

## Hydropower Potentials and Effects of Poor Manufacturing Infrastructure on Small Hydropower Development in Sub-Saharan Africa

Williams Ebhota<sup>1\*</sup>, Pavel Y. Tabakov<sup>2</sup>

<sup>1</sup>Department of Mechanical Engineering, Institute for Systems Science, Durban University of Technology, Durban, South Africa,

<sup>2</sup>Department of Mechanical Engineering, Institute for Systems Science, Durban University of Technology, Durban, South Africa.

\*Email: ebhotawilliams1@gmail.com

### ABSTRACT

Adequate access to reliable, quality and affordable power is crucial to standard of living globally. Therefore, this study discusses the present power accessibility level, the causes of power inadequacy and measures required to realise power adequacy and sustainability in Sub-Saharan Africa. Based on secondary research information sources, this study reported that presently in the region, four out of five people depend on firewood (traditional biomass) for cooking; power sector is typified of inadequacies of power generation, transmission and distribution infrastructure and emission of greenhouse gases. The effective amount of hydropower potential available in the region is 4,000,000 GWh/year and only 76,000 GWh/year of this potential that has been developed. The study attributes the low level of hydropower development to poor and inadequate manufacturing infrastructure. Further, the study sees the development of manufacturing infrastructure and other basic infrastructures as a panacea for power adequacy and sustainability in the region.

**Keywords:** Hydropower, Small Hydropower, Manufacturing Infrastructure, Sub-Saharan Africa, Electricity, Hydro Turbine, Renewable Energy

**JEL Classifications:** Q4, Q56

### 1. INTRODUCTION

The growth of Sub-Saharan Africa (SSA) economy has remain sluggish as a consequence of low levels of power supply and infrastructure. This is deterring many wanting to invest across all sectors in the region. The region needs to development large capital projects to grow the economy from the present level to an acceptable level, were it can attract investors. This will require dynamic planning, robust working structures, skills development and reliable funding sources. The power sector in the region faces numerous challenges such as inadequate generation and transmission infrastructure, insufficient fund and unskilled or low numbers of skilled workforce. Other challenges are high cost of executing power projects, epileptic and unreliable supply, poor maintenance of existing facility, poor metering and billing systems, vandalising, and terrorising activities.

“Ban Ki-moon, former UN Secretary-General, stated that energy is the golden thread that connects economic growth, social equity

and environmental sustainability” (“Smart Villages, 2017). New Thinking for Off-Grid Communities”). The socio-economic development and all-inclusive growth of the region have been dragged down by unreliable, inadequate and high cost of power generation and distribution. Power and related infrastructure sectors are growth and development facilitators, which SSA must revolutionised in order to pave way for industrialisation and better standard of living. Subsequently, all national governments of SSA consider power sector as one of the priority areas to be developed. Due to its importance in socioeconomic development and all-encompassing growth, power sector development has always attracted international communities’ interventions. Sadly, both domestic and international interventions are yet to achieve the expected results. This study therefore, analyses and examines present power issues in SSA and discusses more enduring ways of increasing and sustaining power (electricity) in the region. Figure 1 shows infrastructural comparison in selected countries, 2015-2016.

## 2.BACKGROUND STUDY

### 2.1. Present Power Situation in SSA

An estimated 17% (about 1.2 billion people) of the world population have no access to electricity. And about 95% of this figure are living in the rural areas of developing countries in SSA and Asia (International Energy Agency [IEA], 2015). The SSA's power industry track records and statistics are miserable and appalling due to low accessibility, epileptic and poor quality supply. In 2014 factsheet, IEA reported that two-thirds of SSA population, which is about 620 million people has no access to electricity and other modern energy services (IEA, 2014a). And in the region, four out of five people depend on firewood (traditional biomass) for cooking (IEA, 2014b; Nufu-Noma, 2011). The Power sector is typified by gross inadequacies of generation, transmission and distribution infrastructure, poor quality supply, and emission of greenhouse gases (GHG) from fossil plant. About 600 million people in the region have no electricity connection at all. However, South Africa has the highest electrification rate in the region of about 88%, follow by Nigeria, Cote d'Ivoire, Senegal, Cameroon, Gabon, Ghana, and Botswana of above 50% each (Eberhard et al., 2016). However, South Sudan, Burundi, Malawi, and Sierra Leone are countries in SSA that have the lowest electrification rates (all below 10%) (IEA, 2015).

Rural areas in SSA are the most affected in the power accessibility inadequacy. IEA reported in 2014 that only about <2% of the population in the rural areas have access to electricity (IEA, 2014b). The urbans areas where there are relatively improved rate of supply and high access, but are bedevilled by poor quality supply and frequent power outage. Although, efforts are being made to slow the dismal power picture of SSA, the rapidly growing population of the region shadows these efforts and the improvements made. The total installed capacity (excluding South Africa) of the region is about 80 GW, as shown in Figure 2, and this is equivalent to Republic Korea capacity. Averagely, per capita installed generation capacity across SSA is close<sup>th</sup> of Latin America's generation.

The dismal perennial power generation, coupled with transmission and distribution network facilities inadequacies are the principal causes of low electricity consumption and access. IEA has declared that SSA region has the poorest power in the world, considering the number of people without access to electricity (IEA, 2014b). The present power situation has defied all the interventions by the governments of the countries in the region and international supports.

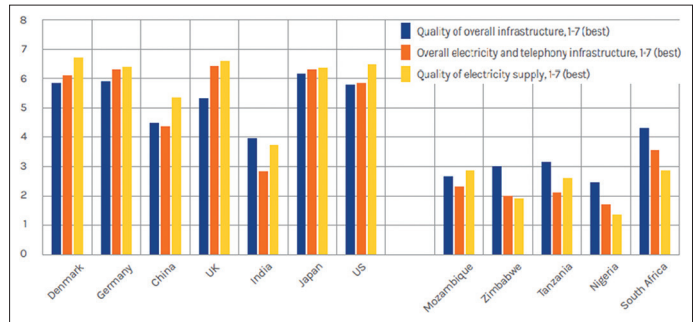
### 2.2. Generation and Consumption Rates

The average electricity consumption in the region is about 150 KW-hr/capita, which is minute of India or Brazil's consumption rates. It has been predicted that if this trend continues, about 655 million people in Africa will be without access to electricity (IRENA, 2012a). The stalled capacities of selected countries are shown in Figure 3.

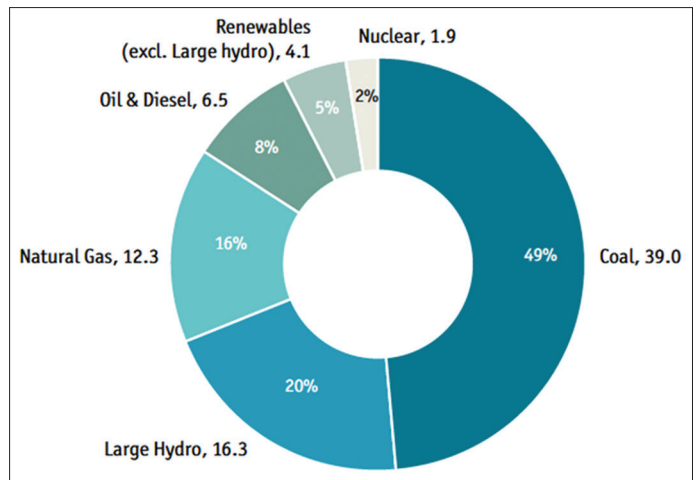
### 2.3. SSA Power Requirement

In 2011, IEA predicted that SSA electricity requirement will rise at a compound annual growth rate of 4.6% and that the present

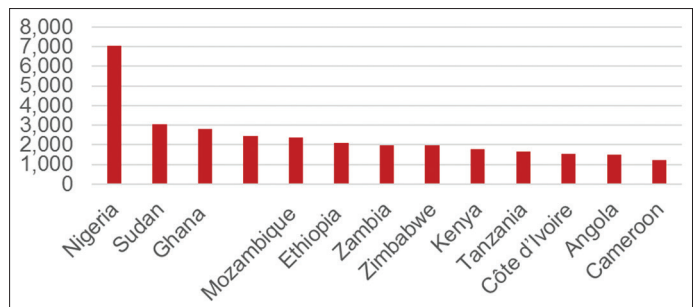
**Figure 1:** Infrastructural comparison in selected countries, 2015-2016 (JCRA, 2017)



**Figure 2:** Sub-Saharan Africa's power generation (GW) (EIU, 2016)



**Figure 3:** Significant installed power generation capacity in Sub-Saharan Africa, 2013 (Eberhard et al., 2016)



electricity need will be more than 200% increase by 2030. To adequately address the power challenges in SSA, the annual investment in the power sector was estimated to be \$40.8 billion (Eberhard et al., 2016). KPMG reported in 2016 that a quarter of 70 GW power capacity installed in SSA is lost due to poor maintenance and infrastructure. The report added that World Bank has estimated the required power in the region in short term basis to be 70 GW. This will require an annual investment between \$120 and \$160 billion to provide adequate power to the region by 2030 (De Buys et al., 2016). Over 30 countries in Africa have adopted expensive short-term measures to augment power insufficiency and shortages or face power blackouts. The economic consequence of this occurrence is decline of gross domestic product by more than 2%.

### 2.4. Renewable Energy

The region still derives significant amount of energy from fossil sources such as oil, coal, and gas. Renewable energy can play a substantial role in the region’s energy source due to its abundance - in Kenya and Ethiopia from geothermal power while in the Democratic Republic of Congo to Zambia hydropower. The installed capacity of renewable energy in SSA has increased by 60% in the last 15 years. However, the region has dropped from 2.7% to 1.8% in the global perspective over the same period (IRENA, 2015). In 2016, Economist Intelligence Unit (EIU) reported the Director of IRENA’s Innovation and Technology Centre, Dolf Gielen, assertion that 40 SSA countries have the last 10 years plan of renewable energy. About 100 GW of renewable projects is said to be in the pipeline in the region, which shows the region’s openness to renewable energy. Africa Union in conjunction with United Nation (UN) are championing the African Renewable Energy Initiative, which has a goal of 300 GW renewable energy capacity by 2030. IRENA reported that SSA generates power of about 30 GW from renewable energy sources, which is between 25% and 30% of the installed capacity. This is dominated by large hydro, accounting for almost 25% (EIU, 2016).

### 2.5. Global Technologies Landscape Effects on SSA Power

The various interventions to change the present power situation in SSA have not been effective as expected. The interventions are seemed to have been overtaken and consumed by challenges arising from changes in the global technologies landscape, which has given birth to several disruptors in the industry. This has stimulated a shift from landscape of stakeholders and players, traditional generation practices and mixes, methods of operations and systems and funding channels. It has shifted towards the use of new and ground-breaking technologies and dynamics in power infrastructure of SSA. These disruptors that propelled paradigm shift in the industry, have been categorised by Deloitte (Deloitte, 2015) into six classes as presented in Table 1. It is obvious that a fresh and a systematic power infrastructure investment will be required to meet the present and future energy demand in SSA.

This notwithstanding, there are some positive improvement in this challenge choked power sector in SSA. This is evidenced in the significant tariff drop of South African Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) due to the competition that exist in the system. Another indication of gradual shift from these challenges is wind and solar PV technologies tariff drop, which is put at 72% and 46% drop respectively (Eberhard et al., 2016). Other indicators are Nigerian electricity industry privatisation; massive upgrading, revamping and process optimisation of existing generation and distribution assets in the region; construction of new generation assets, and the shift to energy trilemma. Trilemma is the balancing of the three energy sustainability elements according to the World Energy Council. These elements are energy security, environmental sustainability, and energy equity Figure 4.

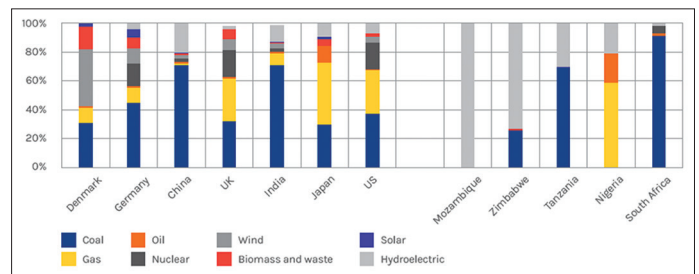
The region still derives significant amount of energy from fossil sources such as oil, coal, and gas. Renewable energy can play a substantial role in the region due to its abundance- in Kenya and

**Table 1: Trends of power disruption in SSA**

Disruptors	Need trend
African economic growth	Demand generation Growing commercial and industrial sector Emerging middle class Access to electricity
Shifting the energy mix	New capital Wind, solar, biomass Gas to power Nuclear Coal Hydro
Changing role of customers	Customer shift Consumer to producer Self-generation Demand managers Every company is an energy company
Renewable technology	Renewable technology Affordability of new technologies Solar PV, storage Off-grid solutions
Smart grids, smarter utilities	Smart utilities Smarter utility management Analytics Smart grids Smart metering
Changing market structures and dynamics	Market restructure Consumer to producer Self-generation Demand managers Every company is an energy company

SSA: Sub-Saharan Africa

**Figure 4: Sources of power generation in five Sub-Saharan Africa countries and international comparators, 2014 (JCRA, 2017)**



Ethiopia from geothermal power while in the Democratic Republic of Congo to Zambia hydropower.

#### 2.5.1. Hydropower

The available hydropower potential in Africa is about 283 GW, and this is more than 300% of the present electricity consumption in SSA [1]. About 50% of this potential is located in Central and East Africa (Congo, Cameroon, Ethiopia, DR Congo, and Mozambique). Significant amount is also found in West Africa (Guinea, Nigeria and Senegal) and Southern Africa (Madagascar,

Mozambique, South Africa and Angola). Out of the effective 4,000,000 GWh/year hydropower potential available in the region, only 76,000 GWh/year is being generated from a total of 20.3 GW installed capacity as depicted in Figure 5. This is below 10% of the useful hydro potential available (GSMA, 2014). The proposed Grand Inga project in DC Congo has been described as the largest hydropower project (44 GW) in the region, which will tremendously transform SSA power supply when completed.

Harnessing the hydropower potentials in SSA in large scale, will require infrastructure like road to access sites, transport equipment and personnel and for grid transmission. Others requirements include up to date hydrological information about potentials, skilled personnel for design and production of hydro turbine components and systems, and manufacturing infrastructure. In addition, a policy framework is needed for effective regulation, sufficient fund and smart business models. In this study, hydropower will be categorised into small hydropower (SHP), medium hydropower and large hydropower (LHP), as shown in Table 2.

Larger hydropower involves large dams and storage reservoirs and supplies large grids connection. However, there is a decline in the use of LHP due to the several challenges that the scheme poses such as:

- Large investment capital.
- Domestic markets maybe too small to consume all the power generated by LHP.
- Water level fluctuation due to seasonal and annual changes.
- LHP dam poses environmental threat such as altering the ecosystem, displacing communities and effects on water availability for other uses.
- Inadequate skilled personnel in hydropower development in some developing countries, etc.

2.5.2. SHP

The generation of electrical power capacity of not more than 100 MW from a water source is considered as SHP. However, there is no internationally agreed standard of SHP capacity classification as the definition of capacity varies from country to country as shown in Table 3. However, few international organisations such as the International Association for Small Hydro, the European SHP Association the United Nations Industrial Development Organization (UNIDO), have generally accepted capacity of up to 10 MW as SHP (Energypedia, 2017).

SHP electrification scheme has been described as most effective for rural and standalone electrification scheme, provided there is availability of SHP potential (Obadote, 2009). This is because the technology is very robust and can last for about 50 years or more with minimal maintenance and is environmentally friendly (Oliver, 2002). Other merits are: Reduction in network problems; reduction in transmission losses; abundant SHP resources that largely untapped in SSA; cleaner renewable energy (emits low GHG (CO<sub>2</sub>)); and it a simple technology that promotes domestic participation. Intergovernmental Panel on Climate Change in 2004, reported that transport and agriculture sectors contributed least to the world’s GHG emissions GHG (13%), forestry (17%)

Table 2: Broad classification of hydropower (Arun and Tormod, 2009; Energypedia, 2017)

Class	Size
SHP, MW	SHP<100
MHP, MW	100≤MPH≤500
LHP, MW	LHP>500

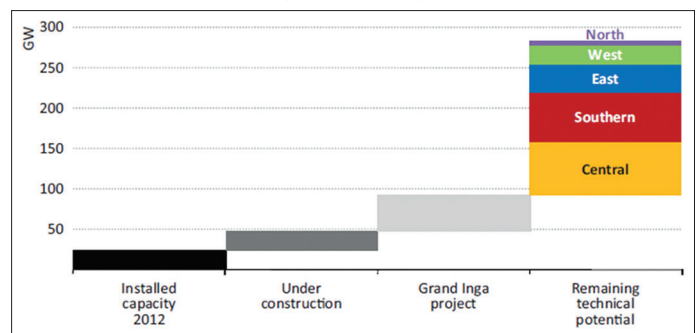
SHP: Small hydropower, MHP: Medium hydropower, LHP: Large hydropower

Table 3: Various size classifications of SHP (Basnayot, 2006; BHA, 2012)

Country	Micro (kW)	Mini (kW)	Small (kW)
United States	<100	100-1000	1-30
China	-	<500	0.5-25
USSR	<100	-	0.1-30
France	5-500	-	-
India	<100	101-1000	1-15
Brazil	<100	100-1000	1-30
Norway	<100	100-1000	1-10
Nepal	<100	100-1000	1-10
Various	<100	<1000	<10

SHP: Small hydropower

Figure 5: Hydropower potential and installed capacity in Africa (GSMA, 2014)



while energy production contributed the highest (26%) (Singal, 2009). The high GHG emission from energy sector is due to the use of fossil fuels for power (SPLASH). Power generation from renewable energy sources, hydropower system produces the lowest cost of electricity, which is between 0.02/kWh and 0.05/kWh USD (IRENA, 2014; UNIDO, 2013).

Although SHP has been recognised in SSA as a reliable rural and remote areas electrification scheme in the region, the installed capacity is not sufficient. The huge SHP potential in SSA has not been tapped sufficiently, as seen in Figure 6 (Liu et al., 2013). Many SHP viable sites in the region are yet to be developed due to several limiting factors such as insufficient policy for rural electrification; lack of sufficient fund for SHP; type of Electricity market in the region; lack of strong synergy among the stakeholders; insufficient application of energy research outputs in the region; inadequate human and manufacturing facility development (Williams and Freddie, 2017).

This occurrence is credited to several factors such as finance, technical, political, environmental, policy etc. Electrification of rural areas, and standalone and diversification of energy source favour the use of SHP in SSA. It equally fits into the global

pursuit of a cleaner energy to replace or reduce the use of fossil fuels, which are currently the main sources of power generation in the region (Mary, 2008). Significant use of energy will reduce emission of CO<sub>2</sub> in the region by 27% (Antonio et al., 2015). SHP is subdivided into classes based capacity, as presented in Table 4.

### 3. EFFECTS OF INFRASTRUCTURES ON SHP DEVELOPMENT IN SSA

#### 3.1. Inadequate Domestic Manufacturing on SHP Development

According to UN, the slow pace of economic development of Africa is due to poor infrastructure. Promotion of industrial development in the continent, will stimulate economic growth and poverty reduction. The present manufacturing status of Africa is drastically not proportionate to its population and global manufacturing trend. The level of manufacturing in Africa is only about 1% of the world’s manufacturing, while the continent’s population is 15% of the global population (Chiponda, 2011). Poor manufacturing infrastructure has multiplicity effects on SHP production costs, as the time and cost of transporting facility is increased (economic distance), and heightens project delivering uncertainty. Amongst the infrastructures for economic growth, power and manufacturing infrastructures are intertwined and pose the biggest challenges to the region. To put SSA on economic recovery and development track, power and manufacturing infrastructures need to be revamped simultaneously. Economic growth depends largely on power generation expansion, while sustainability relies on domestic manufacturing.

This study identifies poor designing and manufacturing of SHP components and devices as one the principal barriers against the development of SHP in the region. This factor has been overlooked in the past and even now. The insufficient human and manufacturing infrastructure capacities in SSA, spurs the lingering inadequate power accessibility challenges in the region. The region was ranked the lowest by UNESCO in a study of engineering, manufacturing and construction in undergraduate studies from 2008-2010 (Deloitte, 2015). At present, the economies of most countries in SSA are based on mineral resources while manufacturing plays an insignificant role. The region’s weak manufacturing performance does not provide the needed support for SHP equipment domestic manufacturing participation. Further, there are shortages of the necessary skills and new productive capabilities [28]. The consequence of this is poor and inadequate domestic manufactured SHP components and systems to meet the present region’s power need or for export. Due to these inadequacies, the region depends heavily on foreign SHP equipment products and technologies. Su-Saharan Africa’s gets transport, power equipment and other machinery mostly from Japan, South Korea, Germany, the United Kingdom, China, and the United States as shown in Figure 7.

#### 3.2. Hydro Turbine Design and Manufacturing Procedures

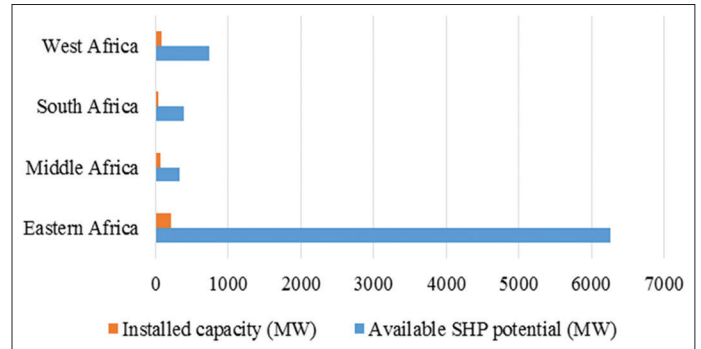
In design process, a correlation exists between manufacturing and material selection processes, shown in Figure 8. To

**Table 4: Classification of SHP (Energypedia, 2017)**

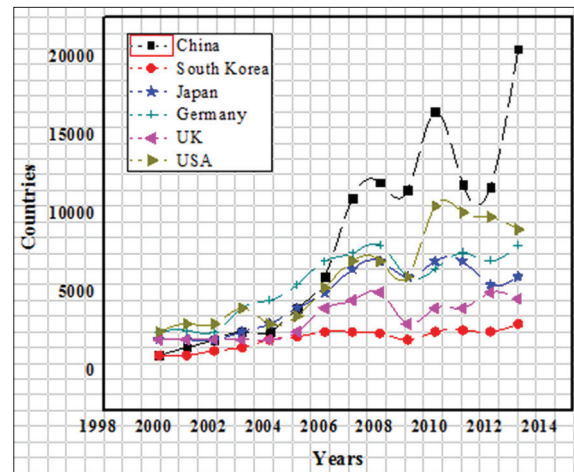
Category	Capacity	Application
Mini (MH)	<1 MW	Grid connection
Micro	<100 kW	Partially grid connection
Pico (PH)	<10 kW	Island grids
Family (FH)	<~1 kW	Single households/clusters

SHP: Small hydropower

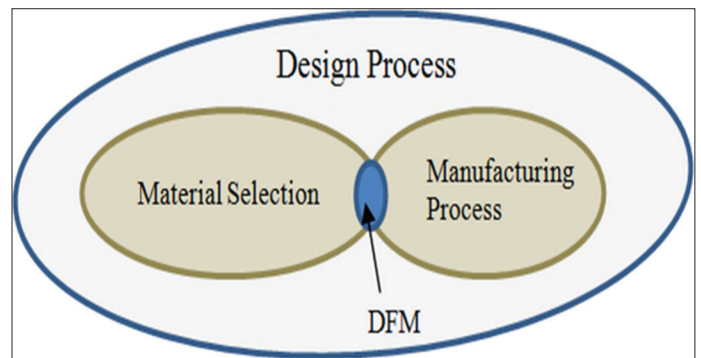
**Figure 6:** Small hydropower potential in regions of Africa (Liu et al., 2013)



**Figure 7:** Sub-Saharan Africa main sources of transport, power and other machineries (Richmond, 2015)



**Figure 8:** Correlation between material selection and manufacturing process. DFM: Design for manufacturing



successfully design a product for manufacturing, the design process should harmonise manufacturing facilities and material availability. The poor manufacturing system

in SSA has consequence effects on SHP mechanical and electromechanical components and systems. However, if the region's manufacturing status is integrated with locally sourced materials during SHP design process, good hydro turbine products can come out of the region.

### 3.3. Transportation Infrastructure

Across SSA, it is obvious to see dilapidating infrastructures in various sector such as transport, education, manufacturing, communication and power. The roads in the region are poorly maintained and often the roads in rural areas are untiled and this affects transportation of SHP facilities to sites and distribution network. Rail network is limited and less dependable than use of truck in the region. Transportation infrastructural decay, causes increase in the economic distance and often increases production costs, shipping costs and delay in project delivery time.

## 4. DOMESTICATION OF SHP IN SSA

Chinese SHP manufacturers are playing vital roles in the growth of SHP in the region. In SHP scheme, cost reduction should not override other local production motivating reasons. Other issues that are vital to be considered are technology adaptation, improve manufacturing, and strengthening of region's human resources in SHP research and development. Although, local manufacture of SHP systems would not solve these issues alone, but would go a long way to make SHP a source of economic strength in the rural areas of SSA. The advantages of domestic production of SHP technology include:

### 4.1. Foreign Currency

The local manufacturing of SHP devices and systems will have a significant influence on the sustainability of the domestic market. At present, most countries in SSA depend on imports for energy supply equipment and systems. This means that every locally manufactured and installed SHP component and system will result in a net saving of foreign currency.

### 4.2. SHP Projects Costs Reduction

Domestic manufacturing has the prospective of enlarging the existing markets, in addition, it creates jobs, training, services and financing to decrease SHP projects costs. It will provide opportunities to create parts and adapt SHP technology to meet African specific requirements. Local production of SHP products specifically for SSA markets have potentials of stimulating economic growth of the region. Domestic development of SHP technology could lead to cost reduction and then create a competitive advantage of manufacturing SHP components with locally sourced materials.

## 5. EFFECTS OF OVERDEPENDENCE ON FOREIGN POWER TECHNOLOGIES

The power challenges in SSA will persist as long as the region heavily relies on foreign power generation technologies. There

are severe consequences of overdependence on foreign power technologies, such as:

### 5.1. Power Projects and Maintenance

Power projects delivering time, installation, maintenance and repair of SHP facility and downtime are negatively affected by overreliance on foreign power generation and distribution technologies.

### 5.2. Power Sustainability

Power sustainability in the region is threatened by overreliance on foreign power technologies. Overdependence on foreign SHP technologies increases project cost, resulting from costs of shipping and hiring of expatriates.

### 5.3. Encourages Dependence on International Donors

Inadequate power accessibility orchestrated by insufficient local power equipment production promotes dependence on international donors for power projects execution. This is not a reliable way of power sustainability and overcoming the power challenges in the region.

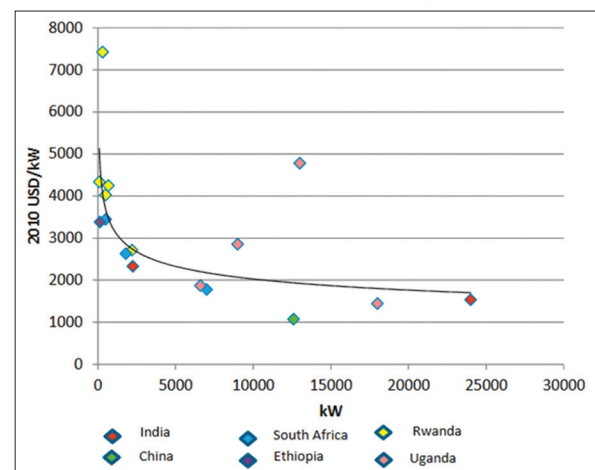
### 5.4. High Cost of Power Project Execution

Although, the cost of SHP project varies from country to country in the developing countries, it is higher in SSA countries than Asia countries, as shown in Figure 9. This is due to relatively higher domestic manufacturing of SHP equipment in Asia countries. High cost of shipping of power equipment and hiring of expatriates are responsible for the high cost of power projects in SSA.

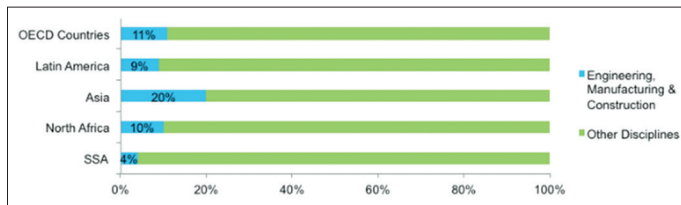
### 5.5. Other Resultant Technical Challenges

Other resultant technical challenges due to overreliance on foreign power technology are inadequate skilled personnel for SHP components manufacturing, installation, operation, and maintenance; and readily available parts to replace worn out ones. Skills and manpower development are significant in moving power sector forward. Despite this, university graduates of engineering, construction and manufacturing only account for 4% compared to other discipline in SSA, as shown in Figure 10.

**Figure 9:** Costs of installed capacity small hydropower in developing countries (IRENA, 2012b)



**Figure 10:** Percentage of Sub-Saharan Africa University graduates in engineering, construction and manufacturing (2008-2010) (Deloitte, 2015)



## 6. STEPS TO INCREASE POWER ACCESSIBILITY AND SUSTAINABILITY IN SSA

### 6.1. Building SHP Capacities

Increase in the domestic manufacturing will significantly reduce the cost of SHP projects in the region. Apart from project cost reduction, domestic manufacturing also decreases operational, maintenance and repair costs and downtime. At present in SSA, there is deficit of skills in power industry and supporting sectors that has created technical gap and challenges for local design and development of SHP equipment. Building SHP capacities for both personnel and equipment manufacturing will greatly enhanced chances of increasing power accessibility and sustainability in the region.

Immediate, medium and long terms plans should be used in bridging the human and infrastructure capacities gaps. For rapid response, governments in the region should take the advantage of existing technologies in Asia, Europe and America. Governments in the region should import SHP technologies skills, equipment and systems to expedite skills and technology transfer through reversed engineering and adaptive programmes. For medium and long terms plan, governments in the region should partner with foreign investors to provide the needed technical training to improve the current skills deficit in SSA. The skills should be developed through technical training schools and government should give priority to the study of science and engineering in the region. Funds and other encouragements should be provided to students enrolling for science and engineering in graduate and postgraduate programmes.

### 6.2. Technologies and Systems for Rural Electrification

As it stands now, according to World Bank, about 66% of the population of SSA has no access to electricity and they are predominantly in rural areas (World Bank, 2015). In order to make huge impact in electricity accessibility, rural electrification should be given the desired attention and renewable energy technologies (RETs) should be deployed. Large sections of rural areas can be reached out to with SHP technology since the region has huge SHP potentials. This technology is simple and is the cheapest source of renewable energy and is suitable for stand-alone mini-grid or off-grid systems.

### 6.3. New Technologies and Systems

The development of SHP in SSA should follow the modern trend in RETs that includes new innovations, such as process automation

systems and smart metering. This will open up opportunities for feature relevance and optimisation, which will guarantee sustainability in SSA.

### 6.4. Public-private Partnership (PPP)

In Europe and America, entrepreneurs and innovators are major players in power sector revolution, especially in the development and utilisation renewable energies. Their involvement brought unprecedented trends in both new innovations and disruptions to the sector. As stakeholders in the industry, they take opportunities by identifying power challenges and packaging solutions in form of business models. The business approach has evolved to what is now known as PPP in power sector. Active PPP in power sector is a tested and trusted strategy of increasing power supply in Europe and America. Although, PPP approach has been introduced in SSA, it needs to be strengthened. A lot of PPP power projects are required to increase power accessibility in the rural areas of SSA.

### 6.5. Regional Power Development Synergy

Sustainability of adequate and reliable power supply in SSA can be strengthened through the synergy of the countries in the region to build SHP technologies capacity. The capacity building for SHP technology development include foundry, mechatronics, fluid mechanics; computer aided manufacturing, and material engineering.

### 6.6. Promulgation of Renewables and Energy Supply Services Decentralisation Policies

Governments in the region need to engage in design, planning and policies to get a view of what is really required and to control factor necessary for power industry going forward. The need to share renewables and decentralise energy supply services is significant in boosting energy accessibility in SSA. Policies and regulations that will develop domestic renewable technologies in line with trilemma concept should be promulgated in the region. The world is faced with environmental change and sustainable development challenges. To appropriately respond to these issues, developed countries need to dismantle and change ancient practice, while developing countries can directly apply new technologies and new institutional frameworks. The frame work should allow enterprising industry, and direct energy research and investment focus areas on promotion of domestic based modern RETs and innovations. Also, policy based utilities restructuring that will encourage greater PPP in the SSA electricity market, with a focus on renewable energy sources and project funding should be established.

## 7. CONCLUSION

Despite the abundant of huge SHP potentials in SSA, the region's economic growth is impeded by inadequate, non-reliable and low quality power supply. Globally, SHP scheme has been described as a reliable rural and remote areas electrification scheme. This study sees this scheme as the best electrification option for rural and remote areas. However, the development of the scheme in the region has been effected by the obvious inadequate infrastructure. The most suitable and sustainable electrification scheme for provoking developments and economic activities in the rural and

remote areas is SHP. It is regarded as a matured power technology that has low operation and maintenance cost and provides the lowest power generation prices of all off-grid technologies. SHP schemes have been tested globally and certified as a formidable scheme for power production in developing countries. The abundant untapped SHP potential in SSA needs to be converted to a more effective power in the form of electricity. Domestic technology development with facilitate lower cost of power projects, and faster power project delivery and subsequently, rapid energy increment in the region. To develop domestic SHP technology in the region, it will require human and manufacturing infrastructure capacities building, which will increase domestic participation in the design, and manufacturing of SHP components and systems.

## 8. ACKNOWLEDGMENT

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