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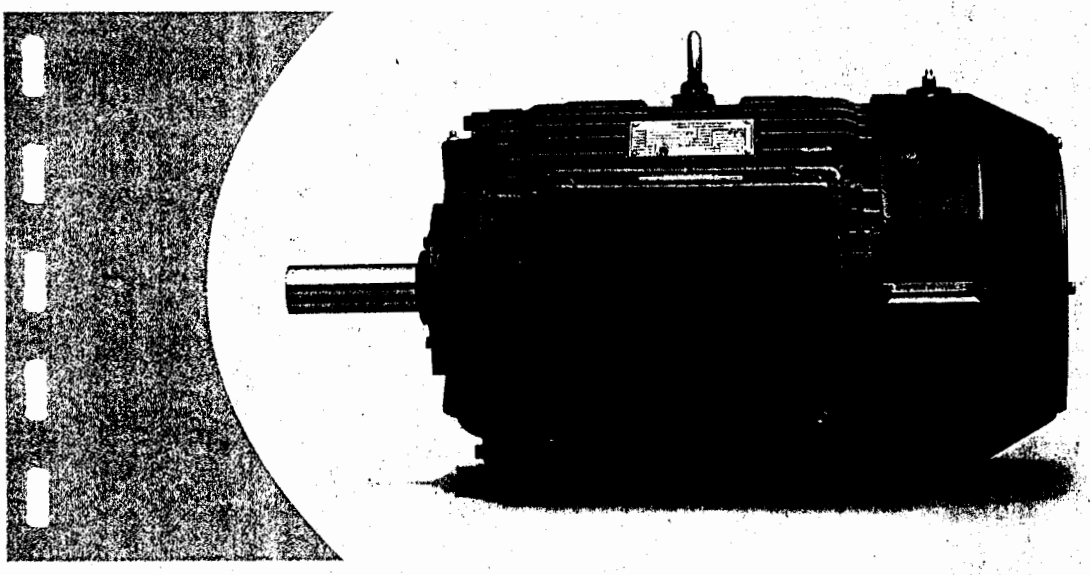

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OVERVIEW TO RENDER RENEWABLE ENERGY SUSTAINABLE IN AFRICA

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ABSTRACT

A comprehensive evaluation of the various sources of energy and their potential in meeting the energy needs of the people was done. Data on conventional energy generation and consumption was collated on a global scale to ascertain the future of conventional non renewable energy sources as it pertains to the issue of global energy crisis. The main focus is on assessing the potentials of renewable energy towards meeting the energy demands of nations. A detail evaluation of the different renewable energy sources was done; data on their extent of availability was collated to ascertain the degree of energy security which can be derived from renewable energy sources. Attempt was made in designing a renewable energy master plan, its objectives; short, medium and long term targets were critically analyzed coupled with the strategies, planned activities and mile stone in ensuring a sustainable energy future.

Keyword; Renewable energy, Global energy crisis, Energy master plan, Sustainable energy

1. INTRODUCTION

Highly Reliable and affordable energy services are among the essential ingredients of economic development, including eradication of extreme poverty as emphasized in the United Nations Millennium Development Goals (MDGs). Modern energy services mainly provided by liquid and gaseous fuels, as well as electricity are essential for building enterprises and creating jobs. Convenient, reliable and affordable energy is also important for improving health and education, and for reducing the human labour required to cook and meet other basic needs. The overwhelming importance of energy to human life can be seen in the correlation between energy consumption and economic growth which shows that energy consumption and GNP per capital are directly proportional, that is an increase in the supply and consumption of energy will invariably bring about a proportionate increase in the GNP per capital of any nation. Meeting this essential and pressing human energy needs economically and sustainably requires a balanced energy master plan that relies mostly on renewable energy and less on the burning of fossil fuels. Roughly 1.6 billion people world wide lack access to affordable and reliable energy service and 2.4 billion people rely on traditional biomass for cooking [UN-Energy Dept]. This energy divide breeds poverty, constrains the delivery of social services, limits opportunities for women, and gradually wears away environmental sustainability at the local, national, and global levels. Much greater access to energy services is essential to address this situation and to support the achievement of the Millennium Development Goals. At the World Summit on Sustainable Development (WSSD) in 2002, the global community agreed that renewable energy must be part of the solution. The Johannesburg Plan of Implementation, adopted at the WSSD, addresses renewable energy in several of its chapters. In Chapter II, on poverty eradication, governments agreed to improve access to reliable and affordable energy services for sustainable development, so as to facilitate the achievement of the MDGs. This included actions to increase the use of renewable energy sources. Often time and most recently, the energy needs of human, the poor inclusive have most often been met via petroleum-based liquid fuels, burning of coal and by extension of the national electricity grid, which is powered mainly by fossil fuels and hydropower. However, these conventional energy systems are often out of reach for people in remote areas, and even in urban centers, they are sometimes too expensive for the poor people to afford. In addition, energy generation from fossil fuels has plunge the entire globe into severe environmental danger, more also, the changing prices of petroleum and natural gas have had a disproportionate impact on poor people who depend on kerosene and liquefied petroleum gas (LPG) for their basic cooking and heating. In many poor countries, governments subsidize basic fuels such as kerosene, and the cost of these subsidies has skyrocketed in the past two years reducing the funds available to governments to pay for education, health care, clean water, and other public investments that are essential for meeting the MDGs. In addition, Oil and gas are non-renewable: they will not last forever. The author is of the view that renewable energy sources such as: wind, Solar, nuclear, hydro, bio energy and geothermal have an important role to play along side fossil fuels in achieving the much talked about balanced energy master plan.

2. ENERGY SITUATION IN AFRICA

Africa currently constitutes 14% of the world's population, but accounts for only 2% of GDP. Although the continent produces 7% of the world's total energy, but consumption of modern energy sources in sub-Saharan Africa is extremely low (WEC, 2005) owing to the region's reliance on traditional biomass. Electricity, the most important energy source in the delivery of the all-important modern functions such as health, education,

lighting, and social services, accounts for only 4% of sub-Saharan Africa's total energy consumption. Moreover, in sub-Saharan Africa, between 1980 and 2000, electricity consumption declined from 132.6 kWh to 112.8 kWh per capita, even as the world average energy consumption increased substantially (World Bank, 2004). For rural sub-Saharan Africa, where the majority of the population lives, the reality is worse. Africa is endowed with enormous natural resources, including fossil and renewable energy resources, but most of these energy resources are yet to be exploited, which is a contributing factor in making the continent the lowest consumer of energy, as illustrated in Figure 1. 17 per cent of the region's population and less than 5 per cent of rural areas are electrified (Davidson and Sokona, 2002). This situation needs to change if sub-Saharan Africa is to be economically competitive with other developing regions of the world and realize its sustainable development goals. One sure way to do this is to exploit the vast renewable energy potential in the entire region of Africa which has remained largely unattended to. In spite of abundant resources of both fossil and non-fossil energy resources, the majority of the population in African countries is without access to electricity for lighting and relies on low quality energy resources, such as firewood and charcoal to satisfy cooking needs. It is estimated that 64 per cent of Africa's population—equivalent to about more than 500 million people have no access to electricity. These figures mask huge differences between the various African countries.

Table 1: Access to Electricity and Modern Cooking Fuels in 2002

Country	Populat. Using Biomass [Million]	% of total pop.	Pop. Without Electric [Million	% of total pop.
North Africa	-		9	5 -10
SSA	575	35 -40	526	35 -40
Africa	-		535	35 - 40
South Asia	713	20 -25	798	20 -25
Latin America	96	8 -10	46	5 - 8
China and East Asia	998	20 -25	216	10 -15

Sources: World Bank, 2000 and IEA 2004

The total electricity production for Africa in 2000 was 441 TWh (IEA, 2002). The bulk of the electricity produced in Africa is from thermal stations, because of the large coal plants in South Africa and oil fired generation units of Nigeria and North Africa. In spite of the massive exploitable hydropower capacity in Africa, its contribution to total power generation is relatively low. Hydropower contributes about 18 per cent of the total power generation in Africa.

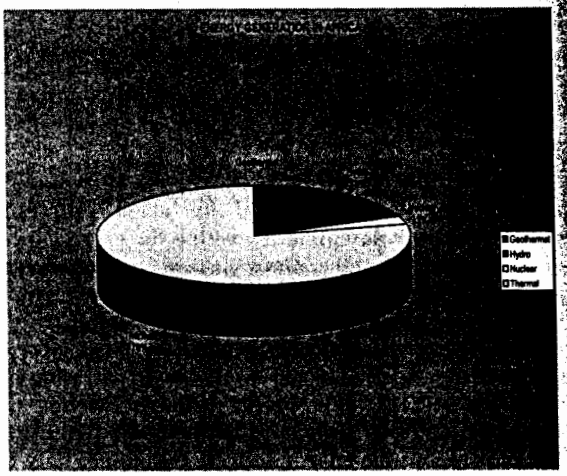

Figure 1: Electricity production in Africa (2004)
Source: IEA, 2005.

Table 2: Countries Energy Information

Countries	Total Energy Consumption [Quadribillion]	Total Energy Generation [Quadribillion]	Emiss. [MmT]
Ghana	0.126	0.061	1.49
Guinea	0.022	0.004	0.36
Guinea-Bissau	0.005	0.000	0.10
Liberia	0.007	0.000	0.14
Mali	0.015	0.007	0.17
Niger	0.016	0.005	0.33
Nigeria	0.985	5.604	25.49
Senegal	0.066	0.002	1.24
Sierra Leone	0.014	0.000	0.26
Togo	0.019	0.000	0.34

Sources: EIA, *International Energy Annual, 2003*

Table 1 reveals that the bulk of energy from the continent of Africa is from fossil fuels hence the high degree of carbon dioxide emissions.

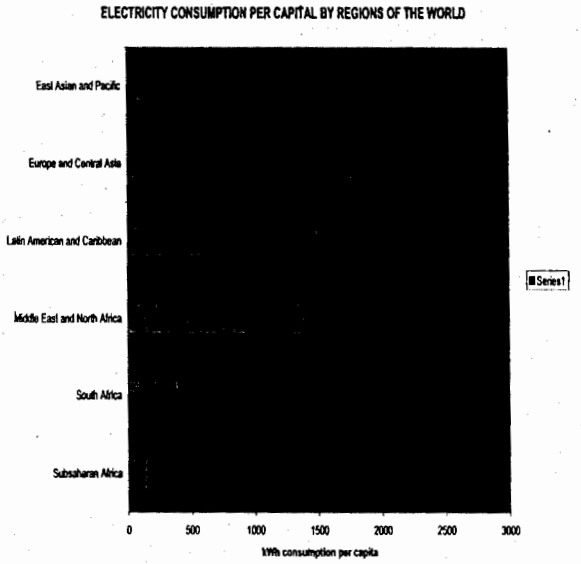

Figure 2: Electricity consumption per capita by regions of the world (2000)

Table 3: Electricity Overview Billion Kilowatt-hours

Countries	Electricity Consumption 2003	Electricity Generation 2003	Hydro [% of Total]
Ghana	5.08	5.36	90.2
Guinea	0.72	0.78	49.6
Guinea-Bissau	0.05	0.06	0.0
Liberia	0.47	0.51	0.0
Mali	0.76	0.82	53.6
Niger	0.26	0.23	0.0
Nigeria	14.46	15.59	32.9
Senegal	1.24	1.33	0.0
Sierra Leone	0.24	0.26	3.3

Sources: EIA, *International Energy Annual, 2003*

Just how limited are our fossil fuel reserves? Some estimates say our fossil fuel reserves will be depleted within 50 years, while others say it will be 100-120 years. The fact is that neither one of these projections is very appealing for a global community that is so heavily dependent on fossil fuels to meet basic human needs. The fact remains that we are going to run out of fossil fuels for energy and we have no choice but to prepare for the new age of energy production since, most certainly, human demands for energy will not decrease. Nobody really knows when the last drop of oil, lump of coal or cubic foot of natural gas will be collected from the Earth. All of it will depend on how well we manage our energy demands along with how well we can develop and use renewable energy sources. More also as the population grows, energy demands will increase proportionately. Not only will it be important for renewable energy to keep up with the increasing population growth, but it must outpace not only these demands but begin replacing fossil fuel energy production if we are to meet future energy needs.

3. MODEL FOR PREDICTING FUTURE ENERGY SITUATION

CASE 1: POPULATION PROJECTION MODEL

```
Program population (input, output);

Uses winert;

Var T: integer;

 Pt,a,y: real;

Const Po = 10;

r = 0.55;

function pow (x:real; n:integer):real;

 begin

 pow:=exp(x*ln(n));

 end;

Begin

Writeln ('input first number');

Readln (T);

a:=1+r;

y:=pow(a,T);

Pt:= Po*y;

Writeln('Pt =', Pt:3:1);

End.
```

CASE 2: ENERGY CONSUMPTION MODEL

```
Program population (input, output);

Uses winert;

Var T: integer;

 Pt,a,y: real;
```

```
Const Po = 10;
 r = 0.55;
function pow (x:real; n:integer):real;
begin
 pow:=exp(x*ln(n));
 end;
Begin
Writeln ('input first number');
Readln (T);
a:=1+r;
y:=pow(a,T);
Pt:= Po*y;
Writeln('Pt =', Pt:3:1);
End.
```

CASE 3: ENVIRONMENTAL PREDICTION MODEL

```
Program population (input, output);
Uses wincrt;
Var T: integer;
 Pt,a,y: real;
Const Po = 10;
 r = 0.55;
function pow (x:real; n:integer):real;
 begin
 pow:=exp(x*ln(n));
  end;
Begin
Writeln ('input first number');
Readln (T);
a:=1+r;
y:=pow(a,T);
Pt:= Po*y;r
 Writeln('Pt =', Pt:3:1);
 End.
```

The program is written in Pascal language, it was run using some arbitrary figures and it runs successfully.

P_0 = initial population, initial amount of energy consumed or initial concentration of emitted gas.

r = the population growth rate

T = the projected time in years.

Arbitrary figures where used say P_0 =10, r = 0.55 and T changes from 3, 13 to 23.

Table 4: Data generation using model no.1

Time in Years [T]	Population Growth Rate [r]	Projected Population [P_t]
2003	0.55	37.239
2013	0.55	800.481
2023	0.55	64066.937

Table 5: Data generation using model no.2

Time in Years [T]	Energy Consumption Growth Rate [r]	Projected Energy Consumption [P_t]
2003	0.55	37.239
2013	0.55	800.481
2023	0.55	64066.937

Table 6: Data generation using model no.3

Time in Years [T]	Carbon dioxide Emission rate [r]	Projected carbon dioxide Emission [P_t]
2003	0.55	37.239
2013	0.55	800.481
2023	0.55	64066.937

Source: S.T Wara and I.R Ilaboya [2009]

3.1 MODEL ANALYSIS

The model results reveal that with an increasing population, the amount of energy consumed by the inhabitants will increase proportionately. More also, for a continent that depends largely on the burning of fossil fuels for bulk energy generation, the amount of gaseous emissions will quadruples thus plunging the entire continent into severe pollution problems. One sure solution to this is an integrated energy approach in which the overwhelming importance of renewable energy must

be recognized, and properly harnessed to meet the projected energy need.

4. AFRICAN RENEWABLE ENERGY SITUATION

Table 7: Small hydropower developed and potential in selected African countries

Country	Small Hydro potentials [MW]	Harnessed [MW]
Uganda	46	8.0
Mauritius	-	6.70
Kenya	600	14.0
Burundi	42	18.0
Zambia	4	1.05
Tanzania	70	9.0
Lesotho	-	8.74

Source: Karekezi and Ranja, 1997, Unilever Kenya, 2006.

Much of the unexploited potential for small hydro is in remote areas of Africa (Hydronet 3, 1994). Eastern and Southern Africa has many permanent rivers and streams providing excellent hydropower development potential. However, as shown in Table 3, small hydro utilization in the region is still very low.

Table 8: Average Wind Speed Potential and Number of Wind Pumps

Countries	wind speed potentials (m/s)	Number of wind pumps
Botswana	2 – 3	200
Djibouti	4	7
Nigeria	3.5 – 5.5	-
Eritrea	3.8	<10
Guinea	2.4 – 4.0	-
Kenya	3	272

Sources: Diab, 1988; Stassen, 1986; Linden, 1993; Fraenkel et al., 1993; Kenya Engineering, 1994;

In comparison with other parts of the world, Africa has seen little development of modern wind turbines and most of its wind machines (found in Eastern and Southern Africa) are used for water pumping rather than for electricity generation.

Table 9: Geothermal Potential for Selected Africa Countries

Country	Potential generation in [MW]
Kenya	2000
Ethiopia	700
Djibouti	230 – 860
Nigeria	0.00
Tanzania	150
Algeria	>1000

Source: BCSE, 2003; Khennas, 2004

Using today's technology, Africa has the potential to generate 2,500 MW of energy from geothermal power (BCSE, 2003). Of this geothermal power potential, only 127 MW has been tapped in Kenya, and less than 2 MW in Ethiopia [KENGEN 2003].

Today's world energy systems, relying on fossil and nuclear fuels, endanger the very existence of humanity; it pollutes the environment and destroys the natural ecosystem. The world is faced with a crisis that requires a total transformation in the way we create energy, shifting to sustainable energy that flows freely from the sun, the wind, the tides, and the center of the earth would be a step in the right direction. Sustainable energy is energy which has minimal negative impacts, both in its production and consumption, on human helth and the environment, and that can be supplied continuously to future generations. Sustainable energy is the provision of energy such that it meets the needs of the present without compromising the ability of future generations to meet their own energy needs. Sustainable energy sources are most often regarded as including all renewable sources, such as Biofuels, solar power, wind power, wave power, geothermal power and tidal power. They hold the promise of:

- Providing highly affordable and reliable energy to the people. The energy is clean and non polluting
- Enhanced energy security by providing supplies that are abundant, diverse and indigenous (non-import dependent), with no resource exhaustion constraints;
- Reduced global and local atmospheric emissions when used in place of fossil fuels;
- Improved options to meet specific user and infrastructure needs, particularly in rural areas and in newly industrializing and developing countries;
- Renewable energy technologies used to generate electricity are flexible in scale and type of use. They can be exploited locally, used both for centralized and dispersed power generation, and the energy sources used are indigenous.
- Small and medium renewable energy technology can play an important role in poverty alleviation.

This is particularly true of small – scale renewable energy technologies that are made locally and operate on the basis of solar, thermal or animal power.

Incorporation of renewable energy into countries energy portfolios brings along the following immediate and long term effects.

Such systems provide energy that is affordable to the poor and also good sources of livelihood. More also high population of labour force that would be trained to manufacture highly sensitive renewable energy infrastructure, thus bringing about a high level capacity building program to the knowledge and knowhow of the rural populace.

Renewable energy can also contribute to education by providing the constant energy required to run computers, printers and other audio visual learning aids.

Renewable energy sources deserve specific recognition for their potential to revitalize agricultural economics. Biofuels and wind power in particular could provide a new source of business for farmers and agricultural processors, creating economic opportunities and jobs in rural areas that have suffered decades of falling crop prices. Renewable energy could play a vital role in minimizing fuel imports by providing an alternative to thermal based electricity in the form of, for Example, small hydro power units, cogeneration (using biomass as fuel) and geothermal energy (Mbuthi, 2004; Yuko, 2004) they offer diversification in energy generation, thus strengthening energy security. Renewable energy technology provides cleaner fuels which can reduce transport-related pollution. More also wind, solar, hydro or geothermal energy can reduce the need for coal or other fossil fuel power plant that cause significant local and regional pollution. They hold the promise of contributing to rural development and provision of reliable electricity.

In addition to their high reliability, renewable energy is fast becoming competitive with conventional energy. It is true that many sustainable energy generators are capital – intensive to install. However this is moderated by the fact that their "fuel" is abundant, free and more environmentally friendly than conventional source. In addition, technological advances, government incentives and the development of economic of scale are all contributing to falling cost of renewable energy equipments. The cost of solar PV for example has gone down considerably by 90%, bringing solar energy increasingly closer to cost – competitiveness with conventional fuels.

Table 10: Renewable Energy Cost Assessment

S/No	Source	Current Cost	Cost Reduction by 2020
1	Bioenergy	Fairly High	10 – 15%
2	Wind onshore	Relatively Low	15 – 25%
3	Wind offshore	High	20 – 30%
4	Solar PV	Fairly High	30 – 50%
5	Geothermal	High	10%
6	Hydro	Relatively Low	10%

Source: US Energy Dept.

5. THE RENEWABLE ENERGY MASTER PLAN [REMP]

The Renewable Energy Master Plan [REMP] is an integrated approach designed for countries who intend to integrate renewable energy sources into their energy portfolio. The vision and objective are clearly articulated to fit into any environment under any kind of policy.

- **THE RENEWABLE ENERGY MASTER PLAN ARTICULATES**
  - Countries vision and focus for achieving sustainable energy development
  - Sets out a road map for increasing the role of renewable energy in achieving this vision.
- **IT ENVISIONS**
  - An economy that gradually moves from a monolithic fossil economy to one driven by an increasing share of renewable energy in the national energy mix.
  - Exploiting renewable energy in quantities and at prices that will promote the achievement of equitable and sustainable growth
  - An energy transition from fossil fuels to less carbon intensive economy increasingly powered by renewable energy

The overall objective of the REMP is to articulate a roadmap for national development through the accelerated development and exploitation of RENEWABLE ENERGY.

- Expanding access to energy services to all persons irrespective of their location
- Raising the standard of living, especially in the rural areas;
- Stimulating economic growth, employment and empowerment;
- Increasing the scope and quality of rural services, including, schools, health services, water supply, information, entertainment and stemming the migration to urban areas;
- Reducing environmental degradation and health risks, particularly to vulnerable groups such as women and children

- Increase market for local infrastructure through local content development

Towards attainment of the targets, a range of cross cutting issues including the following must be addressed, namely:

- Policy, regulatory and institutional frame work:
- Product standards and quality control
- Capacity Building
- Research and Development
- Public Awareness

Major Strategies and Implementation Issues

- Reviewing the policy, legal, fiscal and regulatory instruments that would attract domestic and international investment to develop renewable energy resources in the country
- Mobilizing key stake holders
- Removing key subsidies in the energy market

Source: Prof A.S Sambo, Energy Commission of Nigeria

The Renewable Energy Master Plan is given as a guide line to countries intending to introduce renewable energy program into their energy mix. The policies and strategies are very flexible and can fit into any environment.

6. CONCLUSION

By 2020 the energy mix will have changed considerably from what it is today. An increase in alternative and renewable energy will be likely. The possibilities of using both wind and solar power are already being tested and will mostly increase due to successes of the current studies. The only constraint on both of these is capital, which Africa and most developing countries are severely lacking, but as countries opens up foreign investment and increases government revenue through trade of manufactured goods and potential natural gas, capital will increase proportionately [World Bank 2002]. The use of fuel wood and the burning of fossil fuels must decrease in the near future owing to the massive amount of deforestation and other related environmental hazards.

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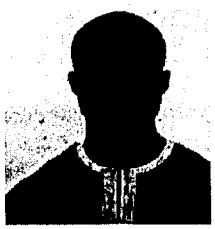
Co-author: 

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