# FEASIBILITY REPORT

# ON

# ESTABLISHMENT OF LOCAL MANUFACTURE FACILITY AND TRANSFER OF TECHNOLOGY FOR SMALL HYDRO POWER TURBINES IN WEST AFRICA

**By**

**UNIDO REGIONAL CENTRE FOR SMALL HYDRO POWER in AFRICA**
**ABUJA, NIGERIA.**

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| S/N | Abbreviations | Meanings |
|---|---|---|
| 1. | ECN | Energy Commission of Nigeria |
| 2. | NDA | Niger Dams Authority |
| 3. | NEPA | National Electricity Power Authority |
| 4. | PHCN | Power Holding Company of Nigeria |
| 5. | FGN | Federal Government of Nigeria |
| 6. | UNIDO | United Nation Industrial Development Organization |
| 7. | R & D | Research and Development |
| 8. | SHP | Small Hydro Power |
| 9. | ECOWAS | Economic Commission of West African States |
| 10. | DOE | Department of Energy |
| 11. | FEMA | Forum of Energy Minister's in Africa |
| 12. | NEPAD | New Partnership for African Development. |
| 13. | REA | Rural Electrification Agency |
| 14. | MDG | Millennium Development Goal |
| 15. | UNDP | United Nations Development Programme |
| 16. | GEF | Global Environmental Fund |
| 17. | GHG | Green House Gases |
| 18. | RETs | Renewable Energy Technologies |
| 19. | W.A | West Africa |
| 20. | PRODA | Project Development Agency |
| 21. | NASENI | National Agency for Science and Engineering Infrastructure. |

## 1.0 INTRODUCTION / BACKGROUND.

7-Point Agenda of the Federal Government of Nigeria high points are wealth creation, improved lifestyles of the populace and improved national economy. Human Capacity Development and provision of Critical Infrastructure have been identified as the linchpins for actualizing these goals. For sustainable wealth creation to be achieved and for Nigeria to be among the top 20 economies in the world by 2020, the nation must cease to be a "dumping ground" for manufactured goods from all-over the world and join the rest of the advancing economies in the manufacture of goods for local consumption and export.

The development of cottage, small and medium industries and the manufacture of quality products at competitive prices depend on constant supply of reliable electricity and the utilization of Advanced Manufacturing Technology.

More than 60% of communities in Nigeria are still not connected to the National Grid. The cost of extending the grid is currently high, compared with the cost of installing off-grid electricity generation plants. Absence of electricity in rural areas is an indication of poverty and lack of developed infrastructure. This has promoted urban migration in search of employment and improved standard of living due to the presence of large, medium, and small scale industries that are heavily dependent on electricity.

Nigeria is blessed with a vast amount of water resources from which electricity could be generated. With Small Hydro Power (SHP) plants, electricity can be generated even from small streams and rivers. SHP plants are easy to install and manage. When used for stand-alone, decentralized electricity supply, it does not require very high investments in transmission lines since the end-users are close to the source of generation of the electricity.

## 1.1 PROJECT BACKGROUND

Nigeria is a coastline country in West Africa that got its independence in October 1960. The British Government built the first generating plant in Nigeria in Lagos in 1898. The generation, transmission Ordinance No 15 of 1959 vested distribution and marketing of electricity on the defunct Electricity Corporation of Nigeria (ECN). Later, the Niger Dams Authority was set up in 1962; in 1972 the Niger Dams Authority (NDA) and the ECN became merged by Decree No 24 of 27$^{th}$ June 1972 to give birth to the National Electricity Power Authority (NEPA). The Electricity Reforms Act of 2005 further gave birth to the Power Holding Company of Nigeria (PHCN), which is currently undergoing restructuring into business units as well as the National Electricity Regulating Commission (NERC).

More than 18 State Governments are already working towards the deployment of SHP for electricity generation in their states. In some states, the plan is to establish SHP plants in each of their Senatorial Districts and later to all their Local Government Areas. The Federal Government through its Rural Electricity Agency (REA) and Non-Governmental organisations are also working towards the deployment of SHP in selected sites all over the country.

Electricity generation in rural communities would increase and the need for productive use of the power generated (apart from lighting and domestic uses only) would also increase. The demand for the locally fabricated SHP turbine would increase. All these would result to an increase in the demand for skilled personnel in these areas.

## 1.2 Demographic Trends

By the last census in 2006, Nigeria had a population of 1,390Million with an annual growth rate of 3.0%, to make it one of the fastest growing populations in the world. With a total area approximately 923,768Km$^2$, Nigeria is the tenth largest country in the world and located on the Equator.

It is demarcated into 36states and a Federal Capital Territory, with Abuja as Capital. It is also by far the most populous – the National Population Commission (NPC) has estimated that the population of the country would be 150million, 154million, 154.8million and 235.6million in the years 2000, 2010 and 2025 respectively. In other words, the population of the country would triple in the next 20years. In order, therefore, to even maintain the current low standard of living and quantity of life, the country needs to double the number of schools, health facilities, food production, housing, water supply, electricity supply etc. in the next 25years. This poses a great sustainable development challenge to Nigeria, one of which is energy infrastructure.

1.3 UNIDO Initiative.

In order to increase the percentage access to electricity and to promote rural industrialization, there is a need for increased electricity generation. With the current high cost of generation due to importation of electromechanical equipment, there is a need for an increased local content in the deployment of SHP plants for electricity generation. Local manufacturing of SHP equipment would lead to lowered cost of SHP development, job and wealth creation.

In order to support its initiative to promote Small, Mini and Micro hydropower in Africa, UNIDO had established a Regional Centre for SHP in Abuja, Nigeria in 2005. This UNIDO Centre is mandated to provide technical assistance to African countries in developing and implementing their SHP projects targeted to access clean energy to rural areas and creation of income generation opportunities through productive activities.

Subsequently, UNIDO Regional Center in collaboration with ECOWAS Commission organized an EGM in SHP development for West Africa during 7-9 August 2007 with the objective of formulating a strategy for SHP development in West Africa. During the EGM, experts from 11ECOWAS member states recognized enormous potential for SHP development in the Sub-region for eradicating poverty in the rural areas. However, they identified lack of technical capacity in the area of small hydropower in West African countries and emphasized the need for UNIDO to provide necessary capacity building as well as local fabrication of Micro and Mini hydro equipment in West Africa and strongly recommended UNIDO's intervention in the transfer and adaptation of Micro hydro equipment technology to West Africa. Therefore, this intervention is intended to develop local capacity in the design and manufacture of SHP turbines and generator systems in a sustainable way so that technology is widely disseminated as a means of provision of rural energy for productive uses.

Figure 1 below shows the geo – political map of Nigeria.

**FIG 1.0 MAP OF NIGERIA.**


**Location of the Project Site.**

| | |
|---|---|
| City and State : | Enugu , Akure |
| Travel Duration from Capital : | 5 hours by road. |
| Name of nearest Airport | Enugu and Akure |
| Travel from nearest Airport | 1 Hour |
| Name of nearest Port | Lagos and Port Harcourt |
| Travel from nearest Port | 5 Hours by road |

**Fig 2.0 MAP OF NIGERIA SHOWING ENUGU AND ONDO STATE**

## 2.0 HYDRO TURBINES MARKET ANALYSIS IN NIGERIA

### 2.1 Economic Situation.

Nigeria is richly endowed with both human and natural resources. The economy depended for a long time, to a large extent on oil revenue, which accounted for 90% of foreign exchange earnings in 2002. However, agriculture remains the main stay of the economy as it accounts for 40% of GDP, employs over 70% of the workforce and provides 90% of the non – oil export earning (2)

Recent CBN reports show that economic growth in Nigeria, which averagely is below 3% per annum from 1996 to 1999, took an upward turn between 2000 and 2001. Growth increased from 2.8% in 1999 to 4.2% in 2001 and declined to 3.3% in 2002. However, since population growth averaged 3% per annum over the period, this improvement in GDP growth made little impact on the standard of living in the country.

Poverty in Nigeria is associated with high unemployment, poor governance, corruption, lack of accountability, gross violation of human rights, nepotism and a skewed income distribution; additional factors include poor infrastructure and impaired access to productive and financial assets by women and vulnerable groups. Poverty has a gender dimension as women are overrepresented among the poor due to subordinate status of women, traditional and socio-cultural practices, discrimination and lack of access to assets and financial services. The incidence of poverty has increased over time. Available data from the Federal office of statistics indicate that although the incidence of poverty declined between 1985 and 1992 but since then, it has been on the rise. By 1996 it was estimated that approximately 65.6% Nigerians (67.1million people) lived below the poverty line. Poverty was more pronounced in rural than urban areas with poverty rates of 69.8% and 55.2% respectively.

Poverty incidence in the country for 1980, 1985, 1992, were 28.1, 42.1, 46.3 and 65.5 percent respectively. A common feature of poverty in Nigeria is that it is largely Rural based. However, there is an increasing evidence of pauperization of the urban areas, for instance, while the number of the poor in rural areas fell sharply from 26.3million between 1985 and 1992, those in urban areas rose from 9.7million to 11.9million in the same interval.

### 2.2 Electricity Generation.

It is estimated that, on the average, consumers are cut off from grid electricity for 10hours everyday. This has compelled many consumers (mostly industrial) to procure electricity generating sets for private use. The high cost of spare parts and fuel for running these generators make it uneconomical and inconvenient for use. The distribution of households in the country by types of electricity supply is presented in Table 2.2, which shows that about 80% of the rural populations have no electricity, which partly explains why the standard of living in the rural areas has remained low with poor economic growth.

**Table 2.0: Percentage of Households by Type of Electricity Supply.**

| Type of Electricity | Urban | Semi - Urban | Rural |
|---|---|---|---|
| No Electricity | 24.37 | 55.21 | 83.65 |
| PHCN Only | 73.32 | 38.80 | 13.24 |
| Rural Electricity Only | 1.85 | 5.99 | 2.81 |
| Private Generator Only | 0.23 | 0.00 | 0.29 |
| PHCN/Rural Electricity | 0.23 | 0.00 | 0.00 |

Rural Electricity generated by other organisation apart from PHCN

Electricity is an essential instrument for industrial, social, and economic development. With a very expansive landmass, the Power Holding Company of Nigeria has enormous task of extending the grid electricity to all the areas. At present, the country has only about 11,000 kilometers of Transmission lines. In view of the cost of equipment procurement, rehabilitation and repairs and the high running cost of diesel generators, there is need to consider other electricity generation resources as an alternative option, particularly for the rural areas.

## 2.3 Rural Electrification

The nationwide rural electrification programme aimed at connecting all Local Government Headquarters (LGHQ) and some other strategic and important towns and villages to the national grid is very crucial to the overall development of the country in general and particularly that of the rural areas. It is pertinent to note that of all the vital infrastructures necessary for the upliftment of our rural areas, the provision of electricity supply is undoubtedly the most important. Rural Electrification is, therefore, the key to the transformation of our rural areas from mere producers of farm products and fetchers of wood to an agro-based community with a standard of living rising above subsistence level. It is, therefore, obvious that the success of the nationwide rural electrification is crucial to the realization of the objectives of the nation's development programmes. This is particularly true with the poverty Alleviation/Poverty Reduction Programme of the Federal Government. This statement underscores the reason why the present Administration has made nationwide rural electrification one of its cardinal objective programmes for implementation.

The National Electrification Programme implemented during the period 1989 – 1999 was able to complete 340 projects, while additional 110 projects were carried out from 1999 – 2006. Fig. 3.0 below shows the level of electrification in Nigeria.

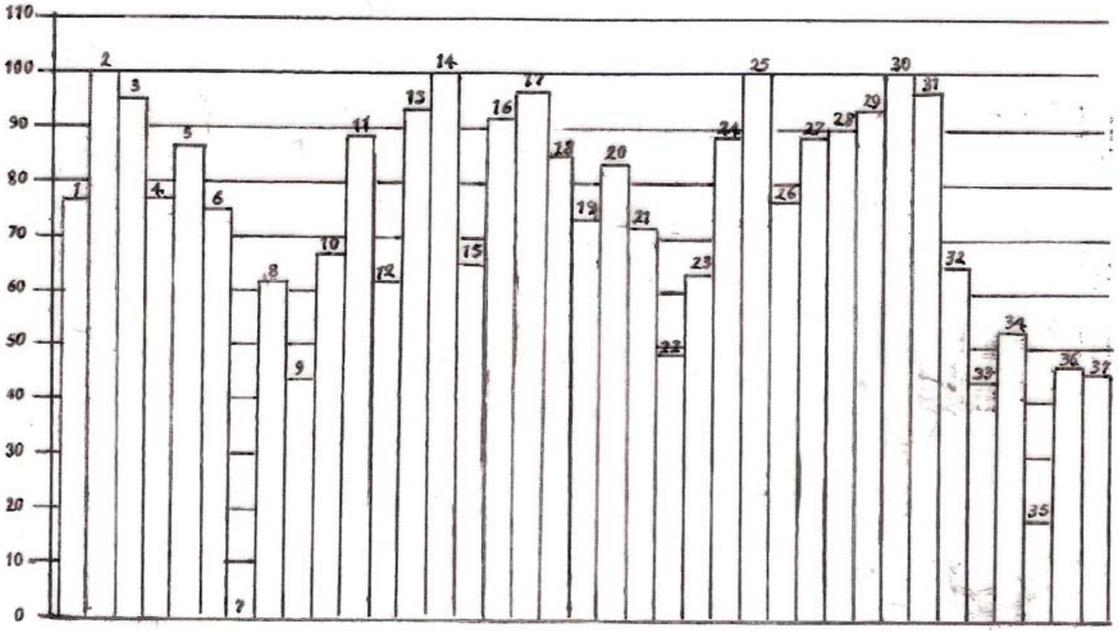


Fig 3.0

1. Abia 2. Abuja 3. Adamawa 4. Akwa Ibom 5. Anambra 6. Bauchi 7. Bayelsa 8. Benue 9. Borno 10. Cross River 11. Delta 12. Ebonyi 13. Edo 14. Ekiti 15. Enugu 16. Gombe 17. Imo 18. Jigawa 19. Kaduna 20. Kano 21. Katsina 22. Kebbi 23. Kogi 24. Kwara 25. Lagos 26. Nassarawa 27. Niger 28. Ogun 29. Ondo 30. Osun 31. Oyo 32. Plateau 33. Rivers 34. Sokoto 35. Taraba 36. Yobe 37. Zamfara

## 2.4 Access to (Modern) Energy Services

In Nigeria, less than 30% of households are connected to the national grid. Due to poor services and the high cost of electricity provided by the National Electric Power Authority (NEPA) now Power Holding of Nigeria, (PHCN) Nigeria’s sole monopoly, cooking and heating with electricity are limited to the affluent households that can afford standby generator. In the urban areas where LPG is available, it is very expensive and this has made its use unattractive to the majority. Kerosene prices are also very expensive and this has made its use unattractive to the majority. Kerosene prices are also very high in view of current deregulation in the downstream oil sector and the activities of middlemen in the distribution chain. On the whole, modern energy services account for less than 25% of fuel consumption in Nigeria. On the other hand, traditional energy services account for over 65% of Nigeria’s total fuel energy cost of cleaner modern energy sources. These traditional energy sources are generally inefficient and are of low quality and poor people’s energy choices are limited, as they cannot afford to pay for the efficient modern energy services.

## 2.5 Market Potential

The major / key drivers for the Turbine market in Nigeria are population growth; government – sponsored programs such as NEEDS; MDG's; Rural electrification; access to rural energy; high cost of fuel; O & M related expenses associated with diesel based generator sets together with the unreliability of fuel supply. These factors are currently prevalent in the Nigerian economy and are the basis for fuel interchange / alternative fuels such as the Small Hydropower that operates on hydro turbines.

### 2.5.1 Renewable Energy Programme

The energy policy for Nigeria launched in 2005 has further been followed with an Energy master plan. The Federal Govt of Nigeria has a 10yr target for the contribution of RETs to the economy – (2007 - 2017).

The target in MW based on peak demand from SHP are 40(2007); 100(2008) and 400(2016). Planned Small hydro electricity project are shown in Table 2.6 below.

**Table 2.1: Small hydro Electricity Projection in Nigeria**

| No of System | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cumulative No. of Systems.<br>(Ave.nominal power = 10MW) ,<br>Cum. power, MW | 0<br>0<br>0<br>0 | 1<br>1<br>10<br>10 | 2<br>3<br>20<br>30 | 4<br>7<br>40<br>70 | 5<br>12<br>50<br>120 | 5<br>17<br>50<br>170 | 5<br>22<br>50<br>220 | 5<br>27<br>50<br>270 | 5<br>32<br>50<br>320 | 5<br>37<br>50<br>370 |
| Sys cost A @ US$1500/Kw, $m<br>Sys cost B @ US$2000/Kw, $m<br>Sys cost C @ US$2500/Kw, $M | 0<br>0<br>0 | 15<br>20<br>25 | 30<br>40<br>50 | 60<br>80<br>100 | 75<br>100<br>125 | 75<br>100<br>125 | 75<br>100<br>125 | 75<br>100<br>125 | 75<br>100<br>125 | 75<br>100<br>125 |
| Sys cost A @N130/US$,bN<br>Sys cost B @N130/US$,bN<br>Sys cost C @N130/US$,bN | 0<br>0<br>0 | 1.95<br>2.6<br>3.25 | 3.9<br>5.2<br>6.5 | 7.8<br>10.4<br>13 | 9.75<br>13<br>16.25 | 9.75<br>13<br>16.25 | 9.75<br>13<br>16.25 | 9.75<br>13<br>16.25 | 9.75<br>13<br>16.25 | 9.75<br>13<br>16.25 |
| 1000 Tons $CO_2$ saved (If natural gas used) | 0 | 13.14 | 26.28 | 52.56 | 65.7 | 65.7 | 65.7 | 65.7 | 65.7 | 65.7 |
| 1000 Tons $CO_2$ saved (If fuel oil used) | 0 | 19.053 | 38.106 | 76.212 | 95.265 | 95.265 | 95.265 | 95.265 | 95.265 | 95.265 |

Typical characteristics of some of the SHP designed for implementation are shown in Table 2.2

## 2.6 Hydro Sites in Nigeria

The SHP development programme conceived and implemented by UNIDO and Energy Commission of Nigeria has generated well over 200 identified potential sites at different levels of investigation / studies. More than 30% of the states have indicated interest in the development of potential sites in their different states.

Hydro sites, existing and those being developed are shown in Fig 4.0. The total number of identified sites for SHP development is over 200 across the country. A quick glance shows that about 20% of these sites are at advanced stages of investigations. However, Table 2.2 shows some investigated potential sites at corresponding level of investigation. The range of these sites, apart from the waterfall is (1.5-40) m, which falls squarely within the Crossflow turbine application range. The average capacity lies in the micro/mini scheme class, which is the type of scheme that meets the demand by rural communities from earlier studies carried out.

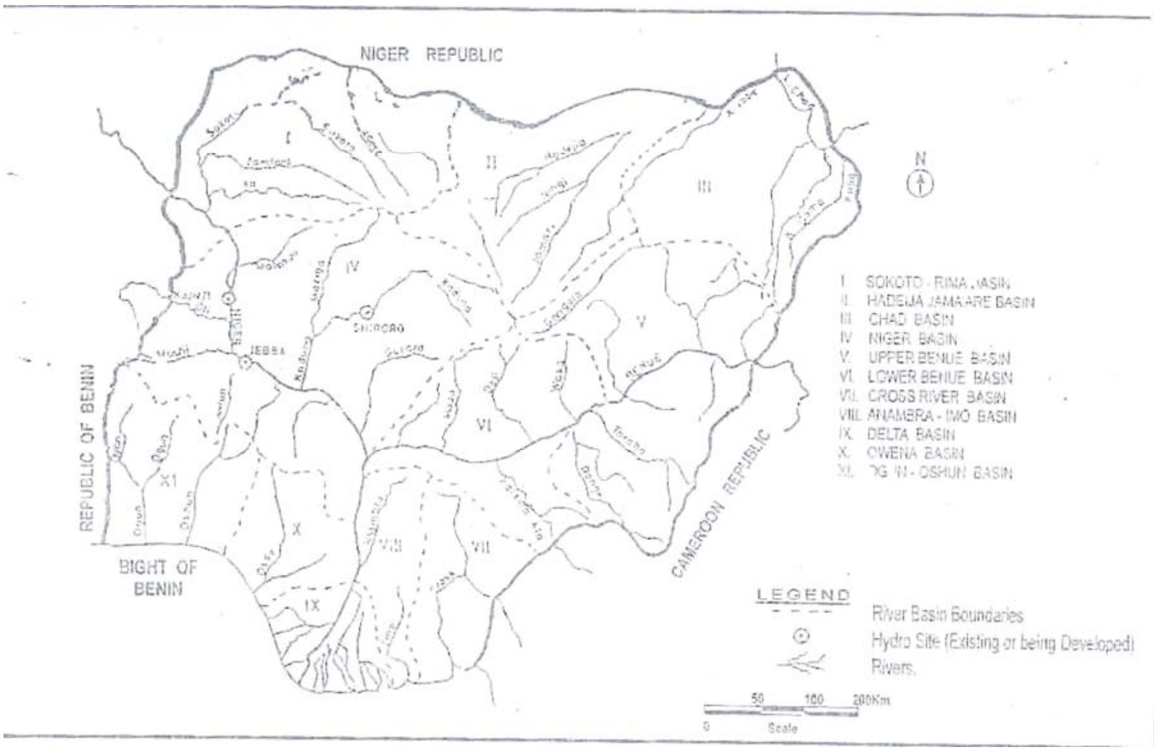


Fig 4.0 Nigeria River System and Basins

**Table 2.2 Investigated Potential SHP Sites**

| S/N | Location/State | Town | LGA | Water Head | Discharge $m^3/s$ | Potential Cap. (MW) | Stage of Investigation |
|---|---|---|---|---|---|---|---|
| 1. | Jiba | Jiba | Jiba | 18.0 | 290-400 | 31.3 | Pre-feasibility |
| 2. | Fajina | Ajiwa | | 12.5 | 400-5 | 30.0 | ‘‘ |
| 3. | M/Fashi/Katsina | M/Fashi | M/Fashi | 12.0 | 329-553 | 23.0 | ‘‘ |
| 4. | Mairuwa/Katsina | Funta | Funta | 8.0 | 350-550 | 16.8 | ‘‘ |
| 5. | Gwaigwaiye /Katsina | Funta | Funta | 12.0 | 600-900 | 43.2 | ‘‘ |
| 6. | Zobe/Katsina | Dutsinma | | 19.8 | 600-900 | 71.3 | ‘‘ |
| 7. | Sabke | Mapadua | | 12.5 | 250-350 | 18.7 | ‘‘ |
| 8. | Iddo/Osun | Iddo | Oriade | 12.5 | 2.699 | 0.24 | ‘’ |
| 9. | Sepeteri/Oyo | Sepeteri | Shaki East | 14.23 | 1.984 | 0.17 | ‘‘ |
| 10. | Oke-adan/Oyo | | Yaw South | 16.0 | 2.245 | 0.22 | ‘‘ |
| 11. | Erin-Ijesa/Osun | Erin-Ijesa | Oriade | 230.0 | 0.910 | 1.3 | ‘‘ |
| 12. | Owena/Ondo | Owena | Bolorunduro | 22.5 | 7.79 | 1.1 | ‘’ |
| 13. | /Edo | Ugonoba | Uhunmode | 10.0 | 8.09 | 1.49 | ‘‘ |
| 14. | Itapaji/ Ekiti | Itapaji | Oye | 21 | 2.00 | 0.30 | DPR |
| 15. | Eficghim/Cross River | Ajassor | Etung | 19 | 3.00 | 0.20 | DPR |
| 16. | Doma/Nasarawa | Doma | Doma | 29 | 2.22 | 0.45 | DPR |
| 17. | Okinni/Osun | Okinni | Egbedore | 20 | 12.80 | 1.90 | DPR |
| 18. | Ero / Ekiti | | | 27 | 2.95 | 0.557 | |
| 19. | Numan/Adamawa | | | 15.77 | 57.13 | 6.30 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20. | Ikpoba/Edo | | | 8.40 | 25.19 | 3.20 | |
| 21. | Monkin/ Adamawa | | | 18.00 | 3.17 | 0.90 | |
| 22. | Evboro/Edo | Benin | Ovia S.W | 5.00 | 1.72 | 0.020 | Feasibility |
| 23. | Agih -2/Niger | Aboh | | 9.00 | | | |
| 24. | Ikun/Niger | Iknu | | 8.50 | | | |
| 25. | Itu/C-River | Itu | | 5.8 | | | |
| 26. | Erinle/Osun | Ede | | 10.5 | | | |
| 27. | Opeki/Oyo | Poeki | | 12.5 | | | |
| 28. | Konsi/Oyo | Ighono | | 10.0 | | | |
| 29. | Okugha/Oyo | Ayete | | 10.0 | | | |
| 30. | Yewa/Ogun | Egger | | 2.65 | | | |
| 31. | Yewa/Ogun | Yewa – mata | | 3.38 | | | |
| 32. | Onitsha/Anambra | Onitsha | | 5.65 | | | |
| 33. | Ikeji Ile/Osun | Ikeji/Osun | Oriade | 10.00 | 0.20 | 0.011 | DPR |
| 34. | Kwa falls/C-River | Aningeje | Akamkpa | 25 | 4.7 | 0.70 | Prefeasibilty |
| 35. | Buinya Irruan/C-River | Buinya Irruan | Boki | 20 | 0.12 | 0.014 | Prefeasibility |
| 36. | Bebi Strip/C-River | | | 15 | 0.13 | 0.0120 | Prefeasibility |
| 37. | Umana Dam | Umana | | | | | |
| 38. | Inyishi Dam/Imo | | | | | | |

## 2.7 Market Projection

A quick review shows the market windows for the project as Renewable Energy Programme; Rural Electrification Programme, SHP projects, the as well as the bulk potential sites already identified or investigated for which DPR are yet to be developed.

Overall, the estimated small Hydro Power demand (3) projected upto 2030 is shown in Table 2.3 This estimated potential is for sites already identified and yet to be studied, as well as those sites at advanced level of investigation.
However, a threshold of 740MW, which is for, investigated sites in Nigeria gives a revised potential as shown in Table 2.8

**2.3 ESTIMATED NIGERIA SMALL HYDRO POWER DEMAND**

| S/N | Year | Estimated Demand (mW) | Estimated Potential (mW) | Revised Potential /MW |
|---|---|---|---|---|
| 1. | 2000 | 190 | 500 | 100.0 |
| 2. | 2005 | 300 | 500 | 100.0 |
| 3. | 2010 | 500 | 1.500 | 300.0 |
| 4. | 2015 | 750 | 2,000 | 400.0 |
| 5. | 2020 | 1,300 | 2,500 | 500.0 |
| 6. | 2025 | 2,100 | 3,000 | 600.0 |
| 7. | 2030 | 3,315 | 3,500 | 700.0 |

Source Energy Commission of Nigeria

## 3.0 SELECTION OF SITE / INSTITUTION

The general features of an average Turbine consists essentially of four main components: the casing, the gate apparatus, the runner and the draft tube.

The production of these components simply involves the following mechanical activities: machining/assembly; working of spiral case, draft tube etc; Forging, Moulding and Casting. These activities require workshop facilities indicated in A-3.1

The equipment required for manufacturing these components, as well as the relevant tools are is shown in A- 3.2

It is obvious that in addition to the mechanical, the human resource (skills) as well its management is necessary in the manufacturing process. All these inputs contribute to, amongst others, the basic requirement for local manufacturing of the cross flow turbine.

It is equally important to state that the mechanical activities mentioned above are common to other useful items of the production and manufacturing sector of an economy. In the choice/selection of a site, it is necessary to carry out a survey of some identified R & D institution / organizations in the country.

### 3.1 Detailed Survey of Sites.

The following identified R&D institution or organization were visited one after the other, with a view of physically inspecting the facilities on ground; interact with the management and appraise the level of human skills within its operational capacities and activities.

1. Project Development Agency, Enugu (PRODA)
2. Hydraulic Equipment Development Institute NASENI (HEDI), Kano.
3. National Agency for Science and Engineering Infrastructure (NASENI) Idu-Karimo, Abuja
4. Engineering Material Development Institute NASENI (EMDI), Akure
5. Science Equipment Development Institute NASENI (SEDI), Enugu.

The detailed survey for each R&D institution / organization is shown in
A – 3.3

### 3.2 SELECTION CRITERIA

In the choice of an R&D institution/organization a scoring methodology was used. The technical requirements as well as human skills have been emphasized in the scoring points and shown in Table 3.0 below.

**Table 3.0** **SCORING ITEMS AND POINTS**

| | | |
|---|---|---|
| 1. | Workshop facilities available | 10pts |
| 2. | Equipment available | 10pts |
| 3. | Tools available | 10pts |
| 4. | Land / Premises | 5pts |
| 5. | Skills | 10pts |
| 6. | Organization structure | 5pts |
| 7. | R & D Facilities | 5pts |
| 8. | Duration of Activities Existence | 5pts |
| | Total | 60p |

### 3.3 Scoring and Analysis

Scores allocated in line with criteria shown in Table 3.0 are shown in Table 3.1 below for all organizations surveyed. NASENI Headquarters coordinates the activities of the development institutes surveyed.

Table 3.1 SCORING OF SURVEYED INSTITUTE.

| S/N | Scoring Items | PRODA | NASENI HEDI | NASENI SEDI | NASENI EMDI |
|---|---|---|---|---|---|
| 1. | Workshop Facilities | **6** | **6** | **8** | **8** |
| 2. | Equipment available | **6** | **6** | **8** | **8** |
| 3. | Tools available | **8** | **8** | **8** | **8** |
| 4. | Land / Premises available | **8** | **8** | **8** | **7** |
| 5. | Skills | **8** | **6** | **7** | **7** |
| 6. | Organization Structure | **4** | **4** | **4** | **4** |
| 7. | R & D Facilities | **4** | **3** | **4** | **4** |
| 8. | Existence Duration | **4** | **2** | **3** | **3** |
| 9. | Total | **48** | **43** | **50** | **49** |

All the institutes under NASENI are relatively young R & D institutes with modern machines. PRODA is much older with more obsolete machines. The two organizations NASENI and PRODA are comparatively strong for the project, implementation. However, NASENI /SEDI has the highest score of 50 pts and so selected.

## 4.0 TECHNICAL ANALYSIS

### 4.1 Basic Concept and Selection of Turbine.

Hydro – turbines are usually designed for specific applications and outputs, and services depending upon how much water is available every year. A good understanding of energy requirements and characteristics of water resources is essential for proper selection of hydro – turbine Scheme.

The selection of turbine is based on the head, the flow rate and output rating. The three categories of hydro schemes are:

- High head – 150m above
- Medium head – 20m to 150m
- Low head – 2m to 20m

Low head schemes are generally Run - of – River Schemes with a low high barrage or weir across a river or canal.

An analysis of Table 2.2 shows the bulk of the sites to be exploited are in a head range of 2.65m – 29m with the exception of the waterfall (230m)

### 4.2 Types of Turbines

There are two common classifications of turbine. The reaction turbine and impulse turbine and they are dictated by the water flow action and structural features. It is further differentiated by the flow direction in the passage of the runner. The turbine may further be classified by its arrangement of shaft as vertical and horizontal, and by its feature as fixed blade and adjustable blade etc.

The classification of small turbine and its application head range are shown in Table 4 – 1 below:

Table 4 .1 Small Turbine Classification

| Energy Conv | S/N | Flow Direction | Head Range (m) |
|---|---|---|---|
| Reaction | 1. | Tubular | 2 – 15 |
| | 2. | Axial flow | 3 – 30 |
| | 3. | Diagonal flow | 30 – 120 |
| | 4. | Francis | 30 – 150 |
| Impulse | 5. | Pelton | 100 – 180 |
| | 6. | Turgo | 20 – 300 |
| | 7. | Cross flow (Mitchell - Banki) | 8 – 80 |

#### 4.2.1 Justification of Cross – flow Turbine

The feature of the water characteristics of sites to be developed shows a large swing for low head turbines. In this head range only the Cross –flow in the impulse group and the Tubular, Axial flow in the Reaction group of turbines, but more of Tubular.

Comparatively, impulse turbines have free surface flow on the runners and rotate in air and not in water as the reaction turbines.

Impulse turbines convert all the net head into kinetic energy in a nozzle. Generally, the impulse turbines do not have draft tubes whereas the reaction turbines do. Since it makes sense to start such a project by designing simple, less complicated, small turbines and build up experience gradually, the choice is to start with an impulse turbine.

The energy generated is equally important in the choice of turbines. Most of the sites to be developed are below 500KW capacity. In the case of power output below 500KW, the Cross – flow competes well with Francis and Pelton turbines.
Similarly, turbines with relatively low power outputs are likely to be horizontally mounted and has a wide range of relative discharge $0.4 > Q/Q_1 < 1.0$
Hence, the Cross – flow turbine is recommended for ease of manufacture and 'leap – frogging' the technology for domestication in the Country.

### 4.3 Crossflow (Banki) Turbine.

The **Banki turbine** (also known as the **Michell**, **Crossflow** or **Ossberger** turbine) is a hydropower system similar in appearance to an over-shot water wheel. Unlike the water wheel, however, it uses a nozzle and blades instead of buckets. The "middle" of the Banki turbine is left open and the blades that would normally form the walls of the buckets are angled. It is, in effect, a "leaky" water wheel.

Water flowing into the top of the turbine not only spins the wheel by its weight, but as it flows past the blades and into the middle of the turbine, its direction is changed. This extracts additional power via Newton's Third Law. A venturi enhances this effect by funneling the water at a high speed onto the blades.

The Banki turbine uses concepts from both impulse and reaction turbine design. This allows it to perform well in a wide range of heads. The system is somewhat similar to the Pelton wheel in concept, but requires less engineering in the wheel itself.

The Banki turbine has lower efficiency than other turbine designs but enjoys a niche market for low cost and home made installations. A reasonably efficient turbine runner can be constructed from pipe sections that are slit to form the blades (70% - 80% efficiency at 10 feet of head). The venturi and associated plumbing may be fabricated with sheet metal tools. It is somewhat more complex than in an over-shot wheel, but by no means difficult. A locally made Crossflow (Banki) turbine that has same power as a large Diesel engine is within the means of most small and amateur workshops.

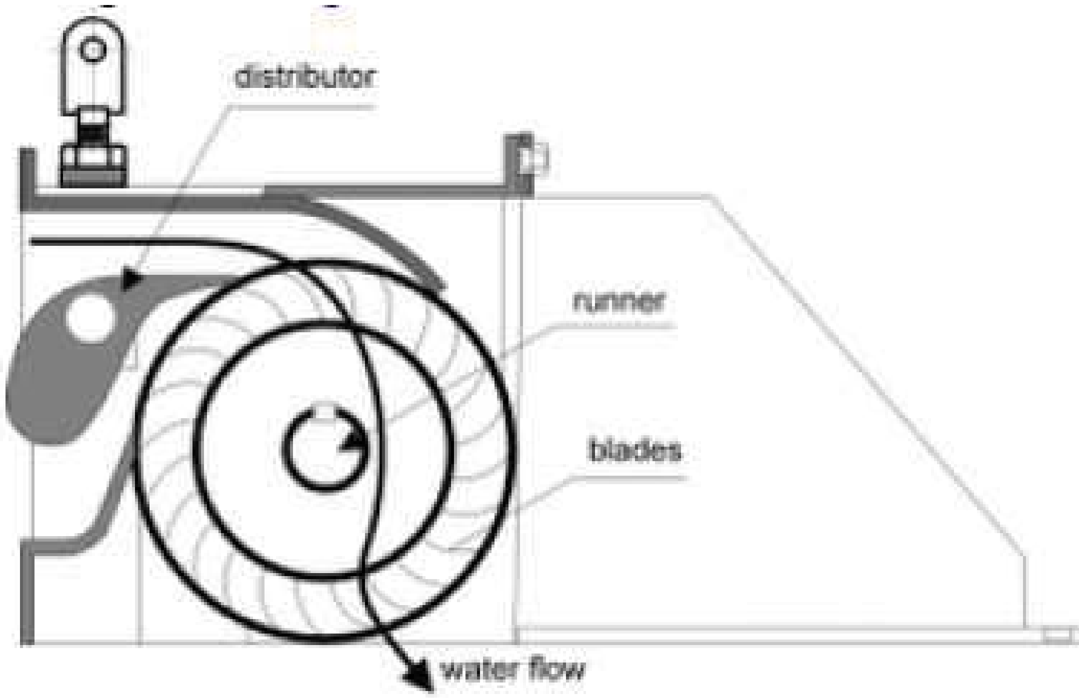


**Figure 5.0** A Banki Turbine

## 4.4 TURBINE DESIGN ISSSUES

As discussed earlier, the design of the turbine starts with the static head of water available. But first of all, let us look at the features of a Cross flow Turbine. It consists essentially of four main component; the casing, the gate, the runner and draft tube.

i. Casing: Conventionally, the casing is spiral in shape. However, for low heads, the spiral casing can be dispersed with, and the turbine is placed in an open flume.
ii. The GATE Apparatus: This consists of a ring of guide vanes, which control the direction and quantity of water reaching the runner. The guide vanes are arranged to swivel together based on an interconnected linkage system. Each vane is provided with a safety device such as shear pin, which will break if an obstruction prevents closure of the vane.
iii. The Runner: This extracts the whirl components of water, converts it to rational energy and discharges the water with minimum whirl or minimum absolute velocity.
iv. The Draft Tube: This is long tap eying pipe, which conveys the discharged water from the runner to the tailrace and recovers from it the kinetic energy. The simplest form of draft tube is conical in shape, with cone angle of 5º to 7º

### 4.4.1 RUNNER DESIGN

The design of the runner is based on:

a. The selection of suitable runner coefficient which is a function of the specific speed.
b. Consideration of velocity diagram.
c. Consideration of changes of velocity in the runner passages.

The specific speed of a turbine is defined as

$n^s$ =N
Where $n^s$ = specific speed
N = rotational speed of turbine rev/mm
W = Power output of turbine
H = effective static head of water
The runner coefficient defined as
Φ = u
Φ = is the runner coefficient at a given point.
u = is peripheral velocity at that point
Charts are available to determine at various points on the runner as a function of ns, the specific speed at the inner and outer profiles and the water entry and water exit edges.

The actual runner dimensions are obtained by using the equation

$$D = \frac{60u}{LlN} \quad \text{------------------------------------------------------------------ } 1.0$$

Where D is the diameter at the point considered.

Graphs also enable us to determine the height of the guide vane B

Consideration of the velocity diagram enables us to calculate the guide vane exit angle and the runner blade inlet angle.

The number of vanes can be determined based on the speed.

Having determined the dimension of the turbine runner, we must now look at the other critical areas of the designs. The runner must be supported by a shaft. To design the shaft, we must decide on the nature of bearing supports we need. It will be safe to assume that power out – take from the shaft is by means of a pulley to the gearbox and alternator.

For the bearing supports, we have a choice of one thrust bearing with two guide bearings or one tapered roller bearing with one guide bearing. If the turbine runner is not too heavy, the $2^{nd}$ alternative will suffice. But if it is too heavy, then it is best to use a thrust bearing with two guide bearings. With this decision, we can design the shaft, which is a straightforward calculation.

## 4.5 CHOICE OF MATERIALS AND MANUFACTURE METHODS

### 4.5.1 Turbine Runner:

The turbine runner can be cast integrally in plain carbon or stainless steel. One best practice is to cast the hub, and form the blades from steel plates. If it is desired, the surfaces could be protected by chrome plating. The blades are then bolted to the hub.

### 4.5.2 Shaft:

The shaft is machined from carbon steel bar stock – plan carbon steel. At this stage one machine shop and one foundry are sufficient.

#### 4.5.3 Bearing Housing:
Sometimes, it may be difficult to obtain standard bearing locally. In that case, they can be made by casting and machining, or machining from bar stock. One area that needs special attention in the bearing and housing is the sealing and lubrication arrangement.

#### 4.5.4 The Gate Apparatus:
The top and bottom discs can be made from mild steel plates. The same with the guide vanes. The top pins of the guide vanes rotate in either brass or Teflon bushes.

#### 4.5.5 Pulley:
This will be machined from bar stock or may be produced by casting and machining.

#### 4.5.6 Gear Box:
Where it is not possible to purchase a gear system with the right speed ratio, the gear system can be produced by machining.

### 4.6 Recommended Manufacturing Procedure
The following procedure is suggested for the actualization of the project:

1. Select site
2. Carry out hydrological and load surveys. – Site capacity determination
3. Constitute turbine sub-team, and provide with data on head, power requirement and maximum water out – take.
4. The team carries out the design up to the stage of working drawings and detailed methods of production. The team will also identify where each component will be made. At this stage one machine shop and one foundry are sufficient. The design could be completed within one month.
5. The components are manufactured with adequate supervision by the team – two months
6. The components are subjected to necessary quality control and are assembled and tested in-house.
7. At the design stage, the basic requirement for flume, the turbine support structure and the draft tube will be determined, and given t o the site design team. The data should include foundation and bolting down requirements.
8. When the site structures are ready, the turbine will be installed on site, and basic test – runs will commence.
9. On successful commission of the power plant, seminars and workshops on the process and lessons learnt will be organized to train more potential small turbine manufactures.

### 4.7 Work plan Spreadsheet
A work plan on spreadsheet is attached – A- 4 and made up of the following major activities:

Identification and Preliminary Assessment of facilities.
Team of Experts Visit
Bidding, Selection and Award of contacts
Additional facilities Procurement
Real and Model SHP Components
Production of Selected SHP components
Capacity building: Training the Trainers
Fabrication of SHP components parts

Assembly and Testing
Commercialization.

#### 4.7.1 Assessment of Facilities

A basic requirement of workshop facilities and equipment/tools for designated workshops as shown in 3.0 was used by RC in carrying out a detailed survey of facilities for the R & D institutions listed below:

NASENI (HEDI), Kano
NASENI (SEDI), Enugu
PRODA Enugu
NASENI (EMDI), Akure

#### 4.7.2 Team of Experts Verification

A brief report on surveyed sites shows inadequacy in specifications of some equipment as well as the functional capacity. This prompted a revisit to the following institution's location:

NASENI (HEDI), Kano
NASENI (SEDI), Enugu
PRODA, Enugu
NASENI (EMDI), Akure

The recommendation by the team of experts for additional facilities is shown in A – 4.2
The estimated cost of this activity is 5,000USD for 14days work duration.

#### 4.7.3 Bidding, Selection and Contract Award

In line with the Due Process Regulations in Nigeria, it is necessary to prepare a bidding document; publicly advertise the intention of procurement; open and assess submitted bids, select winners and award the contract for supply of the items bides. The duration for the activity is 30days with an estimated cost of 5,000.00USD

#### 4.7.4 Procurement of Additional Facilities

The procurement, shipment, delivery to project site, installation and testing of these additional facilities is projected for 6 weeks at an estimated cost of 1,000,000.00 USD.

#### 4.7.5 Real Model SHP Component Procurement.

In order to facilitate smooth production and training, the need to procure real and model SHP equipment becomes important and crucial. It is projected that identification; procurement and shipment should take 35days at an estimated cost of 60,000:00 USD.

#### 4.7.6 SHP Component Production.

In establishing and specifying standards to be adopted, existing documents such as IEC/TC-44, AHEC and IN-SHP should be of immense value.

These specified standards will conform to international standards and ease the preparation of relevant engineering drawings, as well as the preparation of the manufacturing layout. These activities are projected for 60days at an estimated cost of 10,000: 00 USD.

#### 4.7.7 Training the Trainers

It is planned in the transfer of this technology; to train identified experts outside Nigeria and on return commission them on the local fabrication of hydro turbines.

In this respect UNIDO has put in place plans for the above and to be implemented as soon as firm commitment is made by all parties involved in the project. This activity primarily involves capacity Building in SHP Equipment Manufacturing. It is projected to cover a period of 65days at an estimated cost of 54,000:00USD

### 4.7.8 Fabrication of SHP Components

The model SHP (sample) component parts, the manufacturing layout, and test equipments once in place at the designated workshop, signals commencement of fabrication. Once the components are fabricated, testing follows and then certification. The requirement and tolerance for each component part of SHP is given in detail in (6). The projected duration for this activity is 42days with an estimated cost of 69,000:00USD

### 4.7.9 Assembly and Testing

The certified components parts are then moved to the designated workshop for assemble into integrated SHP equipment. The SHP equipment performance is then established as functioning equipment on a potential site earlier developed for same capacity of equipment. The duration for this activity is projected as 29days at an estimated cost of 10,000:00USD.

### 4.7.10 Commercialization

A business plan is drawn up once the performance test is okay for the SHP equipment manufactured. An investor's forum is then planned and implemented to commence the process of commercializing the product. The commercialization activity is projected for 24 days with an estimated cost of 25,000:00USD

### 4.7.11 Project Implementation Meetings

As it is common, with all profits, it is necessary to hold regular, monthly meetings once the project commences. This provides the unique opportunity of nipping in the bud, some exigencies/issues/matters that have not been considered in the overall planning and design of the project. 11no meetings are planned for the whole project implementation duration at an estimated cost of 550:00 USD per meeting totaling 5,500:00USD.

### 4.7.12 Project Implementation Cost.

The Technical Analysis discussed above gives a project implementation cost estimate of 1,253,000:00 USD for an implementation period of 378days – Table 4.2

**Table 4.2 PROJECTED MANUFACTURING COST ESTIMATE AND DURATION.**

| S/N | Activity | Estimated Cost (USD) | Duration (Days) | Remarks |
|---|---|---|---|---|
| 1. | Facilities Assessment | 10,000:00 | 25 | |
| 2. | Expert Team visit | 5,000:00 | 14 | |
| 3. | Bidding / Contract Award | 5,000:00 | 30 | |
| 4. | Procurement of Additional facilities | 1,000,000:00 | 44 | |
| 5. | Procurement of model SHP | 60,000:00 | 35 | |
| 6. | Design of SHP components (Engineering drawings) | 10,000:00 | 60 | |
| 7. | Training of Trainers | 54,000:00 | 65 | |
| 8. | Fabrication of SHP Components | 69,000:00 | 42 | |
| 9. | Assembly and Testing | 10,000:00 | 29 | |
| 10. | Commercialization | 25,000:00 | 23 | |
| 11. | Project meetings | 5,500:00 | 11 | |
| | Total | 1,253,000:00 | 378 | |

## 5.0 Financial Analysis:

The financial analysis was prepared using the Break-Even, Net Present Value (NPV) and Payback Period methods..

**Table 5.1 Break-Even Analysis**

| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Turbines (Qty) | 1 | 2 | 3 | 4 |
| Turnover (NGN | 4,800,000 | 9,600,000 | 14,400,000 | 19,200,000 |
| | | | | |
| Fixed Cost | 2,356,000 | 2,356,000 | 2,356,000 | 2,356,000 |
| Variable Cost | 2,746,000 | 5,492,000 | 8,238,000 | 10,984,000 |
| Total Cost | 5,102,000 | 7,848,000 | 10,594,000 | 13,340,000 |
| | | | | |
| Margin | (302,000) | 1,752,000 | 3,806,000 | 5,860,000 |

***Interpretation*** Our fixed cost was arrived at after adding up the following: investment cost depreciated (straight line) over 30 years, engineers salary cost. Other costs were assumed to be variable as they have a direct relationship with quantity produced. With the foregoing assumptions the project reported a break-even quantity of 2 turbines annually.

### 5. 2 NPV Analysis

| | | | | | |
|---|---|---|---|---|---|
| Total Project Cost | 30,360,000 | NGN | **Selling Condition** | | |
| Capital Cost per Turbine installed capacity | 337,333 | NGN | Selling Price | 4,800,000 | NGN/Turbine |
| Capital Cost per Turbine installed capacity | 2,811 | US$ | Turnover | 1,200,000 | NGN/month |
| 1 US$ = | 120 | NGN | Increase | 8% | Per Annum |
| Plant Capacity/Annum (Year 0) | 3 | Turbine | Capacity (30yrs) | 90 | Turbines |
| Annual Demand Growth | 2 | % | | | |
| Average Annual Inflation | 8 | % | | | |
| Average Interest/Discount rate | 12 | % | | | |
| Service Life | 30 | years | NPV | 5,004,891 | NGN |
| O&M/Turbine | 4,030,000 | NGN/turbine | FIRR | 13.38% | |

***Interpretation***: With a discount rate of 12% and a life span of 30 years, our projected cash flow is worth NGN35.4 million today, which is higher than the initial NGN30.4million paid in order to start the project. The resulting NPV of the above project is NGN5million which means the project will receive the required return at the end of the project. Therefore pursuing the above project will definitely be an optimal decision.

## 5.3 Payback Analysis

| | | |
|---|---|---|
| Total Project Cost | 30,360,000 | NGN |
| 1 US$ = | 120 | NGN |
| Production/Annum (Year 1) | 3 | Turbine |
| **Payback Period** | **7.75** | **Years** |

***Interpretation***: With a project cost of 30.4million and a varied net cash flow as shown in the attached table the project would be completely paid for in the 9th month of year 8th, otherwise stated as 7.75 years.

## 6.0 SUSTAINABILITY PLANS

When the local people in the communities are involved in the development of Small Hydro projects and the local content of the projects increases, installation costs are reduced. Security of equipment and investment are also guaranteed, as such are viewed as community investment. Examples from Kenya and other developing countries like Peru and Sri Lanka have shown that Small Hydro projects can be **self sustaining** and profitable.

Measures already in place, policy – wise, institutional framework, regulatory mechanisms e.t.c. are summarized as:

- Policy and Targets for SHP contribution to the Power Vision of Nigeria by FGN
- Establishment and nurturing of appropriate and dynamic Science and Engineering Infrastructure base for achieving home initiated and home sustained industrialization through the development of relevant processes, capital goods and equipment necessary for job creation, national economic well being and progress by NASENI.
- UNIDO – RC – SHP in Africa, Abuja established with the mandate of providing technical assistance required for the deployment of SHP for electricity generation in the African sub region.
- Training of trainers by UNIDO's technical partners who will train private entrepreneurs for quick results and commercialization of product (Turbine) - SME
- Producing under license of EU Company for competitiveness in the international and regional markets.
- Low production cost for competitive pricing
- Continuous Sensitization and awareness creation of the communities on benefits of SHP towards barriers removal
- Mechanism for Productive energy uses of SHP plants as demonstrated by UNIDO Pilot SHP projects in Enugu and Bauchi.
- Education Information dissemination of benefits of SHP to communities on regular basis.
- Electricity Act 2005 encouraging Public Private Participation (PPP) as well as Independent Power Production (IPP)
- Scaling – up, replicating and mainstreaming as tools for linking micro level energy activities to macro – level national priorities e.g. NEEDs II, NAPEP, MGD etc
- Markets creation for SHP through new financing options – Local funds, aids and grants, foreign direct investment (DFID,WB,$A_F$DB) and Carbon financing.
- NATIONAL Energy Policy (NEP), Energy Master plan (EMP) and regulatory framework (NERC)
- Appropriate financial mechanism for scaling up SHP projects under consideration by FGN
- South – South Cooperation encouraged by UNIDO.

## 7.0 Conclusion

African countries have significant hydropower and specifically SHP sources which if exploited can contribute greatly to the overall energy needs of the continent. Exploiting these resources will require overcoming the major technical, institutional and financial barriers. However, the significant lesson for countries in Africa is to scale-up the SHP in the continent. Presently, the continent has the highest rate of return on investment and this feature should be fully exploited for the development of small hydropower.

Sustainability plans for the project must recognize and put in place the following:

Regulatory framework – Predictable
Stable investment framework
Long – term strategic policy commitments – Govts
Identifying indicators that drive sustainability of clean energy investments
Stabilizing these indicators to allow sustainability returns
Engaging stakeholders – statutory, non – stability and public consultation.

Energy is central to sustainable development and poverty reduction efforts. It affects all aspects of development – social, economic and environmental – including livelihood access to water, agricultural productivity, health, population levels, education and gender – related issues.

World leaders have pledged to achieve the millennium Development Goals, including the overarching goal of cutting poverty in half by 2015. Meeting the M.D.G will require concerted international efforts to bring about major increases in people's access to modern energy services in D.C.

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## WORKSHOP REQUIREMENT

1. Machine shop
2. Working shop
3. Forging shop
4. Foundry shop
5. Repair shop
6. Substation
7. Electrical shop
8. Quality Control shop

## REQUIRED MANUFACTURING EQUIPMENT

1. Circular saw
2. Hand saw
3. Centre Lathe – Width 900mm min
   Height 250mm min
4. Milling machine
5. Planning/ shaping machine
6. Arc welding equipment
7. Boring machine
8. Drilling machine
9. Grinding machine
10. Bending machine / Press
11. Gas cutting equipment
12. Shearing machine

## REQUIRED TOOLS.

13. Hammers
14. Screw drivers
15. Allen key set
16. Open spanner set
17. Ring spanner set
18. Socket spanner set
19. Files, chisels
20. Centre punch
21. Vernier calipers
22. Puller
23. Vice etc.

| DETAILED SURVEY OF FACILITIES FROM SMALL HYDRO TURBINE MANUFACTURING IN NIGERIA | | | | | | |
|---|---|---|---|---|---|---|
| INSTITUTION: **PRODA, ENUGU**. TYPE OF WORKSHOP : **FABRICATION WORKSHOP** DATE: **23/7/08** | | | | | | |
| **S/N** | **DESCRIPTION OF EQUIPMENT** | **SPECIFICATION/CAPACITY** | **APPLICATION** | **MAKE/MODEL** | **STATUS** | **AVAILABLE SKILLS** |
| 1 | Universal Punching Machine | 50 tonnes | Drop forging and punching of holes | Bombay Machine Company, India | Good | |
| 2 | Round Rolling Machine | $14cm^3$ | Rolling of angles and bars | Hassleholm, Sweden | Good | |
| 3 | Brake Press | 30 - 70mm | | Hamburger, Germany | Good | |
| 4 | Universal Shearing/Punching Machine | 45kpa/mm | Shearing/punching of holes of thick guages metal | Stogerel, Czechoslovakia | Good | |
| 5 | Power Guidotine | 4mm guage | Shearing of sheets and metal plates | Albertstahl Maschinenfabrik Stuttgart | Good | |
| 6 | Heavy duty Pyramid Rolling Machine | 3700 x 13 | Rolling of thick plates | Herkulus Watzler | Good | |
| 7 | Pillar Drilling Machine | 32mm maximum diameter | Drilling operations | Elha Hovelhife Westf | Good | |
| 8 | Variable Speed Pillar Drilling Machine | 90kg/mm2; 32mm maximum hole | Drilling of holes | Promyslovy Kombimet Dacice | Good | |
| 9 | Power Pitch Rolling Machine | Maximum 3mm guage | Rolling of small sheets | England | Good | |
| 10 | Manual Shearing Machine | Maximum of 2mm guage, 8 standard wire guage, 42kg/mm2 | Shearing of sheets of metal | England, Edward and Co. | Good | |
| 11 | Vertical Drilling Machine | Maximum hole 13mm | Drilling of holes | Associated British Machine tools | Good | |
| 12 | Various Welding Machine (4Nos) | Maximum guage (8) | Arc welding of metals | Various Company Germany | Good | |
| 13 | Oxy-acyteline Welding Equpment (6 Nos) | Welding Kp to 6mm thick plates | Welding/thermal cutting of metals | Gloor, England | Good | |
| 14 | Horizontal Planning Machine | Up to 10ft length | Surface planning of metals | Bombay Machinery Company India | Good | |
| 15 | Tic Welding Equipment | AC 50 - 230amps DC 56-21amps | Aluminum and alloy weldings | BOC England | Good | |
| 16 | Seam Welding Machine | 185wg | for welding of water tight joints | Bombay Machinery Company India | Good | |
| 17 | Surface Grinding Machine | Continous (max. length of bay - 6ft) | Grinding of Surfaces Skill - 4 | Bombay Machinery Company India | Good | Overall 4 |

| DETAILED SURVEY OF FACILITIES FROM SMALL HYDRO TURBINE MANUFACTURING IN NIGERIA | | | | | | |
|---|---|---|---|---|---|---|
| INSTITUTION : **PRODA, ENUGU**. TYPE OF WORKSHOP : **QUALITY CONTROL** DATE: **23/7/08** | | | | | | |
| **S/N** | **DESCRIPTION OF EQUIPMENT** | **SPECIFICATION/CAPACITY** | **APPLICATION** | **MAKE/MODEL** | **STATUS** | **AVAILABLE SKILLS** |
| 1 | Metallurgical Microscope | x1000 (Magnification) | For Metallographic Analysis | NIKON Optiphot Japan | Good | |
| 2 | Specimen Cabinet | 10 cabinets | For Specimen Storage | Buehler | Good | |
| 3 | Microscope Camera | DK - 81 | For metallographic photomicrograph | Buehler Coventry | Good | |
| 4 | Sieve Shaker | Octagon 200 | For Sieve Analysis of Sand | Endecotts, England | Good | |
| 5 | Specimen Mounting Press (Moulding Unit) | 6000 psi | For Specimen Mounting | Buehler England | Good | |
| 6 | Sand Permeability Tester | 2450 x 240v x 1Amp | For testing Permeability of sand | Ridsdale England | Good | |
| 7 | Weighing Scales (Big and Small) | 2000g and 100g | For Weighing of Specimen | Ridsdale England | Good | |
| 8 | Autopolisher (Mass) | 12 modules | For automatically polishing of specimen | Buehler England | Good | |
| 9 | Manual Polisher | 4 stages | For Polishing od Specimen | Buehler England | Good | |
| 10 | Abrassive Cutter | Diameter 120mm disc | For Cutting of Specimen | Buehler England | Good | |
| 11 | Darkroom Photo Development and Printing | | For devlopment and printing of metallographic pictures | Buehler England | Good | Overall 5 |

| DETAILED SURVEY OF FACILITIES FROM SMALL HYDRO TURBINE MANUFACTURING IN NIGERIA | | | | | | |
|---|---|---|---|---|---|---|
| INSTITUTION: **PRODA, ENUGU**. TYPE OF WORKSHOP : **PATTERN SHOP.** DATE: **23/7/08** | | | | | | |
| **S/N** | **DESCRIPTION OF EQUIPMENT** | **SPECIFICATION/CAPACITY** | **APPLICATION** | **MAKE/MODEL** | **STATUS** | **AVAILABLE SKILLS** |
| 1 | Wood Circular Saw - Heavy duty | 18mm thickness | Cutting of Woods | T. Robinson & sons England | Good | |
| 2 | Wood Surface Plaining Machine | 18mm thickness | Smoothing of Wood Surfaces | Guillet England | Good | |
| 3 | Universal Wood Plaining | 12mm thickness | Continous Plaining of wood surfaces | Guillet England | Good | |
| 4 | Band-Saw Wood Cutting Machine | 30 inches | General wood cutting | T. Robinson & sons England | Good | |
| 5 | Moticing Machine | 25mm - 100mm | Punching of holes for wood joints | T. Robinson & sons England | Good | |
| 6 | Radial Arm-Saw | 24 inches travel length | Circular wood cutting | De Walt England | Good | |
| 7 | Wood - Cutting M/c | 6500 upm | Plaining of wood | HOBENLLE ZUSATZGERAT | Good | |
| 8 | Black-Smith Forge | 1440rpm | Forge work | ALLOSA Willian AlldayEngland | Good | |
| 9 | Air Compressor | 300kgkm2 (115 psi) | Compresses air supply | BROOMWADE England | Good | Overall 4 |
| | | | | | | |

**DETAILED SURVEY OF FACILITIES FOR SMALL HYDRO TURBINE MANUFACTURING IN NIGERIA**

INSTITUTION: **HEDI-KANO**. TYPE OF WORKSHOP: **MACHINE SHOP** DATE: **16/7/08**

| S/N | DESCRIPTION OF EQUIPMENT | SPECIFICATION /CAPACITY | APPLICATION | MAKE/MODEL | STATUS | AVAILABLE SKILLS |
|---|---|---|---|---|---|---|
| 1 | LATHE MACHINE | 1.0M Lenght 15" Swing | TURNING,THREADING, BORING | DEAN SMITH & GRACE, ENGLAND | Good | 5 Technicians |
| 2 | HORIZONTAL MILLING MACHINE | 90cm | CUTTING OF GEAR,SLOTS,KEYWAYS & GENERAL MILLING OPERATIONS | ELLIOT,ENGLAND | Good | |
| 3 | SHAPING MACHINE | 40cm | CUTTING OF INTERNAL KEYWAYS | ALFA | Fair | |
| 4 | RADIAL DRILLING MACHINE | 47.5mm (max. drill bit) | DRILLING OF HOLES,BORING AND REAMING | MAS, Czechoslovakia | Good | |
| 5 | LATHE MACHINE | 0.6m | TURNING OF SMALL COMPONENTS LIKE SLEEVES,BUSHING ETC. | HUNGARY | Good | |
| 6 | LATHE MACHINE | 2m long, 16" SWING | TURNING,THREADING | GRAHAM &NORMANTON | FAIR | |
| 7 | MOBILE CRANE | 5 TONS | | | FAIR | |
| | | | | | | |

**DETAILED SURVEY OF FACILITIES FOR SMALL HYDRO TURBINE MANUFACTURING IN NIGERIA**

INSTITUTION: **HEDI-KANO**. TYPE OF WORKSHOP: **FOUNDRY** DATE: **16/7/08**

| S/N | DESCRIPTION OF EQUIPMENT | SPECIFICATION /CAPACITY | APPLICATION | MAKE / MODEL | STATUS | AVAILABLE SKILLS |
|---|---|---|---|---|---|---|
| 1 | ROTARY FURNACE | 100kg(0il fired) | melting of ferrous and non ferrous metals | EMDI, Nigeria | Good | 4 Technicians |
| 2 | TILTING FURNACE | 100kg(0il fired) | melting of non-ferrous metals | EMDI, Nigeria | Good | |
| 3 | DIE CASTING MACHINE | | casting of small non-ferrous components | TECHNOCRAT INDIA | Good | |
| 4 | ELECTRIC HEARTH FURNACE (2 Nos.) | 30kg (coal fired) | melting of non-ferrous metals | Locally made, Nigeria | Good | |
| 5 | METAL MOULDING BOXES | various sizes | for mould making | Locally made, Nigeria | Good | |
| 6 | WOODEN MOULDING BOXES | various sizes | for mould making | Locally made, Nigeria | Good | |
| 7 | SPRING BALANCE | 50kg (max) | weighing metals | Germany | Good | |
| 8 | SAND MIXING ACCESSORIES | lot | sand mixing for mould making | Locally made, Nigeria | Good | |
| 9 | MOULD MAKING TOOLS | lot | mould making | Locally made, Nigeria | Good | |
| 10 | LADDLES | 20x30kg | for collecting,holding and pouring of molten metal into mould | Locally made, Nigeria | Good | |
| 11 | DIESEL TANK | 105 litres | for storing of diesel used for firing | Locally made, Nigeria | Good | |
| 12 | USED ENGINE OIL TANK | 105 litres | for storing of used engine oil for firing | Locally made, Nigeria | Good | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 14 | TOOLS AND ACCESSORIES USED DURING MELTING AND POURING OPERATIONS | lot | used during melting and pouring of molten metal anto moulds | | Good | |
| 15 | BLOW LAMP | Kerosine type | For drying moulds ready for casting | Locally made, Nigeria | Good | |

**DETAILED SURVEY OF FACILITIES FOR SMALL HYDRO TURBINE MANUFACTURING IN NIGERIA**

INSTITUTION: **HEDI-KANO**. TYPE OF WORKSHOP : **PATTERN SHOP.** DATE: **16/7/08**

| S/N | DESCRIPTION OF EQUIPMENT | SPECIFICATION/ CAPACITY | APPLICATION | MAKE/MODEL | STATUS | AVAILABLE SKILLS |
|---|---|---|---|---|---|---|
| 1 | Portable drilling machine | 13mm dia | Drilling | D72605 Bisigen Germany | Good | 3 Technicians |
| 2 | Wood lathe machine | 230 X 800mm | Turning | Ratatein Hungary | Good | |
| 3 | Planing machine | 300mm width | cutting, planning & riveting | PE Germany | Good | |
| 4 | Portable finishing sand | | Sanding | Colt Power Tool, Germany | Good | |
| 5 | Jig sawing machine | 55mm Dia | Sawing curve | Colt Power Tool, Germany | Good | |
| 6 | Spraying Machine | 3kw | Spray painting | 1JSM75/15 | Good | |

**DETAILED SURVEY OF FACILITIES FOR SMALL HYDRO TURBINE MANUFACTURING IN NIGERIA**

INSTITUTION: **HEDI-KANO** TYPE OF WORKSHOP: **FABRICATION SHOP** DATE: **16/07/08**

| S/N | DESCRIPTION OF EQUIPMENT | SPECIFICATION/ CAPACITY | APPLICATION | MAKE/ MODEL | STATUS | AVALAIBLE SKILLS |
|---|---|---|---|---|---|---|
| 1 | Hydraulic press | 6 tons, M30 1675 | Press fitting during assembly | Marta-Weike, Frankfurt | Good | 3 Technicians |
| 2 | Electric power saw | any thickness | for cutting materials | Klacger | Good | |
| 3 | Electrc Hearth | Non-ferrous metals | mekting of non-ferrous metals | Locally made, Nigeria | Fair | |
| 4 | Pillar Drilling machine | | for drilling jobs | Femipari Vallalat | Good | |
| 5 | Grinder | | grinding jobs | Bosch | Good | |
| 6 | Manual Shear | 3mm | Cutting of metal sheets | Locally made, Nigeria | Good | |
| 7 | Arc Welding machine | 250A | welding jobs | K.Strauss Equipment, Germany | Good | |
| 8 | Arc Welding machine | | | Scema arc welding | Good | |
| 9 | Air Compressor | 59kg 37N 3*380v 7amps 29kv 220v | General air supply | Koventa Podnik mistriko pranyshu Ceska Trebera | Fair | |
| 10 | Guillotine | 2mm | cutting of metal Sheets | Machinet abrick it Jorg Amersoft, Holland | Fair | |
| | | | | | | |

**A – 3.5**

**DETAILED SURVEY OF FACILITIES FOR SMALL HYDRO TURBINE MANUFACTURING IN NIGERIA**

INSTITUTION: **EMDI, AKURE**. TYPE OF WORKSHOP : **MACHINE/FABRICATION WORKSHOP** DATE: **25/7/08**

| S/N | DESCRIPTION OF EQUIPMENT | SPECIFICATION/ CAPACITY | APPLICATION | MAKE/MODEL | STATUS | AVAILABLE SKILLS |
|---|---|---|---|---|---|---|
| 1 | Spot Welding Machine | 380V, 50A | Spot Welding | SIP, Italy | Good | 5 Technicians |
| 2 | Gas Welding Machine | 40Bar-Acetylene 300Bar-Oxygen | Cutting thick metal sheets and welding of non-ferous metals | BOC, Italy | Good | |
| 3 | Arc Welding Machine | 500A | General Welding | SIP, Italy | Good | |
| 4 | Guillotone | 3 x 1200mm | Cutting Metal Sheets | Chinese | Good | |
| 5 | Eccentric Press | 280mm(max.workpiece height), 3kw | Press fitting duing assembling | W.Paul Muller, Germany | Fair | |
| 6 | Surface Grinding Machine | 7" (2880rpm) | Grinding flat Surface | Jones-Shipman 540, England | Good | |
| 7 | Pillar Drilling Machine | 2.2kw (32mm maximum drill bit size) | Drilling holes | Interkrem Machine, Gemany | Fair | |
| 8 | Shaping Machine | 600 x 400 x 300mm | Shaping Metals | TAY SHIN Machinery Works, China | Good | |
| 9 | Vertical Milling Machine | 500 x 100 x 250mm | Milling jobs such as slots, end miling, key ways. | BFW, India | Good | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10 | Universal Lathe Machine | 1.0m length, 250mm Swing | Turning, boring, facing, threading. | ZMM SLIVEN | Good | |
| 11 | Universal Lathe Machine | 1.5m length | Turning, boring, facing, threading | HUICHON-5, Korea | Good | |
| *12 | Mini lathe/driling machine | 0.3m length | Turning,boring of small components | Hobby Matt BFE 65, Baujahr | Good | |
| *13 | Mini lathe machine | 150mm length 50mm swing | Turning, facing | OMRON, Japan | Good | |
| *14 | Engraving Machine | 3250 rpm | Drilling and name plating | SWWCO, Nigeria | Good | |
| *15 | Tools grinding Machine | 0.7 kw, 2,800 rpm | Grinding tools | SHIMATO, MADRAS | Good | |
| 16 | Pedastal Grinder | Minigrind GP-30 | Grinding tools | Nigeria Machine Tools (NMT),NIGERIA | Good | |
| 17 | Drilling/Miling Machine | 25mm drilling 13mm endmilling 63mm facemilling | Drilling and milling | Clark Metal Work, England | Good | |
| 18 | Power saw | 150mm height/diameter of workpiece, 1.5kw | heavy duty cutting | DONJIN, Korea | Good | |
| 19 | Universal Lathe Machine | 1.0m length, 250mm swing | Turning, boring, facing, threading | CHIN SHIN, China | Fair | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 20 | Arc Welding Machine | 38A -180A | Welding of Metal | ESAB, Ukraine | Good | |
| 21 | Radial Drilling Machine | 40mm drill | Drilling | KITCHEN & WADE, ENGLAND | Good | |
| | | | | | | |
| * | Machines for sharpening tools | | | | | |
| | | | | | | |

**DETAILED SURVEY OF FACILITIES FOR SMALL HYDRO TURBINE MANUFACTURING IN NIGERIA**

INSTITUTION : **EMDI, AKURE**. TYPE OF WORKSHOP : **FOUNDRY** DATE: **25/7/08**

| **S/N** | **DESCRIPTION OF EQUIPMENT** | **SPECIFICATION/CAPACITY** | **APPLICATION** | **MAKE/MODEL** | **STATUS** | **AVAILABLE SKILLS** |
|---|---|---|---|---|---|---|
| 1 | INDUCTION FURNACE (2 Nos.) | 150kg x 2 | MELTING CAST IRON,STEEL & ALLOYS | MAHIMA MELBOURNE, AUSTRALIA | Good | **5 Technicians** |
| 2 | CRANE | 2TONS | LIFTING OF MATERIALS | LOCALLY FABRICATED | Good | |
| 3 | SAND MIXER | 250KG | MIXING OF MOULDING SANDS | LOCALLY FABRICATED | Good | |
| 4 | PEDESTAL GRINDER | 1400rpm | GRINDING OF FETLING | LOCALLY FABRICATED | Good | |
| 5 | ROTARY FURNACE (2 Nos.) | 100KG & 10KG | MELTING OF CAST IRON | EMDI AKURE | Good | |
| 6 | CRUCIBLE FURNACE | 80KG | MELTING NON-FERROUS METALS | Nigeria Machine Tools (NMT),NIGERIA | Good | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 7 | WEIGHING SCALE | 250KG | WEIGHING | AVERY, ENGLAND | Good | |
| 8 | MOULD DRYING EQUIPMENT | 33.1 KG | DRYING OF MOULDS | UTILIN GAS | Good | |
| 9 | MUFFLE FURNACES (3 Nos.) | 1200˚C | HEAT TREATMENT | BDC1280576, BULGARIA | Good | |
| 10 | CARBON EQUIPMENT ANALYZER | 1370˚C | ANALYZING MOLTEN CAST IRON MELT | DIGICARB 2, LEEDS | Good | |
| 11 | DIP PYROMETER | 400˚C | MEASURING TEMPERATURE OF MOLTEN METAL | LEEDS | Good | |
| 12 | OPTICAL PYROMETER | 1700˚C | MEASURING TEMPERATURE OF MOLTEN METAL | | Good | |
| 13 | SALT BATH FURNACES (2 Nos.) | 1000˚C | AUSTEMPERING | EMDI AKURE | Good | |
| *14 | 250KG ROTARY FURNACE | 1500˚C | MELTING OF CAST IRON | EMDI AKURE | Good | |
| **15 | BAND SAW | 410mm x 200mm THICKNESS | CUTTING WOOD | SHANDONG GONGYOU GROUP, CHINA | Good | |
| **16 | 12" TABLE SAW | 105mm CAPACITY | CUTTING OF WOOD | TJ212/2, CHINA | Good | |
| **17 | WOOD PLANING & THICKNESSING MACHINE | 300mm | PLANING AND THICKNESS | MLQ 343 | Good | |

| | | | | | | |
|---|---|---|---|---|---|---|
| * EQUIPMENT TO BE ACQUIRED SOON | | | | | | |
| ** PATTERN SHOP EQUIPMENT | | | | | | |
| **DETAILED SURVEY OF FACILITIES FOR SMALL HYDRO TURBINE MANUFACTURING IN NIGERIA** | | | | | | |
| INSTITUTION : **EMDI AKURE**. TYPE OF WORKSHOP : **ADVANCE MATERIALS LABORATORY (QUALITY CONTROL)** DATE: **25/7/08** | | | | | | |
| | | | | | | |
| **S/N** | **DESCRIPTION OF EQUIPMENT** | **SPECIFICATION/CAPACITY** | **APPLICATION** | **MAKE/MODEL** | **STATUS** | **AVAILABLE SKILLS** |
| 1 | Universal Testing machine | 50KN load frame | Tensile and Compression Test | Instron | Good | **2 Technicians** |
| 2 | Min X-ray difractometer | | Phase Analysis and characterization of materials | Radicon MD 10, RUSSIA | Good | |
| 3 | ULTRA VIOLET VISIBLE SPECTROPHOTOMETER | TABLE-TOP Uv-Us SPEC | Optical characterization | Jenway 6405 | Good | |
| 4 | Mega-pure system deionizer | 50kΩcm, Conductivity | Ionization of water (organic & inorganic removal) | Barristead D2-system | Good | |
| 5 | Weighing scales (2Nos.) | 1 x $10^{-3}$g - 300g | Weighing of small specimen | Ohms Sv 1.10 | Good | |
| 6 | Metallurgical microscope suite (4Nos.) | x 1000 (magnification) | Metallographic and Structural Analysis | Olympus(BH2), Nikon (ME600) | Good | |
| 7 | Fume chambers (2Nos.) | 2 and 4 Cabinets | | locally sourced | Good | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8 | Micro-hardness Tester | ASTM-E384 microhardness | micro-hardness testing of materials | LECO comp. LM 700AT | Good | |
| 9 | Specimen mounting press | 6000 psi. | mounting specimen | Buehler | Good | |
| 10 | Grinder/Polisher | 50-500 rev/min | polishing and grinding of specimen | South-Bay Technology Inc. | Good | |
| 11 | Isomet Low speed Saw | Low speed cutting | cutting of samples | Buehler(ISOMET) | Good | |
| 12 | PH-Meter | | testing the PH of samples | Jenway, model 3505 | Good | |
| 13 | Rectangular water bath (2Nos.) | 6 Holes rectangular bath | Heat treatment of sample in waterbath | Inter Cabs (US) | Good | |
| 14 | Vacuum oven | 0-30 mm/Hg 0-210˚C | Drying of sample under vacuum | Sheledon Man Inc/400E | Good | |
| 15 | Hot plates with magnetic stirrer (3Nos.) | 0-220˚C | Heating and drying of samples | Gallenkamp,Cornin g, | Good | |
| 16 | Rheometer | | study the flow behaviour of material | KRUSS RL3979-251 | Poor | |
| 17 | Oven | 0-250˚C | Drying of samples | | Good | |
| 18 | Glove box | 50-60 psi | | Coy lab, USA | | |

**DETAILED SURVEY OF FACILITIES FOR SMALL HYDRO TURBINE MANUFACTURING IN NIGERIA**

INSTITUTION: **EMDI AKURE**. TYPE OF WORKSHOP: **ADVANCE MANUFACTURING CENTRE** DATE: **25/7/08**

| **S/N** | **DESCRIPTION OF EQUIPMENT** | **SPECIFICATION/CAPACITY** | **APPLICATION** | **MAKE/MODEL** | **STATUS** | **AVALAIBLE SKILLS** |
|---|---|---|---|---|---|---|
| 1 | VERTICALMACHINING CENTER | 20 KVA, 6500A, IP 64 | MASS PRODUCTION OF COMPONENTS & PARTS | VMC 750 QINGHA, CHINA | Good | |
| 2 | ELECTRIC DISCHARGE MACHINE | 600 X 400 X 400mm | MAKING MOULDS FOR CASTING | PDS-432CSC CNC PRODIS,TAIWAN | Good | |
| 3 | CAD/CAM CENTRE | | COMPUTER AIDED DESIGNS & COMPUTER AIDED MANUFACTURING | | Good | |
| *4 | CNC LATHE | | | | | |
| *5 | CNC SHAPING & DRILLING | | | | | |
| *6 | FILAMENT WINDING MACHINE | | | | | |
| * | EQUIPMENT TO BE ACQUIRED | | | | | |

**A – 3.6**

**DETAILED SURVEY OF FACILITIES FOR SMALLHYRO TURBINE MANUFACTURING IN NIGERIA**

**INSTITUTION:** SEDI – ENUGU **TYPE OF WORKSHOP:** FABRICATION & ASSEMBLY **DATE:** 24/07/08

| S/N | DESCRIPTION OF EQUIPMENT | SPECIFICATION/ CAPACITY | APPLICATION | MAKE/MODEL | STATUS | AVAILABLE |
|---|---|---|---|---|---|---|
| 1. | Pneumatic Press | 37.7mm swing<br>7.5 KW (DSK 100A) | For Punching<br>(Punch and Die jobs) | Diosgyori Gepgyar Hungary | Poor | |
| 2. | Pnematic Press (2Nos) | 33.8mm swing<br>4.5KW (DSK 40A) | For Punching<br>(Punch and Die jobs) | " | Good | |
| 3. | Pneumatic Press (2Nos) | 27.8mm swing (DSK 25A) | For Punching | " | Good | |
| 4. | Shear Vibrating Machine | 7KW | Perforating Electrical Panels | Szerszamg Epipari muvek | Good | |
| 5. | Pedestal Grinding Machine | 1470rpm | Grinding | Evis | Good | |
| 6. | Spot Welding Machine 2No | 380V | Spot Welding of Metal sheets. | VEB Holland | 1 Good<br>1 Fair | |
| 7. | Pillar Drilling Machine | Ø 32mm (max Drill bit) | Drilling of Holes | Hiteka Hungary | Good | |
| 8. | Folding Machine | 5mm x 4 ft | Folding Metal sheet | Gefi Gyor Hungary | Good | |
| 9. | Arc Welding Machine | 50 – 500A | General welding work | China<br>USA<br>Hungary | Good | |
| 10. | Manual Press | 320mm (work piece) | Press Fitting | Spuldzielnia Pracy, | Good | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | 10Tons | | Metalling | | |
| 11. | *Air Plasma Cutter | KLG – 80 | Cutting of Non- Ferous Metal | Chaos of Heng welding Equipment China | Good | |
| 12. | *Tig Welding Machine | Ws 160 | Welding of non – ferrous metals | Warp Engr. Ltd | Good | |
| 13. | *Mig welding set | Mig - 300 | Welding of Steel | Pro arc PVT Ltd. | Good | |
| 14. | Guillotine | 3mm x 4ft | Cutttting of Metal sheet | Diogyori Gepgyar, Hungary | Good | |
| 15. | Automatic cylindrical cutter | Ø 100mm | For cutting cylindrical object (pipes, Reds e.t.c) | Hungary | Good | |
| 16. | Power saw | 400mm | For rods and pipes | Duanues Hungary | Good | |
| 17. | Band saw sharpening machine | 2,900rpm | For sharpening band saw blade | Mefmc cups Romania | Good | |
| 18. | Circular saw sharpening | 380V | For sharpening circular saw blade | “ | “ | |
| | | | | | | |

* Awaiting installation

**DETAILED SURVEY OF FACILITIES FOR SMALLHYRO TURBINE MANUFACTURING IN NIGERIA**

**INSTITUTION:** SEDI – ENUGU **TYPE OF WORKSHOP:** MACHINE SHOP **DATE:** 24/07/08

| S/N | DESCRIPTION OF EQUIPMENT | SPECIFICATION/ CAPACITY | APPLICATION | MAKE/MODEL | STATUS | AVAILABLE |
|---|---|---|---|---|---|---|
| 1. | Tool milling machine | FND - 32 | To bore holes and cut gears, Hexagon and Grooves | Poland | Good | |
| 2. | Unversal Milling Machine | 400mm | Making slots and keyways | Stanko imports USSR | Good | |
| 3. | Slotting Machine | 150mm (Travel slot lenght) | Internal spline keyway, gears | Kdmmyhad, USSR | Good | |
| 4. | Universal center lathe machine (4 no) | 1.5mm x 200mm | Turining | Technoimpex Hungary | Good | |
| 5. | Lathe Machine (4 no) | 1m x 150mm<br>E3N - 01 | Turning | “ | 3 Good<br>1 poor | |
| 6. | Surface grinder | 300 x 150mm | Grinding flat Surface | Jotes Poland | Good | |
| 7. | Universal Cylindrical grinder | 1000mm x 150mmØ | Grinding cylindrical workplace (internal & external) | Wadonice | Fair | |
| 8. | Horizontal Milling machine | 5Ømm length<br>Ø 100mm | Milling jobs | Mycka Hungary | Good | |
| 9. | Shaping machine | Extra Heavy<br>200 x 200 x 200mm | Shaping of solid workplaces | Hitecman France | Good | |
| 10. | Turflet Lathe | 80mm length<br>50mm diameter | For turning small components | Tos Trencin Czhechoslovakia | Good | |
| 11. | Pillar Drilling machine | 15mm max drill bit | Drill Jobs | Femipari vallalat Hungary | Good | |
| 12. | Engraving machine | | | China | Good | |

**DETAILED SURVEY OF FACILITIES FOR SMALLHYRO TURBINE MANUFACTURING IN NIGERIA**

**INSTITUTION:** SEDI – ENUGU **TYPE OF WORKSHOP:** FOUNDRY **DATE:** 24/07/08

| S/N | DESCRIPTION OF EQUIPMENT | SPECIFICATION/ CAPACITY | APPLICATION | MAKE/MODEL | STATUS | AVAILABLE |
|---|---|---|---|---|---|---|
| 1. | Oven Furnace | 50kg of molten wax | For blending wax | Iron and metal Industry Hungary | Good | 5 |
| 2. | Oven | 10kg of molten wax | For melting wax | “ | Good | 5 |
| 3. | Wax pulper machine | 10kg | For pulping wax into paste stage | “ | Good | 5 |
| 4. | Injection Machine (wax press) | 5bars | For injecting wax into the die mould | “ | Good | 5 |
| 5. | Chiller | 3.7KW<br>380V<br>5.9A | For cooling | “ | Good | 5 |
| 6. | Suspension Mixer | 1.5KW<br>380V | For mining chemicals | “ | Good | 5 |
| 7. | Dewaxing machine | 2.5KW<br>380V | For removing wax | “ | Good | 5 |
| 8. | Drying Machine | 0.175KW<br>440 – 1Min | For drying jobs | “ | Good | 5 |
| 9. | Oven (Double Chamber) | 21KW, 3Phase | For heat treatment | “ | Good | 5 |
| 10. | Oven (Single chamber) | 42KW<br>50HZ<br>3Phase | For Heat Treatment | KGYV<br>BUDAPEST | Good | 5 |
| 11. | Induction Furnace | 56KW<br>700v<br>8,000HZ | For melting cast iron steel | Veb Inducal Golligen | Fair | 5 |
| 12. | Drilling Machine | 0.37Kw<br>380/220V<br>50HZ | For drilling Objects | Evic Budapest | Good | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13. | PIT Furnace | 50KG | For Non- Ferrous metals | | Good | 5 |
| 14. | Moulding Machine | 60KG | For moulding | Format<br>10 - 1 | Good | 5 |
| 15. | Sand miller mixing machine | 4KW<br>380V<br>50Hz | For mixing the moulding Sand. | Dozamez<br>Ms – 0075c | Good | 5 |
| 16. | Die casting machine (3 Nos) | 120 tons(1)<br>49 tons (2) | For die casting | FMO KRAKON<br>PATO - 6 | Good | 5 |
| 17. | Shake - out machine | $6cu^3$/hr<br>1.5kw | Shaking out Moudle casting | M/3 Technocrats<br>TDC - 40 | Good | 5 |
| 18. | Sand blasting machine | | Cleaning and Casting | 7 – 5.16619 | Good | 5 |
| 19. | Grinding machine | 2.990 rpm<br>Max wheel size<br>175/20x20 | For Grinding Jobs | Ak - 22 | Good | 5 |

**DETAILED SURVEY OF FACILITIES FOR SMALLHYRO TURBINE MANUFACTURING IN NIGERIA**

**INSTITUTION:** SEDI – ENUGU **TYPE OF WORKSHOP:** ELECTRICAL R & D **DATE:** 24/07/08

| S/N | DESCRIPTION OF EQUIPMENT | SPECIFICATION/ CAPACITY | APPLICATION | MAKE/MODEL | STATUS | AVAILABLE |
|---|---|---|---|---|---|---|
| 1. | Coil making machine | 1KW | Production of Tranformer coils for higher capacity | Hiradastechnikai Gepayara | Fair | |
| 2. | Modified Lathe machine | 3KW | Production of low power transformer coils | Tos celakonivice n.p | Good | |
| 3. | Pneumatic press machine | 7.5KW | Stamping out transformer Lamination | Diosgyori Gepgar | Good | |
| 4. | Pneumatic press machine | 4 & 3KW | Production of Bobbin (Transformer former) | Diosgyori Gepgar (DKS25A) | Good | |
| 5. | Transformer Trainer | 500W | For teaching transformer parameters | SEDI - E | Good | |
| 6. | Basic machine Trainer | 1000W | Teaching Electrical machine application | SEDI - E | Good | |
| 7. | Wooden former | - | Motor coil production | Locally made | Fair | |
| 8. | UVE Exposure | - | Production of PCB | - | Poor | |
| 9. | Digital Bench Multimeter | 1000V | For continuity testing | DT 9205 | Good | |
| 10. | Digital Insulation tester | 10,000V | For testing insulation | Duoyi DY30 - 1 | Good | |
| 11. | Digital Tachometer | 10,000rpm | For measuring rpm | Tm 2100 | Good | |
| 12. | Silicon dopping machine | - | For dopping and lamination | - | Good | |
| 13. | Doilling Machine | 3KW | For drilling holes on control panels of electric components | - | Good | |
| 14. | Ovum | 5KW | For drying of Transformer | - | Good | |
| 15. | Impregnating | 5KW | For impregnating coils and lamination | - | Poor. | |

## NATIONAL AGENCY FOR SCIENCE AND ENGINEERING INFRASTRUCTURE (NASENI)

Location: Idu, Industrial Area, Abuja

Postal Address: NASENI
Federal Ministry of Science & Technology
Idu, Industrial Area
P.M.B. 391
Garki, Abuja.
Overseeing Ministry: Federal Ministry of Science and Technology, Abuja

Mandate/Activities: Specifically in the area of capital goods, research, production, and reverse engineering with respect to broad areas:

- Engineering materials
- Engineering Equipment; Mechanical, Hydraulic, Pneumatic etc.
- Engineering Designs and Standardization.
- Power Equipment: Generation, Transmission, Distribution, Prime movers; Mechanical.

4.1 **Mission:** To establish and nurture an appropriate, dynamic and Engineering Infrastructure base for achieving home – initiated and home sustaining industrialization through the development of relevant process, capital goods and equipment, necessary for job creation, national economic well being and progress.

4.2 **Vision:** To create an enabling knowledge – driven environment for local mass – production of standard parts, goods and services, required for the Nation’s Technological advancement.

4.3 **Target:** Small and Medium Scale industries, through the impartation of technologies, engineering principles and practices for the production of equipment that will meet international standards as well as flourish local capital goods industry.

**Management Structure:**
In pursuant of its mandate, the Agency operates through 7 development institutes: -

Science Equipment Development Institute –

- SEDI, Enugu.
- SEDI, Minna

Electronics Development Institute –

- ELDI, Awka

Hydraulic Equipment Development Institute

- HEDI, Kano

Engineering Materials Development Institute

- EMDI, Akure.

National Engineering Design Development Institute

- NEDDI, Nnewi

Power Equipment and Electrical Machines Development Institute-

- PEEMADI, Okene.

**7.0 Human capacity:** NASENI Head Quarters has engineers trained in the field of Small Hydro POWER Technology. One was trained in China in 2006; two others will conclude their training in June 2008. Also available is a pool of engineers trained in the use of CAD software such as: Autodesk, Solid Works, Pro-Engineer; Modeling and Simulation software such as Mat lab, COM sol, Hysys, Granary Design, Ansys.

NASENI is adopting the process of Reverse Engineering for the Turbine project in collaboration with identified stakeholders and some Nigerian Higher Institutions with relevant competences.

NASENI has the human and material capacity to implement the Turbine Fabrication project as follows:

- Over 70 graduate engineers
- Over 5 PhD engineers
- Over 30 M Sc.
- Over 50 Scientist
- Over 100 technologist, technicians
- Over 100 craftsmen and artisan
- Over 100 Research fellows
- A mandate to source for and utilize experts in any discipline and from anywhere
- Work with a lot of universities in the implementation of some projects.
- Sponsor some research and development projects in tertiary institutions and R & D Institute.

**8.0 Workshop Facilities:**

All the Development Institute are equipped with the typical AMC as the following:

Mini – foundries
Mechanical workshops
Advanced Manufacturing centre (AMC)

**9.0 Equipment List:**

A list of newly acquired equipment and machinery for the development institutes are shown in A.3 -2

i. Vertical Milling Machine
ii. CNC Lathe
iii. Surface Grinder
iv. Electric Discharge Machine (EDM)
v. Rotary furnace

vi. Induction furnace
vii. Pattern shop.

## 10.0 NASENI INITIATIVE IN SMALL HYDRO POWER EQUIPMENT MANUFACTURING

### 10.1 Scope

In the long term, the Agency is working towards the establishment of a Small Hydro Power Machinery and Equipment Development Institute and a Manufacturing Industry to go along with it. However, in the short term, the Agency is adopting a model which will lead to quick harvest of "low-hanging fruits" to show that it is do-able. Knowing that the "heart" of a Small Hydro Power project is the turbine, a domestically made Small Hydro turbine will therefore "leap-frog" the process of rural electrification and ultimately bring down the per kilowatt installation cost of Small Hydro Power plants. Hence, NASENI's current focus on the local fabrication of small hydro turbine with capacity ranging between 70 and 100KW.

### 10.2 Methodology

The Agency is adopting the process of Reverse Engineering for this project in collaboration with identified stakeholders and some Nigerian Higher Institution with relevant competencies.

### 10.3 Capacity to run the Proposed Project

#### 10.3.1 Experience (Skills) Garnered from Past and On-going Projects

NASENI has successfully used the reverse engineering method to develop the local fabrication of the Seed Oil Expeller. Also, the Agency's Collaborative efforts in R & D with some universities have yielded result on the design and production of cassava flour processing plant project.

### 1.0 The Seed Oil Expeller

This is one of our flagship products in the concept of Reverse Engineering. The Agency acquired a seed oil expeller with the aim of replicating it and developing the requisite skills for its mass production. Currently, the Agency has successfully replicated it; the prototype seed oil expeller is available. The working drawings in 2D and 3D AutoCAD designs are also available.

The machine was fabricated, assembled and in perfect working condition. Oil from groundnut and palm kernel have been produced. Work is also on-going on the production of the manufacturing layout which will be published and made available to Small and Medium Enterprises (SMEs) who will be involved in proliferation of the machine. NASENI has shown that this is do-able.

### 2.0 Integrated Cassava Flour Processing

The project is still on-going and was aimed at designing and manufacturing a prototype cassava/yam processing plant with a capacity up to 2.5tons per day, and providing the technological environment for the private sector to produce high quality cassava and yam flour and the local manufacturing of the processing plant. The Project is run in collaboration with five Universities with core competences in various equipment that make up the production line. These are:

Abubakar Tafawa Balewa University, Bauchi (ATBU)
Federal University of Technology, Minna (FUTM)
Federal University of Technology, Owerri (FUTO)
Federal University of Technology, Akure (FUTA); and
Obafemi Awolowo University, Ile Ife, (OAU).

All the component machines of the processing plant have been produced and tested. The remaining phases of the project include the integration and instrumentation of the component machines and then commissioning. Thereafter, an investors' forum will be organized in order to cede it to a private firm interested in mass producing the processing plant.

## NASENI DEVELOPMENT INSTITUTES MANDATES

In pursuant of its mandate, the Agency operates through Development Institutes. So far, there are seven Development Institutes established. They are:

(i) **Science Equipment Development Institute (SEDI), Enugu**

- The development and production of scientific equipment and their production systems, and the transfer of these to private sector satellite industries;

(ii) **Science Equipment Development Institute (SEDI), Minna**

- The development and production of scientific equipment and their production systems, and the transfer of these private sector satellite industries;

(iii) **Electronic Development Institute (ELDI), Awka (**formerly, **Centre for Adaptation of Technology (CAT))**

- The development and production of electronic materials and assemblies, and their production systems, and the transfer of these to private sector satellite industries;

(iv) **Hydraulic Equipment Development Institute (HEDI), Kano**

- The development and production of hydraulic and pneumatic machinery, materials , and their production systems and transfer of these to private sector satellite industries;

(v) **Engineering Materials Development Institute (EMDI), Akure**

- The development and production of engineering materials and their production systems, and the transfer of these to private sector satellite industries;

(vi) **National Engineering Design Development Institute (NEDDI), Nnewi (**formerly, **National Engineering Design Development Centre (NEDDEC))**

- The development of engineering design capacity and its dissemination to Small and Medium Enterprises (SMEs) in order to standardize Nigerian made products and make them globally acceptable.

(vii) **Power Equipment and Electrical Machines Development Institute (PEEMADI), Okene**

The development and maintenance of power and electrical equipment and their production systems and the transfer of these to private sector satellite industries.

## List of Newly Acquired Equipment and Machinery

| S/N | Description | Qty. | Location |
|---|---|---|---|
| 1. | Spindle Digital coil winding machine with one size tension and nozzle. Type WH-7611 | 2 | PEEMADI-Okene |
| 2. | Spindle Digital coil winding machine with tapping device type WH-8001 | 1 | PEEMADI-Okene |
| 3. | Spindle Digital coil winding machine with tail stock type WH-7511 | 2 | PEEMADI-Okene |
| 4. | Spindle Digital coil winding machine with one size tension and nozzle type WH-7611 | 6 | PEEMADI-Okene |
| 5. | Spindle Digital coil winding machine with tapping device type WH-8001 | 3 | PEEMADI-Okene |
| 6. | Spindle digital coil winding machine with tail stock type WH-7511 | 6 | PEEMADI-Okene |
| 7. | Local Winding Machine (from Akure) | 2 | PEEMADI-Okene |
| 8. | CNC lathe machine type CKD 6150D/1500 | 2 | 1. SEDI-Minna<br>2. NEDDI-Nnewi |
| 9. | Vertical milling machine type VMC 750 | 2 | 1. HEDI-Kano<br>2. SEDI-Minna |
| 10. | Shaping machine type B6085 | 2 | 1. PEEMADI-O<br>2. PEDI-Ilesha |
| 11. | Vertical milling machine type VMC 750 | 4 | 1. NEDDI-Nnewi<br>2. SEDI-Enugu<br>3. EMDI-Akure<br>4. PEEMADI-O |
| 12. | Electrical Discharge Machine type PDS-432CS 60A - | 2 | 1. PEEMADI-O<br>2. NEDDI-Nnewi |
| 13. | CNC Lathe Machine | 1 | PEEMADI-Okene |
| 14. | Sheet Production & Type F Clay Brick Plants. | 1 | PEDI-I |
| 15. | (EN) Lathe Fagor 8040TC Controller and Accessories. (From Technovation) | 2 | 1. PEEMADI-O<br>2. PEDI-I |
| 16. | Electrical Discharge Machine. (From Technovation) | 1 | EMDI-A |
| 17. | Virtual Manufacturing Laboratory | 1 | NASENI-HQ |
| 18. | Pro-E Laboratory | 1 | NASENI-HQ |
| 19. | Vertical Milling Centers VMC 750 | 16 | 16 Nigerian Universities. |
| 20. | Rapid Prototyping Machine | 2 | PEDI-I |

## SUMMARY:

| Machine / Centre | CNC LATHE | VMC | SHAPING MACHINE | EDM | EN LATHE | WINDING MACHINE | SHEET PRODT'N PLANT | VML | PRO-E | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **NASENI-HQ** | | | | | | | | **1** | **1** | **2** |
| **SEDI-M** | **1** | **1** | **-** | **-** | **-** | **-** | **-** | | | **2** |
| **SEDI-E** | **1** | **1** | **-** | **-** | **-** | **-** | **-** | | | **2** |
| **NEDDI-N** | **1** | **1** | **-** | **1** | **-** | **-** | **-** | | | **3** |
| **HEDI-K** | **-** | **1** | **-** | **-** | **-** | **-** | **-** | | | **1** |
| **EMDI-A** | **-** | **1** | | **1** | **-** | **-** | **-** | | | **2** |
| **PEEMADI-O** | **1** | **1** | **1** | **1** | **1** | **22** | **-** | | | **27** |
| **PEDI-I** | **-** | **-** | **1** | | **1** | | **1** | | | **3** |
| **Total:** | **4** | **6** | **2** | **3** | **2** | **22** | **1** | **1** | **1** | **42** |

| | | | | | |
|---|---|---|---|---|---|
| 1 | **Exchange rate (US$ to NGN)** | | 120 | NGN | |
| | | | | | |
| 2 | **Production Capacity per Annum (Year 1)** | | 3 | | |
| | | | | | |
| 3 | **Investment Cost** | | | | |
| | S/N | **Description Cost** | **Amount US$** | Amount (NGN) | |
| | 1 | Additional facilities | 1,000,000.00 | 120,000,000.00 | |
| | 2 | Expert Team Verification | 5,000.00 | 600,000.00 | |
| | 3 | SHP Model Procurement | 60,000.00 | 7,200,000.00 | |
| | 4 | SHP Component - Engineering Drawing | 10,000.00 | 1,200,000.00 | |
| | 5 | Training Cost (ToT) | 54,000.00 | 6,480,000.00 | |
| | 6 | Fabrication of SHP Component | 69,000.00 | 8,280,000.00 | |
| | 7 | Assembling and Testing | 10,000.00 | 1,200,000.00 | |
| | 8 | Commercializtion & Investors Forum | 25,000.00 | 3,000,000.00 | |
| | 9 | Project Implementation Meeting | 5,500.00 | 660,000.00 | |
| | 10 | Contingency | 14,500.00 | 1,740,000.00 | |
| | | **Grand Total** | **1,253,000.00** | **30,360,000.00** | |
| | | | | | |
| 4 | **Material Cost** | | | | |
| | **S/N** | Description | Lots/Turbine | Unit Price (NGN) | Amount (NGN) |
| | 1 | Turbine Runner | 1 | 400,000 | 400,000 |
| | 2 | Shaft | 1 | 750,000 | 750,000 |
| | 3 | Bearing Housing | 1 | 300,000 | 300,000 |
| | 4 | Gate House Apparatus | 1 | 300,000 | 300,000 |
| | 5 | Pulley | 1 | 200,000 | 200,000 |
| | 7 | Gear Box | 1 | 100,000 | 100,000 |
| | 7 | Contingencies | 1 | 200,000 | 200,000 |
| | | **Sub-Total** | | | 2,250,000 |
| | | | | | |
| 5 | **Transferred Cost** | | | | |
| | **S/N** | Description | Qty/Turbine | Unit Price (NGN) | Amount (NGN) |
| | 1 | SEDI, Enugu | 1 | 96,000 | 96,000 |
| | | | | | |
| | | **Sub-Total** | | | 96,000 |
| | | | | | |
| 6 | **Other Cost** | | | | |
| | **S/N** | Description | Qty/Turbine | Unit Price (NGN) | Amount (NGN) |
| | 1 | Cost of Design/Supervision by Turbine Team | 1 | 400,000 | 400,000 |
| | | **Sub-Total** | | | 400,000 |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 7 | **Wages: Fixed Cost** | | No of staff | Rate | Total |
| | 1 | Project Engineer | 1 | 1,200,000 | 1,200,000 |
| | | | | | |
| | | **Sub-Total** | | | 1,200,000 |
| | | | | | |
| 8 | **General expenses - Fixed cost** | | | | |
| | | Description | Unit | rate | Amount |
| | 1 | Telephone, Postages, couriers & others | 12 | 12,000 | 144,000 |
| | | **Sub-Total** | | | 144,000 |
| | | | | | |
| | **O&M Turbine/Turbine** | | | | **4,090,000** |
| | **O&M Turbine/Turbine per annum (Year 1)** | | | | **12,270,000** |
| | | | | | |
| | | | | | |
| 9 | **Turnover** | | | | |
| | **S/N** | Description | Selling Price (US$) | Selling Price (NGN) | Turnover (NGN) |
| | 1 | Turbine 50kw | 40,000 | 4,800,000 | 14,400,000 |
| | | **Grand Total** | | | 14,400,000 |
| | | | | | |
| | | | | | |
| | | **Margin Year 1** | | | |
| | | | | | |
| | | Fixed Cost | | | 1,344,000 |
| | | Variable O&M | | | 2,746,000 |
| | | Total Cost | | | 4,090,000 |
| | | | | | |
| | | | | | |