional energy systems. As a result, renewables and energy efficiency development appears ad hoc and not explicitly linked to national energy plans.

The rationale for promoting renewables and energy efficiency in national energy policies is not well argued. This might partially explain why limited attention is accorded to renewables and energy efficiency. Consequently, the large-scale conventional energy sector (i.e. electricity and petroleum), which serves a smaller proportion of the population receives the bulk of energy investments in most countries in the region. In contrast, small-scale renewable energy options, which serve the bulk of the population, receive limited budgetary support. For example, the budgetary allocation for the energy sector in Zambia in 2002, indicates a heavy emphasis on electrification (mainly conventionally powered grid extension). Only 0.2 per cent of planned investments in the public investment plan was allocated to renewable energy and energy efficiency systems (Ministry of Finance and National Planning, 2002).

At the international level, promotion of renewables and energy efficiency is often driven by climate change and environmental drivers that do not resonate in Africa. Stressing the environmental benefits of renewables has not been effective in engendering support for renewable and energy efficiency in the region. Since Africa is not yet a net emitter of greenhouse gases, the promotion of renewable energy and energy efficiency systems is likely to be more successful if advanced on the basis of their socio-economic benefits and cost advantages.

On the whole, support for renewable energy and energy efficiency appears lukewarm. For example, a number of Governments in the region do not have a comprehensive vision, policy and plan on renewable energy and energy efficiency systems. Consequently, RE&EE systems development is often undertaken within an energy planning and policy vacuum often leading to discouraging results.

4. WHY SHOULD AFRICA PROMOTE RENEWABLES?

Given the large renewable energy resource potential that already exists in Africa, it is only logical that Africa promotes these indigenous resources. The region is endowed with substantial renewable energy resources, for instance, 1,100 MW of hydropower capacity; 9,000 MW of geothermal potential (hot water and steam based); abundant biomass; and, significant solar potential (BCSE, 2003).

Furthermore, the increasingly unreliable large-scale conventional energy supplies in the region poses a significant energy security threat. Renewable energy systems offer diversification in energy supply, thus strengthening energy security by broadening national energy generation portfolios. Countries with diversified energy generation are better-off than those which heavily depend on centralized large-scale hydro or conventional thermal-based generation, as the former is dependent on rainfall and the latter on imported petroleum fuels both of which can have a degree of uncertainty in supply. Reliance on a narrow range of energy supply options can lead to an energy crisis. Renewables can contribute to lowering the risk profile of a country's energy sector.

The energy sector in numerous African countries is characterized by high oil import bills, accounting for a significant proportion of export earnings (Karekezi and Kimani, 2001; AFREPREN, 2001). In addition, high oil imports increase the vulnerability of African countries to external oil price shocks which have an adverse impact on balance of payments. The use of renewable energy resources can reduce dependence on imported petroleum fuels (Mbuthi, 2004; Yuko, 2004). Table 4 estimates the potential for replacing electricity generation from fossil fuels by biomass-based cogeneration in three Eastern and Horn of Africa countries.

Table 4. Potential of cogeneration to replace electricity generation from fossil fuels

Country	Electricity generation from oil and petroleum (GWh)	Biomass-based cogeneration potential (GWh)
United Rep. of Tanzania	143	315
Kenya	1,509	2,606
Ethiopia	19	1,750

Sources: Adapted from IEA, 2003.

This is best illustrated by power sectors in the three East African countries. In the United Republic of Tanzania and Uganda, the power sectors are predominantly large-scale hydro. Due to prolonged drought during the period of 2005/2006, the water level in the hydropower dams was very low leading to severe electricity generation shortfalls. Consequently, the two countries have been experiencing load shedding lasting about eight hours a day. By contrast, Kenya's power sector has a much lower risk profile as it has several electricity generation options including hydropower, geothermal, thermal and a limited amount of wind energy. While the drought of 2005/2006 affected its hydropower dams, the availability of other renewable options contributed to a steady supply of electricity.

Another important reason for Africa to promote renewables is to enhance the competitiveness of its agricultural commodities. For agro-processing industries such as coffee, tea, sugar, sisal and cotton located in remote areas (sometimes away from the grid), embedded renewable-based generation can lower energy costs, thereby making the products competitive in the world market. Embedded generation can also contribute to the stability of the national or local grid where agro-processing industries are connected.

The failure of conventional energy systems to reach the majority of the population should be a strong incentive for African governments to promote renewables. For example, after more than 40 years of independence, the majority of the population, especially the poor, still have no access to modern energy services such as electricity. On the other hand, there is growing evidence that investment in small and medium-scale renewable energy technology projects, e.g. small-hydro, could be an important option for providing modern energy services to the poor, particularly those residing in remote and scattered rural settlements (Mapako and Mbewe (eds.), 2004; Karekezi and Kithyoma, 2002; UNDP, 2004; World Bank, 2004). Renewable energy systems can play an important and cost-effective role in rural electrification, particularly in areas far from the grid.

Another incentive for the promotion of renewables in Africa is the important role of renewable energy technologies (RETs) in poverty alleviation. This is particularly true of small-scale RETs that are made locally and operate on the basis of solar, thermal or animate power. In some cases, renewable energy technologies are sometimes the only options in rural areas due to limited coverage of conventional energy networks (electricity and pipelines). Such technologies cannot only provide energy that is affordable to the poor but can also be a source of employment and enterprise creation for both the rural and urban poor in Africa. Examples of such renewables include (Mapako and Mbewe (eds.), 2004; Karekezi and Kithyoma, 2002; UNDP, 2004; World Bank, 2004; The Economist, 2004):

- Low-cost but more efficient biomass-based combustion technologies (e.g. improved cooking stoves, efficient charcoal kilns, brick making kilns, fish smokers, tea dryers and wood dryers).

- Pico and micro hydro for shaft power that can be used to process agricultural produce and increase its value, as well as for water pumping.
- Low-cost efficient hand tools and animal drawn implements, which would increase the agricultural productivity of rural areas of east and Horn of Africa.
- Treadle and ram pumps for irrigation, which increase agricultural output thus generating income for the rural farmer.
- Solar dryers that can lower post-harvest losses and enable the rural farmer to market his/her produce when prices are higher.
- Solar water pasteurizers that provide clean potable water and reduce water borne diseases, which translate into increased availability of labour and thus increases agricultural output and income.

Medium and large-scale renewables also provide significant job creation opportunities. For example, geothermal resource development and exploitation can create significant job and enterprise opportunities both directly and indirectly. In 2002, the 45 MW plant at Olkaria I (Kenya) employed 493 people: 15 scientists, 21 engineers, 82 technicians, 175 artisans/craftsmen and 200 support staff (Mariita, 2002).

The following table provides estimates of the job creation potential of various electricity generation options. As the table shows, renewable energy options (geothermal and wind) have much higher job creation potential than conventional energy systems (coal and natural gas):

Table 5. Estimated job creation potential of energy technologies

Energy option	Construction, manufacturing and installation (employees/MW)	Operation and maintenance (employees/MW)	Total employment (employees/MW)
Geothermal	4.00	1.70	5.70
Wind	2.51	0.27	2.78
Natural gas	1.00	0.10	1.10
Coal	0.27	0.74	1.01

Sources: Adapted from Kammen, et al., 2004; EERE, 2006.

It is also possible to ensure that benefits from medium to large-scale renewable energy projects flow to low-income groups. For example, using a wide variety of innovative revenue sharing measures, the cogeneration industry in Mauritius has worked closely with the Government of Mauritius to ensure that substantial benefits flow to all key stakeholders of the sugar economy, including the low-income smallholder sugar farmers (Deepchand, 2003).

It is also important that Africa promotes renewables because, in contrast to conventional energy technologies (e.g. oil, coal, natural gas and large hydropower) that are mature and have evolved into large-scale investment industries, most renewables are relatively new technologies that do not require large amounts of capital. Most of them are also relatively less sophisticated meaning that a significant industry could be developed in Africa even where technical expertise is limited. The chances of an African country (with the exception of South Africa) becoming a significant player in the world's conventional energy equipment supply and services market are slim but, with financial support combined with astute strategic technological initiatives, it may be possible for an African country to become a significant player in the small and medium-scale renewables equipment and services market. For example, Kenya is now emerging as a leader in geothermal energy development, with geothermal experts from Kenya offering their expertise in developing geothermal power plants in other countries in the region (Mariita, 2002). Mauritius is also considered a leader in bagasse-based cogeneration within the region.

Last but not least, increased concerns over the local, regional and global environmental impacts of conventional energy systems is another reason for Africa to promote renewables. In addition, there is a growing volume of grant resources (GEF and CDM) available for appropriate renewable energy systems in Africa that could be taken advantage of.

While Africa's contribution to greenhouse gases is negligible, arguably the widespread use of renewable energy for electricity generation does not only accrue local environmental benefits, but also enhances the global environment. For instance, in Mauritius, the impact of the bagasse energy projects on the environment has been quantified. In the short term, bagasse projects have avoided the use of 215,000 tons of coal, the emission of 650,000 tons of CO_2 and the generation of 35,000 tons of coal ash. The long-term figures are 375,000 tons of coal-based generation displaced, 1,130,000 tons of CO_2 and 60,000 tons of coal ash avoided once the target of producing 110 kWh of electricity for each ton of sugar cane is achieved. These environmental benefits could be used to attract CDM financial support to the county. Similarly, Eastern and Horn of Africa countries could derive significant environmental benefits from the increased development of cogeneration (Deepchand, 2001).

? Review question

List the potential benefits of promoting renewable energy in Africa.

5. WHY SHOULD AFRICA PROMOTE ENERGY EFFICIENCY?

There are several reasons for Africa to promote energy efficiency. First and foremost, the rate of energy demand increase in many sub-Saharan African countries appears to be outpacing the rate at which energy supply is being increased. Therefore, an obvious option is the implementation of energy efficiency measures that would free up supply capacity to meet the rising demand.

Secondly, the worsening energy crisis in the region has served as a “wake-up call” to the region’s policy makers on the importance of energy efficiency. In the electricity subsector, drought-induced generation capacity short falls are becoming prevalent. In the petroleum subsector, the steep increase in world oil prices is having a devastating effect on sub-Saharan African economies. Energy efficiency programmes would help to mitigate the adverse impacts of these crises.

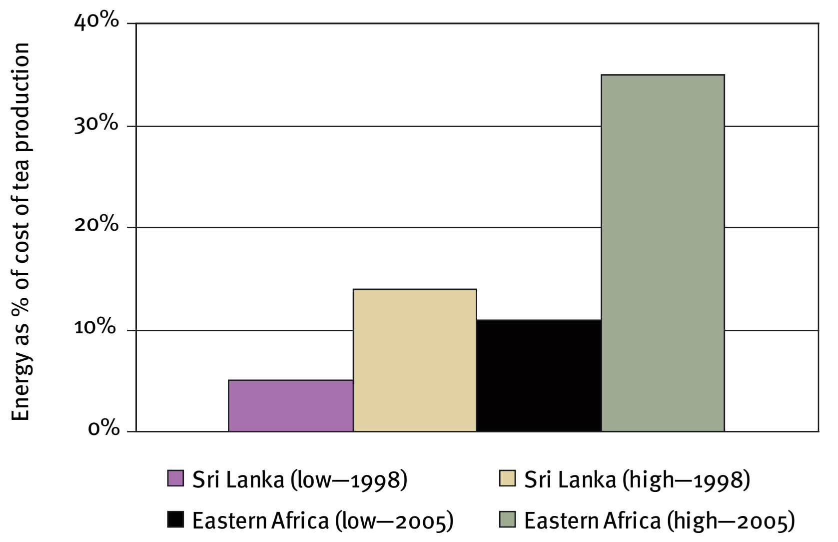
Thirdly, with the gradual withdrawal of donor participation in the financing of large-scale energy investments, alternative financial resources are limited and expensive. Therefore, implementation of energy efficiency programmes could delay the need for new investment in additional/enhanced energy supply infrastructures. This is very important for African countries, which are capital constrained.

Fourthly, energy efficiency measures can “shave off” peak loads in a power system thereby minimizing the need for huge investments to meet peak demand which lasts for only a few hours in a day. For example, the peak load experienced in the mornings is often associated with water heating. Therefore, using energy efficient water heating technologies such as solar water heaters can “shave off” a significant amount of the peak load.

Fifthly, energy efficiency measures can significantly reduce the cost of energy supply. For example, in Tunisia where a major programme of the national utility is promoting solar water heaters, it is estimated that by converting water heating systems to use solar only, it can reduce the utility’s cost of electricity supply by about 20 per cent (Awerbuch, 2005).

Sixthly, the high cost of energy in the industrial sector in sub-Saharan African countries is eroding the competitiveness of their products in the local, regional and international markets (GEF-KAM, 2005). Therefore, industrial energy efficiency reduces the cost of production thereby enhancing competitiveness, especially where commodity prices are not set by the producer. For example, the world price of tea is not set by the respective producing countries. Therefore, to ensure the profitability of tea production, tea factories have to keep their cost of production (especially energy costs) as low as possible. A comparison between two competing regions, i.e. Eastern Africa and Sri Lanka, reveals that the cost of energy for tea production in Eastern Africa accounts for a larger proportion of the cost of production than in Sri Lanka. The significant difference is essentially due to lack of energy efficiency measures and the limited use of abundant renewable small hydro resources that are often found in tea-growing regions—see figure IV.

Figure IV. **Energy as percentage of cost of production**



Another reason why Africa should promote energy efficiency is that it can be an important source of job creation. For example, the production of energy efficient charcoal and fuelwood stoves has provided a significant amount of employment opportunities in urban and rural areas. An ideal illustration is the introduction of the Kenya ceramic jiko—an energy efficient charcoal stove—which is currently produced by over 200 businesses, the bulk of which are informal sector manufacturers (Solutions Site, 2006).

Lastly, the promotion of energy efficiency in Africa can help in arresting environmental degradation such as deforestation and associated soil erosion caused by charcoal production; indoor air pollution caused by the use of traditional biomass; and local air pollution associated with thermal electricity generation. In addition, the climate change benefits accrued from energy efficiency can attract CDM-related financing and grant financing from agencies such as the Global Environment Facility (GEF).

Review question

List the potential benefits of promoting energy efficiency in Africa.

6. CONCLUSIONS

By way of conclusion, the following points can be made:

- The rationale for promoting renewables and energy efficiency is not well argued in governmental energy policy documents. Consequently, financing for renewable energy and energy efficiency development is miniscule compared to that of conventional energy systems.
- At international level, promotion of renewables and energy efficiency is often driven by climate change and environmental concerns which are sometimes not applicable in Africa.
- A solid rationale for renewable energy and energy efficiency promotion in Africa can be built around the following:

    Enhanced energy security arising from reduced exposure to high oil import costs and frequent drought-related hydropower crises.

    Availability of plentiful and cost-competitive renewable resources such as hydropower, solar and geothermal resources.

    Ability to provide cost-competitive energy services to remote rural settlements that are far from the grid.

    Significant job and enterprise creation potential of renewables and energy-efficiency initiatives.

LEARNING OUTCOMES

Key points covered

These are the most important points covered in this module:

- Africa has a vast range of new and renewable energy resources with significant potential. However, in spite of the enormous potential, renewable energy sources only contribute about 1 per cent of the region's modern energy supply.
- The rationale for promoting renewables and energy efficiency in national energy policies is not well argued. Consequently, the large-scale conventional energy sector (i.e. electricity and petroleum), which serves a smaller proportion of the population receives the bulk of energy investments in most countries in the region.
- Renewable energy systems offer diversification in energy supply, thus strengthening energy security by broadening the energy generation portfolio used within a country.
- The energy sector in numerous African countries is characterized by high oil import bills, accounting for a significant proportion of export earnings.
- Energy efficiency measures can "shave off" peak loads in a power system thereby minimizing the need for large supply investments to meet peak demands which last for only a few hours in a day.
- Energy efficiency measures can significantly reduce the cost of energy supply.
- The high cost of energy in the industrial sector in sub-Saharan African countries is eroding the competitiveness of their products in the local, regional and international markets. Energy efficiency measures can therefore enhance the region's competitiveness.
- Although the environmental rationale for promoting renewables and energy efficiency in Africa is weak, there are strong energy security and socio-economic reasons for promoting sustainable energy in Africa.

Answers to review questions

Question: List the potential benefits of promoting renewable energy in Africa.

Answer:

- Renewable energy systems offer a potential for diversification in energy supply, thus strengthening energy security by broadening the energy generation portfolio used within a country.
- The use of renewable energy resources can reduce dependence on imported petroleum fuels
- The use of renewable energy enhances the competitiveness of agricultural commodities.
- Renewable energy systems can play an important and cost-effective role in rural electrification particularly in areas far from the grid.
- Renewable energy technologies (RETs) can help in poverty alleviation.
- Renewable energy technologies, particularly, the medium and large-scale renewables provide significant job creation opportunities.
- Most renewables are relatively new technologies that do not require large amounts of capital. They are also relatively less sophisticated meaning that a significant industry could be developed in Africa even where technical expertise is limited.
- Alternative renewable energy-based electricity generation options can be used, such as wind, small hydropower, bagasse-based cogeneration and geothermal, to reduce adverse local, regional and global environmental impacts of increased reliance on conventional energy options.
- The climate change benefits of renewables in Africa can be an attractive carbon trading option that can increase the flow of concessionary finance to the region.

Question: List the potential benefits of promoting energy efficiency in Africa.

Answer:

- Implementation of energy efficiency measures can free up energy supplies to meet growing demand.
- Energy efficiency measures could particularly mitigate the worsening energy crises in the region.
- Implementation of energy efficiency programmes could delay the need for new investment in energy supply infrastructure.
- Energy efficiency measures can “shave off” peak loads in a power system thereby minimizing the need for huge investments to meet peak demand.
- Energy efficiency measures can significantly reduce the cost of energy supply.
- Industrial energy efficiency reduces the cost of energy used in production thereby enhancing competitiveness.

- Energy efficiency can be an important source of job creation.
- Promotion of energy efficiency in Africa can help in arresting environmental degradation such as deforestation and associated soil erosion caused by charcoal production; indoor air pollution caused by use of traditional biomass; and local air pollution associated with thermal electricity generation.
- In addition, the climate change benefits accrued from energy efficiency investments can attract CDM-related financing.

Presentation/suggested discussion topics

Presentation:

INTRODUCTION – Module 1: Overview of renewable energy and energy efficiency

Suggested discussion topics:

1. What are the main renewable energy resources present in your country? How could these resources be utilized and what are the barriers to this occurring?
2. In your opinion what is the level of energy efficiency in your country? What kind of programmes/policies/regulations could promote greater efficiency in your country?

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ENDA: www.enda.sn/energie

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GLOSSARY/DEFINITION OF KEY CONCEPTS

Climate change	All forms of climatic variations, especially significant changes from one prevailing climatic condition to another.
Carbon intensity	The amount of carbon by weight emitted per unit of energy consumed.
Developing countries	Countries which fall within a given range of GNP per capita, as defined by the World Bank.
Emissions	Flows of gas, liquid droplets or solid particles released into the atmosphere.

Energy demand (millions toe)	The amount of modern energy required by various sectors of a country.
Energy imports (US$ million)	The total cost of energy brought from foreign countries into the domestic territory of a given country.
Energy production (million toe)	The amount of modern energy produced within the country.
Energy reserves	Estimated quantities of energy sources that have been demonstrated to exist with reasonable certainty on the basis of geologic and engineering data (proven reserves) or that can reasonably be expected to exist on the basis of geologic evidence that supports projections from proven reserves (probable or indicated reserves).
Energy services	The end use ultimately provided by energy.
Energy sources	Any substance or natural phenomenon that can be consumed or transformed to supply heat or power.
Energy supply	Amount of energy available for use by the various sectors in a country.
Energy use per capita (Kgoe)	The average amount of energy consumed per inhabitant in a given country.
Fossil fuel	An energy source formed in the earth's crust from decayed organic material, e.g. petroleum, coal, and natural gas.
Geothermal energy	Natural heat from within the earth, captured for production of electric power, space heating or industrial steam.
Geothermal Plant	A plant in which the prime mover is a steam turbine that is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the earth. The fluids are extracted by drilling and/or pumping.
Global warming	An increase in the near surface temperature of the earth due to increased anthropogenic emissions of greenhouse gases.
Greenhouse effect	The effect produced due to certain atmospheric gases that allow incoming solar radiation to pass through to the earth's surface, but prevent the radiations which are reradiated from the earth, from escaping into outer space.
Greenhouse gas	Any gas that absorbs infrared radiation in the atmosphere.
Gross domestic product (US$ million)	The total output of goods and services produced within the territory of a given country.

Gross domestic product growth rate (per cent)	The annual rate of increase/decrease in the gross domestic product.
Gross national product (US$ million)	The total output of goods and services produced within the territory of a given country (GDP), plus the net receipts of primary income from investments outside the country.
Gross national product per capita (US$)	The average income per inhabitant of a country, derived by dividing the GNP by the population.
Household energy expenditures	The total amount of funds spent on energy consumed in, or delivered to, a housing unit during a given period of time.
Household stoves	Household heating and cooking devices.
Household	A group of people who share a common means of livelihood, such as meals regardless of source of income and family ties. Members who are temporarily absent are included and temporary visitors are excluded.
Hydro turbine	A device used to generate electricity using kinetic energy from moving water.
Improved household stoves	Household heating and cooking devices that have been altered in design to improve their efficiency.
Institutional stoves	A heating and cooking device commonly used in medium and large institutions.
Kenya ceramic jiko	An improved household stove that uses charcoal and has a ceramic lining to improve efficiency. Widely disseminated in Kenya, and adopted in many African countries.
Less developed countries	Countries that are below a given level or threshold of per capita GNP as defined by the World Bank.
Micro hydro	Small-scale power generating systems that harness the power of falling water (above 100kW but below 1MW).
Modern energy	Refers to high quality energy sources e.g. electricity and petroleum products, as opposed to traditional energy sources such as unprocessed biofuels.
National budget (US$ million)	Estimated government expenditure on goods and services, including expenditure on national defence and security.
National debt (US$ million)	The direct liabilities of the government owed to debtors.
Petroleum consumption	The sum of all refined petroleum products supplied.
Photovoltaic cells	Devices used to transform solar energy into electrical energy.
Pico hydro	Small-scale power generating systems that harness the power of falling water (less than 100 kW).

Population (millions)	The total number of people living within the borders of a country, whether citizens or not.
Primary energy	Energy sources in their crude or raw state before processing into a form suitable for use by consumers.
Small and micro enterprises	An enterprise that generates income up to a certain pre-defined limit.
Small hydro	Small-scale power generating systems that harness the power of falling water (1-15 MW).
Solar collector	A device which is capable of absorbing solar radiation and converting it into some other form of energy.
Solar thermal technologies	Devices that use the sun as the primary source of energy for heat appliances, e.g. solar water heaters, solar dryers.
Solar water heaters	Devices that use solar energy to heat water for domestic, institutional, commercial and industrial use.
Sub-Saharan Africa	All African countries north of the Republic of South Africa and south of the North African countries (Algeria Egypt, Libya, Morocco, Tunisia).
Traditional energy	Low quality and inefficient sources of energy, predominantly biomass in nature and not often traded (e.g. wood fuel, crop residues and dung cakes).
Traditional stoves	Inefficient heating and cooking devices that use firewood, charcoal and other biomass based fuels.
Wind pumps/mills	Devices that use wind energy to lift water from underground sources.
Wind turbines	Devices used to generate electricity using kinetic energy from wind.
Wood stoves	Heating and cooking devices that use firewood as the main fuel.

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Introduction

Module 1:
OVERVIEW OF RENEWABLE ENERGY AND ENERGY EFFICIENCY

Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Module overview

- Introduction
- Background on energy supply and consumption in Africa
- Status of renewable energy and energy efficiency in Africa
- Why Africa should promote renewables
- Why Africa should promote energy efficiency

Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Module aims

- Provide a summary of the energy sector in Africa
- Highlight the potential benefits/contribution of renewables to Africa's' energy sector and explain why Africa should focus on renewable energy
- Highlight the potential benefits/contribution of energy efficiency to the African energy sector and explain on why the region should promote energy efficiency

Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Module learning outcomes

- Enhanced understanding of the potential benefits/ contribution of renewables to the Africa's energy sector
- Better understanding of the potential benefits/contribution of energy efficiency to Africa

Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Energy Supply in Africa

- Africa produces less than 10% of the world's energy supply

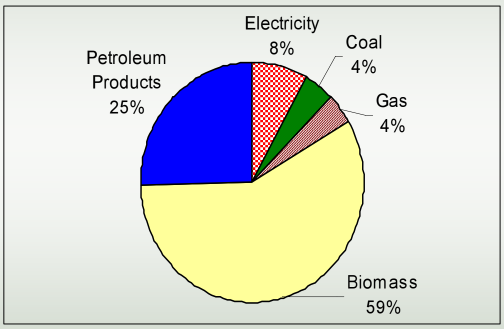
Type	Amount (Mtoe)	Percentage
Solar/wind/tide	0.058	0.01
Geothermal	0.680	0.06
Nuclear	3.300	0.30
Hydro	7.300	0.66
Petroleum Products	128.560	11.69
Gas	129.890	11.81
Coal	139.010	12.64
Biomass *	272.100	24.74
Crude Oil	418.780	38.08
Total	***1,099.678***	***100.00***

* Biomass refers to combustible renewables (mainly fuelwood, charcoal and agro-residues) and waste. *Source: IEA, 2005*

Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Energy Consumption in Africa

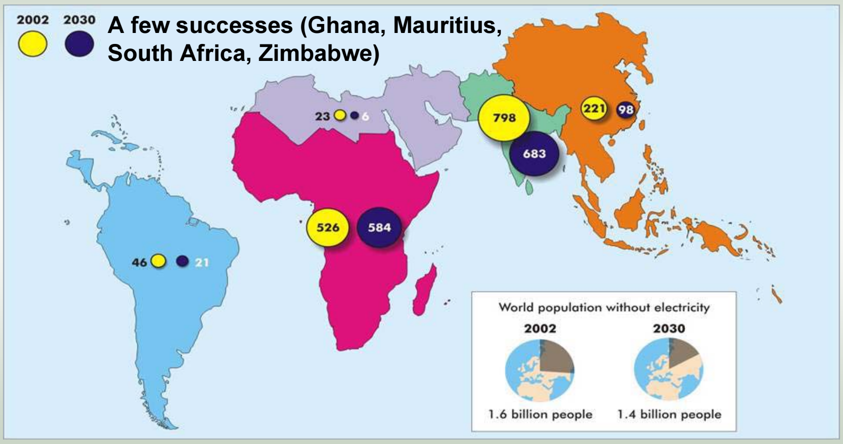


* Biomass refers to combustible renewables (mainly fuelwood, charcoal and agro-residues) and waste. *Source: IEA, 2005*

Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Population with NO Electricity (millions)



Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Status of Renewables in Africa

- Renewable Energy = energy forms that occur naturally and cannot be depleted
- Africa is endowed with substantial renewable energy resources
  - More than 1.1 GW of exploitable technical **small hydropower** potential
  - More than 9,000 MW of **geothermal** potential (steam/hot water only
  - Abundant **biomass** potential
  - Substantial **solar** potential (the daily average solar radiation ranges between 5 and 6 kWh/m^2)

Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Emphasis on Conventional Energy Options

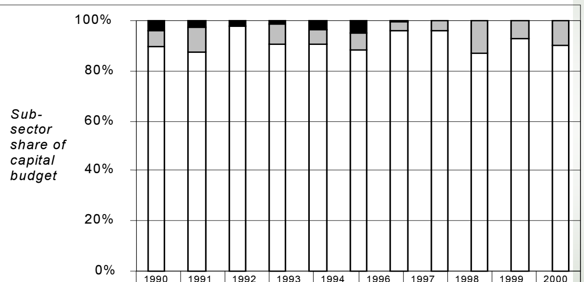
- Higher proportion of funding allocated to conventional energy sector i.e. large-scale hydro and petroleum
- Ethiopia: Virtually entire energy budget allocated to conventional large-scale investments
- Smaller-scale renewables largely left out (even dominant biomass is ignored)
- Results – contributes to low levels of access to modern energy which, in turn, contribute to increased poverty
- *Note: Not that conventional energy is bad, it just takes long to reach the poor*

Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Emphasis on Conventional Energy Options

Energy Sector Capital Budget – Ethiopia (1990-2000) % and Million Birr

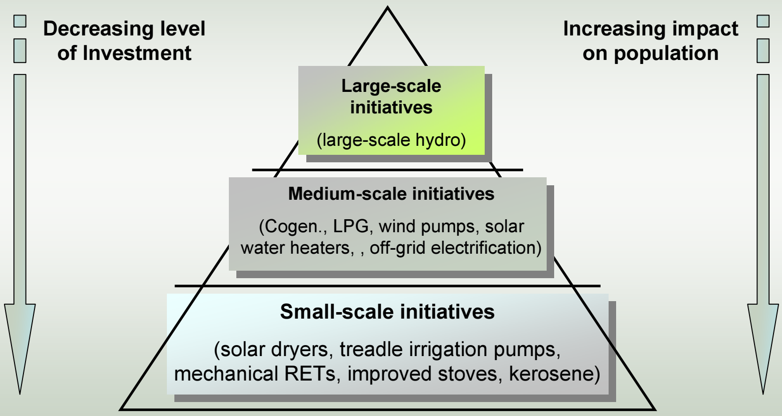


	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000
Traditional and alternative	14.2	5.9	4.0	4.1	10.5	0.7	0.5	0.5	0.4	0.5
Petroleum	21.8	19.8		20.1	16.9	5.5	36.1	81.0	93.2	94.3
Electricity	314.0	182.0	187.0	240.0	267.0	145.0	861.0	539.0	1,209.	886.0

Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Energy Pyramid Need for Better Balance



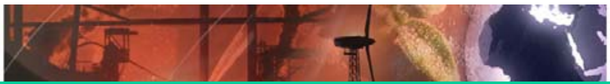
Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Status of Energy Efficiency in Africa

- Compared to renewables, very little done on energy efficiency
- Energy efficiency programmes largely absent
- Significant waste recorded
  - Kenya - 10 – 30% of primary energy input wasted
- Top 3 target sectors for energy efficiency programmes
  - Industry
  - Transport
  - Residential

Module 1



SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Status of Energy Efficiency in Africa (2)

- Potential energy efficiency measures using renewables
  - Solar water heaters – savings of up to 40% on electricity bill for residential
    - Utility-based Projects: Morocco, Tunisia and Egypt
  - Renewables for producing combined heat and power
    - Bagasse-based cogeneration
    - Geothermal energy

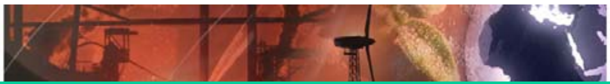
Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Renewables and Energy Efficiency Policies in Africa

- Underdeveloped renewables and energy efficiency is reflection of energy policies
- Focus on conventional energy systems
- Lack of implementation plans for renewables and energy efficiency
- Rationale for promoting renewables and energy efficiency not well argued:
  - Leads to focus on conventional energy systems
  - Does not attract significant budgetary allocations

Module 1



SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Renewables and Energy Efficiency Policies in Africa (2)

- Promotion of renewables and energy efficiency through climate change and environmental drivers do not resonate in Africa
- Conclusion: Support for renewables and energy efficiency is lukewarm

Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Why should Africa promote Renewables?

- Significant energy resource potential exists
- Increasingly unreliable conventional energy supply
- Lowering the risk profile of energy sector
- Enhance competitiveness of agro-industries
- Minimise high oil import bills
- Job creation potential
- Can attract CDM-related financing

Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Cogeneration Potential for Replacing Oil

Country	Electricity generation from oil and petroleum (GWh)	Biomass-Based Cogeneration Potential (GWh)
Tanzania	143	315
Kenya	1,509	2,606
Ethiopia	19	1,750

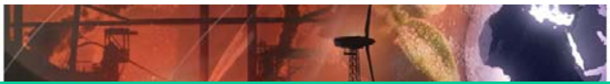
Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Estimated Job Creation Potential

Energy Option	Construction, manufacturing and installation (Employees/MW)	Operation and maintenance (Employees/MW)	Total Employment (Employees/MW)
Geothermal	4.00	1.70	5.70
Wind	2.51	0.27	2.78
Natural gas	1.00	0.10	1.10
Coal	0.27	0.74	1.01

Module 1



SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Why should Africa promote Energy Efficiency?

- The rate of increasing energy demand outpaces the rate of increases in supply
- “Wake up call” from energy supply shortfalls
- Gradual withdrawal of donors from large scale energy investments
- Delayed investment from “shaving off” peak loads

Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

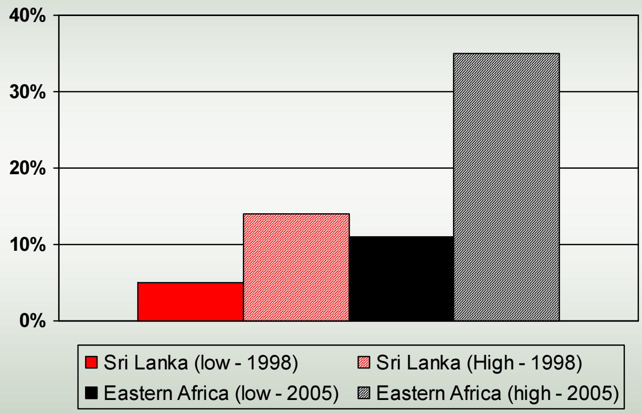
Why should Africa promote Energy Efficiency? (2)

- Reduction in the cost of energy supply
  - Tunisia: Switch to SWH to reduce electricity cost by 20%
- Job creation potential
- Can attract CDM-related financing
- Industry: Reduction in the cost of production

Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

Energy Cost as % of Cost of Production



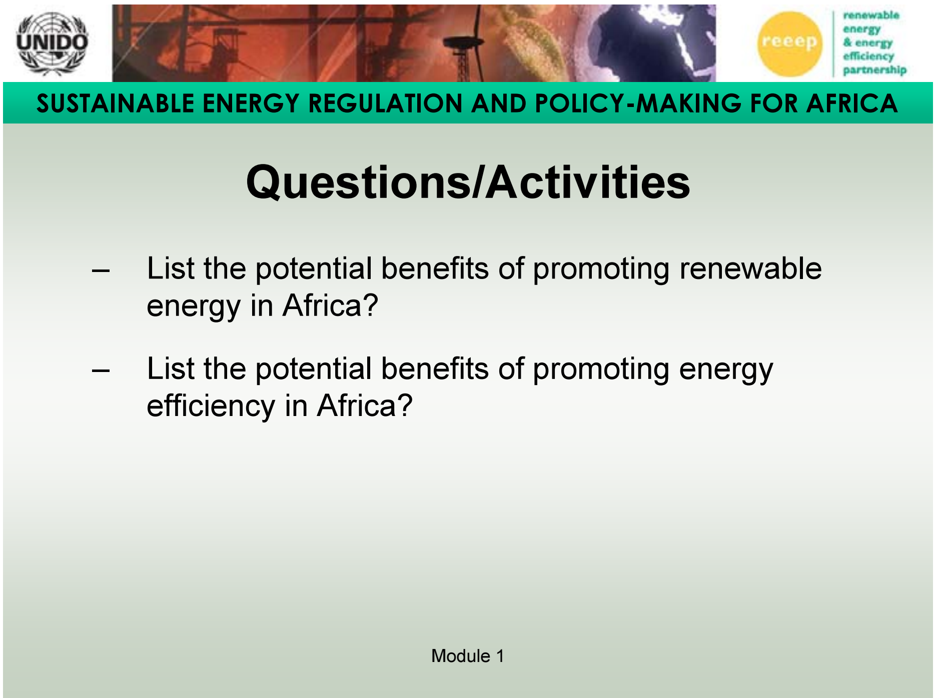
Module 1

SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA

CONCLUSIONS

- Rationale for promoting renewables and energy efficiency not well argued:
  - Climate change and environmental concerns not applicable in Africa
- Solid rationale for promoting renewables and energy efficiency:
  - Enhanced energy security: reduce exposure to high oil import costs
  - Availability of plentiful and cost-competitive renewables (hydro & geothermal)
  - Ability to provide cost-competitive energy services to remote rural settlements
  - Significant job and enterprise creation potential

Module 1


UNIDO
reeep
renewable energy & energy efficiency partnership
SUSTAINABLE ENERGY REGULATION AND POLICY-MAKING FOR AFRICA
Questions/Activities
– List the potential benefits of promoting renewable energy in Africa?
– List the potential benefits of promoting energy efficiency in Africa?
Module 1

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