Alternative Energy Sources for Power Generation: An Instrument for Mitigating Rural-Urban Drift*

By

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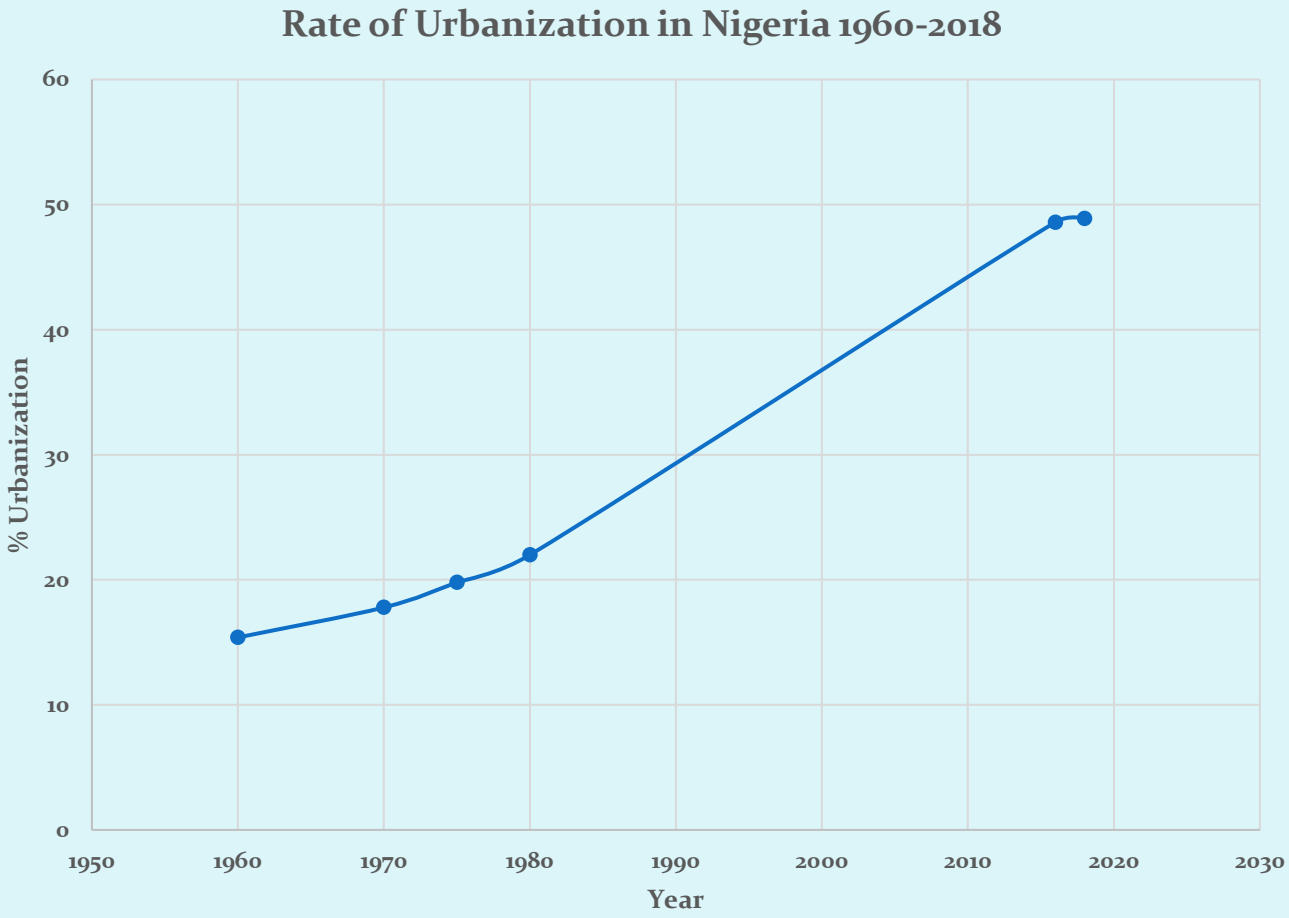
1. Introduction

- I am indeed honoured to be invited to make a presentation during the 2018 Engineering week and Annual General Meeting of the Nigeria Society of Engineers, Abuja Chapter.
- My presentation titled: "*Alternative Energy Sources for Power Generation: An Instrument for Mitigating Rural-Urban Drift*" is chosen to fit the general theme of the Engineering Week titled: Reversing the Rural-Urban drift Using Sustainable Engineering Infrastructure: FCT Municipality/Area Councils in View".
- Indeed rural-urban drift can only be mitigated through socio-economic empowerment in the rural areas by strengthening the rural infrastructure such as energy supply, good housing, health care, education, good roads, etc.
- The lack of these facilities in the rural areas and their availability in the urban areas establishes the push and pull factors in rural-urban drift.
- Modern energy, indeed, in the form of electricity is one of the major factors, if provided in the rural areas that would drastically reduce the push/pull rural-urban drift factor,
- The rate of urbanization in Nigeria is said to be about 4.3% per annum, with about 49% of the population currently living in the urban areas.

1. Introduction ..... Cont'd



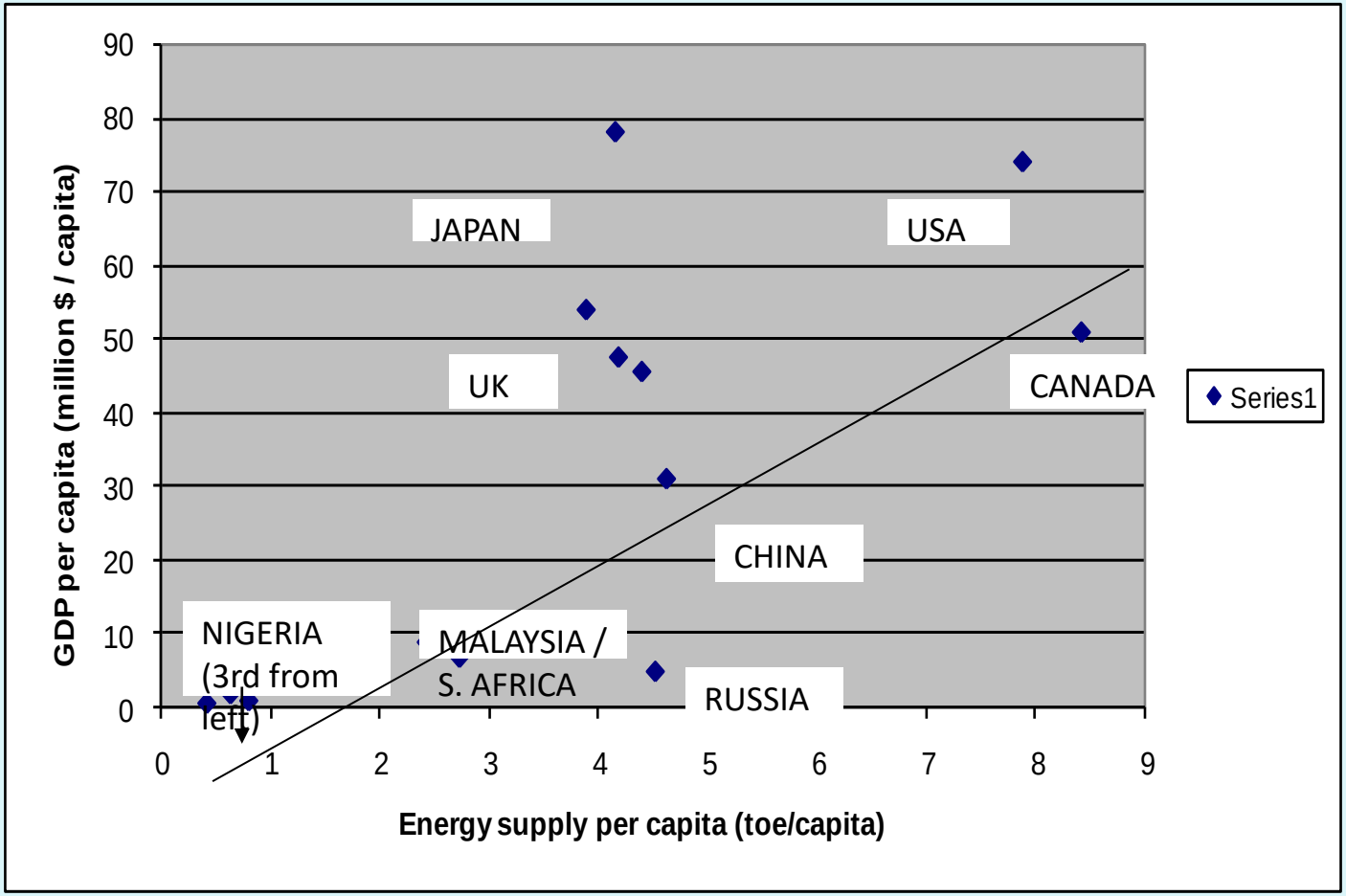
1. Introduction ..... Cont'd

- The Federal Capital Territory (FCT), established in 1976 from areas carved from the then Plateau, Kwara and Niger States; however, commenced operation on 12th December 1991.
- It is 2½ times the size of Lagos, the preceding capital of Nigeria.
- The FCT has Six (6) area Councils with the Abuja Municipal City Council (AMAC) pulling migrants from the other less developed Five (5) Council areas of Gwagwalada, Bwari, Kuje, Abaji and Kwali; and indeed from all over the country.
- It is reported that the FCT is one of the fastest growing city in the world. It grew by 140% between year 2000 and 2010.

1. Introduction ..... Cont'd

- Energy is technically defined as the capacity to do work. From thermodynamics point of view, when work is done on or by a system, the state of the system changes. Thus, energy may be viewed as an agent of change or transformation.
- From social sciences point of view, the change or transformation derived from adequate energy supply in the economy manifests as economic growth and social development.
- This is usually depicted graphically by the plot of GDP/capita against Energy consumption/capita for various countries of the world and HDI Vs Energy consumption/capita.

1. Introduction ……Cont'd



Energy and Economy

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3. Energy As A Driver for National Development

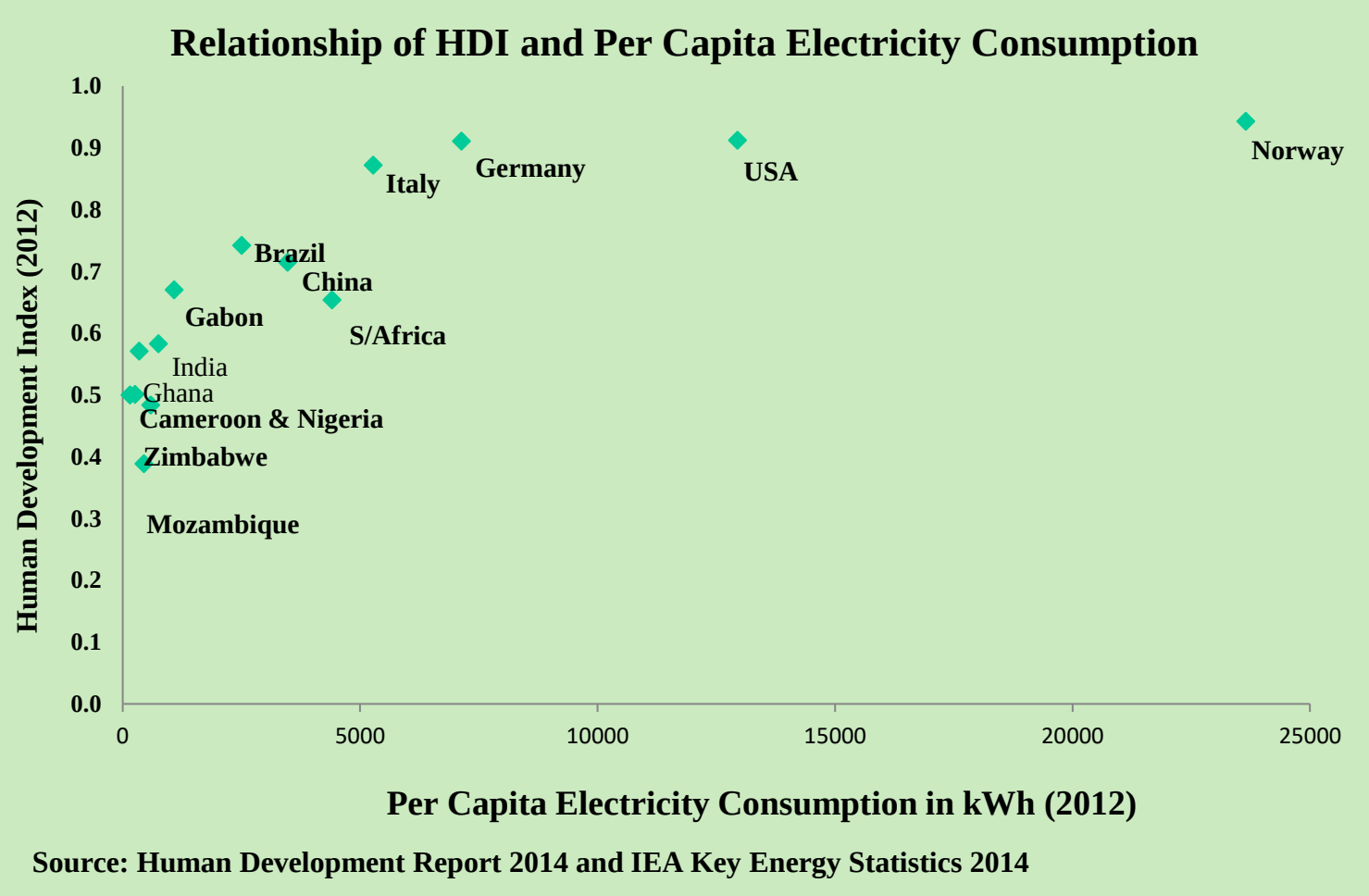


Fig. 2: Electricity Consumption in kWh

1. Introduction ..... Cont'd

- Energy, however, exists in various forms: potential, kinetic, electromagnetic, mechanical, electrical, chemical etc; and one form may be transformed to another according to the laws of nature.

- An energy resource, in its basic form, may be processed into any of the following final energy forms:
  - Electricity
  - Fuels
  - Heat

1. Introduction ..... Cont'd

- Nigeria is endowed with fossil, nuclear and renewable sources of energy.
- Renewable energy is energy derived from energy source that can be regenerated naturally within a relatively short time frame. For example, solar radiation, wind, hydropower, biomass, geothermal, sea wave and tide.
- Unlike fossil type energy resource of crude oil, natural gas and coal, which have been formed over millions of years ago and are therefore depletable at any rate of consumption; renewable energy sources are more or less non-depletable due to its regenerative ability within relatively short time through natural process.
- They are also relatively environmentally friendlier and have good potentials for job creation especially in the rural areas.
- Nuclear energy is from the atom, from where radiation is emitted through mainly atomic fission or fussion. It is a low carbon energy source.
- While renewable and nuclear energy are considered low carbon energy sources and therefore climate friendly; however, nuclear radiation safety poses a health and social concern.
- Sustainable energy technologies are technologies that allow development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

2. Energy Resources & Infrastructure in Nigeria

a) Fossil Energy Resources and Nuclear Energy Sources

S/N	Resources	Reserves	Production (2016)	Domestic Utilization (2016)
1	Crude Oil	37.2billion barrels	0.670billion barrels	0.032billion barrels for local refineries (14% capacity utilization)
2	Natural Gas	187 Tscf	2.78Tscf	89% : Utilized 11% : flared
3	Coal	2.7 billion tonnes	0	Negligible
4	Tar Sands	31 billion barrels of oil equivalent	0	18.25 million barrels
5	Nuclear	Yet to be quantified	0	30kW experimental nuclear reactor

Source: NNPC/ECN

2. Energy Resources & Infrastructure in Nigeria

(b) Renewable Energy Resources

S/no	Resource		Reserve	Utilization Level
1	Large hydro power		11,250MW	1,972MW
2	Small Hydro power		3,500MW	64.2MW
3	Solar Energy		4.0kW/M^2/day 6.5kW/M^2/day	50 MW solar PV stand-alone No solar thermal electricity
4	Wind		2-4m/s at 10m height	2x2.5KW electricity generator; 10MW wind farm in Katsina
5	Biomass	Fuel wood	11 million hectares of forest and woodlands	43.4 million tonnes of firewood/yr
		Municipal waste	- 18.3 million tonnes in 2005* & about 30 million tonnes/yr now	-
		Animal waste	- 243 million assorted animals in 2001	-
		Energy Crops and agric waste	- 28.2 million hectares of Arable land	8.5% cultivated

Source: REMP (2005)
* FM EMV

Sustainable Energy Technologies for Power Generation

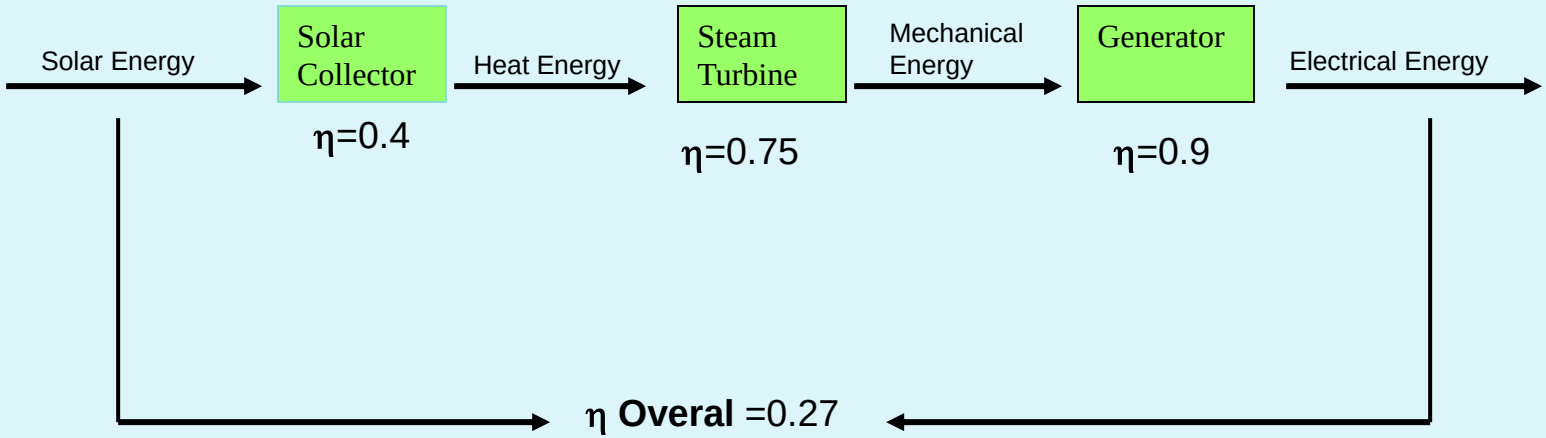
(a) Solar Energy:

- Exists in the form of electromagnetic radiation of wavelength ranging from 100μm and 1.0mm mainly ultraviolet, visible and infra-red radiations at the Earth's atmosphere.
- It may be transformed directly into heat using solar collectors or directly to electricity using solar PV cells.

Sustainable Energy Technologies for Power Generation ..... Cont'd

(i) Solar Thermal Process:-

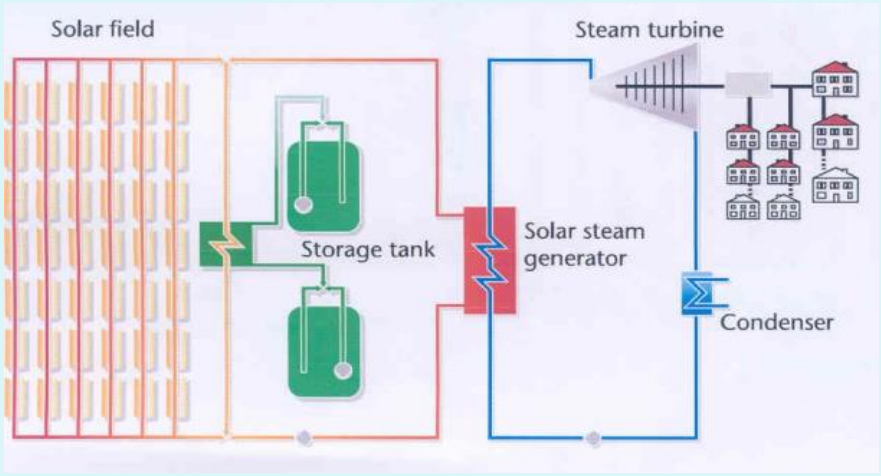
Solar Energy → Heat Energy → Mechanical Energy → Electrical Energy



3. Sustainable Energy Technologies for Power Generation ..... Cont'd

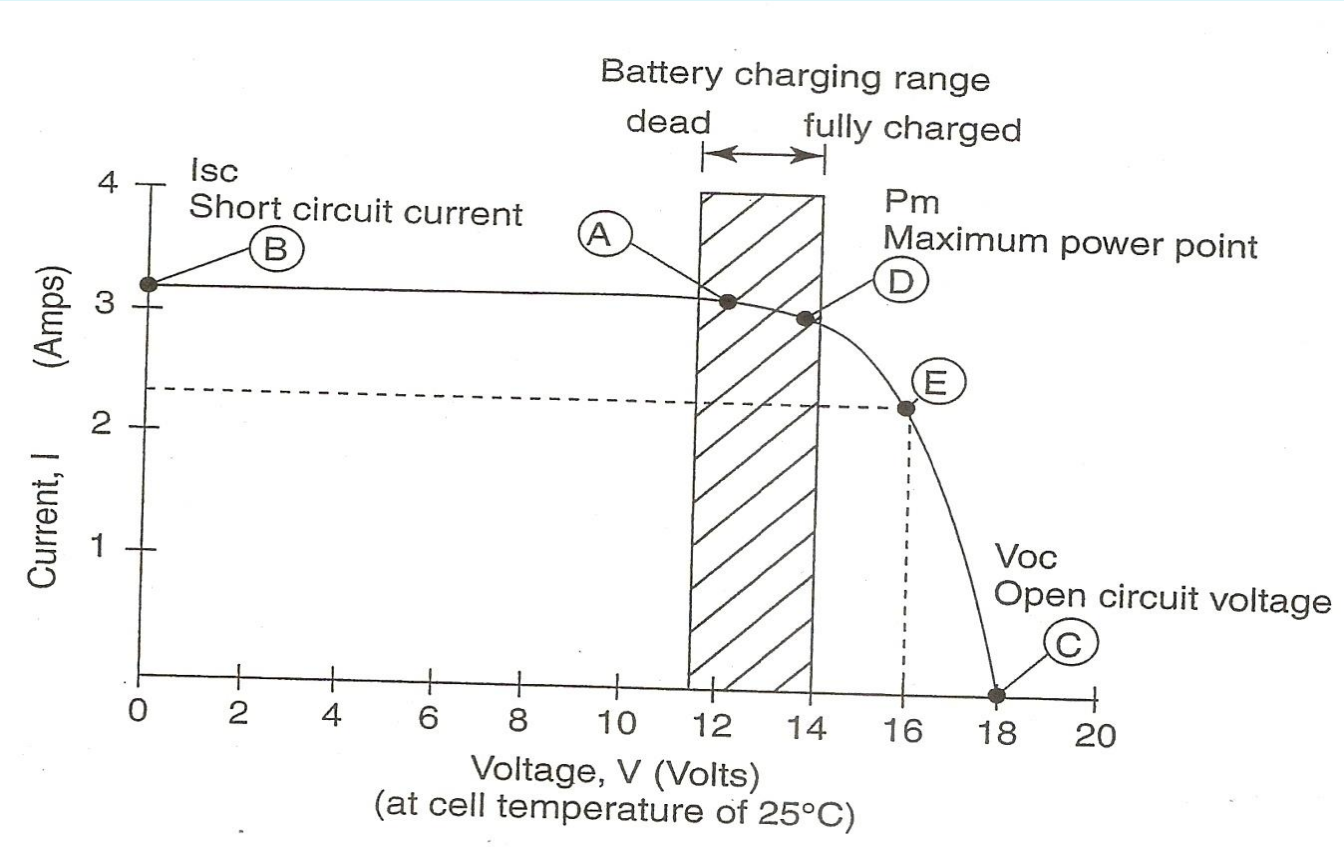
Solar thermal Plant in Spain (Heliostat)

50 MW Solar thermal Plant in Spain (Parabolic)



Rankine Cycle

(ii) Solar PV



Source: Mark Hankins (2010)

Figure 5. Typical Characteristics of Solar PV Modules

3. Sustainable Energy Technologies for Power Generation ..... Cont'd

Solar PV

Commercially Available Solar Cell Module Types

Type of PV technology	Maximum cell efficiency	Typical commercial module efficiency	Notes
Crystalline Silicon			
Monocrystalline	24%	11–17%	Fully mature technology: 35% of world production (2007)
Polycrystalline	20%	11–15%	Fully mature technology: 45% of world production (2007)
Ribbon	19%	7–13%	Fully mature technology
Thin Film			
Amorphous Silicon	13%	4–8%	Initial degradation in performance
Multi-junction Amorphous Silicon	12%	6–9%	Similar to Amorphous Silicon Flexible
Cadmium Telluride	17%	7–8.5%	
Copper Indium Gallium Di-Selenide (CIGS)	19%	9–11%	
Organic (Dye)-type solar modules	12%	3-5%	Relatively uncommon
Other Types			
Hybrid HIT	21%	17%	Combined Amorphous Silicon and Crystalline

Source: Mark Hankins, 2010.

3. Sustainable Energy Technologies for Power Generation ..... Cont'd

Solar PV rural electrification

3KW Solar PV Power Supply, Igu Community II, Bwari Area Council, FCT Abuja, 2012

3. Sustainable Energy Technologies for Power Generation ..... Cont'd

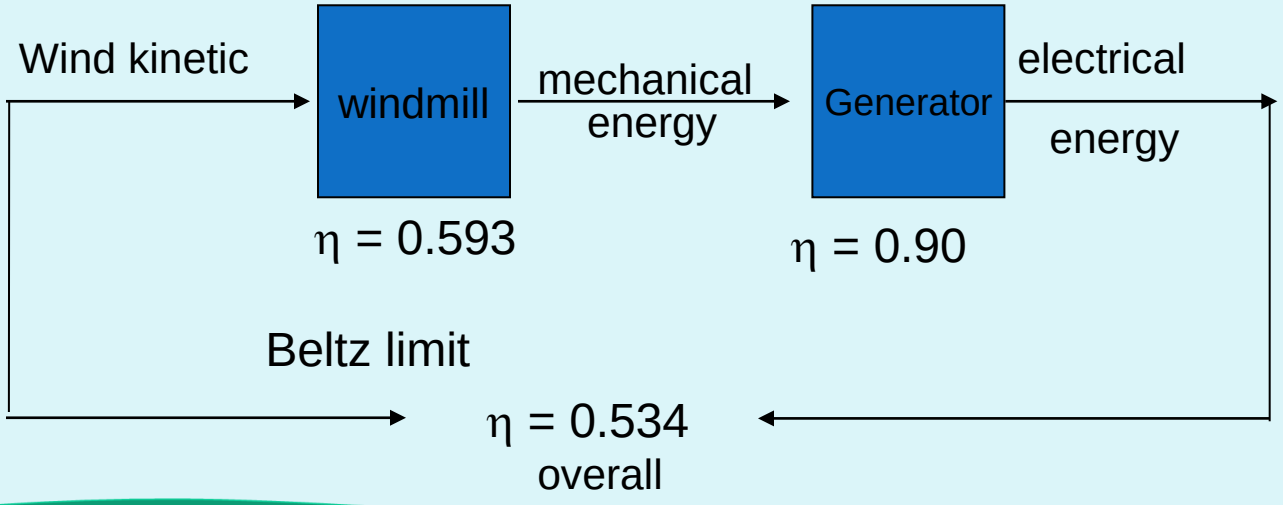
2.5 MW Solar PV, in Sal, Cape Verde
Commissioned October 1, 2010

5 MW Solar PV, in Praia, Cape Verde
Commissioned November 2, 2010

Source: ECREE (2011)

b) Wind Energy:

- Wind Energy exist in the form of Kinetic energy and the power therefrom varies with the cube power of the wind speed and the swept area of the rotor.
- The energy is converted into mechanical energy through aerodynamic propel or turbo modern principles. The mechanical power may be directly used to drive a water pump or an electric generator to produce electricity



3. Sustainable Energy Technologies for Power Generation ..... Cont'd

150MW Osario Wind Farm, Brazil

305 MW Wind Farm at Zanfrana, along the Red Sea, Egypt

5kW aero generator in Sayya Gidan Gada, Sokoto State

3. Sustainable Energy Technologies for Power Generation ..... Cont'd

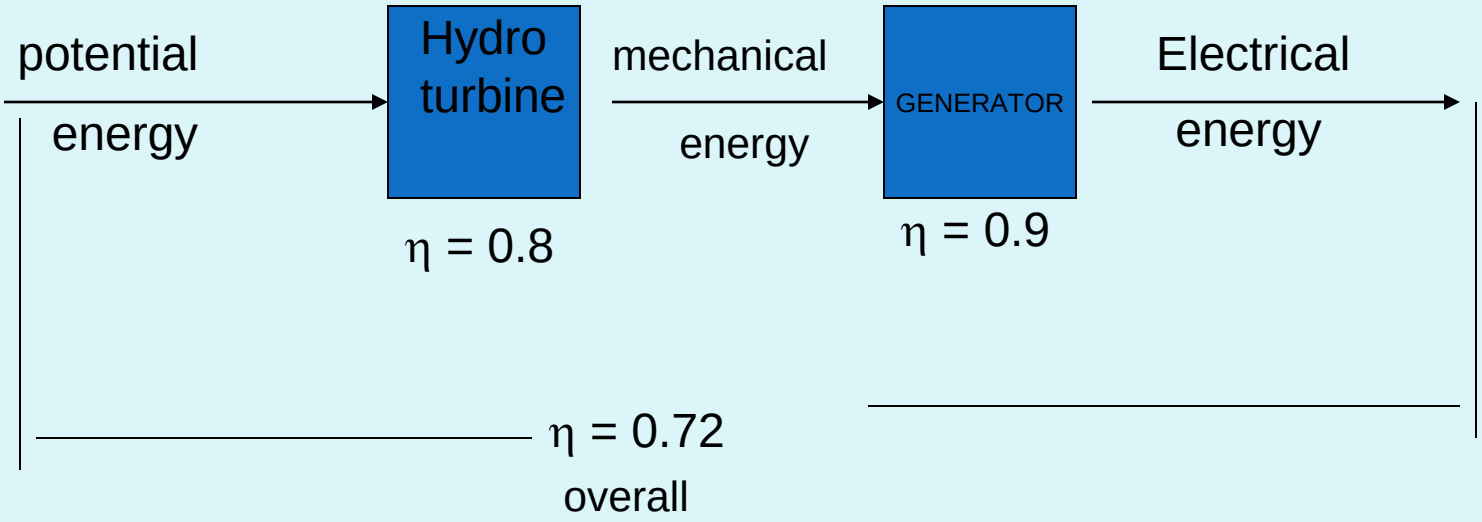
One of the 37 No 275kW Wind to Electricity Machines for the 10 MW Katsina Wind Farm

3. Sustainable Energy Technologies for Power Generation ..... Cont'd

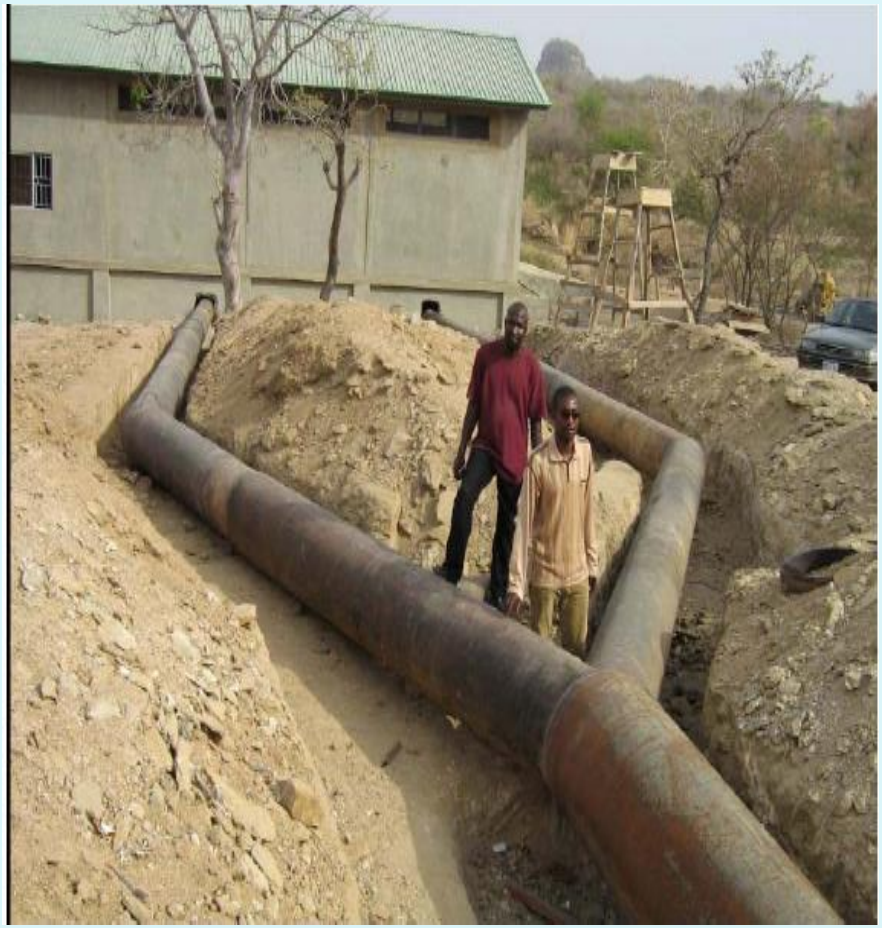
Drag Type wind Turbine for Water Pumping

c) HYDRO ENERGY:

- It exist mainly in the form of potential energy, which is transformed into mechanical energy through turbo machinery principles



3. Sustainable Energy Technologies for Power Generation ..... Cont'd

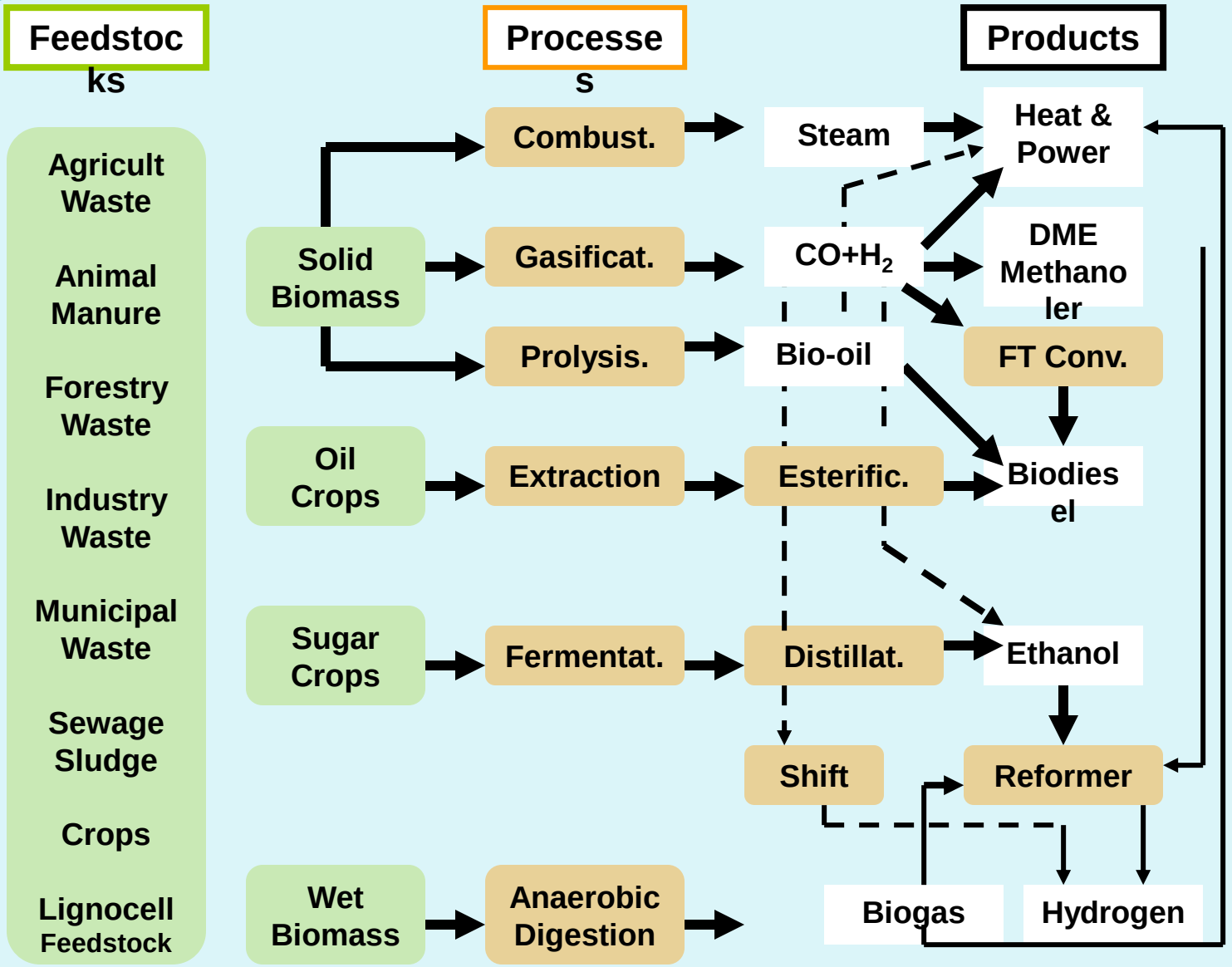


Penstock bifurcation into the 2 x 75 kW Francis Turbines at Waya Dam, Bauchi State

d) **BIOMASS**:

- Refers to non-fossil type matter of biological origin. The energy in biomass is in the form of chemical energy.
- Biomass Feed Stock mainly:
  - Fuelwood
  - Energy crops (1st generation feedstock mainly food crops and 2nd generation feedstock mainly non-food crops) from which bioethanol, biomethanol and biodiesel can be produced for heat, transportation and power generation.
  - Municipal solid waste, agric waste, forest waste, human waste, animal waste, woodchips, etc.

3. Sustainable Energy Technologies for Power Generation ..... Cont'd



Biomass Conversion Paths

3. Sustainable Energy Technologies for Power Generation ..... Cont'd

Sludge

Biogas Digester

Power House

Generating Plant

A 750 kW Plant for Biogas Electricity Generation in Germany

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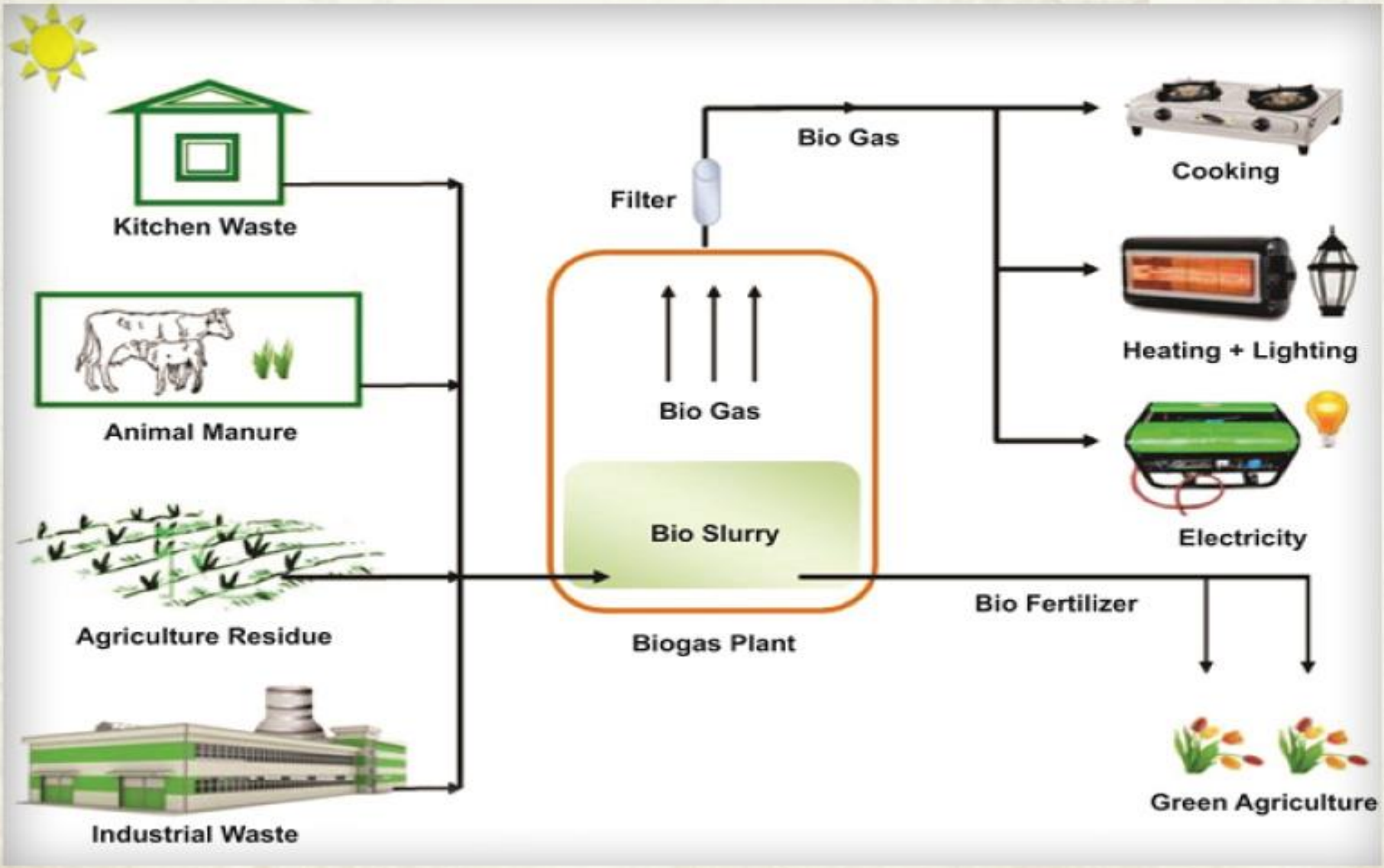
3. Sustainable Energy Technologies for Power Generation ..... Cont'd



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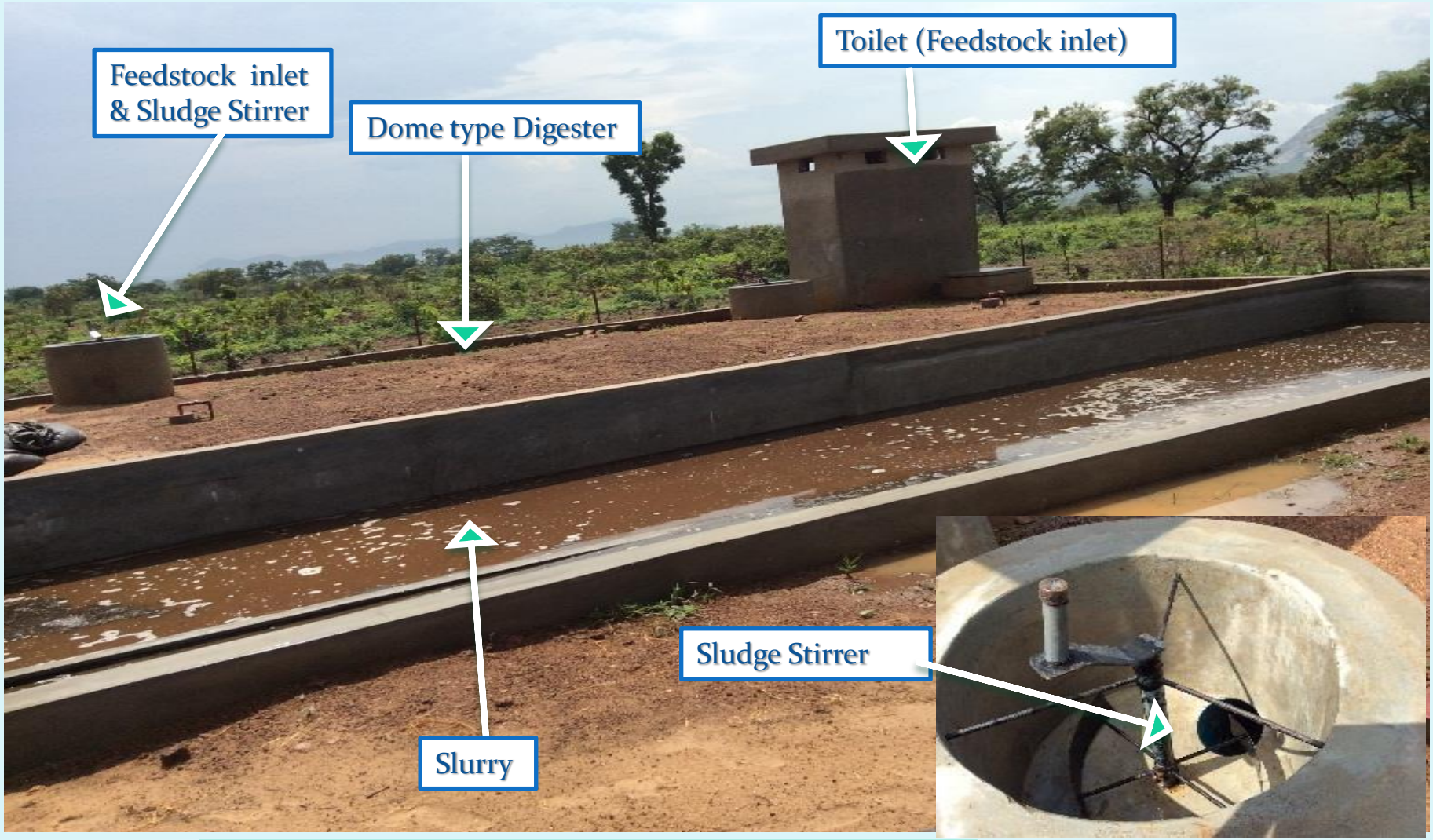


A 10kVA Commercial Biogas Plant for Electricity Generation at Rije Community, Kuje Area Council, FCT

3. Sustainable Energy Technologies for Power Generation ..... Cont'd

Biogas Processing & Flow Controls

Biogas Cylinder

10kWA Generator

Gas Burner

A 10kVA Commercial Biogas Plant for Electricity Generation at Rije Community, Kuje Area Council, FCT

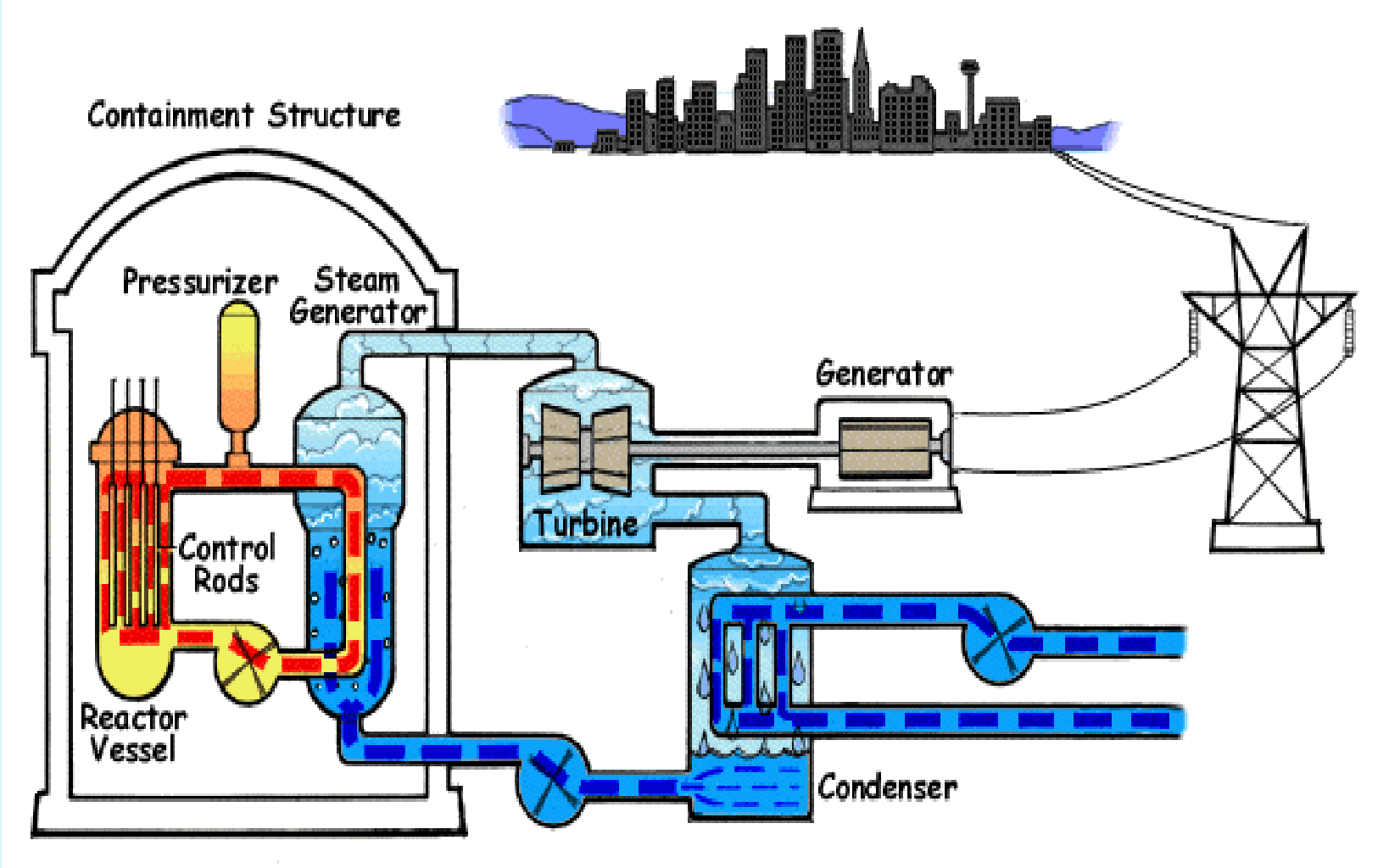
e) Emerging RE Technologies:

- Fuel cells: Electricity can be produced directly from the combination of hydrogen and oxygen in an electro chemical process in a fuel cell. Fuel cells can have efficiencies of up to 80%
- 2nd & 3rd generation biofuels feedstock: Biodiesel from non food feedstock e.g. Jatropha, Switch grass, Algae, non-food parts of crops (stems, leaves and husks)
- Ocean wave and tidal energy technology: Nigeria has a long coastal region where ocean waves and tidal energies can be transformed using turbines (horizontal axis or vertical axis) to generate electricity.
- Solar cells form organic substrates and nanotechnology with higher efficiencies.

f) Energy Efficiency best Practices

- Use of efficient energy production and utilization (efficient power cycles and efficient energy appliances: combined cycles, improved fuelwood stoves, CFLs, LEDS, efficient R & A systems etc)
- Regular energy audits (detection of areas of energy wastages and rectification)
- Simple energy conservation practices (lighting controls, use of daylights, switching off energy appliances when not in use)

(g) Nuclear Power



Typical PWR Power Plant System

3. Sustainable Energy Technologies for Power Generation ..... Cont'd

414 MW Natural Gas Fired Power Plant, Geregu, Kogi State - NIPP

3. Sustainable Energy Technologies for Power Generation ……. Cont'd

h.) Investment Cost of Renewable and other Power Technologies

S/NO	TECHNOLOGY	YEAR ON LINE	COST ($/kW)
1	Advanced open cycle gas turbine	2008	398
2.	Conventional open cycle gas turbine	2008	420
3.	Advanced gas/oil combined cycle	2009	594
4.	Conventional gas/oil combined cycle	2009	603
5.	Distributed generation (base load)	2009	859
6.	Distributed generation (peak load)	2008	1032
7.	Advanced combined cycle with sequestration	2010	1185
8.	Wind	2009	1208
9.	Coal-fired plant with scrubber	2010	1290
10.	IGCC	2010	1490
11.	Conventional hydropower	2010	1500
12.	Biomass	2010	1869
13.	Geothermal	2010	1880
14.	Advanced nuclear	2011	2081
15.	IGCC with carbon sequestration	2010	2134
16.	Solar thermal	2009	3149
17.	Fuel cell	2009	4520
18.	Photo voltaic (PV)	2008	4751

4. Conclusion

- Nigeria has varied sustainable energy resources that can be transformed into final energy of electricity, using appropriate technologies, to improve standard of living in rural areas and mitigate rural-urban drift.

- Public-Private Partnership model is imperative to provide the services in a sustainable manner.

Thank you
and
God Bless