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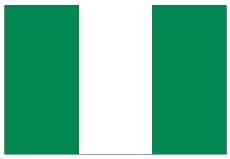
NIGERIA

MARKET REPORT ON SOLAR THERMAL WATER HEATING AND DRYING OF AGRICULTURAL PRODUCTS

NATIONAL CENTRE FOR ENERGY RESEARCH AND DEVELOPMENT, UNIVERSITY OF NIGERIA, NSUKKA
AND
SOKOTO ENERGY RESEARCH CENTRE,
USMANU DANFODIYO UNIVERSITY, SOKOTO



SOLtrain West Africa
A program managed by
ECOWAS Centre for Renewable Energy and Energy Efficiency



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Nigeria Market Report on Solar Thermal Water Heating and Drying of Agricultural Products

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1 General Energy Background

1.1 Nigeria's general energy background

The energy resource potentials of Nigeria include abundant renewable and non-renewable (fossil fuels) energy. Nigeria is Africa's largest oil producer and in 2012 was the world's fourth largest exporter of liquid natural gas (Ley et al., 2015). Crude petroleum export is the main stay of the Nigerian economy contributing about 95% to the total foreign exchange earnings of the country and 85% to the Federal government's collectible revenue. In spite of this, the total primary energy consumption of Nigeria tilts towards renewable energy in its traditional form (Table 1). EIA (2010) estimates that in 2010, the total energy consumption of Nigeria was 4.4 quadrillion Btu (111,000 kilotons of oil equivalent). This high percentage share represents the use of traditional biomass and wastes to meet off-grid heating and cooking needs, mainly in the rural areas. Also, statistics from the International Energy Agency, in 2011 puts total Nigerian primary energy supply at 118,325 ktoe (excluding the electricity trade). The share of biofuels and waste was 82.2%, oil 10.6%, natural gas 6.8%, and hydropower 0.4%. However, in 2012, only 41% of Nigerians had access to electricity and actual electricity demand in Nigeria is estimated at 10,000 MW (ADF, 2013). This electrification rate is falling instead of rising indicating a worsening of the situation based on the fact that the population and other development indices continue to increase while developments in the electricity sector declines. It is important to note that estimates of traditional biomass consumption are imprecise because biomass sources are not typically traded in observable commercial markets.

Table 1: Primary Energy Supply

	2012	**2010**
Total Primary Energy Supply	4.5 Quadrillion Btus	4.4 Quadrillion Btus
Percentage of traditional biomass and Waste	80%	82%
Oil	13%	13%
Natural gas	6%	4%
Hydro	1%	1%

Source: EIA (2012), EIA (2015)

In 2011, a total of 8,222 ktoe of oil products was imported, while 146,439 ktoe was exported. The latter can be subdivided as follows: crude oil totalled 123,944 ktoe; oil products accounted for 1,312 ktoe and natural gas for 21,184 ktoe (Ley et al., 2014). It bears noting that despite being a leading oil and liquid natural gas producer, Nigeria paradoxically imports the fossil fuel products it currently uses. Irrespective of the strong fossil fuel resources, the majority of the energy consumption relies on biofuel and waste. The primary biofuel source used is fuel wood.

1.2 Sectorial energy consumption

The patterns of energy usage in Nigeria's economy can be divided into industrial, transport, commercial, agricultural, and household sectors (ECN, 2003). The share of electricity in final energy consumption is almost marginal at less than 2%.The household sector accounts for the largest share of energy usage in the country - about 78%. This is followed by industrial

use at approximately 8.7% (Ley et al., 2014). This is largely due to the low level of development of the sectors. As shown in figure 1, the major energy-consuming activities in Nigeria's households are cooking (91%), lighting (6%), and use of other electrical appliances (3%) (ECN, 2005).

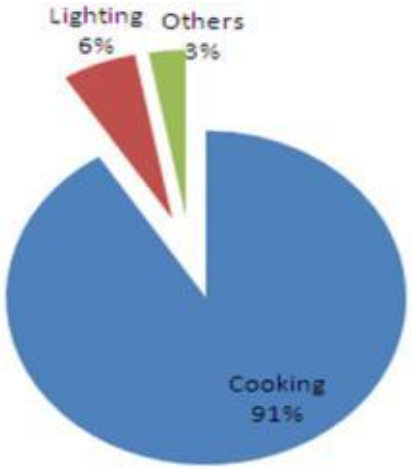


Figure 1: Household consumption pattern (Source: ECN, 2005)

1.3 Energy prices

1.3.1 Electricity

Electricity tariff are set by a government regulatory body known as Nigerian Electricity Regulatory Commission (NERC). The regulatory body operates a multi- year tariff order (MYTO) in which electricity prices are set and then reviewed periodically. Electricity tariff in Nigeria for consumers range from N4/kWh (€0.02/KWh) for the rural areas consuming less than 50 KWh in a month, to N32/kWh (€14.22/KWh) for large household consuming greater than 45 KWh in a month. However, there are slight variations in the tariff between the eleven electricity distribution companies (zones) in Nigeria. The DISCO's and their states of coverage are shown in Table 2.

Table 2: Electricity Distribution Companies in Nigeria

DISCO's	States of Coverage
Abuja Electricity Distribution Company	FCT, Niger, Kogi , and Nassarawa
Benin Electricity Distribution Company	Edo, Delta, Ondo, and part of Ekiti
Eko Electricity Distribution Company	Lagos
Enugu Electricity Distribution Company	Enugu, Abia, Imo , Anambra and Ebonyi
Ibadan Electricity Distribution Company	Oyo, Ogun, Osun, Kwara and part of Ekiti
Ikeja Electricity Distribution Company	Lagos
Jos Electricity Distribution Company	Plateau, Bauchi, Benue and Gombe

Kaduna Electricity Distribution Company	Kaduna,Sokoto, Kebbi and Zamfara
Kano Electricity Distribution Company	Kano, Jigawa and Katsina
Port Harcourt Electricity Distribution Company	Rivers, Cross River, Bayelsa and Akwa Ibom
Yola Electricity Distribution Company	Yola, Adamawa, Borno, Taraba and Yobe

The customers tariff is determined by the consumers estimated monthly demand level (KWh), meter type and the categorized electricity use. The categories are social tariff, residential tariff, commercial tariff, industrial tariff, and special tariff. Fuller details are shown in Table 3.

Table 3: Electricity tariff codes for customers of electricity in Nigeria

Tarrif Code	**Meter Type**	**Customers' demand levels (x)**
Residential		
R1	single phase supply with single phase meter	x < 5KVA
R2S	single phase supply with single phase meter	5KVA ≤ x < 15KVA
R2T	3-phase supply with 3-phase meter	15 KVA ≤ x < 45KVA
R3	3-phase supply with 3-pase meter; Lv demand	45 KVA ≤ x < 500KVA
R4	large 3-phase residential supply on 6.6/11KV	x > 500KVA
Commercial		
C1S	single phase/meter commercial supply	5KVA ≤ x < 15KVA
C1T	3-phase/meter commercial supply	15 KVA ≤ x < 45KVA
C2	3-phase commercial supply. LV maximum dd	45 KVA ≤ x < 500KVA
C3	3-phase commercial supply on 6.6/11KV etc	x > 500KVA
Industrial		
D1S	single phase/ meter industrial supply	5KVA ≤ x < 15KVA
D1T	3-phase/meter industrial supply	15 KVA ≤ x < 45KVA
D2	industrial customers on 3-phase supply/meter	45 KVA ≤ x < 500KVA
D3	large 3-hase industrial supply on 6.6/11KV	x > 500KVA
Special		
A1	Religious houses & agro-allied enterprises	5KVA ≤ x < 15KVA
A1T	Religious houses & agro-allied enterprises with 3-phase supply/meter	15 KVA ≤ x < 45KVA
A2	Universities & Government hospitals etc	45 KVA ≤ x < 500KVA
A3	Universities & Government hospitals on 6.6/11KV or 66/33KV	x > 500KVA
Street lighting		
S1	street lighting tariff	1,3 phase

Electricity prices for Abuja Distribution Company are shown in Table 4 for 2015, 2016 and 2017. The Euro equivalent of the tarrifs are bracketed and are at the approximated present day (September, 2015) exchange rate of ₦225 to €1.

Table 4: Electricity Prices for Abuja Distribution Company

Consumer Type	**2015**		**2016**		**2017**	
Residential	Fixed Charge (₦/month) (€/month)	Energy Charge (₦/KWh) (€/KWh)	Fixed Charge (₦/month) (€/month)	Energy Charge (₦/KWh) (€/KWh)	Fixed Charge (₦/month) (€/month)	Energy Charge (₦/KWh) (€/KWh)
R1	0.00 (0.00)	4.00 (0.02)	0.00 (0.00)	4.00 (0.02)	0.00 (0.00)	4.00 (0.02)
R2	702 (3.12)	20.10 (0.09)	843 (3.75)	20.09 (0.09)	1,011(4.49)	19.28 (0.09)
R3	53696 (238.65)	32.47 (0.14)	63,235 (218.04)	32.47 (0.14)	72,882 (323.92)	31.15 (0.14)
R4	136030 (604.58)	32.47 (0.14)	163,236 (725.49)	32.47 (0.14)	195,883 (870.60)	31.15 (0.14)
Commercial						
C1	702 (3.12)	23.77 (0.11)	843 (3.75)	23.77 (0.11)	1,011 (4.49)	22.80 (0.10)
C2	47772 (212.32)	30.18 (0.13)	57,326 (254.78)	30.18 (0.13)	68,791 (305.73)	28.95 (0.13)
C3	123321(5 48.10)	30.18 (0.13)	147,985 (657.71)	30.18 (0.13)	177,582 (789.25)	28.95 (0.13)
Industrial						
D1	1000 (4.44)	24.35 (0.11)	1,200 (5.33)	24.35 (0.11)	1,440 (6.40)	23.36 (0.10)
D2	25278 (112.35)	31.63 (0.14)	30,334 (134.82)	31.63 (0.14)	36,401 (161.78)	30.35 (0.13)
D3	123321 (548.09)	31.63 (0.14)	147,985 (657.71)	31.63 (0.14)	177,582 (789.25)	30.35 (0.13)
Special						
A1	702 (3.12)	23.31 (0.10)	843 (3.75)	23.31 (0.10)	1,011 (4.49)	22.36 (0.10)
A2	43125 (191.67)	23.31 (0.10)	51,750 (230)	23.31 (0.10)	62,100 (276)	22.36 (0.10)
A3	54375 (241.67)	23.31 (0.10)	65,250 (290)	23.31 (0.10)	78,300 (348)	22.36 (0.10)
Street lighting						
S1	600 (2.67)	19.24 (0.09)	720 (3.20)	19.24 (0.09)	864 (3.84)	18.46 (0.08)

Source: NERC, 2015

1.3.2 Transport fuel prices

The pump price of Premium Motor Spirit(PMS) known as petrol was ₦65/litre (€0.29) from 2007 – 2012. The price was moved to ₦97 (€0.43) in 2012 after initially rising to ₦141 (€0.63) for two weeks when government removed the subsidy on petroleum supply. However, the price was moved down again to ₦87 (€0.39) late 2014 as a result of a fall in the international price of crude. Automotive gas oil (AGO, commonly called diesel in Nigeria)

does not enjoy any subsidy from the government. Its price has hovered between ₦140 (€0.62) and ₦180 (€0.80) per litre. A summary of transport fuel prices are shown in Table 5.

Table 5: Transport fuel Prices.

	2012	**2013**	**2014**	**2015**
PMS (subsidized)(Naira/litre) (€/litre)	97	97	97	87 (0.39)
AGO (deregulated) (Naira/litre) (€/litre)	144	144	144	144 (0.64)

€1=₦225

2 Share of Renewables

The share of renewable energy in the Nigerian commercial energy mix is insignificant compared with other developing countries of the world (ECN, 2007). Apart from biomass and wastes used traditional form in rural areas, the current state of exploitation and utilization of renewable energy resources is very low; limited largely to pilot and demonstration projects developed by the two research centres: National Centre for Energy Research and Development, University of Nigeria, Nsukka and Sokoto Energy Research Centre, Usman Danfodiyo University, Sokoto. The efforts by the Energy Commission of Nigeria in mainstreaming renewable energy into Nigeria's commercial energy mix through the installation of solar energy for rural areas electrification, street lighting, etc. and the role of private commercial renewable energy importers are important but are largely fragmented and undocumented.
The 2010 share of renewable energy in the total consumption is summarized in Table 6 while the installed grid connected renewable capacity is summarized in Table 7.

Table 6**:** Share of renewable energy in total energy consumption

Resource	**Percentage**
Modern Biomass	8.8
Hydropower	0.4
Solar	***
Wind	***
Others	***
Total	**9.2**

*** signifies no data. Source: ECOWAS, 2014

Table 7: Installed renewable energy capacity (grid-connected) in 2014

Resource	**Capacity (MW)**
Hydropower	1977
Wind	0.03
Solar PV	0
Biomass	0.5
Total	**1,978**

Source: ECOWAS, 2014

2.1 Share of hydropower to the overall energy consumption

Hydro power is the most exploited and developed renewable energy technology in Nigeria. The installed grid connected hydropower in Nigeria is 1977 MW consisting of major stations at *Kainji* (760 MW), *Jebba* (578 MW) and *Shiroro* (600 MW) (ECOWAS, 2014). While 98% of the hydro power stations have capacities greater than 30 MW, 2% have capacities less than 30 MW (ECOWAS, 2014). However, studies carried out in twelve states and four river basins, show that over 278 unexploited Small Hydro Power (SHP) sites with total potential of 734.3 MW exist. (Sambo, 2009). SHP which based on Nigeria's level of hydropower development is defined as follows; small (2 MW to 10 MW), mini (≤ 2MW) and micro (≤ 100 kW) sites exist in virtually all parts of Nigeria with an estimated capacity of 3,500 MW (Sambo, 2009). As at 2010, it was estimated that the total contribution of hydro power to the total energy consumption is 0.4% (ECOWAS, 2010) while it currently contributes approximately 30% of the total installed grid-connected generated electricity (NREEEP, 2015).

2.2 Share of biomass to the overall energy consumption

Biomass resources available in the country include: fuel wood, agricultural waste and crop residue, sawdust and wood shavings, animal dung/poultry droppings, industrial effluents/municipal solid waste (Sambo, 2009). Table 8 shows the estimated biomass resources in Nigeria.

Table 8: Biomass Resources and the Estimated Quantities in Nigeria

Resource	Quantity (million tonnes)	Energy Value (GJ)
Fuel wood	39.1	531.0
Agro waste	11.244	147.7
Saw Dust	1.8	31.433
Municipal Solid Waste	4.075	---

Source: Sambo, 2009

In year 2000, national demand of fuel wood was estimated to be 39 million tonnes of which 95% was used in households for cooking and for cottage industrial activities (Sambo, 2009). Residues associated with agriculture either as on-the-farm crop wastes such as cornstalks or as processing waste such as rice husk, corn shells, palm kernel shell, cassava peels, are also good sources of fuels but are mostly used as starter or supplement material in addition to fuel wood. Digestion of animal waste to produce biogas is also in use in some places. Examples include a human waste biogas plant at the Zaria prison and Owerri prisons, cow dung based biogas plants at the fodder farm of the National Animal Production Research Institute (NAPRI), Zaria and Mayflower Secondary School Ikenne, Ogun State and an 18m^3 capacity pig waste biogas plant at the pigry farm of the Ojokoro/Ifelodun Cooperative Agricultural Multipurpose Society in Lagos State. Different sizes of pilot biogas digester projects also exist at the National Centre for Energy Research and Development, University of Nigeria, Nsukka and Sokoto Energy Research Centre, Usumanu Dan Fodiyo University in

Sokoto. Sawdust and wood wastes are other important biomass resources and shows promise for use in biomass fired power plants. ECOWAS (2014) reported 0.5 MW as the contribution of biomass to grid fed electricity in Nigeria. However the overall contribution of biomass to total energy consumption is estimated to be 8.8% in 2010. (ECOWAS, 2014).

2.3 Share of solar electricity (PV) to the overall energy consumption

Solar electricity (PV) in Nigeria is used mainly for off-grid functions such as: water pumping, lighting and entertainment in homes, hospitals and schools, vaccine refrigeration, traffic lighting and lighting of road signs. There is no comprehensive data on the share of PV to the overall energy consumption in the country though the use of solar PV is widespread in Nigeria. ECOWAS (2014) reports that the contribution of solar PV to grid electricity is zero in Nigeria. However, there is an array of solar farms that have just obtained licenses or are in the license pipeline. They include a 100 MW facility in Bauchi State, one of 120 MW in Katsina State, and various others in Ekiti, Kaduna, and Nassarawa States (Ley et al., 2015).

2.4 Share of wind to the overall energy consumption

The level of wind power development in Nigeria is limited to the 5 and the 0.7 KWp windmill located Sayya Gidam and Danjawa villages of Sokoto State, respectively. A pilot project on the generation of large scale grid-connected power using wind energy commenced at Kastina State in 2007 (Abam, 2014). It is only about 0.03 MW of wind energy is connected to the grid in 2014 (ECOWAS, 2014). The Ministry of Power has a 10 MW pilot wind plant in Katsina, which is scheduled for commissioning in the near future (Ley et al., 2015).

2.5 Share of solar thermal (solar water heating) to the overall energy consumption

On the average, the country receives solar radiation at the level of about 19.8 MJm $^{-2}$day^{-1} (Sambo, 2009). Average sunshine hours are estimated at 6 hrs per day and solar radiation is fairly well distributed in Nigeria. Solar thermal applications, which are already developed at research centres in Nigeria, include: solar cooking, solar water heating, solar evaporative cooling, solar crop drying, solar incubators and solar chick brooding systems.
A survey conducted by GIZ Nigeria in 2013 on solar water heating applications in homes, schools, hospitals and hotels revealed shocking results of nearly complete unawareness of this technology amongst the sampled populace. However, a few applications exist in some homes and recently in some schools in Jos, Plateau State. There are also locally made systems for demonstration purposes at the research centres in Nsukka and Sokoto. These systems are yet to be in common use in Nigeria. There is no official data on the share of solar thermal energy to the overall energy consumption.

2.6 Status and use of solar thermal drying of agricultural products

The use of solar energy for drying though open-to-air sun drying is widespread in every part of Nigeria. Sun drying of meat is also common in the Northern part of Nigeria. The use of solar dryers however is not common although the two main research centres in Nigeria (Nsukka and Sokoto) have successfully pioneered research and development in this area. It

is on record that commercial and family sized solar drying systems have been built, tested and have been shown to be a viable option for the drying of crops in Nigeria. These systems are yet to find their way into everyday use by the populace. It would seem that the push to drive these technologies from national laboratories to the market place is simply lacking. ECN (2013) summarizes the renewable energy utilization in Table 9.

Table 9: Renewable Energy Potential

Resources	**Potential**	**Current Utilization and further remarks**
Large Hydropower	11,250 MW	1,900 MW exploited
Small Hydropower	3,500 MW	64.2 MW exploited
Solar	4.0KWh/m^2/day – 6.5 KWh/m^2/day	15 MW dispersed solar PV installations. (estimated)
Wind	2-4 m/s at 10 m height mainland	Electronic wind information system (WIS) available
Biomass (non fossil organic matter)	Municipal waste	18.5 million tonnes produced in 2005 and now estimated at 0.5 kg/capita/day
	Fuel wood	43.4 million tones/yr. Fuel wood consumption
	Animal waste	245 million assorted animals wastes in 2001
	Agricultural residues	91.4 million tonnes/yr. produced
	Energy crops	28.2 million hectares of arable land, 8.5% cultivated

Source: ECN, 2013

3 Solar Thermal Heating Market

3.1 Installed Capacity

There are no official data on the installed capacity of solar thermal systems in Nigeria. However, survey carried out in the course of this study estimates that installed solar water heating collector area is less than 200 m^2 (140 KW_{th}). Details of collector areas installed by different companies are shown in Table 3.1. Pictures can be seen in appendix A.

Table 1: Recorded installed collector area in Nigeria

NAME OF COMPANY	**TOTAL INSTALLED COLLECTOR AREA (m^2)**	**THERMAL POWER (KW_{th})**
Pamtronics Nigeria LTD	17.0	11.9
Eauxwell Nigeria Limited	6.0	4.2
A.O.Demarg NIG LTD	10.0	7.0
Solartech Energy Development Company LTD	4.0	2.8
Amsad Synergy and Investment	6.4	4.5
Dalcy Technologies LTD	6.5	4.6
Dahiru Solar Technical Services	4.1	2.8
NCERD,UNN	16.0	11.2
SERC, UDUS	32.4	22.7
TOTAL	**102.4**	**71.7**

3.2 Systems in operation

Direct thermosyphon systems seem to be the most popular in Nigeria. A few pumped systems for domestic hot water production were also seen in the course of the survey. Typical collectors are evacuated tubes. A 150 litre system will usually have 15 tubes with each collector in a tube measuring 47 mm by 1500 mm. Other storage capacities encountered in the survey are; 200 litre, direct thermosyphon with a tube collector area of 2.25 m^2 and 300 litre, pumped system with flat plate collector area of 5 $m^{2.}$ A typical system using evacuated tubes is shown in Figure 2.

Figure 2: A typical solar water heating system.

3.3 Collector types used

Evacuated tubes and flat plate collectors are commonly in use. Pictures are shown in Figure 3 and Figure 4.

Figure 3: Locally made flat plate collectors by SERC UDUS

Figure 4: Imported flat plate collector for a pumped system at Port Harcourt.

3.3.1 Imported Systems

The trade names with the countries of origin of solar water heating systems encountered during survey are listed in table 7.

Table 10: List of imported systems

S/N	Trade Name	Collector Type	Storage size (litres)	Cost of system	Country of origin
1.	CalpakCiCeroHellas	Evacuated Tube	200		Greece
2.	Solartech LLC	Flat plate	100	₦150,000 (€667)	Dubai
3.	Wagner & Co	Flat plate	300		Germany
4.	Red sun	Evacuated tube		₦120,000 (€533)	Indian
5.	AMS	Evacuated tube		₦120,000 (€533)	Pakistan
6.	Zhejiang Wakin	Evacuated tube	150	N100,000 (€444)	China

3.3.2 Local Production

Local production of solar water heating systems was initially done by government institutions. Recently, some small enterprises dealing on welding and metal works produce these systems on demand. Collector absorbers are made from mild steel, galvanised iron, aluminium and copper sheets. The materials used for transparent covers include commercial window glass, and perspex. Materials that are used for insulation include the following; glass wool saw dust, risk husk, foam, and commercial polyeurezhane foam. Galvanized steel pipes were used for connecting pipes from storage tank to the collector header and risers due to its rigidity and resistance to corrosion. Lagged galvanized iron sheets are used for hot water storage. Absorbers are usually spray painted or brush painted.

3.4 Main Applications

Hot water preparation in homes, hotels, schools and industries are usually prepared by the use of electricity, cooking gas, kerosene stove and fuel wood. Most of the solar water systems seen in the survey were in homes.

3.5 Cost

A typical 150 litre system with evacuated tubes cost about ₦100,000 (€444) with an installation cost of about ₦30,000 (€133).

3.6 Customers

The main customers of solar water heaters are homes, boarding schools and hospitals.

3.7 Companies Involved

3.7.1 Companies involved in the production or assembling of solar thermal systems

The companies involved in the production and assembling of solar thermal systems are listed in Table 11.

Table 11: Companies involved in the production or assembling of solar thermal systems

Name of Company	Address of Company	Contact Person	Phone	E-mail/Web page
National Centre for Energy Research Development, UNN	University of Nigeria. Nsukka	Dr P. E. Ugwuoke	+2348065702570 +2348082770823	www.unn.edu.ng/centres/ centre-energy-research-and-development
Sokoto Energy Research Centre.	UsmaniDanfodio University Sokoto	Prof S. M. Dangoggo		Serc@udusok.edu.ng www.cofex.udusok.edu.ng
UZOMS Welding Art (NIG)	UmukabiaOhuhu, Umahia North	Stanley Nwakamma	+2347036252893	
DIK Engineering LTD	Cold Room Industrial Area. Owerri Ani, Nsukka	Dim Ikechukwu .k	+2348037409945	Dik127engineering@ gmail.com
Hogis Engineering LTD	14 Red Cross Road.Ogbette Enugu	Nicholas Owoh	+2348037260253	
M.A Metal Fabrications	Alheri motors, Near Sokoto Guest Inn, GarbaDurba Road Sokoto	Alh. Mohammed Aliyu Hassan	+23480888437400	
Remakatronix Engineering Company	No 35 Waziri Zayyana Avenue, Katsina	AbdulkarimHamza El Laden	+234806552	remakatronics@gmail.com

3.7.2 Companies involved in import of solar thermal systems

The companies involved in the importation of solar thermal systems are listed in Table 12.

Table 12: Companies involved in the import of solar thermal systems

Name of Company	Address of Company	Contact Person	Phone	E-mail/Web page
Pamtronics Nigeria LTD	Rayfield Road Opposite old Airport Jos, Plateau State	Engr Makus Pam	+2348037012703	www.pamtronics.com
Eauxwell Nigeria Limited	123 Joel Ogunaike Street, Ikeja GRA, Lagos	Enwegbara Edwin	01-8180190	www.eauxwell.com c.edwin@eauxwell.com
A.O.Demarg NIG LTD	Plot 46 Evo Road, GRA Phase II, Port Harcourt. Rivers State	Ade Fadunsin	+2348033002409	www.aodemarg.com solarinfo@aodemarg.com
Solartech Energy Development Company LTD	10 Beach road Jos, Plateau State	Muyi Lawal	+2348036263434	www.solarelectricsystems.net muyi.lawal@solarelectricng.net
Amsad Synergy and Investment	YahayaGusau Road off Sharada Industrial Layout, Kano	Alh. Ahmed Muhammad Sani.	+2348039700027 +2347039216114	amsadsolar@gmail.com www.amsadelectronics.com
Dalcy Technologies LTD	Plot 1088 Joseph Gomwalk Street, Gudu, Abuja	Cyprian Agudosi	+2348067493924	cagudosi@aol.com
Dahiru Solar Technical Services	8/9 Kundila Market Zaria Road Behind Kano State Housing cooperation Kano	Engr Nafiu Baba Dahiru	+2348069352705	dahirusolar@yahoo.com amalisco@yahoo.com
Thumbs-Up Techno-logies LTD	19, Adelabu Street, Masha Surulere, Lagos	Obialor Thompson	+2348123297666	tomobiq@gmail.com

3.7.3 Companies involved in the installation of solar thermal systems

The companies listed in Table 12 are also involved in the installation of solar thermal systems.

4 Political Support Mechanisms

The Nigeria's renewable energy program was specifically initiated by the Federal Ministry of Environment in fulfilment of the country's obligations to the United Nations Framework for Climate Change (UNFCC). Prior to this, the Energy Commission of Nigeria (Established 1988) has been the think tank policy organ of the government for the overall development of the energy sector, including renewable energy.

4.1 Support Mechanisms for renewable energy in Nigeria:

1. There are no import duties on the importation of renewable energy systems into Nigeria.
2. In case(s) of foreign investor(s) or investment(s), all profit can be repatriated to the investor home government without hindrance.
3. The Nigerian Electricity Regulatory Commission has put in place Feed-In-Tariffs for renewable energy generation in Nigeria since June, 2012.
4. The Federal government is developing a National Policy on Renewable Energy and Energy Efficiency (NPREEE) which is expected to drive the development of renewable energy in Nigeria.
5. The Bank of Industry and United Nations Development programme (UNDP) Access to Renewable Energy (AtRE) programme has provided a US$4m (Four million US dollar) fund to which small and medium enterprises (SMEs) as well as households get access to renewable energy. http://boinigeria.com
6. There is a five year tax free holidays (tax exemptions) for pioneer industries. A pioneer company is a company that engaged in manufacturing, processing, mining, servicing and agricultural industries whose products have been declared pioneer products on satisfying certain conditions determined by the Industrial Development Coordinating Committee (IDCC) of the Federal Government of Nigeria under the Industrial Development (Income Tax) Act Cap 179 laws of the Federation (LFN) 1990. The tax holiday is for an initial period of three years; subject to further extension of two years or five years (once and for all without further extension). This fiscal incentive was first promulgated as Decree No. 22 of 1971 but commenced retrogressively from 1st April, 1970.

4.2 Responsible ministries and institutions for support mechanism

1. Federal Ministry of Environment: The ministry was established in 1999 with the statutory responsibility of protecting the environment against pollution and degradation and to ensure the conservation of natural resources for sustainable development of Nigeria. It is also responsible for coordinating all climate change matters under its department of climate change.
2. www.climatechange.gov.ng
3. Federal Ministry of Power: Responsible for the formulation of broad policies and programmes for the power sector and implementing renewable energy programmes and initiatives.
4. http://www.power.gov.ng

5. Federal Ministry of Science and Technology: The mission of this Ministry is to facilitate the development and deployment of science and technology apparatus to enhance the pace of socio-economic development of the country through appropriate technological inputs to productive activities in the nation. Parastatals (agencies of the ministry) include Energy Commission of Nigeria and National Agency for Science and engineering Infrastructure (NASENI).
6. Energy Commission of Nigeria (ECN): They are responsible for the coordination and direction of national energy strategies including those involving renewable energy technologies. The national energy plan for renewable energy is Renewable Energy Master Plan (REMP). http://www.energy.gov.ng
7. National Agency for Science and Engineering Infrastructure (NASENI): Established in 1992 to among others, promote local manufacturing of renewable energy technologies.

4.3 Administrating the support mechanisms

1. Nigerian Investment Promotion Council (NIPC). www.nipc.gov.ng
2. Federal Inland Revenue Service www.firs.gov.ng
3. Bank of Industry. http://boinigeria.com
4. Nigerian Electricity Regulatory Commission. www.nercng.org

5 Test and Research Institutes

Test institutes and research institutions active in the field of solar thermal systems are listed in Table 13.

Table 13: Test and research institutions active in solar thermal systems

Research Institution's Name	Research Institution's Address	Contact person and Phone number	Email / web address
National Centre for Energy Research and Development, Energy Commission of Nigeria.	NCERD- University of Nigeria Nsukka. Enugu State	Dr P. E. Ugwuoke +2348065702570 +2348082770823	www.unn.edu.ng/centres/ centre-energy-research-and-development
Sokoto Energy Research Centre Energy Commission of Nigeria.	SERC- Usmanu Danfodiyo University P M B 2346 Sokoto-Nigeria.	Prof. S.M. Dangoggo +23480	Serc@udusok.edu.ng www.cofex.udusok.edu.ng
Centre for Energy and Power System Research	Federal University of Technology Owerri, Imo State	Engr.Prof. Okafor E N C. +2348033273974	encokafor2000@yahoo.com Ephraim.okafor@futo.edu.ng
Renewable Energy Research Centre, Waziri Umaru	Federal Polytechnic, P M B 1034. BirninKebbi, Kebbi State.	Dr.Sani A. Salihu +2348057039811	www.mautech.edu.ng
Centre For Energy and Environment	Nnandi Azikiwe University, Awka		
Ibrahim ShehuShema Centre for Renewable Energy Research	Shehu Musa Yaradua University P.M.B 2218 Katsina,Katsina State	Dr. A.A Mati Director ISSCeRER; +2348065825699.	aamati2003@yahoo.com
Centre for Renewable Energy.	ModibboAdama University of Technology P.M.B 2076,Yola, Yola State.	Engr Usman Ibrahim Adamu Acting coordinator +234(0)8025526259.	usmaniawk@mautech.edu.ng

A brief description of the institutes is presented below.

NCERD, UNN and SERC, UDUS

The two renewable energy research centres, National Centre for Energy Research and Development, University of Nigeria, Nsukka, and Sokoto Energy Research Centre Usmanu Danfodiyo University Sokoto were established as university based research centres in early 1980's, assigned to carry out research, development, manpower training, commercialization and information dissemination in the various areas of renewable and non-renewable energy technologies such as solar, biomass, biofuels, wind, hydro, geothermal, fossil fuels, energy management and environment. The centres shall also be involved in mounting short courses, diploma and degree programmes in renewable energy technologies in collaboration with relevant academic departments of the university and other institutes.

Centre for Energy and Power System Research Federal University of Technology Owerri

The Centre for Energy and Power System Research Federal University of Technology Owerri was established in 2003 as an arm of Department of Electrical/Electronic Engineering. In October 2006, the University Management repositioned the Centre as one of the major academic centres in the University, in view of the role energy plays in the nation's economy. Amongst other tasks, the centre considers the relevance and economics of secondary sources of energy such as solar, geothermal, wind, tidal, nuclear, biomass, etc. to the Nigeria economy.

Ibrahim Shehu Shema, Centre for Energy Research and Development, Umar Musa Yar'adua University Katsina

The Ibrahim Shehu Shema, Centre for Energy Research and Development, Umar Musa Yar'adua University Katsina was established in May, 2008 at the Umaru Musa Yar'adua University Research Unit under the Vice-Chancellor's Office. The Centre operates the following specialized Research Groups with membership from across the faculties of the University. The centre carries research in the following areas; solar energy, wind energy, small hydro, bio fuel, energy efficiency and conservation.

Centre for Renewable Energy, Bayero University Kano

The Centre focuses on applied and pioneering research, demonstration and development, as well as training on renewable energy technologies. Currently the Centre has identified three (3) units; Nuclear Energy Unit, Bio-Energy Unit and Solar Energy Unit.

Centre for Renewable Energy Research, ModibboAdama University Yola

The centre is charged with conduct of research and manpower development in the field of renewable energy. The centre is presently carrying out research in the following areas; hydropower, solar energy (thermal), wind energy systems and biomass.

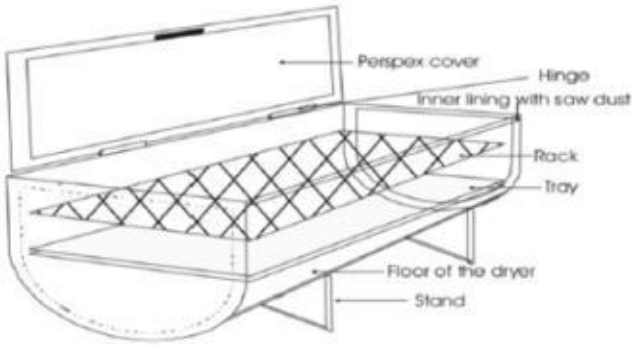
6 Solar Drying Market

6.1 Systems in operation

The use of solar drying systems by farmers is still unpopular in Nigeria (Open air drying is widely used by farmers which is unhealthy and generally uneconomical). In many rural locations in Nigeria, grid-connected electricity and supplies of other non-renewable sources of energy are either unavailable, unreliable or, for many farmers, too expensive. Thus, in such areas, crop drying systems that employ motorized fans and/or electrical heating are inappropriate. The large initial and running costs of fossil fuel powered dryers present such barriers that they are rarely adopted by small scale farmers. The traditional open sun drying utilised widely by rural farmers has inherent limitations. The use of solar drying systems is still at research and development and pilot stages with little support from government. Several passive solar dryers have been developed by the National Centre for Energy Research and Development, University of Nigeria, Sokoto Energy Research Centre, Usmanu Dan Fodioyo University and other tertiary institutions in Nigeria. Most of these dryers are very simple and easy to construct using local materials.
Three distinct sub-classes of the passive solar drying systems can be identified (which vary mainly in the design arrangement of system components and the mode of utilization of the solar heat namely integral-type solar dryers; distributed-type solar dryers; and mixed-mode solar dryers. Some pictures of the dryers are shown in the following figures.

a

Figure 5: Integral mode solar dryer



b

Figure 6: Cross-section of the dryer

Figure 7: Integral mode

Figure 8: Integral mode

Figure 9: Kuchi Fadama iii Assisted Community Solar Meat Drying System (SERC/UDUS)

Figure 10: 100kg Solar Dryers installed in Danjawa

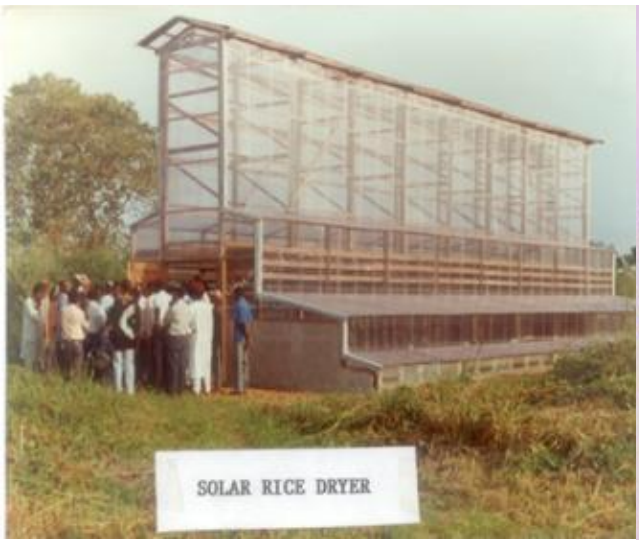


Figure 11: A 2 tonne solar Rice Dryer (NCERD)

Figure 12: A 2 tonne solar Rice Dryer (SERC)

Figure 13: Solar Dryers (SERC)

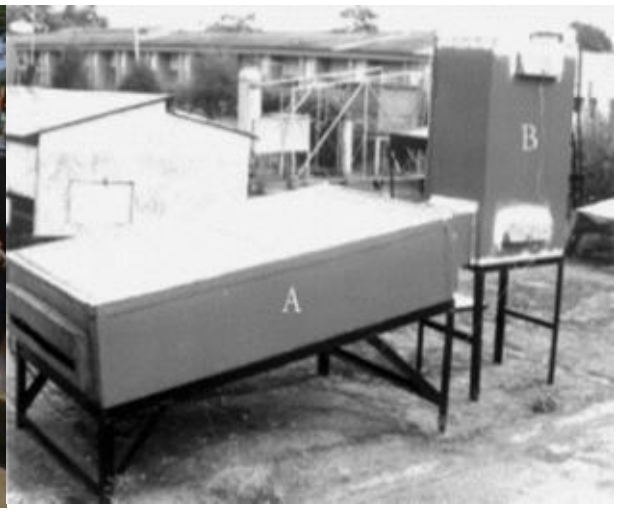


Figure 14: Distributed Type Dryer (NCERD)

6.2 Main Applications

Typical agricultural products cereal (Maize, Beans, Wheat, millet), fruits (Tomato, pepper, nuts), cassava tubers, herbs, timber, fish, meat, other agricultural products are dried using the solar dryers.

The general harvesting season for different crops and fruits listed above are between September and December months of the year except maize which comes earlier around May to August depending on the onset of the rains.

6.3 Cost

The cost of a typical drying system (using a passive solar dryer of 15 kg of maize per batch) is about €445, while that of an active system is about €670.

6.4 Customers

The customers are households and farmers.

6.5 Companies involved

6.5.1 Companies involved in the production or assembling of solar drying systems

Some local companies are involved in the local construction and installation of solar drying systems. The companies are listed in Table 14.

Table 14: Companies involved in the local production of solar drying systems

Company name	Address	Phone no.	Contact person	E-mail address
Remakatronix Eng'g co.	No. 35 Waziri Zayyana Avenue, Katsina	+234806552	Abdulkarim Hamza El Ladan	remakatronics@gmail.com
UZOMS Welding Art (NIG)	Umukabia Ohuhu, Umahia North	+2347036252893	Stanly Nwakamma	
Hogis Eng'g LTD	14 Red Cross Road.Ogbette Enugu	+2348037260253	Nicholas Owoh	
DIK Eng'g LTD	Cold Room Industrial Area. Owerri Ani, Nsukka	+2348037409945	Dim Ikechukwu .k	Dik127engineering@gmail.com
M.A Metal Fabrications	Alheri motors, Near Sokoto Guest Inn, GarbaDurba Road Sokoto	+23480888437400	Alh. Mohammed Aliyu Hassan	

6.5.2 Companies involved in import of solar drying systems

Systems are produced locally. No company has been identified as importers of solar dying systems in the country.

6.5.3 Companies involved in the installation of solar drying systems

The same companies listed in table 6.1 are also involved in the installation of solar drying systems.

6.6 Know-how on solar drying

The institutions that provide the technical know-how on solar drying in Nigeria are as shown below.

Table 15: Institutions providing technical know-how on solar drying

Institution name	Address	Phone no.	Contact person	E-mail address
NCERD	UNN	+2348035626680	Director, NCERD	ncerdunn@yahoo.com
SERC	UDUS		Director, SERD	serc@udusok.edu.ng

6.7 Awareness and Incentives

The Ministry of Science and Technology, the Ministry of Agriculture and Rural Development, are responsible and aware of solar drying and its potential. But still, these ministries need more proactive approach to sensitise the public on social, economic and environmental benefits of using these systems. The provision of incentives, rebates grants and funding R&D and piloting in addition to supporting community involvement for the widespread and adaptation of the alternative energy systems is still not very encouraging.

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8 Appendix A:

8.1 Some solar water heating systems in Nigeria

Figure 15: Evacuated tube solar water heating system installed by light Zaman company at Sabon Titi Kano Nigeria

Figure 16: 500 Litres Thermosyphon Solar Water Heater Installed at Danjawa Renewable Energy Model Village(SERC/UDUS)

Figure 17: 5.4 m^2 Flat plate collector solar water heating system produce and installed by SERC UDUS at the residence of Dr Aliyu Magatakarda Wamakko at Gawon Nama Sokoto, Nigeria.

Figure 18: 300 litre, pumped system with 5.016 m2 collector installed by A. O. Demarg Nig. Ltd. in Port Harcourt, Nigeria.

Figure 19: Evacuated tube, thermosyphon systems installed by Pamtronics Nig. Ltd in Jos, Plateau State.

Figure 20: Evacuated tube, thermosyphon systems installed by Dalcy Technology limited at the National Centre for Energy Research and Development, University of Nigeria, Nsukka.

Figure 21: Evacuated tube, thermosyphon systems installed by Dalcy Technology limited at the National Centre for Energy Research and Development, University of Nigeria, Nsukka.