Energy System Transition: Megatrends, disruptors, future markets and business models

Pre- feasibility Study on Business Opportunities for Women in a Changing Energy Value Chain in West Africa

Situation Analysis Report

DRAFT

With funding from:

With technical assistance from:
Azam Pasha, CEO, Jadenex Technologies FZCO

“The next technology revolution is set to happen in the clean energy sector. If the existing barriers are not addressed now, and women given the support to be engaged in the sector, it would be a missed opportunity not just for women but for the achievement of an inclusive and sustainable development.”

Mahama Kappiah, Executive Director ECREEE, Foreword from ‘Situation Analysis Report on Gender and Energy Issues in the ECOWAS Member States (2015)

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Kadija Simboro	General Director	Farafina Eco-Engineering	Ougahadogou
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Kingsley Adofo-Addo	Relationship Manager for SME Business	Ecobank Ghana	Accra

Joseph Fehintola	Head of Micro Credit	AB Microfinance Bank Nigeria Limited	Lagos
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El Ahji Malick Soumare	Investment Manager	GRoFIN	Dakar
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Kindly forward any additional material on policies, programmes, and initiatives for inclusion to **Monica Maduekwe**, the Project Manager (MMaduekwe@ecreee.org).

List of Abbreviations and Acronyms

5Cs: Character, Capacity, Capital, Collateral, Conditions
B2B: Business to Business
B2C: Business to Consumer
CNI: National Confederation of Industry
CO2: Carbon Dioxide
CRA: Credit Rating Agency
CSO: Civil Service Organization
DG: Distributed Generation
DSO: Distribution system operator
E&A: Energy and Agriculture
ECREEE : Ecowas Center for Renewable Energy and Energy Efficiency
EOQ: Economic Order Quantity
EPI: Environmental Performance Index
ESMAP: Energy Sector Management Assistance Program
EU ETS: European Union Emissions Trading System
FDI: Foreign Direct Investment
FEI: Female Entrepreneurship Index
FONSI: Fonds Souverain d'Investissement Strategique
GDP: Gross Domestic Product
GEDI: Global Entrepreneurship Development Index
GEI: Global Entrepreneurship Index
GII: Global Innovation Index
GOGLA: Global Off-Grid Lighting Association
GW: Gigawatt
GWh: Gigawatt-hour
IBM: International Business Machine
ICT: Information and Communications Technology
INSEAD: Institut Européen d'Administration des Affaires
IPP: Independent Power Producer
ISO 9001: International Standards Organization
JRC: Joint Research Center
LCOE: Levelized Cost of Electricity
LPG: Liquefied Petroleum Gas
MIT: Massachusetts Institute of Technology
MW: Megawatt
ND-GAIN: Notre Dame Global Adaptation Initiative
PE: Private Equity
PPP: Public-Private Partnership
PPP$: Purchasing power parity
PV: Photovoltaic
PwC: Pricewaterhouse Coopers
RISE: Regulatory Indicators for Sustainable Energy
SE4ALL: Sustainable Energy for All
SENELAC: Société Nationale d'électricité du Sénégal
SME: Small and Medium Enterprises
STEM: Science, technology, engineering, and mathematics
ToR: Terms of Reference
TSO: Transmission system operator
TVET: Technical and Vocational Education and Training
UN Agencies: United Nations Agencies
UNDP: United Nations Development Program
UNEC: United Nations Economic Commission
UNIDO: United Nations Industrial Development Organization
USAID: United States Agency for International Development

VC: Venture Capital
WAPP: West Africa Power Pool
WEF: World Economic Forum
WER: World Energy Resources
WIPO: World Intellectual Property Organization

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Executive Summary

The essence of this situation analysis report on the 'Pre-feasibility study of Business Opportunities for Women in a Changing Energy Value Chain in West Africa' is to identify barriers and challenges to promoting women's entrepreneurship in the energy sector across West Africa, and using this information to develop a gender responsive, regional energy market development strategy that taps into the innate entrepreneurial capacity of ECOWAS women.

This pre-feasibility study is part of the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) project entitled: **Feasibility Study on Business Opportunities for Women in a Changing Energy Value Chain in West Africa,** which is funded by the New Partnership for Africa's Development Infrastructure Project Preparation Facility (NEPAD-IPPF), a multi-donor Special Fund hosted by the African Development Bank Group (AfDB). The project seeks to ensure that the region meets its goal of universal energy access for its over 300 million people by harnessing West African womens' entrepreneurial capacity towards increasing the establishment of energy businesses and deployment of energy technologies to meet the energy needs of the region's largely unserved population. In line with this objective, the project focuses on regional energy infrastructure development and business opportunities for women-owned businesses in four countries of ECOWAS.

As a precursor to the feasibility studies, the pre-feasibility study aims to identify opportunities in the underfinanced small to medium sized women-owned energy businesses in West Africa, having the potential to encourage economic growth in the ECOWAS region. The project on 'Feasibility Study on Business Opportunities for Women in a Changing Energy Value Chain in West Africa' is a product of the ECOWAS Policy for Gender Mainstreaming in Energy Access which aims, among others, to increase women participation in energy-related fields in the private sector by 25% by 2020 and 50% by 2030. This study is in line with sustainable development goals numbers 5 (achieve gender equality and empower all women and girls) and 7 (ensure access to affordable, reliable, sustainable and modern energy for all) promulgated by the United Nations.

The pre-feasibility study employed the energy transformation framework from the 2014 PricewaterhouseCoopers ('PwC') report on 'The road ahead: Gaining momentum from energy transformation'. The study applies that framework to evaluate the West African entrepreneurial ecosystem (in Nigeria, Ghana, Senegal and Cote d'Ivoire) as it concerns women entrepreneurs. It analyses the megatrends that are impacting the West African energy sector, the disruption factors that are changing the sector, ways through which the current energy market is evolving, ways by which women entrepreneurs are adapting and transforming their business models in order to sustain profitability and longevity.

Results from the study show two types of forces impacting business models and transformations in energy-based businesses which are – external forces (i.e. changing energy generation, transmission, storage and distribution dynamics), and internal forces (i.e. a company's strategic capabilities which include its operational, human resource and financial dynamics). Both external and internal forces are **drivers of change** in the energy value chain which bring about changes in market models in the locality, country or region. The women entrepreneurs act as **agents of change** on the energy value chain, capitalizing on the changes that happen in the energy market to deliver benefits – in the form of better products and services to consumers ('**beneficiaries of change**') creating both economic and social impact. The women entrepreneurs, acting as agents of change, are required to undergo certain transformations in their business models in order to adjust to the changing market models. The continuous pressure to adapt due to both external and internal forces is a dynamic process, and those women entrepreneurs who are able to adapt are those that are better suited to reap the maximum profitability from the opportunities these evolving markets provide them. However, for these women entrepreneurs to capitalize on these new opportunities, they need the support of other stakeholders namely – government agencies, commercial banks, funds, regulatory agencies, and developmental organizations. We have evaluated the drivers of change not

only through secondary data (collected from study reports and data collected from agencies) but also primary data (collected through in-field interviews with women entrepreneurs).

The overall evaluation of our research pointed out that the energy value chain in West Africa is fast evolving due to diffusion of global advances in sustainable energy technologies and women entrepreneurs have already started transforming their business models to adapt to these changes. The challenges that exist for women entrepreneurs range from handling operational complexities, technological ability, employee training and development, recruitment challenges to financial prudence. The requirement to balance personal and business responsibilities, dealing with cultural stigma and lack of technical (and or operational) and financial expertise exerts pressure and restricts the growth of women-owned business, hence there is an urgent need to address their business challenges to help them thrive and succeed in the face of West Africa's energy transition.

Some of the key achievements of this assignment have been:

- **a)** Identification and formalization of the first-ever database of women entrepreneurs involved in the energy value chain across the four largest countries in West Africa
- **b)** Gaining a comprehensive understanding of women-owned businesses regarding their operational, commercial, technological, labor, legal & regulatory and financial circumstances
- **c)** Gaining insight into the operational, labor and financial challenges faced by women entrepreneurs and simultaneous identification of tactical and strategic solutions to address those challenges
- **d)** Collection of formal field research data on women-led entrepreneurship on the energy value chain that can be processed for supporting other women entrepreneurial policy developments
- **e)** Identification of feasibilities studies that will become templates for expansion and diversification of women entrepreneurs across the West African region
- **f)** Provide banks and funds with an understanding of the operational and financial profile of women owned businesses and to help them estimate the value, tenor, and pricing of products that may fit women entrepreneurs' business requirements
- **g)** Providing multi-lateral agencies and government institutions perspective for mainstreaming women entrepreneurs on the fast-changing energy value chain
- **h)** Providing women entrepreneurs an insightful perspective of their businesses, identify areas for improvements and identify new opportunities for growth and development
- **i)** Bringing women entrepreneurs and all stakeholder of the women entrepreneurial ecosystem together to network, discuss and resolve issues that can help women entrepreneurs grow their businesses

1. Introduction

This situation analysis report presents the findings of the pre-feasibility study undertaken across the selected four countries which are **Nigeria, Ghana, Cote d'Ivoire and Senegal** in **West Africa**[1]. The prime focus of this assignment was to identify and evaluate the businesses of women entrepreneurs involved with renewable energy and energy efficiency products and services with the goal of providing recommendations on how they may transform and capitalize on the changing energy value chain and, thus, enhance and sustain the profitability and longevity of their businesses.

The study followed the energy system transition analytical framework proposed by ECREEE and conceptualized by Price waterhouse Coopers (PwC) in the report '*The road ahead* - Gaining momentum from energy transformation' which looks innovatively into the structure and transformation of the energy value chain. The report identifies five global megatrends that are shaping the energy sector and opening opportunities for market creation and development. The five disruption factors resulting from these megatrends are impacting the energy markets at one level (i.e. market models) and the business operations (i.e. business models) of energy companies at another level. These megatrends are changing and shaping the future of the energy value chain and will lead to the emergence of new roles concerning participants in the energy value chain that includes – energy generation, transmission, storage, distribution, and consumption.

The pre-feasibility study adapted and employed this framework, as shown in Figure 1, to analyze West Africa's **women entrepreneurial ecosystem,** looking at the current state[2] and possible changes that may occur in the short term. The study covered the whole energy value chain, identified businesses owned by women, their explicit and implicit challenges, and proposed recommendations which would enable women entrepreneurs in the region adopt new business models for transformation to responsive and larger sized businesses.

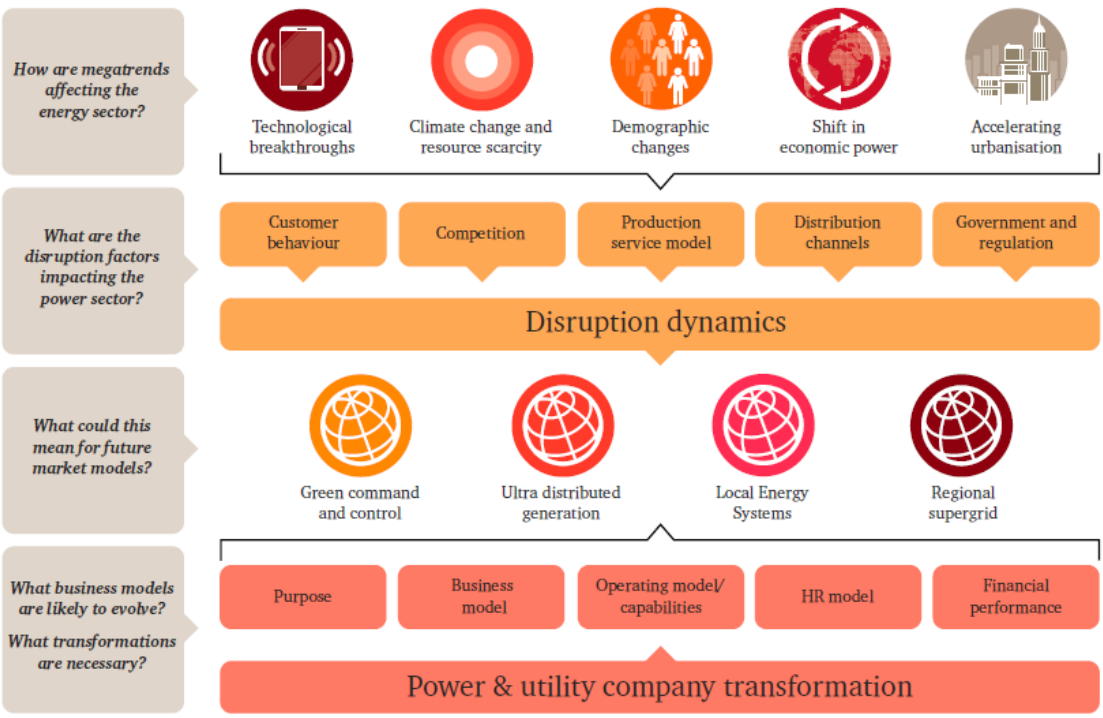


Figure 1: PwC Energy Transformation Framework

[1] Women entrepreneurs from other West African countries like Burkina Faso, Mali, Togo, and Sierra Leone were also interviewed in order to document some of the exceptional work being doing by women entrepreneurs in these countries.

[2] This assignment doesn't go into predictive modelling but only focuses on identifying strategic capabilities of women-owned businesses and qualitatively determining their adaptability to change

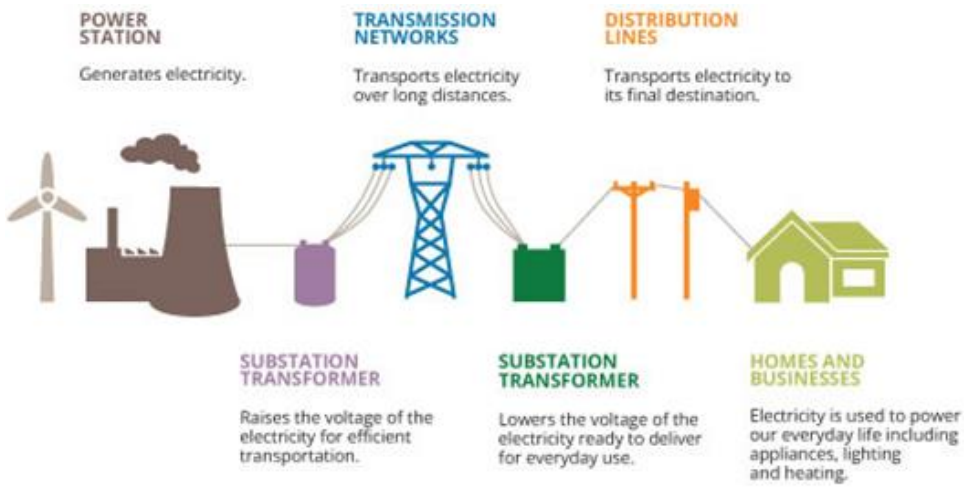


Figure 2: The energy value chain

This study has looked at the complete energy value chain from energy generation, transmission, storage, distribution to consumption with focus on renewable energy and energy efficient energy sources and products and services provided and consumed across this energy value chain.

The study shows that two forces are affecting the business models of, and driving the need for transformations, for energy-based businesses. These forces are *external forces* (megatrends and disruption factors) and *internal forces* (a company's strategic capabilities which include its

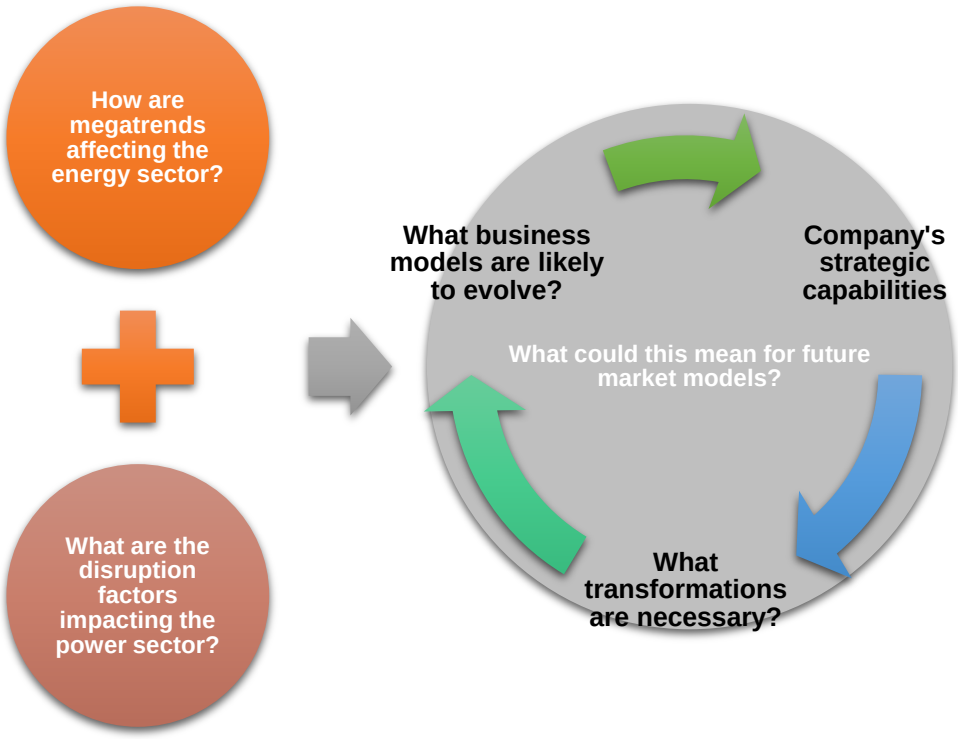


Figure 3: Modified Energy Transformation Framework

operational, human resource management and financial competence). Both external and internal forces act as **drivers of change** in the energy value chain.

These drivers of change create alterations in market models that exist in a specific locality, country (nation), or region. Women entrepreneurs act as **agents of change** across the energy value chain translating the changes that happen in the market to deliver benefits – better products and services to consumers ('**beneficiaries of change**'), thereby creating economic and social impact. Women entrepreneurs acting as agents of change need to undergo frequent transformations within their business models to adjust to the changing market models. The process of continuous market

change and business model adaptation is a dynamic process, and women entrepreneurs who adapt are better suited to harvest the greatest benefits these opportunities provide. However, for these women entrepreneurs to be able to capitalize on these new opportunities, the support of other stakeholders like government agencies, commercial banks, funds, regulatory agencies, and developmental organizations is required.

The study looked at each of the components in the PwC Energy Transformation Framework for the selected four countries in West Africa to estimate the extent to which the global megatrends apply to these countries, what disruptions are impacting the power sector and how these disruptions and megatrends are modifying the regional, national and local energy market models. Furthermore, the study evaluated women-owned businesses, specifically their business models, challenges they face and what business model changes and transformations are required by them to face the changing energy market dynamics. We have done a comprehensive evaluation of women-owned businesses to understand their purpose (by looking at the company, product, and service profile), business model, operating model/capabilities, human resources model, and financial performance. The framework has been used to evaluate the 'present' state of women entrepreneurs and to determine their strategic capabilities for making the right moves in the future to capitalize business opportunities provided by evolving energy market models[3].

In line with the goal to develop a gender-responsive regional energy market development strategy, the pre-feasibility study delivered the following:

1. *Identification of 16 women-owned businesses in the selected four countries in West Africa*, based on a set selection criteria
2. *Identification of business opportunities for women entrepreneurs in form of four feasibility study ideas or projects* (in renewable energy and energy efficiency products or services) that will move to the next stage, where comprehensible feasibility studies will be undertaken for these selected four feasibility study ideas or projects. We envisage that these feasibility studies or projects will be converted into bankable information memorandum that will be used to secure funding facilities from commercial banks, private investors, and funds for women entrepreneurs who choose to get involved in these business opportunities.

2. Methodology & Plan

The complete flow of activities undertaken in this pre-feasibility study, as stated in the Terms of Reference, is illustrated below:

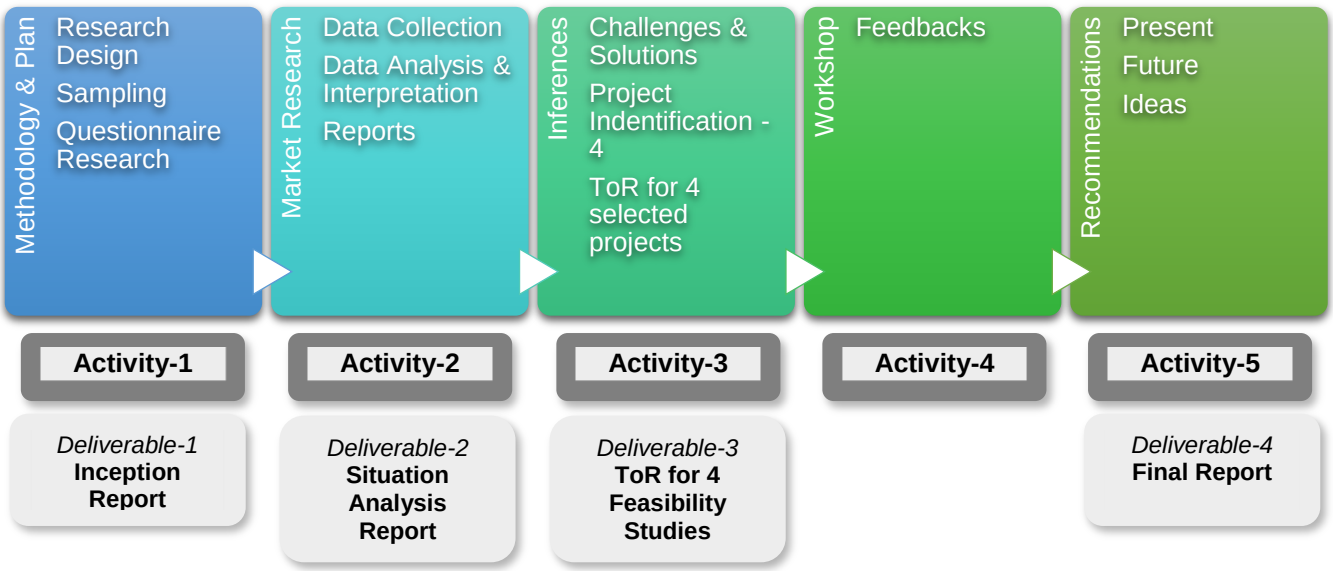


Figure 4: Pre-feasibility Study Activities Flow

[3] This did get into predictive modelling for change but only focus on judgmental predictive based on present situation data as it fits into PwC framework

2.1. Research Design

The research design involved laying down the basic foundation of how the research needs to be undertaken in compliance with the PwC Energy Transformation Framework. The four components of the framework were divided based on *quality and quantity of data that can be collected* and the *level of complex analysis* that is required in order to deliver the scope of this pre-feasibility study.

The **first three components** of the PwC energy transformation framework (i.e. megatrends in the energy sector, disruption factors, and future market models), which we categorized as external forces, were evaluated primarily through **secondary research and analysis.** The **fourth component** (business model evolution and transformations necessary), which we categorized as internal forces (determined by a company's strategic capabilities), was evaluated through **primary research and analysis**.

2.2. Sampling

Sampling was done on a judgmental basis to cover diverse elements of this pre-feasibility study, while retaining the depth of feedback that was needed to be achieved interviewing the respondents. Sampling was done on two parameters which were: **country selection** (i.e. the four pilot countries selected for the study) and **stakeholder selection** (i.e. women entrepreneurs and other participants that make up the renewable energy and energy efficiency entrepreneurial ecosystem).

2.2.1. Country selection[4]

Four countries were selected to represent the 15 countries in West Africa (ECOWAS), which were:

a) Nigeria - Lagos
b) Ghana - Accra
c) Cote d'Ivoire - Abidjan
d) Senegal - Dakar

The selection logic for the selected four countries is based on secondary data analysis and discussions with stakeholders of renewable energy and energy efficiency in the region. The rationale for selection of these four countries was:

a) Market Size (economy and population sizes)
b) High per-capita use of electricity on a proportionately larger population size (compared with an average per capita for West African countries)
c) Pressure to diversify: Due to increasing oil consumption (and depleting reserves), there is increasing pressure to diversify sources of energy (to renewable energy and energy efficient sources)[5]

[4] We added other countries in the region in our survey as there were examples of successful women entrepreneurs – e.g. in Burkina Faso, Mali, Togo, and Sierra Leone

[5] ECOWAS (2014) 'ECOWAS Renewable Energy and Energy Efficiency Status report 2014', *The American journal of nursing*, 81(7), p. 1297.

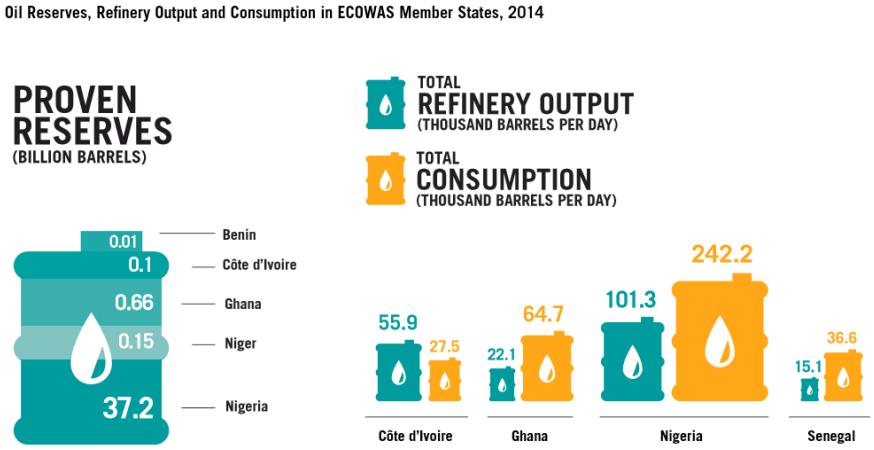


Figure 5: Proven Oil Reserves (selected 4 countries)

d) Regionally balanced representation: A balanced representation of Anglophone and Francophone economies in West Africa (with regards to population size, GDP size and electricity generation and consumption).

e) Significant impact on human lives due to household air pollution, hence a high pressure on renewable energy and energy efficient sources based energy generation

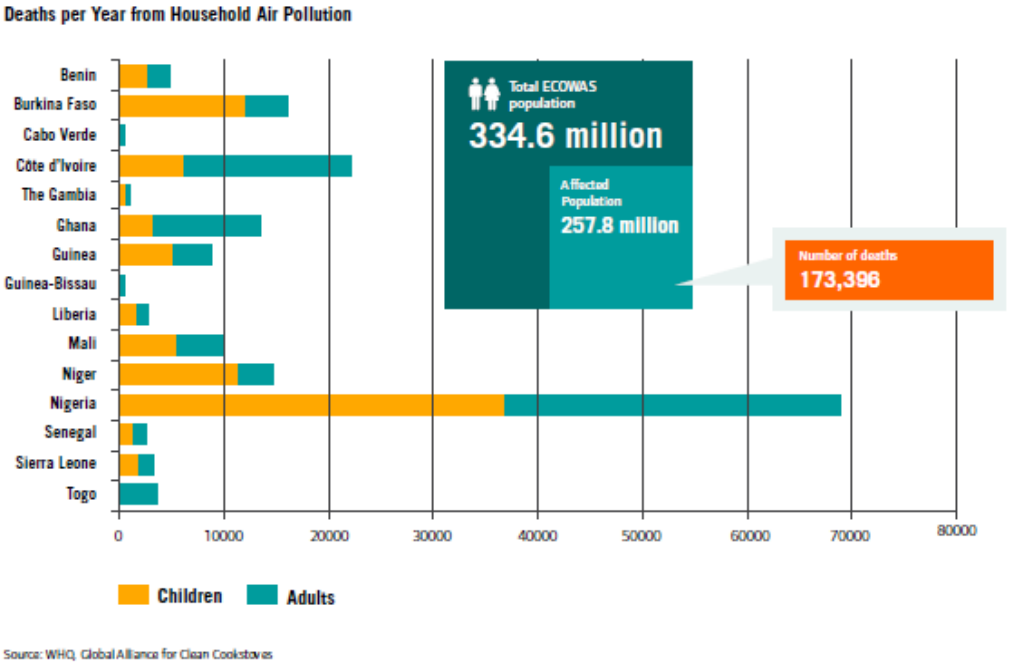


Figure 6: Impact of Air Pollution on Population in West Africa

f) Diffusers of technology in the region – the selected four countries have diverse energy mix hence allowing for renewable energy and energy efficient based technology diffusion across the West African region – 'A diverse energy mix increases the probability of renewable energy technology adoption.'[6]

g) Trade hubs of the region – presence of the West African region's largest and busiest Ports and Airports

h) Producers of significantly higher renewable resources (in volume, not in percentage of total energy produced) in the region when compared to other West African countries.

i) Agriculture based economies with significant value of GDP coming from agricultural resources. Traditional biomass is used the most in the rural areas, particularly the residential areas, for cooking. Biomass is also used in traditional agricultural processing and manufacturing industries to produce heat (for cooking and drying). Biomass forms include

[6] Birte Pfeiffer and Peter Mulder, 'Energy Economics', Volume-40, November 2013, Pages 285-296

firewood, charcoal etc. Dependence on these low efficiency fuels, i.e. traditional biomass, is limiting the industrialization potential of the agricultural sector and contributes to deforestation.

j) All these countries are a major part of the West African 'Solar Corridor' and '2GW renewable energy corridor.'

k) These selected four countries have relatively larger entrepreneurial populations to interview women entrepreneurs for research purposes[7]

l) A significant cluster of commercial banks with international banking relationships to facilitate local and international banking instruments, terms, and rates

m) Increased Private Equity (PE) /Venture Capital (VC) deal activity in these countries[8]

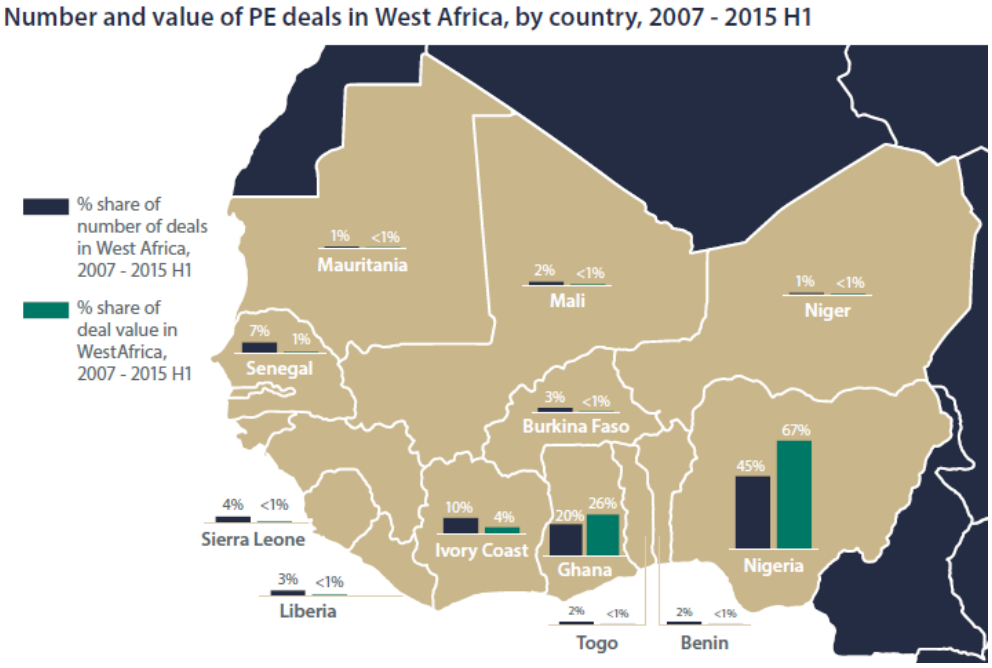
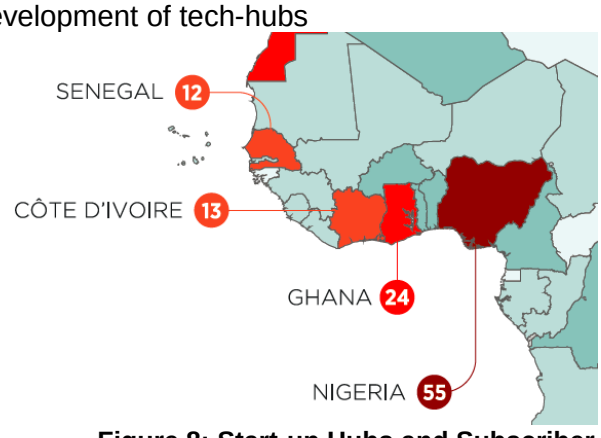


Figure 7: Deal Activity in West Africa

n) Indications of growing startup activity indicated by significant subscriber base, and development of tech-hubs



WESTERN AFRICA	UNIQUE SUBSCRIBERS (m)	PENETRATION
Côte d'Ivoire	12.5	53%
Ghana	18.9	67%
Nigeria	86.0	45%
Senegal	8.4	53%

Figure 8: Start-up Hubs and Subscriber base in selected 4 countries

o) Low ranks for 'Ease of Doing Business'[9] compared with other countries in world – thereby indicating an environment extremely challenging for entrepreneurship. Ghana, even though its Ease of Doing Business ranking for 2018 has declined, is still the best in the West African region for overall rankings.

[7] http://www.noceilings.org/entrepreneurs
[8] https://www.avca-africa.org/media/1310/avca-spotlight-on-west-africa-private-equity-public-version.pdf
[9] http://www.doingbusiness.org/rankings

ECONOMY	EASE OF DOING BUSINESS RANK (2017)	EASE OF DOING BUSINESS RANK (2018)	DIFF
GHANA	108	120	Deteriorated
COTE D'IVOIRE	142	139	Improved
SENEGAL	147	140	Improved
NIGERIA	169	145	Improved

Figure 9: Ease of Doing Business Rankings

2.2.2. Stakeholder selection

This included the selection of individuals from the selected four countries (in West Africa) that belonged to:

a) Donor Agencies: Private Sector Development (and gender mainstreaming) departments of ECREEE, World Bank, African Development Bank and any other donor agencies involved with social impact projects across the selected four countries in West Africa

b) Governmental Agencies: Energy Commission and Renewable Energy Departments within Ministry of Energy

c) Commercial Banks & Investor Funds: Private banks and Micro-Finance Institutions and private funds with a presence in the selected four countries from West Africa

d) Entrepreneurs: **37 women entrepreneurs** (Small and Medium Enterprises – SME[10] and start-ups) working in the selected four countries in West Africa dealing with renewable energy and energy efficiency resources based products and services. These were established businesses, but included were few start-ups[11], and complying with below criteria[12]:

i. Women-owned businesses

ii. Potential for serving regional energy markets through products, goods, services

iii. With over ten employees[13]

iv. With an annual turnover of $50,000[14] *or more*

2.3. Questionnaire Design

In gathering primary data from women entrepreneurs, a questionnaire (see Appendix-1) was designed and administered. The questionnaire was meant to collect data through interviews carried out during the field visits to the selected four countries. The questionnaire included closed-ended questions, but some information was also captured in the form of qualitative feedback. The questionnaire has been developed to: understand the product or service type, business model, operating model, human resources, and financial operations of women entrepreneurs. The intention was to evaluate the success factors and challenges women entrepreneurs face in their present renewable energy and energy efficiency ecosystem. Interviews with Donor Agencies, Government

[10] The European Central Bank proposed a SME classification as highlighted below:

Company category	Staff headcount	Turnover	or	Balance sheet total
Medium-sized	< 250	≤ € 50 m		≤ € 43 m
Small	< 50	≤ € 10 m		≤ € 10 m
Micro	< 10	≤ € 2 m		≤ € 2 m

[11] Start-ups include women lead start-up ideas with proven business and commercial success in some other country whereby with knowledge transfer probability of commercial success in West Africa is high

[12] For the start-ups the women entrepreneurs should expect their business to reach these numbers within 3years of establishment

[13] This criterion will be flexible depending on the business profile

[14] 97% of our sample women entrepreneurs businesses were compliant with this annual revenue turnover expectation requirement

Agencies, Commercial Banks, and Funds were obtained as qualitative feedback (not by application of structured questionnaire but through formal discussion sessions) as most of the data from these agencies is available through secondary sources. *The whole focus of this project was to identify, evaluate and drive women entrepreneurs towards higher profitability, size, and sustainability*

3. Market Research and Analysis

Three sub-activities were undertaken under Market Research and Analysis, with the objective to collect, analyze and interpret data and, to present the data in a way that helps stakeholders make meaningful decisions.

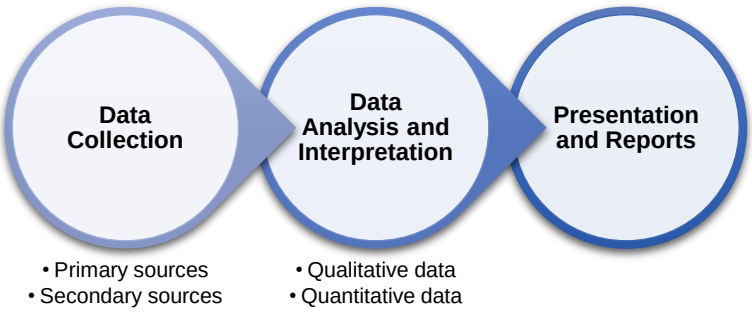


Figure 10: Market Research and Analysis Process

3.1. Data Collection

The data collection technique was structured as below:

Components	*Data Collection*	*Data Source*
1. Megatrends in the energy sector		
A. *Technological breakthrough*	Secondary	The Global Information Technology Report, International Energy Agency, RISE – World Bank, International Renewable Energy Agency, Global Innovation Index
B. *Climate change and resource scarcity*	Secondary	International Energy Agency, EDGAR-JRC, Environmental Performance Index, Notre Dame Adaptation Index, ESMAP, World Energy Council, ECOWAS Center for Renewable Energy and Energy Efficiency, British Petroleum
C. *Demographic changes*	Secondary	International Monetary Fund, Central Investigation Agency, World Bank
D. *The shift in economic power*	Secondary	International Monetary Fund, Central Investigation Agency, Global Competitiveness Report, World Bank, Africa-EU Renewables, World Energy Council
E. *Accelerating urbanization*	Secondary	Central Investigation Agency, World Bank, International Renewable Energy Agency, ECOWAS Center for Renewable Energy and Energy Efficiency, IBM Institute of Business Value
2. Disruption factors		

A. *Customer behavior*	Secondary	ECOWAS Center for Renewable Energy and Energy Efficiency, IBM Institute of Business Value
B. *Competition*	Secondary	World Bio-energy Association, International Renewable Energy Agency, ECOWREX, IBM Institute of Business Value, World Economic Forum
C. *Production service model*	Secondary	International Renewable Energy Agency, ECOWREX, IBM Institute of Business Value, World Economic Forum
D. *Distribution channels*	Secondary + Primary	International Renewable Energy Agency, World Economic Forum, interview with women entrepreneurs (this included energy products, production, transmission, distribution, and consumption companies)
E. *Government and regulation*	Secondary	ECOWAS Center for Renewable Energy and Energy Efficiency, Bloomberg Energy Finance, International Renewable Energy Agency
3. Future market models		
A. *Green command and control*	Secondary+ Primary	PricewaterhouseCoopers, International Renewable Energy Agency, West African Power Pool, United Nations Economic Commission for Africa
B. *Ultra-distributed generation*	Secondary+ Primary	PricewaterhouseCoopers, International Renewable Energy Agency, West African Power Pool, United Nations Economic Commission for Africa
C. *Local energy systems*	Secondary+ Primary	PricewaterhouseCoopers, International Renewable Energy Agency, West African Power Pool, United Nations Economic Commission for Africa
D. *Regional super grid*	Secondary+ Primary	PricewaterhouseCoopers, International Renewable Energy Agency, West African Power Pool, United Nations Economic Commission for Africa
4. Evolving business models		
A. *Purpose*	Primary	Interview with women entrepreneurs (this included energy products, production, transmission, distribution, and consumption companies)
B. *Business model*	Primary	Interview with women entrepreneurs (this included energy products, production, transmission, distribution, and consumption companies)
C. *Operating model/capabilities*	Primary	Interview with women entrepreneurs (this included energy products, production, transmission, distribution, and consumption companies)
D. *HR model*	Primary	Interview with women entrepreneurs (this included energy products, production, transmission, distribution, and consumption companies)
E. *Financial performance*	Primary	Interview with women entrepreneurs (this included energy products, production, transmission, distribution, and consumption companies), and Commercial Banks and Fund Managers

Primary data collection involved meetings – primarily, with women entrepreneurs, secondarily with representatives of donor institutions, government agencies involved in renewable energy and energy efficiency sector and, thirdly with banking institutions and funds involved in financing women entrepreneurs.

Secondary data collection was done from:

a) Reports, case studies and databases that are publicly available from entities like International Energy Agency, EDGAR-JRC, Environmental Performance Index, Notre Dam Adaptation Index, ESMAP, World Energy Council, ECOWAS Center for Renewable Energy and Energy Efficiency, British Petroleum, International Monetary Fund, World Bank, etc.
b) Study and database review of non-public sources like ECREEE, Rural Electric Agencies, World Bank, and UN Agencies

3.2. Data Analysis & Interpretation

Data Analysis and Interpretation included analysis of data gathered in the data collection phase and transforming that data into information that can help infer and deliver the objectives of this study. The analyzed data was a mix of qualitative and quantitative data. Most of the data collected through primary research via a questionnaire, had closed-ended questions and qualified as quantitative data. The variables for testing that were included in the questionnaire were identified during exploratory research that involved secondary data analysis and discussions with stakeholders in the renewable energy and energy efficiency sector.

The information collected was analyzed by deploying statistical tools to interpret and represent the information in a way that is easy to understand, usable for deriving inferences and can be presented to a wider audience that has little or no background in statistical analysis to help them understand the data and its conclusions.

3.3. Presentation and generating the report

The analysis of the information collected has been provided by using statistical graphs and tables, which present data analysis illustrations and help provide conclusive thoughts about the objectives of this pre-feasibility study.

3.4. Limitations

There were certain limitations based on the data that could be collected with the limited resources and within the time at disposal. Hence this assignment was re-shaped (by precise sampling, concise secondary data collection and simplified analytics) to get the most comprehensive perspective and provide recommendations that are practically viable, emphatic, and fast to execute.

The adjustments included modifying the Pricewatehouse Coopers energy transformation framework to fit the women entrepreneur and the regional energy market profile. Quantification of the PwC energy transformation framework involved:

1. identification of right indicators (relevance and credibility)
2. collating the latest data for the selected four countries
3. alignment of secondary and primary data

On the primary data side – the identification of women entrepreneurs that complied to the project selection criteria was challenging – primarily because there was no existing structured database of women entrepreneurs in the energy sector, the data resided with different sources. Furthermore there are not that many women involved in the energy sector and most of them were scattered in the region dwelling in rural areas and running small sized business, well below the project's required business turnover criteria as mentioned in section 3.2.2. of this report.

4. Energy System Transition in West Africa

4.1. Megatrends in the Energy Sector

Megatrends are large disruptions that are happening across the energy markets around the globe and are getting disseminated to developing countries impacting their energy value chains. Megatrends include changes that are happening due to technological breakthroughs, climate change, and resource shortages, demographic changes, shifts in economic power, and accelerated urbanization.

These megatrends were analyzed in the context of the selected four countries to their relevance and impact in shaping the energy systems in those countries.

4.1.1. Technological breakthrough

"The Fourth Industrial Revolution builds on the digital revolution and combines multiple technologies that are leading to unprecedented paradigm shifts in the economy, business, society, and for individuals. It involves the transformation of entire systems. The electricity landscape is a prime example of the Fourth Industrial Revolution as it transforms, becoming more complex than ever before, with rapidly evolving technologies, emerging innovative business models and shifting regulatory landscapes"[15].

Technological developments are happening by leaps and bounds across the globe and are spreading fast to emerging markets including West Africa. These changes are not only making energy production efficient but also cheaper hence more accessible to people.

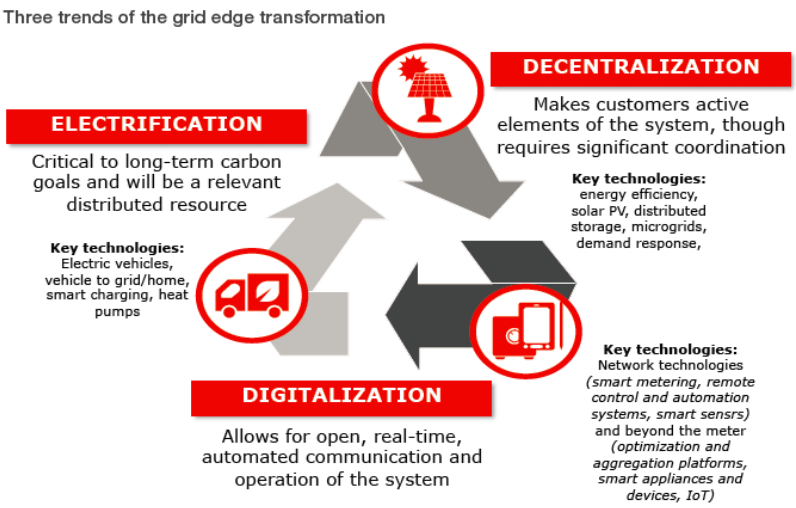


Figure 11: Grid Edge Transformations[18]

"In many jurisdictions, renewable power is replacing or has the potential to replace fossil fuel generation. Smart grids are delivering the potential for greater interactivity with customers. Moreover, the scope for even more transformative technological breakthroughs is increasingly being taken seriously. A breakthrough in the cost and practicality of battery storage technology could be a quantum leap enabler, opening the possibility of off-grid customer self-sufficiency when used in combination with 'own generation.' 'Power–to-gas' is also a potentially transformative technology. All these create opportunities for incumbent power companies, but many also have the effect of eating away at a utility company's traditional revenues and undermining the traditional utility business model.

[15]Astarloa, B. *et al.* (2017) 'The Future of Electricity: New Technologies Transforming the Grid Edge', *World Economic forum*, (March), p. 32. Available at: https://www.weforum.org/reports/the-future-of-electricity-new-technologies-transforming-the-grid-edge.

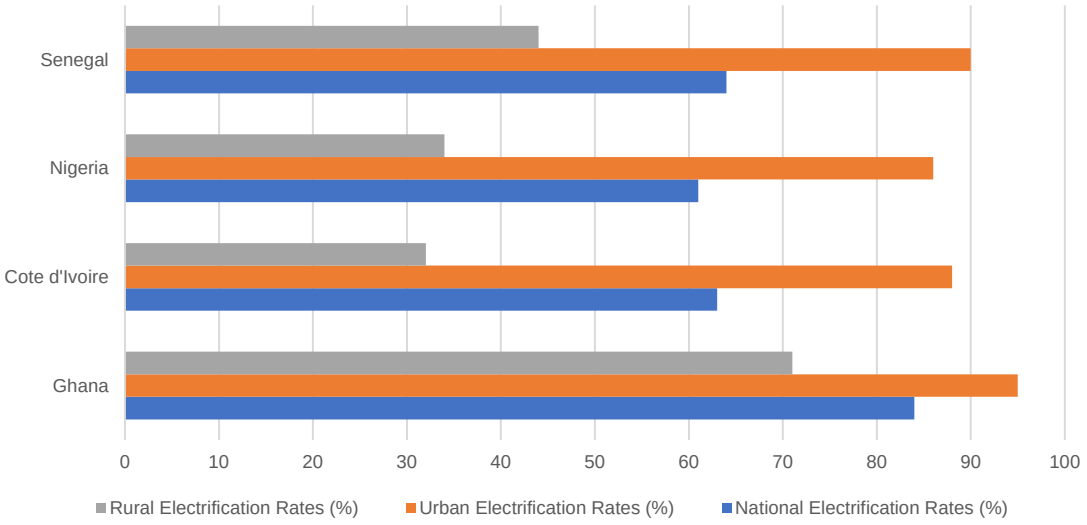
Other technologies, notably the combination of the internet, mobile devices, data analytics and cloud computing with smart grids and smart metering, present opportunities for utility companies to get closer to the customer, play an enhanced 'energy partner' role and exploit data opportunities".[16]

One important implication of technological advancement has been availability and access to energy to areas that are off-grid. As consumers come closer to controlling and managing their consumption patterns, grid edge technologies are transforming the complete energy value chain. Moreover, the three trends that are bringing about grid edge transformations include – decentralization, digitalization, and electrification.

In order to evaluate the technological breakthroughs happening in the selected four countries there needed to be indicators that point out to *direct technological breakthroughs* that are happening in the energy value chain and *indirect technological breakthroughs* that are happening across supportive technological ecosystem (these in turn support technologies that either exist or can exist for digitalization). We looked at several indicators and found four indicators that indicate technological breakthroughs that are happening across the selected four countries, namely: **electrification, decentralization, digitalization infrastructure and innovation**. The first two indicators show a direct disruption of energy markets while the other two indicate indirect technological disruptions which are facilitating new ICT based technologies to diffuse into the 4 selected countries' energy value chain. These four indicators demonstrate the evolving technological landscape that is driving and will drive energy entrepreneurship in the region

4.1.1.1. Electrification

Figure-12 illustrates the present status of electricity rates in each of the countries. These electric rates point out that *low rural electricity rates* in countries like *Côte d'Ivoire and Senegal* offer high potential for off-grid electricity generation, distribution, and consumption. However, if we measure the same potential from the perspective of which country offers the largest number of rural consumers for off-grid electrification, Nigeria comes on top due to having the largest population in the region.



Source: IEA Outlook 2017

Figure 12: Electrification Profile

Furthermore, the 4 selected countries were evaluated on the basis of regulatory indicators for sustainable energy. These indicators provide a good basis to understand the maturity and future direction of electrification in the 4 selected countries (based on the data provided by the World

[16] PricewaterhouseCoopers (2014) 'The road ahead - Gaining momentum from energy transformation', *Pwc*, pp. 1–32. Available at: http://www.pwc.com/en_GX/gx/utilities/publications/assets/pwc-the-road-ahead.pdf.

Bank through their RISE platform[17]). This ranking when seen along with electricity rates, better explains the regulatory environment strengths and weaknesses. Whereas, an observation of electricity rates helps to explain the demand gap.The idea behind including this measurement was to understand how these countries compare on policy and regulatory frameworks for energy access, renewable energy, and energy efficiency (Figure 13: Regulatory Indicators for Sustainable Energy (out of 100). It can be safely assumed that if the country is high-ranking for energy access, renewable energy, and energy efficiency and low-ranking on electrification, then there should is a higher possibility for success for generating off-grid electricity products and services in that country. The premise behind this assumption is that higher RISE ranking indicates the conducive environment for innovative technologies to enter into the energy value chain while the low electrification levels indicate a gap in the market. For example, Senegal has been able to achieve higher scores in energy access due to development of a framework for grid electrification and existence and monitoring of an officially approved electrification plan, while its rural electricity rates show that there exists a significant demand gap that is open for private companies to take advantage of. Moreover, this conclusion is strengthened if we look at higher decentralization numbers in Senegal on off-grid sales, low scalability and large scale products (Figure 16: High-scalability Products). Also, it has performed well on renewable energy as a parameter due to having a legal framework for renewable energy (called “Orientation Act on renewable energy”). Côte d'Ivoire has been able to drive their energy access score by successfully creating electric power that is affordable to consumers, while on the renewable energy side they have incentives and regulatory support that push up their scores. If these ratings are seen along with their present electricity rates – it shows once again that there is a large electricity demand (both products and services) that needs to be fulfilled for rural Cote d’Ivoire.

[17] These ratings are developed by RISE, which is developed by World Bank, SE4ALL, Climate Investment Fund and ESMAP, is a set of indicators to help compare national policy and regulatory frameworks for sustainable energy. It assesses policies and regulatory support in each country for each of the three pillars of sustainable energy—access to modern energy, energy efficiency, and renewable energy. With 27 indicators covering 111 countries and representing 96 percent of the world population, RISE provides a reference point to help policymakers benchmark their sector policies and regulations against those of regional and global peers, and is a powerful tool to help develop policies and regulations that promote sustainable energy goals. Each indicator targets an element of the policies or regulations, which are important to deploy investments, such as establishing planning processes and institutions, introducing dedicated incentives or support programs, and ensuring financially sound utilities. Together, they provide a comprehensive picture of the strength and breadth of government support for sustainable energy and the actions they have taken to turn that support into a reality. http://rise.esmap.org/indicators

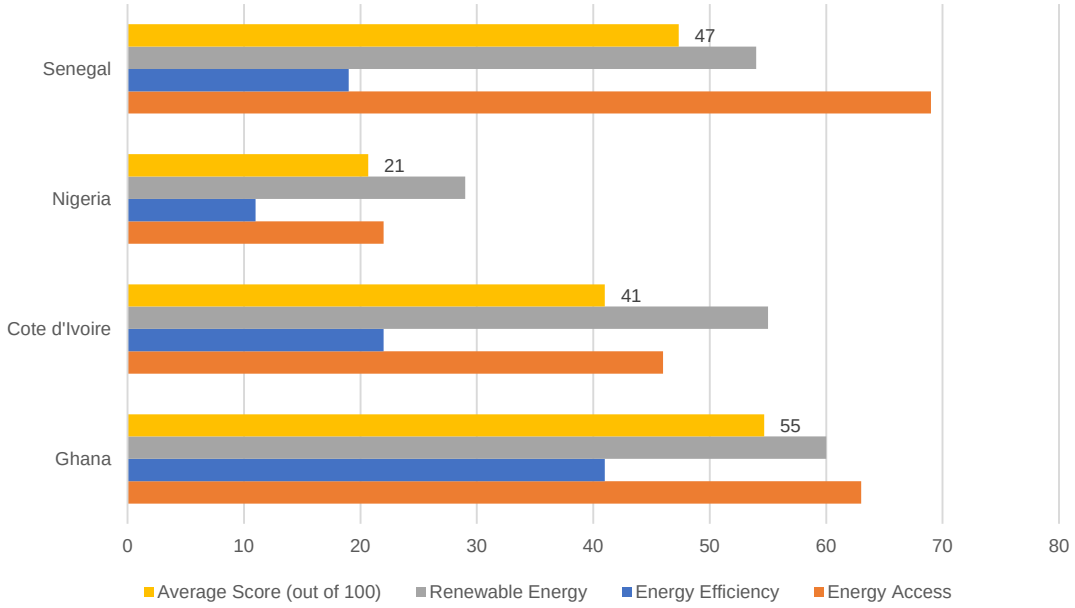


Figure 13: Regulatory Indicators for Sustainable Energy (out of 100)

Source: http://rise.esmap.org/country

4.1.1.2. Decentralization

"Decentralized generation is in many ways the opposite of the traditional model, where one large plant provides energy for an entire region. It means introducing a very large number of small-capacity units that are all connected to the power grid, natural gas supply network or urban heating/cooling networks to generate energy from renewable sources at a local level. Constructed around renewables, this energy generation method is more environmentally friendly and addresses the actual local demand for energy"[18]. Decentralization offers opportunities for developing an off-grid network, including renewable energy and energy efficient electricity generation and distribution for entrepreneurs. There are three pillars for developing a market for decentralized products and services for entrepreneurs and attract investors – a *framework for standalone systems, a framework for mini-grids and framework for grid electrification.*

All 4 selected countries have evolving frameworks for decentralization. The true impact of policy can be measured by sales, if we evaluate the data from IRENA for sales of renewable energy and energy efficient products we find that Nigeria and Ghana lead the way in sales of high-scalability decentralization products while Senegal leads on the table in sales of low-scalability decentralization – both provide entrepreneurs with opportunities to venture into electricity generation, consumption (efficiency) and distribution. One more aspect to note is that Senegal due to its very low rural electric power availability, scattered population (low urbanization) has seen a greater capacity for building up the bio-energy sector.

[18] https://www.engie.com/en/innovation-energy-transition/decentralized-energy-generation/

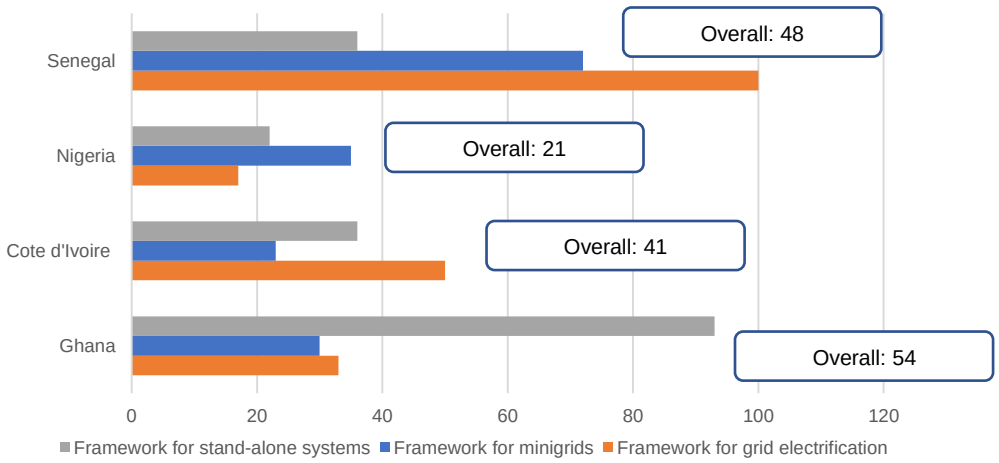


Figure 14: Frameworks for Decentralization (out of 100)

Source: http://rise.esmap.org/country

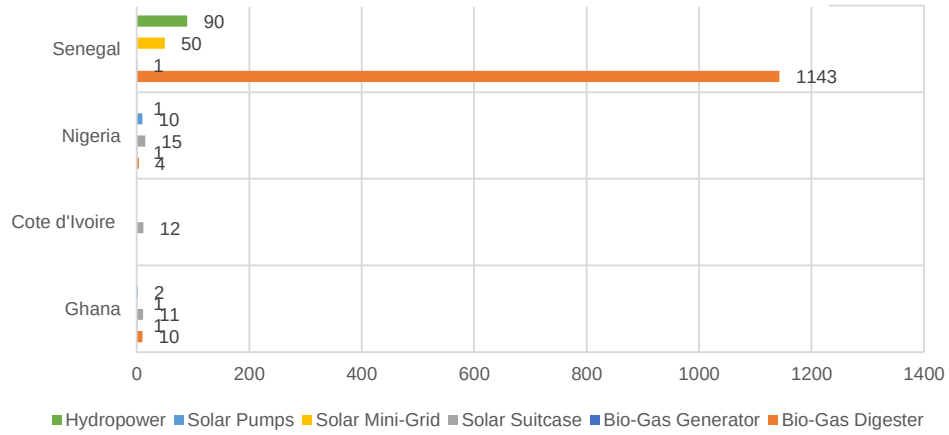


Figure 15: Low-scalability Products[19] (unit sales per annum)

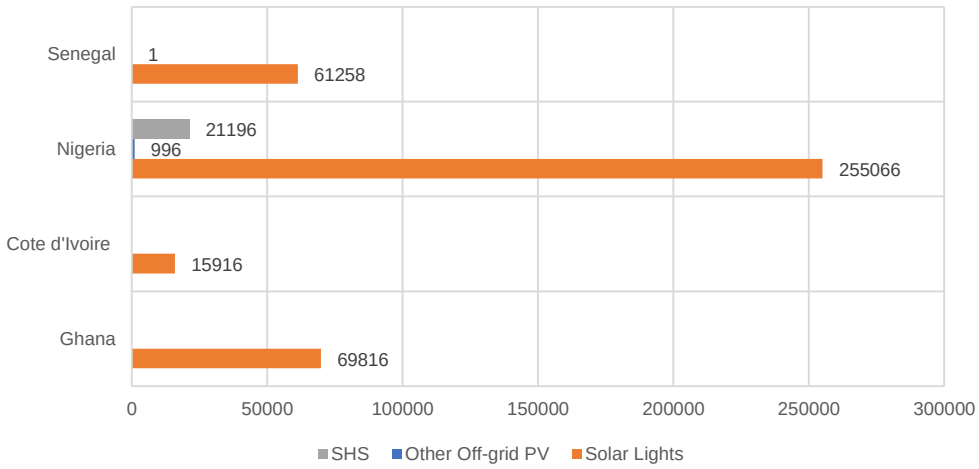


Figure 16: High-scalability Products[20] (unit sales per annum)

Source: http://resourceirena.irena.org/gateway/dashboard/?topic=4&subTopic=1065, 2017

[19] Are products that will involve increased costs to grow sales and result in low revenue turnover due to a lesser number of units sold.

[20] Are products or services that can grown without increasing the cost base – high revenue turnover by more number of unit sales

We looked at The World Energy Outlook 2017 report and their predictions under the Energy for All Case Scenario in Figure 16: High-scalability Products (unit sales per annum) to understand the global perspective on the future of grid, mini-grid and off-grid and their impact on expanding access to electricity. Compared to the global access to electricity, which is at 85% of the total population, the sub-Saharan African access to electricity stands at 37%[21]. And for the selected four countries, 52% of total population has access to electricity. These low electricity access rates indicate that there exists a huge potential for expanding access to electricity in the West African region. The World Energy Outlook (2017) points out that by 2030 in order to provide electricity access to 674 million people around 71% will be met through decentralized systems. Furthermore, for about 195 million people electricity access will come through off-grid technologies.

The principal energy source for decentralized systems will continue to be Solar PV. The majority of women entrepreneurs in the 4 selected countries are presently operating businesses in the Solar PV segment but face operational, technological and financial challenges.'Mini-grids are important because they not only provide households with access but also have the ability to ramp up generation capacity or eventually be interconnected with the grid. Grid expansion continues to play a fundamental role in delivering energy and provides another 185 million people with access"[22]. It can be inferred that Solar PV based mini-grids will be an area of significant entrepreneurship within the West African region.

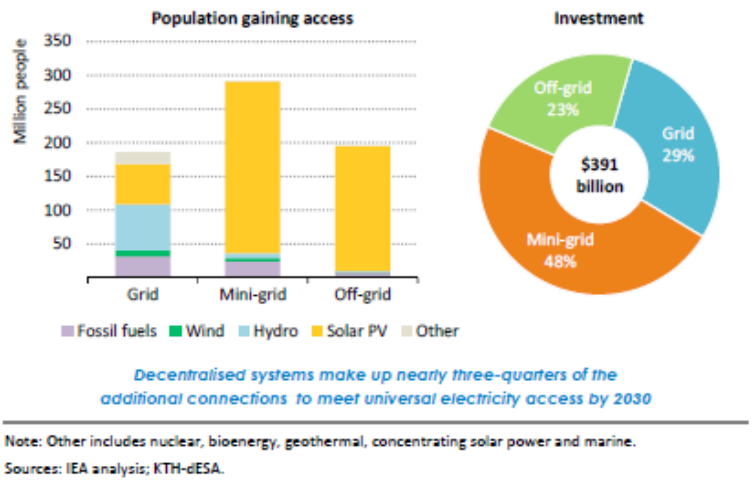


Figure 17: Additional population gaining access and additional investment in the Energy for All Case relative to the New Policies Scenario, 2017-2030

Off-grid electricity is one of the biggest disruptions that has happened across the West African energy market and is already revolutionizing customer behavior significantly. It is still in its nascent stages but is gradually spreading – one critical factor that is driving off-grid expansion is the funding availability of funding for these projects. Senegal has the highest population using off-grid solutions, which have been possible due to the support of energy agencies (SENELAC) and the entry of Independent Power Producers ('IPP').

[21] https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?name_desc=true

[22] International Energy Agency (2017) 'WEO-2017 Special Report: Energy Access Outlook', pp. 1–143. Available at: https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf.

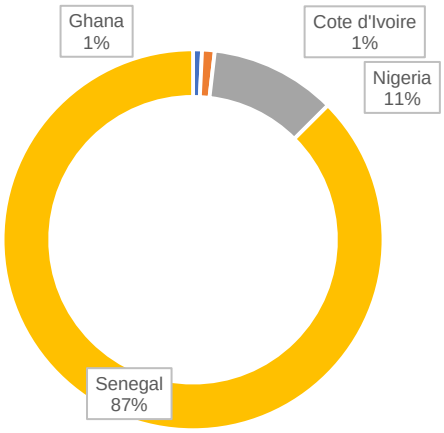


Figure 18: Off-Grid Population

Source: IRENA Database 2017

Looking at the data for off-grid technologies that are being used across the 4 selected countries, it was discovered that Senegal leads the group. The major success for off-grid solutions has happened in solar-based generation systems followed by oil-based generation systems. Senegal leads with wind power facilities in operation and biomass facilities that are under development across the region.

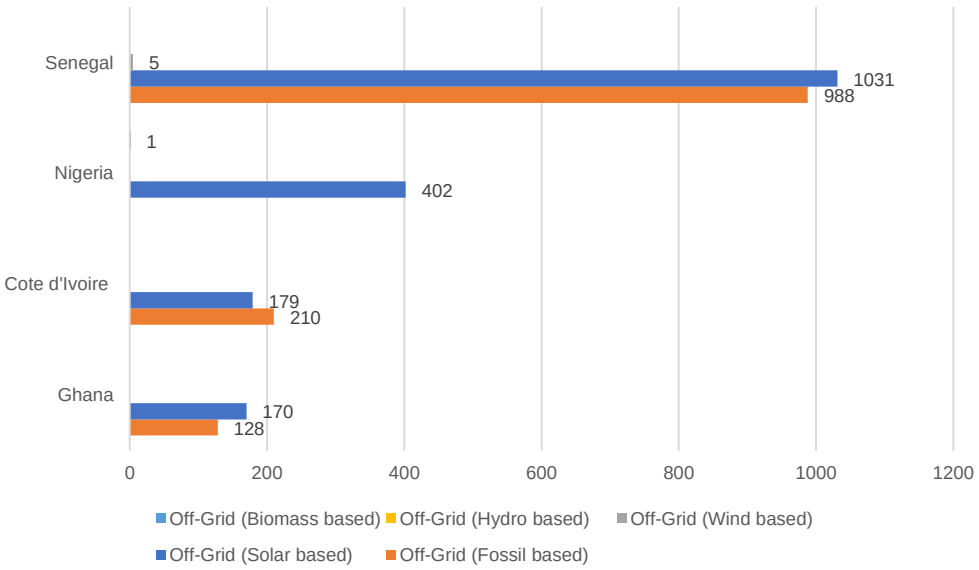


Figure 19: Size of Off-Grid Capacity (in kWp)

Source: ECREEE, 2017

There is a sizeable potential for providing access to rural populations with off-grid systems that are hybrids (using more than one type of energy source) of solar energy with biomass and wind. Presently, the hybrid systems that are operational are a mix of solar and oil-based systems. When we met with women entrepreneurs some of them expressed their desire for developing this kind of hybrid systems but they neither had the expertise nor the awareness about hybrid electricity generation technologies. In the future, it is expected that a sizable proportion of the rural population (up to 25% by 2030) in West Africa will be covered through decentralized energy sources

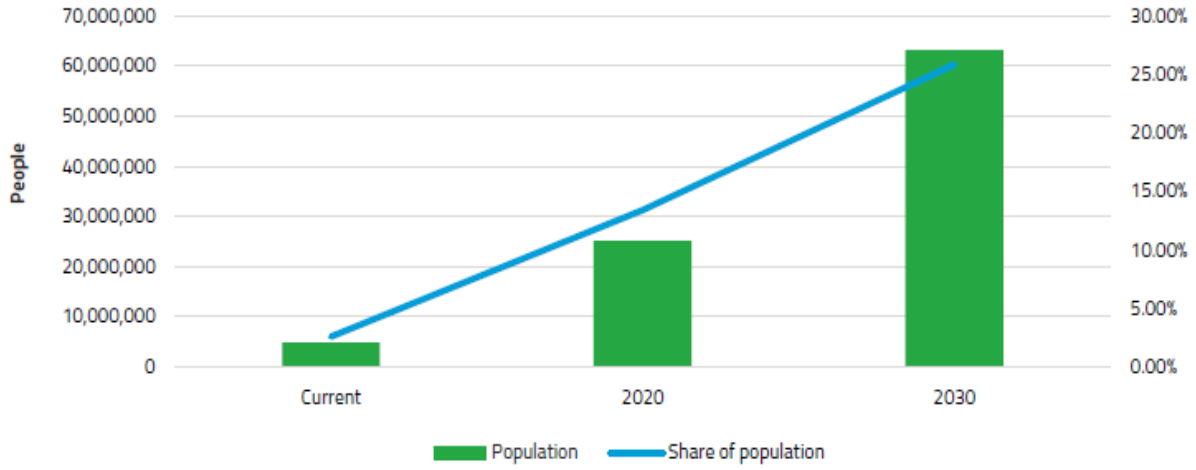


Figure 20: Rural Population served by decentralized renewable energy sources (mini-grids/standalone)[23]

4.1.1.3. Digitalization Infrastructure

"Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business." Digitalization infrastructure refers to the ICT infrastructure that facilitates digitalization and includes – Internet (penetration, speed, usage, etc.), mobile/cellular and information technology. Digitalization infrastructure in the country facilitates development of technology related services which are today (and for the future) the backbone of energy generation, transmission, distribution, storage, and consumption. Almost all smart technologies require fast, responsive, and real-time technological applications that run on Internet or mobile platforms. Countries that are strong in this digitalization infrastructure offer immediate opportunities to attract entrepreneurial appetites and deploy funding interest from investors. Launched by "World Economic Forum in 2001 and significantly extended in 2012, the NRI[24] can help to assess a country's **ability to capitalize on the digital revolution and their preparedness to benefit from the emerging Fourth Industrial Revolution**. The Index aggregates data from 53 indicators, organized based on the networked readiness framework. Networked readiness rests on whether a country possesses the drivers necessary for digital technologies to unleash their potential, and on whether these technologies are impacting the economy and society."[25]

As shown in Figure 21: Digitalization Infrastructure-1 (out of 100), Nigeria has the highest individual internet utilization rate and mobile access close to 100% which is very conducive to allow internet and mobile-based technologies to provide these services to individual consumers. It is interesting to note that Côte d'Ivoire has a very high mobile penetration like Nigeria, but individuals have low Internet usage.

[23] Energy, R., Plans, A. and Ef-, N. E. (September 2017) 'From Vision to Coordinated Action', ECREEE
[24] Network Readiness Index is developed by the World Economic Forum and published as Global Information Technology Report
[25] WEF (2016) *The Global Information Technology Report 2016*, *World Economic Forum*. doi: 10.3359/oz0304203.

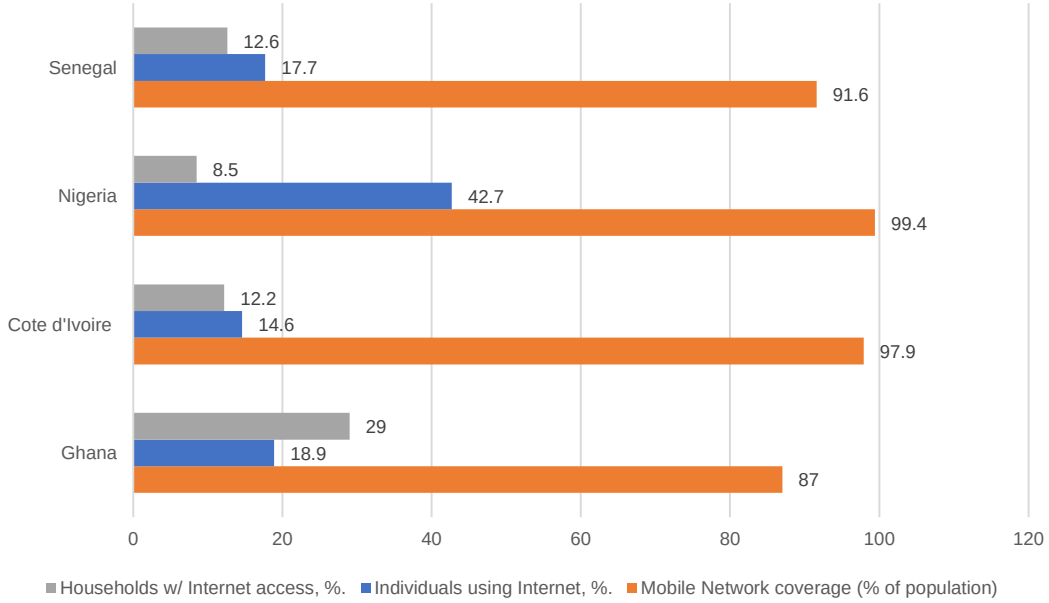


Figure 21: Digitalization Infrastructure-1 (out of 100)

Source: Network Readiness Index 2017

The fixed broadband and pre-paid mobile tariffs (as shown in Figure 22: Digitalization Infrastructure-2) are lowest in Ghana and followed closely by Nigeria but when it is compared with low individual internet usage in Ghana, it shows that businesses or entrepreneurs have still not been able to develop technologies that can be provided through ICT channels to consumers. The low prices and ready ICT infrastructure offers good potential to develop and deploy a smart application with real-time benefits to consumers in these two countries. This inference is better substantiated when compared with Figure 23: Digitalization Infrastructure-3, which shows that the impact of ICT on business models has been the lowest in Ghana when compared to the other 4 selected countries in the region. Even though Internet utilization in Senegal is low, it offers the highest international bandwidth availability per user, which has had a significant impact from ICT on basic services, business models and technology absorption in that country.

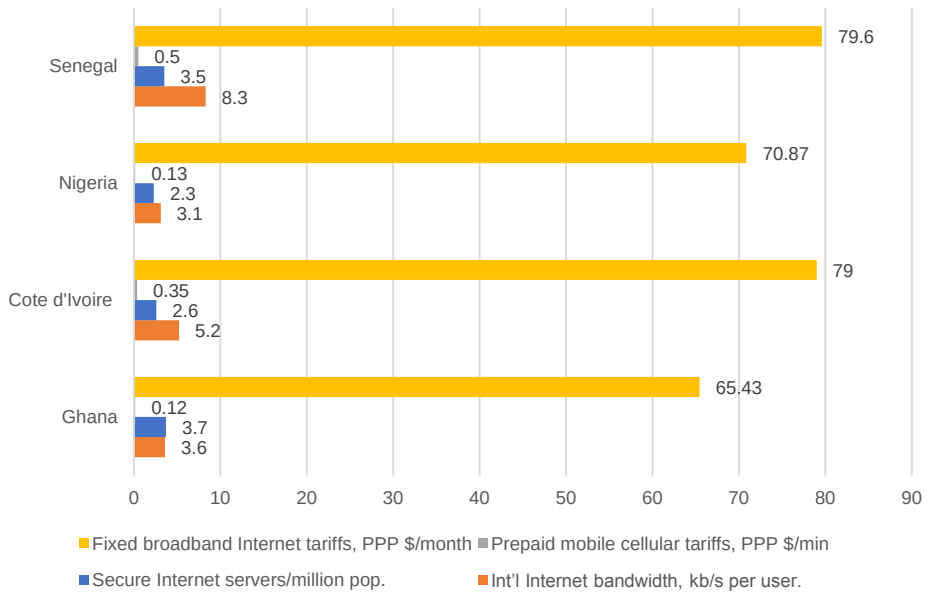


Figure 22: Digitalization Infrastructure-2

Source: Network Readiness Index 2017

Also, as part of the Network Readiness Index (NRI) a survey was conducted which provides a view of the impact ICT has had on basic services, business models, technology absorption and social networks, in the 4 selected countries. The chart below (Figure 23: Digitalization Infrastructure-3) shows how each country is witnessing the impact of ICT on how basic services are provided, how the business model for companies change, how much technology is absorbed by firms and how ICT is facilitating social networks. These rating also reflect consumer dynamics and service providers' (like utility companies) adaptations to information landscape changes.

The ratings in Figure 23: Digitalization Infrastructure-3 show that Senegal narrowly leads the way in terms of the impact of ICTs on various variables, and is fast moving towards a more interconnected information infrastructure. This also shows that even though the hard digitalization infrastructure is more developed in other countries (Nigeria and Ghana), the impact is comparatively higher in Senegal due to greater utilization of the digitalization infrastructure by businesses and consumers to change the way they provide and avail services. This can help us infer that ICT is evolving as a major driver in the transformation of the energy value chain across the West African region (the score are shown in comparison to US to highlight the gap that exist between the developed countries like US and selected four countries from West Africa).

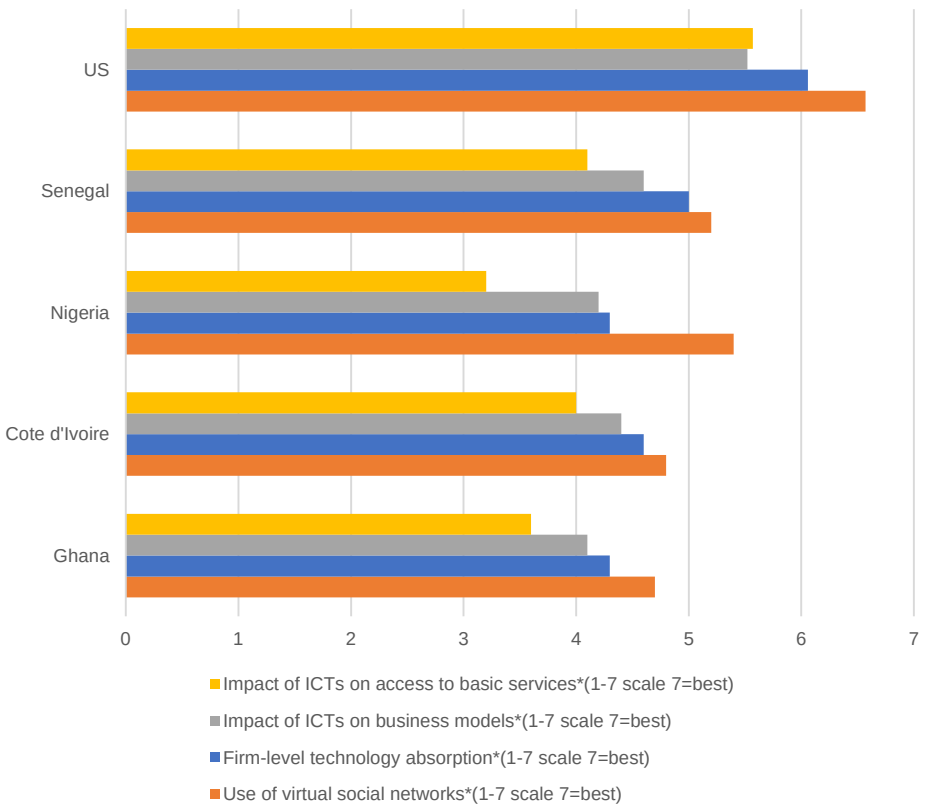


Figure 23: Digitalization Infrastructure-3

Source: Network Readiness Index 2017

4.1.1.4. Innovation

"Innovation can be defined simply as a "new idea, device or method." However, innovation is often also viewed as the application of better solutions that meet new requirements, inarticulate needs, or existing market needs. This is accomplished through more effective products, processes, services, technologies, or business models that are readily available to markets, governments, and society."[26] Innovation is the driver of change in every

[26] https://en.wikipedia.org/wiki/innovation

industry and most specially energy, where innovation impacts not only core energy value chain but also the adjacent industries that are linked to the energy value chain. To evaluate how innovative each of the 4 selected countries are, the Global Innovation Index 2017[27] was used: Four indicators were selected, which are – *knowledge creation, knowledge diffusion, knowledge absorption and knowledge impact*. The overall rankings can be used to compare countries to see how innovation and knowledge are created, spread, and how they impact business and consumers.

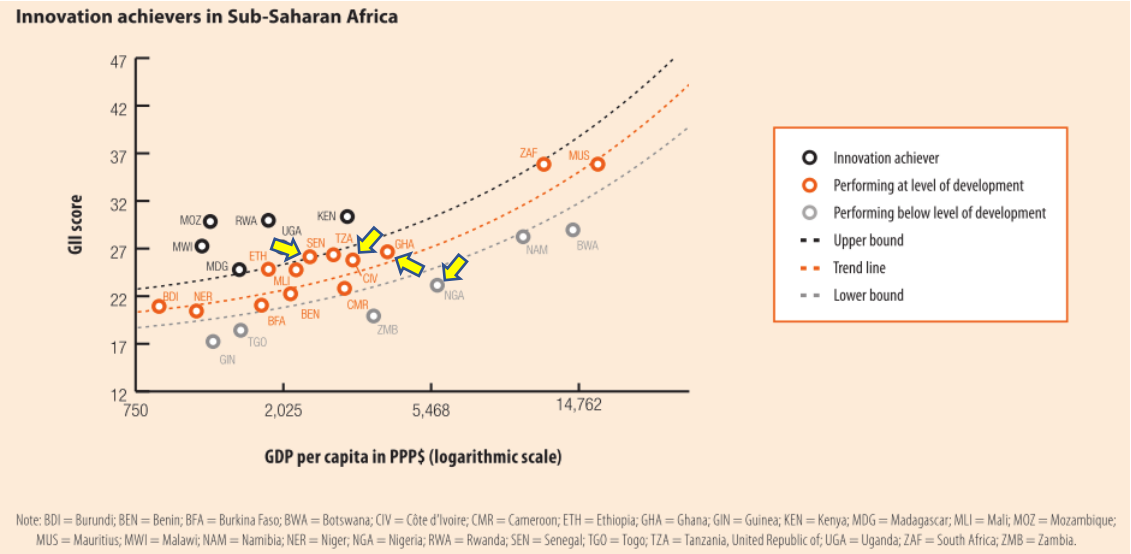


Figure 24: Innovation Achievers in Sub-Saharan Africa[28]

The results show that Senegal is comparatively better than other countries in the overall innovation ranking (Figure 25: Innovation Profile (rankings out of 127) and is especially strong on knowledge diffusion (which includes sub-indicators like intellectual property receipts, high-tech exports, ICT service exports and FDI net outflows). On the other hand, Côte d'Ivoire is the best in the region in creating strong knowledge impact (which includes sub-indicator like - growth rate of PPP$ GDP/worker as a percentage, computer software spending and ISO 9001 quality certificates/billion PPP$[29] GDP).

[27] Launched by INSEAD in 2007, today the GII is co-published by Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO), a specialized agency of the United Nations. The 2017 edition of the GII draws on the expertise of its Knowledge Partners: the Confederation of Indian Industry, PricewaterhouseCoopers (PwC) and Strategy&, and the National Confederation of Industry (CNI) and Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (Sebrae), as well as an Advisory Board of eminent international experts. For the seventh consecutive year, the Joint Research Centre (JRC) of the European Commission audited the GII calculations. The GII is concerned primarily with improving the journey towards a better way to measure and understand innovation using identifying targeted policies and good practices that foster innovation. Written in a nontechnical language, the GII appeals to diverse groups including policy makers, business leaders, academics, and organizations of civil society

[28] Dutta, S. (2016) *The Global Innovation Index 2016*, *Stronger Innovation Linkages for*. doi: 978-2-9522210-8-5.

[29] **Purchasing power parity** (**PPP**) is an economic theory that states that the exchange rate between two countries is equal to the ratio of the currencies' respective purchasing power. – from https://en.wikipedia.org/wiki/Purchasing_power_parity

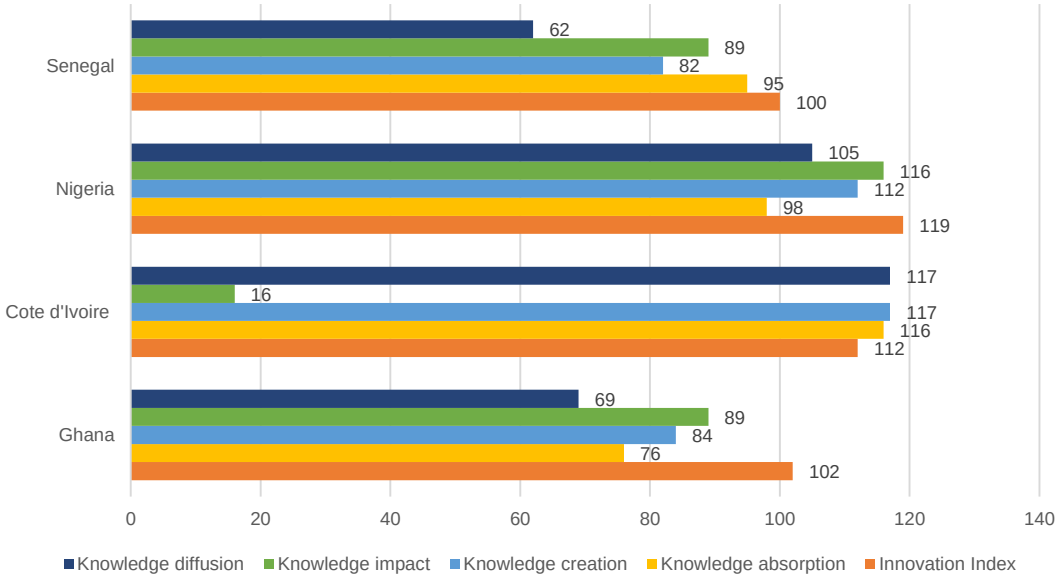


Figure 25: Innovation Profile (rankings out of 127)

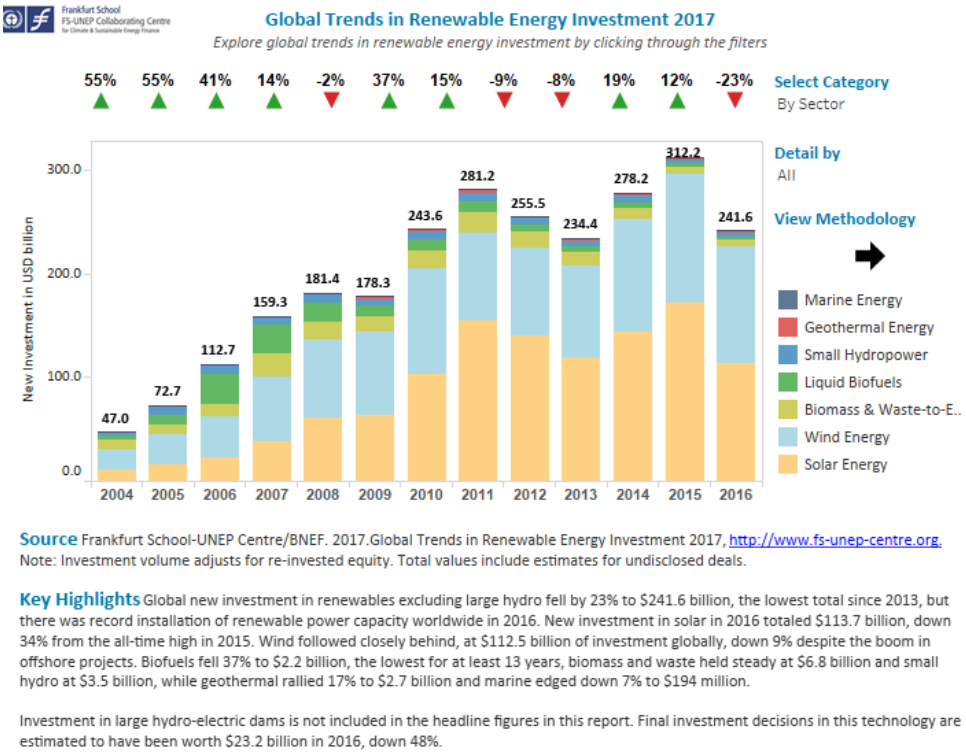
Source: Global Innovation Index 2016

On the overall ranks, Senegal is closely followed by Ghana which has a high ranking on knowledge absorption within the region (this parameter includes - intellectual property payments, high-tech imports, ICT service imports, FDI net inflows and research talent as % in business enterprises). Strength in knowledge absorption is an important aspect which can be instrumental in developing local innovation industry.

In analyzing the innovation profile of the selected four countries one can observe that knowledge impact is an area of concern for Nigeria, Ghana and Senegal, while for Cote d'Ivoire this is a strong area (further evaluation is needed on see how this may be replicated across other countries in West Africa). Another area of innovation where the selected four countries, especially Nigeria and Cote d'Ivoire, show low rankings are in knowledge creation. Knowledge creation (which includes - Patents by origin/bn PPP$ GDP, PCT patent applications/bn PPP$ GDP, Utility models by origin/bn PPP$ GDP, Scientific & technical articles/bn PPP$ GDP, Citable documents H index*) is a challenging area to address within a short time and requires strong policy intervention in areas of education and research. The best placed in the region in terms of knowledge creation and knowledge diffusion is Senegal which shows that if further development of academic and technological research is supported in Senegal it can become a knowledge hub and source of knowledge diffusion in the West African region.

Innovation is a key area for future development of the energy value chain and needs to be evaluated further through academic research. The research needs to further understand what specific factors are restricting West African region from innovating and developing technologies rather than importing them from developed markets.

Having considered the local innovation profile of the selected four countries it would be interesting to see which technologies are performing better as a result of access to finance (it is expected that a higher level finance availability will determine technologies which will gain traction, get innovated and become commercially successful faster than low financed technologies).



Source Frankfurt School-UNEP Centre/BNEF. 2017.Global Trends in Renewable Energy Investment 2017, http://www.fs-unep-centre.org.
Note: Investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals.

Key Highlights Global new investment in renewables excluding large hydro fell by 23% to $241.6 billion, the lowest total since 2013, but there was record installation of renewable power capacity worldwide in 2016. New investment in solar in 2016 totaled $113.7 billion, down 34% from the all-time high in 2015. Wind followed closely behind, at $112.5 billion of investment globally, down 9% despite the boom in offshore projects. Biofuels fell 37% to $2.2 billion, the lowest for at least 13 years, biomass and waste held steady at $6.8 billion and small hydro at $3.5 billion, while geothermal rallied 17% to $2.7 billion and marine edged down 7% to $194 million.

Investment in large hydro-electric dams is not included in the headline figures in this report. Final investment decisions in this technology are estimated to have been worth $23.2 billion in 2016, down 48%.

Figure 26: Global Trends in Renewable Energy Investment 2017

Globally there has been a significant investment growth in solar, wind and biomass areas and these will continue to be areas of opportunity within the West Africa energy innovation landscape. When compared with the innovation index, it can be used to see which countries of the selected 4 can attract innovative technologies faster than others – Ghana due to its high ranks for knowledge diffusion and knowledge absorption offers a point of entry or hub for diffusion of innovative technologies to the rest of the West African markets.

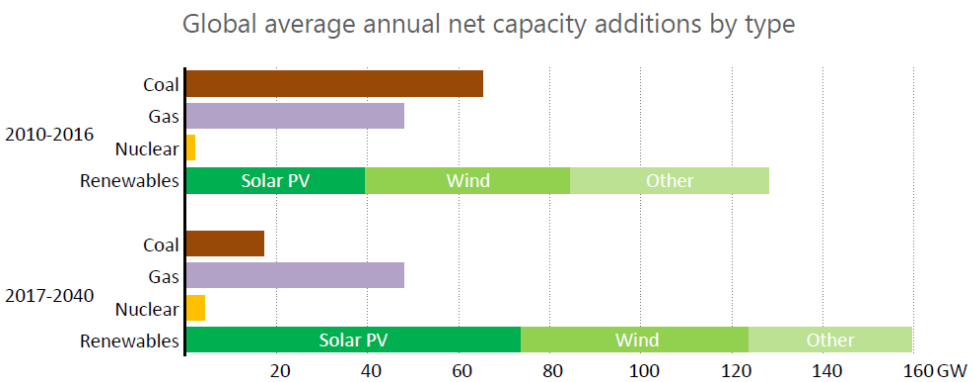


Figure 27: Global Average Net Capacity by Energy Source Type[30]

Patent filing trends over the last few years (Figure 28: Global Patents in Renewable Energy Technologies show that major thrust areas for research and innovation are Solar PV, Solar Thermal, Wind power and PV thermal hybrid. Patenting trends in energy technology were researched since these are the major indicators for innovation and show which innovative technologies are entering the energy value chain. These are technologies where women entrepreneurs can expand or enter through knowledge transfer agreements or agency agreements for commercialization inside West Africa. For example, when comparing this patenting trend chart with the innovation index scores and the high-scalability products sales

[30] 'London, 14 November 2017 ©' (2017), (November), World Energy Outlook

data (Figure 16: High-scalability Products (unit sales per annum) – which suggests highest number of bio-energy plants in Senegal) it shows that Senegal could play a major role in attracting new bio-energy based technologies which can then be diffused from there across the West African region.

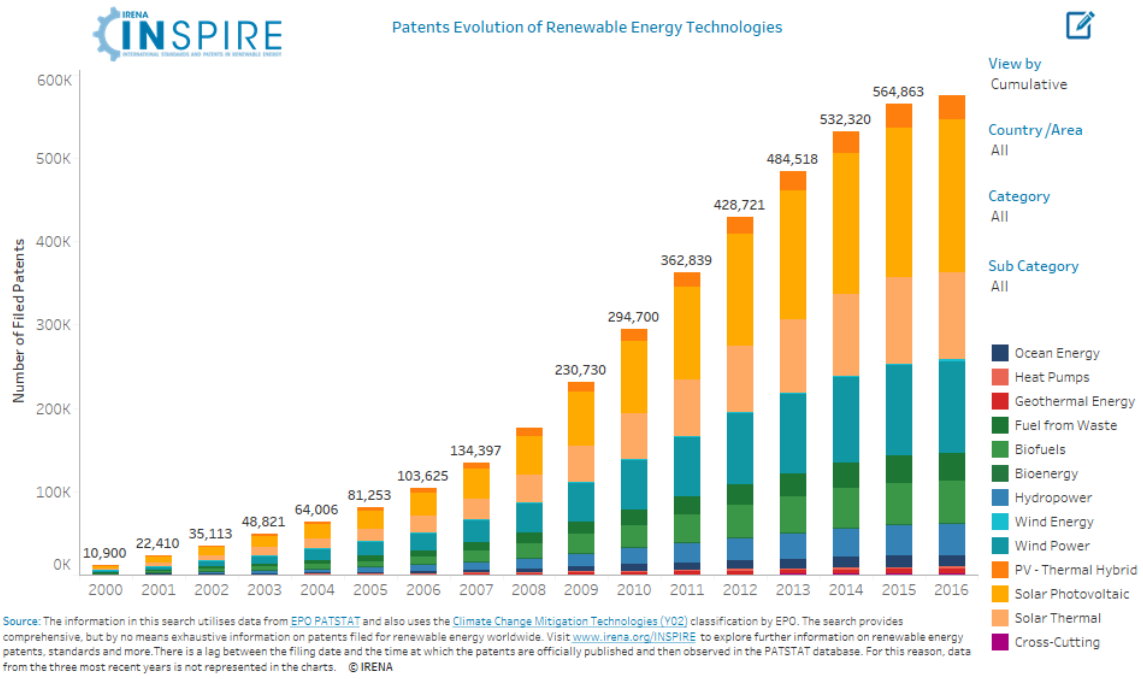


Figure 28: Global Patents in Renewable Energy Technologies

The major technologies that will make a bulk of future energy generation will include solar, wind and bio-energy based technologies hence these will see the fastest commoditization, regulatory compliance, consumer diffusion and commercial funding.

4.1.2. Climate change and resource scarcity

"A growing emphasis on renewables is a response to both climate change and security of supply concerns. In the US alone, over 30% of new electricity generation capacity added in 2010–2013 involved solar, and wind power, up from less than 2% in 2000–2003.2 Solar photovoltaic (PV) is now present on more than 1.2 million Australian homes and producing over 3.3GW per annum."[31]Electricity generation from renewable sources accounted for an average of 61.5% of the total final electricity consumption across the 4 selected countries[32] (with Nigeria being highest at 87% and Senegal the lowest at 43%)[33]. There is a continuous pressure to produce more electricity from renewable energy resources than through fossil fuels, so much so that renewable energy may become the primary source for generating energy.

[31] PricewaterhouseCoopers (2014) 'The road ahead - Gaining momentum from energy transformation', *Pwc*, pp. 1–32. Available at: http://www.pwc.com/en_GX/gx/utilities/publications/assets/pwc-the-road-ahead.pdf

[32] Large scale hydroelectric power contributed the highest share of electricity generation.

[33] http://gtf.esmap.org

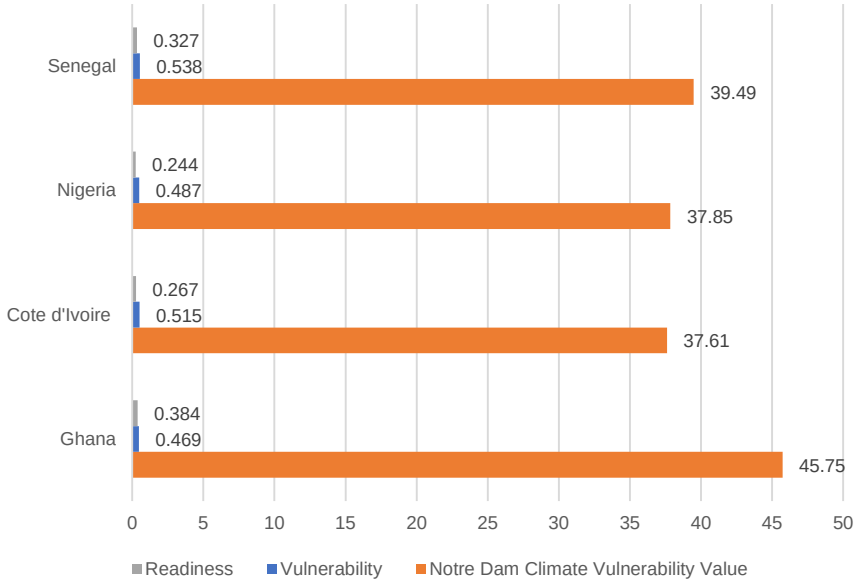


Figure 29: Notre Dam Adaptation Index

Source: Notre Dam Adaptation Index 2017

Environmental vulnerability is creating excessive pressure to align markets with more adjustable, controllable, and predictable sources of energy and the West African region is experiencing similar pressures – to evaluate these vulnerabilities and adaptabilities of the 4 selected countries, an index called – ND-GAIN Country Index was used. As stated "The ND-GAIN Country Index summarizes a country's vulnerability to climate change (measures a country's exposure, sensitivity, and capacity to adapt to the negative effects of climate change. ND-GAIN measures overall vulnerability by considering six life-support sectors – *food, water, health, ecosystem service, human habitat, and infrastructure*) and other global challenges in combination with its readiness (measures a country's ability to leverage investments and convert them to adaptation actions). ND-GAIN measures overall readiness by considering three components – economic readiness, governance readiness and social readiness to improve resilience. It aims to help governments, businesses, and communities better prioritize investments for a more efficient response to the immediate global challenges ahead."[34] The importance of this index is to understand how strong the readiness indicators are in a country and how weak is the country to environmental vulnerabilities – both these indicators act like external forces that affect the energy value chain. In case of an event that affects a country's vulnerabilities, its energy infrastructure will get affected, but if readiness is high due to better infrastructure, this kind of disruptions can be counteracted. The sensitivity of the energy value chain is gradually increasing as there is a larger demand for energy and the resources for electricity are getting scarce.

[34] https://gain.nd.edu/our-work/country-index/

It was observed that Ghana is relatively less vulnerable and better prepared to adapt to changes in

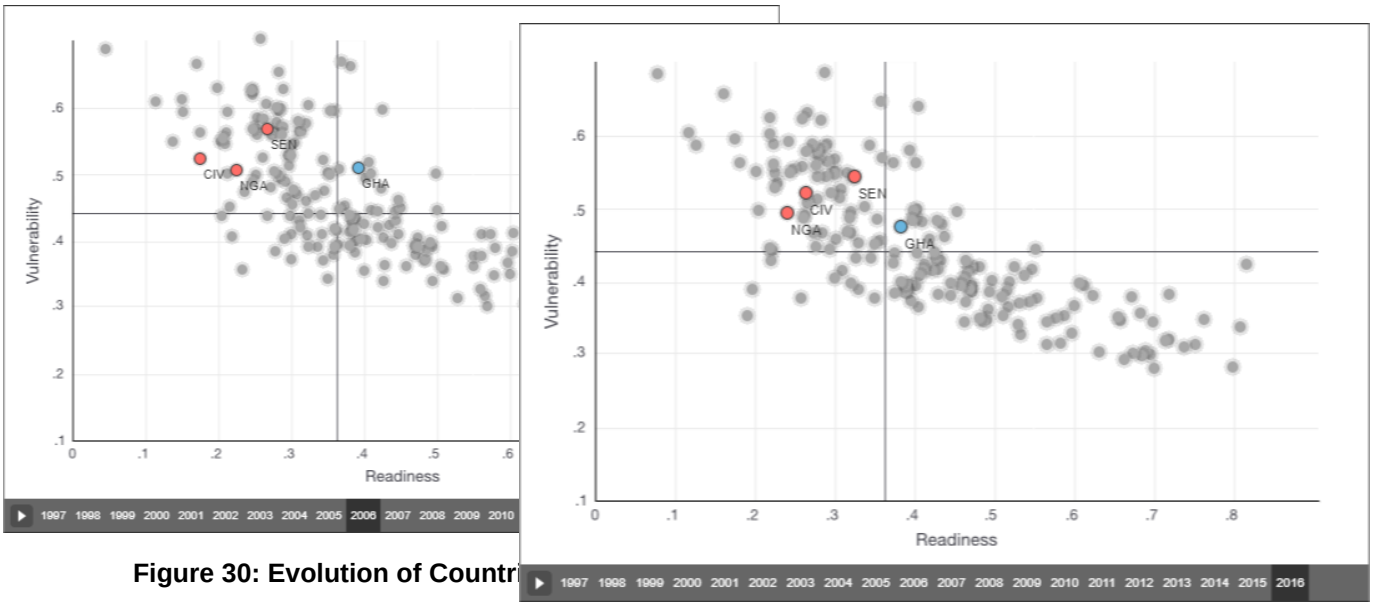


Figure 30: Evolution of Countri

the environment than the other 4 selected countries. When scores are compared at a global level, all 4 selected countries are deeply vulnerable to changes in the environment countries are deeply vulnerable to climate changes vulnerable to climate changes and will face difficulties to counteract the effects of climate change on their economies and social environment. Ghana has reduced its vulnerability and increased its readiness in the last 10 years (by improving – food and water safety, health, ecosystem biomes, human habitats, and infrastructures). Côte d'Ivoire has also improved its score primarily due to improvement in its readiness. Countries that are dependent on fossil fuel generation and origination face a markedly larger vulnerability issue than countries with renewable energy capabilities

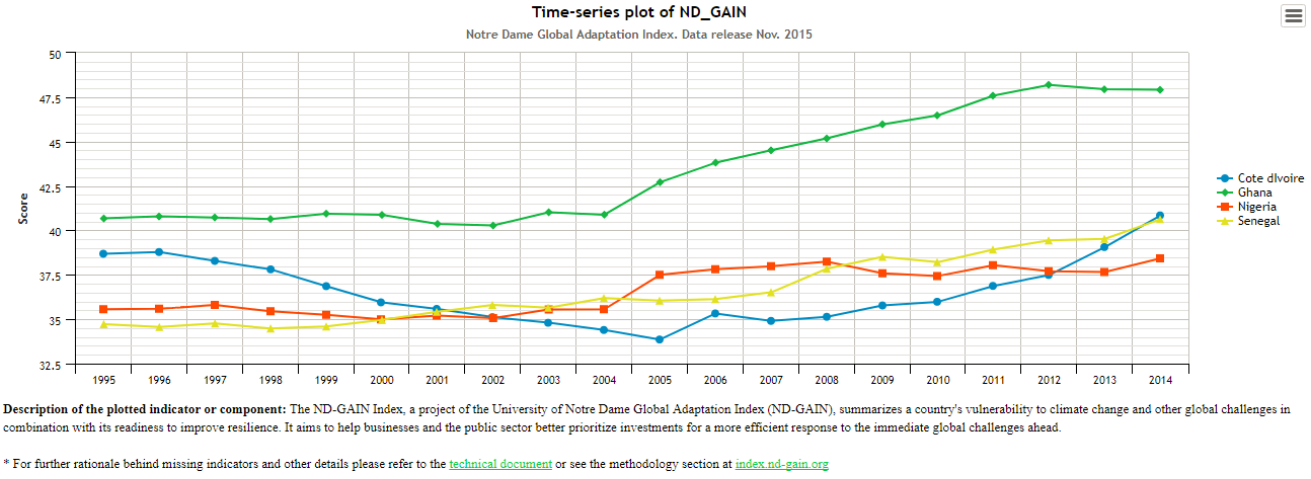


Figure 31: Time series plot of selected 4 countries on Notre Dam Adaptation Index

The other index used to evaluate the environmental ecosystem in selected four countries was '**Environmental Performance Index** (EPI) which is a method of quantifying and numerically marking the environmental performance of a state's policies. This index was developed from the Pilot Environmental Performance Index, first published in 2002, and designed to supplement the environmental targets outlined in the United Nations Millennium Development Goals. *This index*

incorporates two components which are Environmental Health (50%) and Ecosystem Vitality (50%)'[35].

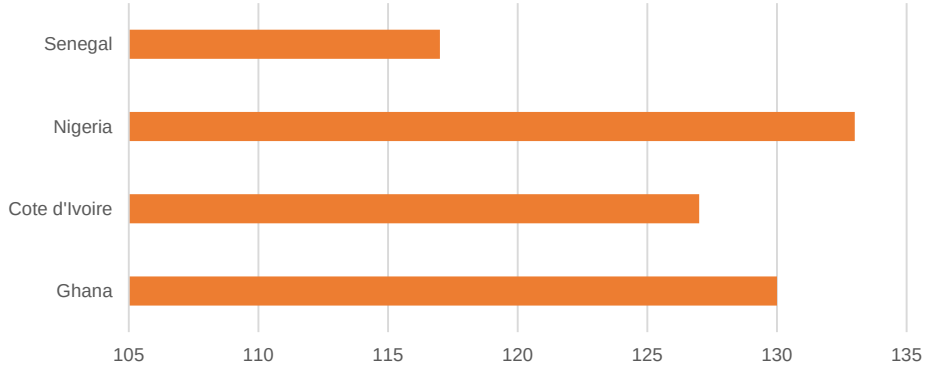


Figure 32: EPI Ranks of selected 4 countries (out of 180)

Data: Environmental Performance Index 2018

The ranking of the 4 selected countries, as a group, indicates that all the 4 selected countries are high on the ranks (low scores) when compared to other countries across the globe. Notably, Nigeria has the lowest rank (highest score) among the 4 selected countries and the highest score for ecosystem vitality among these countries. Having a high ecosystem vitality score means that the country has been able to get high scores on primarily – Climate & Energy[36] and Biodiversity & Habitat (which constitutes 55% of weightage in ecosystem vitality). On both these indicators Nigeria ranks high, especially on climate and energy scoring a rank of 10. Senegal holds a rank of 30 in biodiversity and habitat showing its strength in this area, Côte d'Ivoire has a rank of 65 in biodiversity and habitat, and Ghana has a rank of 55 for climate and energy and 84 for biodiversity and habitat. This data assumes that since Ghana and Nigeria have high scores for climate and energy, the efficient or low-emission energy generation plays a key role in helping these countries get higher scores in these areas. There is the potential to transfer these low-emission energy generation from these countries to other countries in the region, e.g. gas-based electricity generation (LPG based cooking technologies).

[35] https://epi.envirocenter.yale.edu. The EPI is produced jointly by Yale University and Columbia University in collaboration with the World Economic Forum. The 2018 EPI was produced with the generous support of the McCall MacBain Foundation and Mark T. DeAngelis. The 2018 Environmental Performance Index (EPI) ranks 180 countries on 24 performance indicators across ten issue categories covering environmental health and ecosystem vitality. These metrics provide a gauge at a national scale on how close countries are to establishing environmental policy goals. The EPI thus offers a scorecard that highlights leaders and laggards in environmental performance, gives insight on best practices, and provides guidance for countries that aspire to be leaders in sustainability

[36] The Climate & Energy issue category uses five indicators to track a country's progress in reducing three critical greenhouse gases and one climate pollutant. In adding non-CO_2indicators to the 2018 EPI, we have broadened the gauge of national climate change performance. We leverage new emissions inventories to construct a series of metrics intended to yield a more comprehensive assessment of a country's overall performance (https://epi.envirocenter.yale.edu/epi-indicator-report/CCE)

Figure 33: EPI Comparison of selected 4 countries in West Africa

Ecosystem vitality includes parameters for measuring – Biodiversity & Habitat (25% weightage), Forests (10% weightage), Fisheries (10%), Climate & Energy (30% weightage), Air pollution (10% weightage), Water Resources (10% weightage) and Agriculture (5% weightage).

Environment Health includes parameters for measuring - Air Quality (65% weightage), Water Quality (30% weightage) and Heavy Metals (5% weightage)

Carbon emissions are indicators for the amount of carbon footprint the economy is generating and provide a good picture of economic vitality. Compared with global emissions, countries in West Africa have very low emissions profile. Nigeria is the highest in overall emissions followed by the other 4 selected countries. The Figure 35: CO2 Emissions Profile shows Countries by carbon dioxide emissions in thousands of tons per annum, via burning of fossil fuels (blue being the highest and green being the lowest)[37]

37

https://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions#/media/File:Countries_by_carbon_dioxide_emissions_world_map_deobfuscated.png

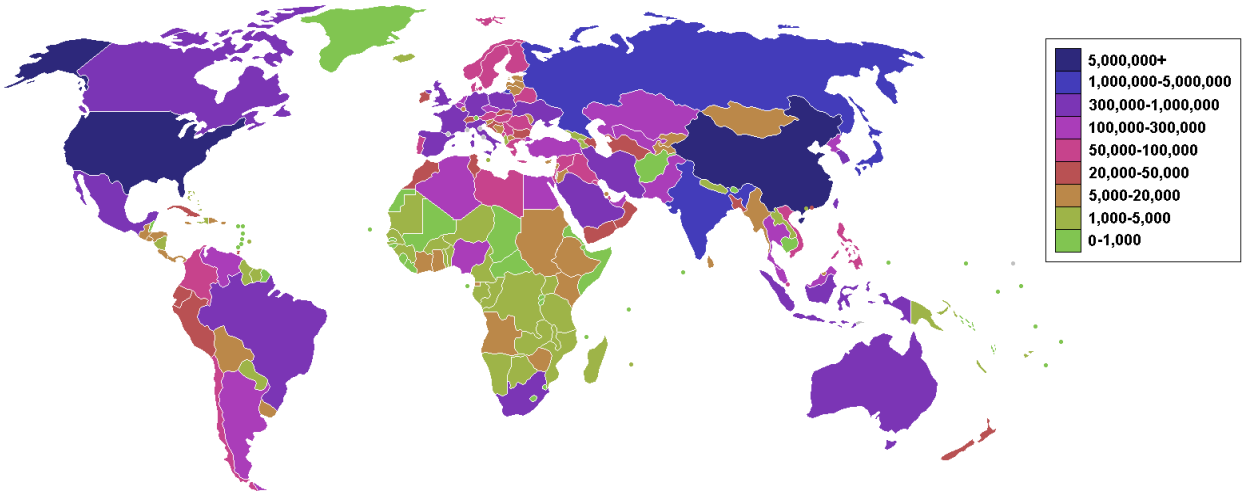


Figure 34: Global Carbon Emissions[30]

The CO_2 emission profile demonstrated that all of the 4 selected countries contributed a small portion of global CO_2 emissions, but when compared with each other, Nigeria produces the highest proportion of regional emissions. Nigeria produces lesser per capita emissions when compared to Ghana (0.52) and Senegal (0.51). It is interesting to note that in Nigeria, per capita CO_2 emissions is 0.46 which is below the 4 selected countries average per capita CO_2 emissions of 0.47. Considering that Nigeria has 73% of the total population of the 4 selected countries (~259 Million) this might be the reason why its per capita CO_2 emissions are lower (per capita are calculated as total emissions divided by the population size). Looking at these charts and earlier EPI rankings it is clear that Nigeria and Côte d'Ivoire both have low-emission economies compared to the other two countries ratings which need to be sustained by using renewable energy and energy efficient electricity generation and consumption technologies.

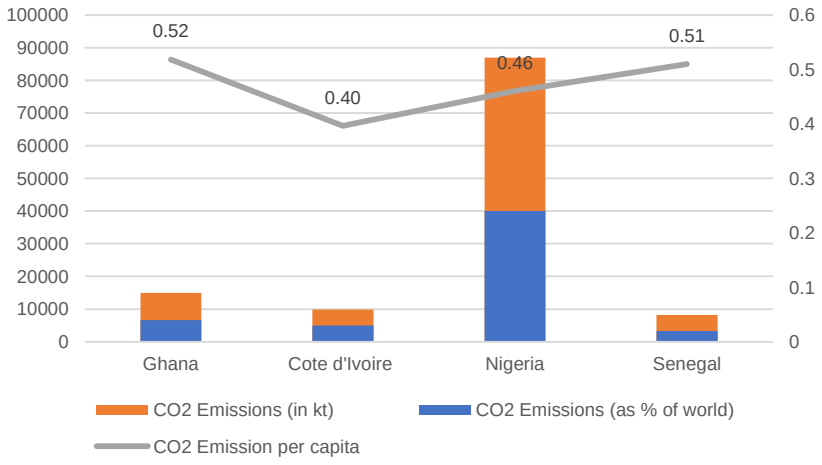


Figure 35: CO_2 Emissions Profile

Data: http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts1990-2015

The renewable energy-based electricity generation capacities have seen a gradual increase over the last 5 years with a current total capacity at 4430 MW[38] which is ~50% of the total installed power capacity in the 4 selected countries)Figure 36: Trends in Renewable Energy Source Type (in selected **4** ***countries)***. These technologies have played a crucial role in making the 4 selected

[38] IRENA database - http://resourceirena.irena.org/gateway/dashboard/?topic=4&subTopic=16

countries low-emission, but as the population of these countries increases the electricity generation capacities need to increase thus creating pressure on the energy value chain.

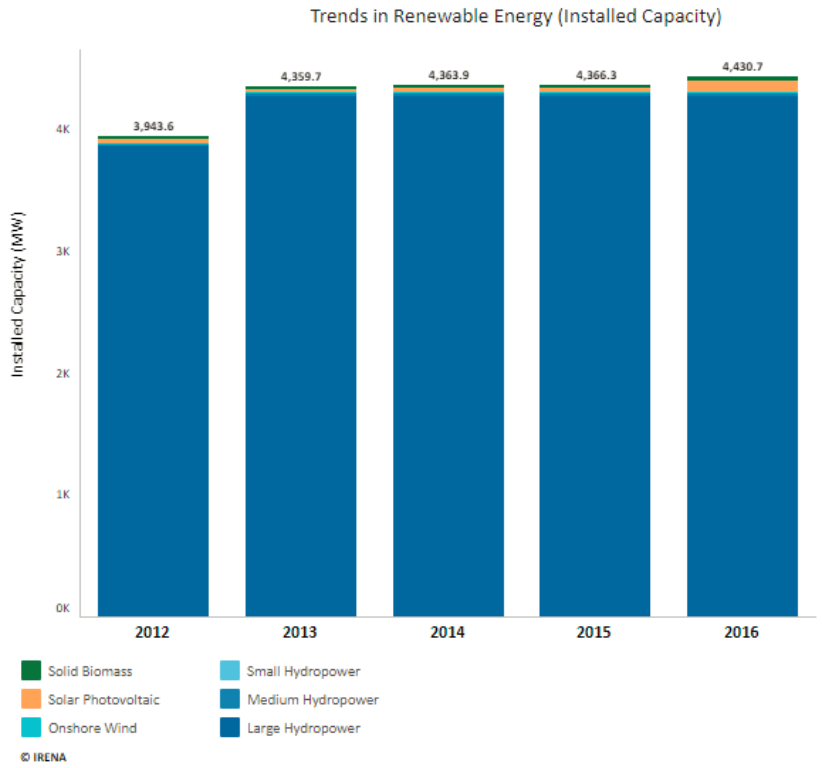


Figure 36: Trends in Renewable Energy Source Type (in selected 4 countries)

Existing Power Generating Capacity (MW)

Country	Oil	Coal	Gas	Hydro	Total
Burkina Faso	146			23	**169**
Cote d'Ivoire			765	585	**1,350**
Gambia	49			0	**49**
Ghana	685		180	1,044	**1,909**
Guinea	19			95	**114**
Guinea-Bissau	4			0	**4**
Liberia	13			0	**13**
Mali	114		20	153	**287**
Niger	15	32	20	0	**67**
Nigeria			3,858	1,358	**5,216**
Senegal	395		49	68	**512**
Sierra Leone	44			56	**100**
Togo/Benin	57			65	**122**
Total	**1,541**	**32**	**4,892**	**3,447**	**9,912**

Figure 37: Power Generation Capacities across West Africa[39]

Electric production in the 4 selected countries was evaluated by source and the gaps between production and consumption. It is interesting to note that there are excesses in energy production,

[39] IRENA WAPP report 2015

but these are depleted due to losses (transmission and generation). Nigeria losses almost 17%, Ghana around 21%, Senegal 17% and Côte d'Ivoire around 20% which are quite significant numbers compared to the global average of 8.2%[40]. Among the 4 selected countries, all have a positive electricity surplus stock, but Senegal has a deficit of 4% around 150GWh. All these findings indicate that as electricity demands grow there will be huge pressure to either boost energy generation capacities or satisfy demand (by expanding off-grid electricity generation capacities) or reduce transmission losses.

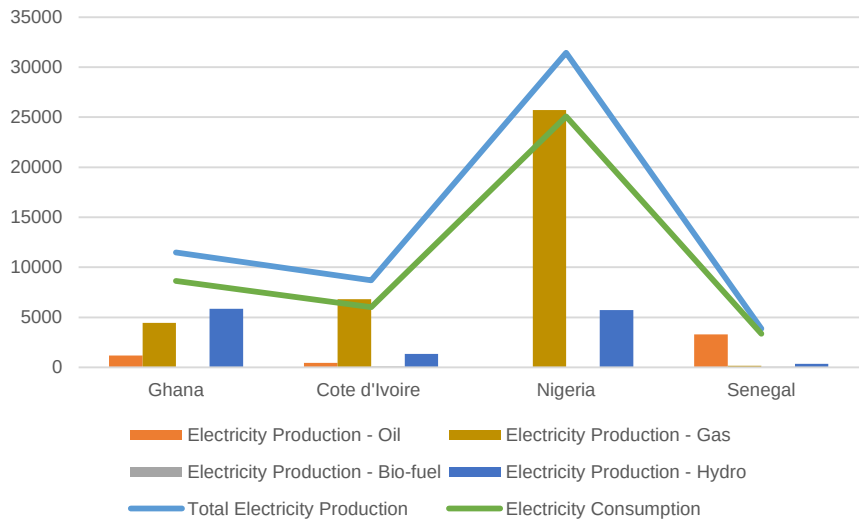


Figure 38: Electricity Production & Consumption

Data: IEA Database 2017

Looking at the projected pipeline under development by WAPP there is a significant amount of renewable capacity expected to come online in the form of gas and hydro-based electricity generation assets (Figure 39: Future Power Generation Capacity Projects across West Africa). Moreover, gas and hydro-based projects will be on-grid, so it will take time to develop adequate transmission infrastructure to completely cover rural areas – thus, it is with the help of private entrepreneurs, IPPs, and foreign investors that a off-grid sector can be developed.

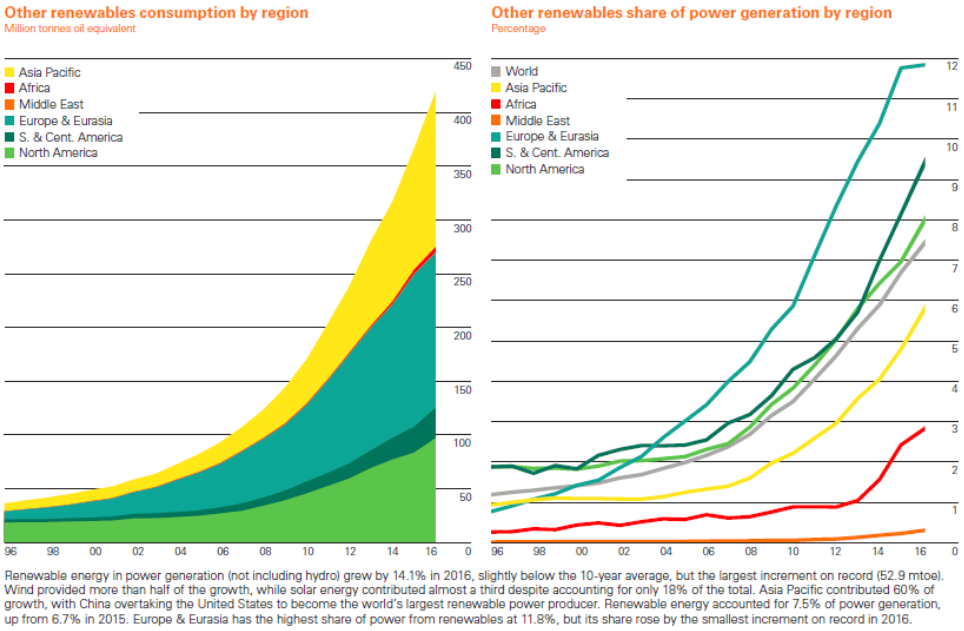
[40] https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS

Capacity of Future Projects- MW (figures in parentheses refer to committed projects)

Country	Oil	Coal	Gas	Hydro	Biomass	Wind	Solar	Total
Burkina Faso	120 (112)	-	-	60	-	-	40	**220 (112)**
Cote d'Ivoire	-	-	1,313 (863)	1,072	-	-	-	**2,385 (863)**
Gambia	16 (16)	-	-	68	-	1 (1)	-	**85 (17)**
Ghana	100	-	2,265 (1,180)	661 (228)	-	150 (150)	10 (10)	**3,186 (1,568)**
Guinea	227 (227)	-	-	3,346 (287)	-	-	-	**3,573 (514)**
Guinea-Bissau	15 (15)	-	-	14	-	-	-	**29 (15)**
Liberia	45 (45)	-	-	967 (66)	35	-	-	**1,047 (111)**
Mali	332 (166)	-	-	434 (90)	33	-	40 (10)	**839 (266)**
Niger	32 (15)	200	18 (8)	279 (98)	-	30	50	**609 (121)**
Nigeria	-	-	13,581 (8,531)	3,300	-	-	-	**16,881 (8,531)**
Senegal	540 (180)	1,000 (250)	-	530	30 (30)	225	8	**2,333 (460)**
Sierra Leone	-	-	-	755	115	-	5	**875**
Togo/Benin	-	-	630 (580)	357 (147)	-	20	35	**1,042 (727)**
Total	**1,437 (776)**	**1,200 (250)**	**17,807 (11,162)**	**11,840 (916)**	**213 (30)**	**426 (151)**	**188 (20)**	**33,104 (13,305)**

Figure 39: Future Power Generation Capacity Projects across West Africa[41]

When comparing these with global renewables consumption and share of renewables in electricity generation it shows that Africa has a very small contribution which is gradually rising. It is suggested this trend will continue and the renewable share in the energy mix will continue to rise and should come close to other developing countries.



Renewable energy in power generation (not including hydro) grew by 14.1% in 2016, slightly below the 10-year average, but the largest increment on record (52.9 mtoe). Wind provided more than half of the growth, while solar energy contributed almost a third despite accounting for only 18% of the total. Asia Pacific contributed 60% of growth, with China overtaking the United States to become the world's largest renewable power producer. Renewable energy accounted for 7.5% of power generation, up from 6.7% in 2015. Europe & Eurasia has the highest share of power from renewables at 11.8%, but its share rose by the smallest increment on record in 2016.

Figure 40: Global Renewable Energy Consumption and Generation Trends[42]

[41] IRENA (2013) 'Southern African Power Pool: Planning and Prospects for Renewable Energy', pp. 1–91. Available at: www.irena.http://www.irena.org/documentdownloads/publications/sapp.pdforg.

[42] BP (2017) 'BP Statistical Review of World Energy 2017', *British Petroleum*, (66), pp. 1–52. doi: http://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf.

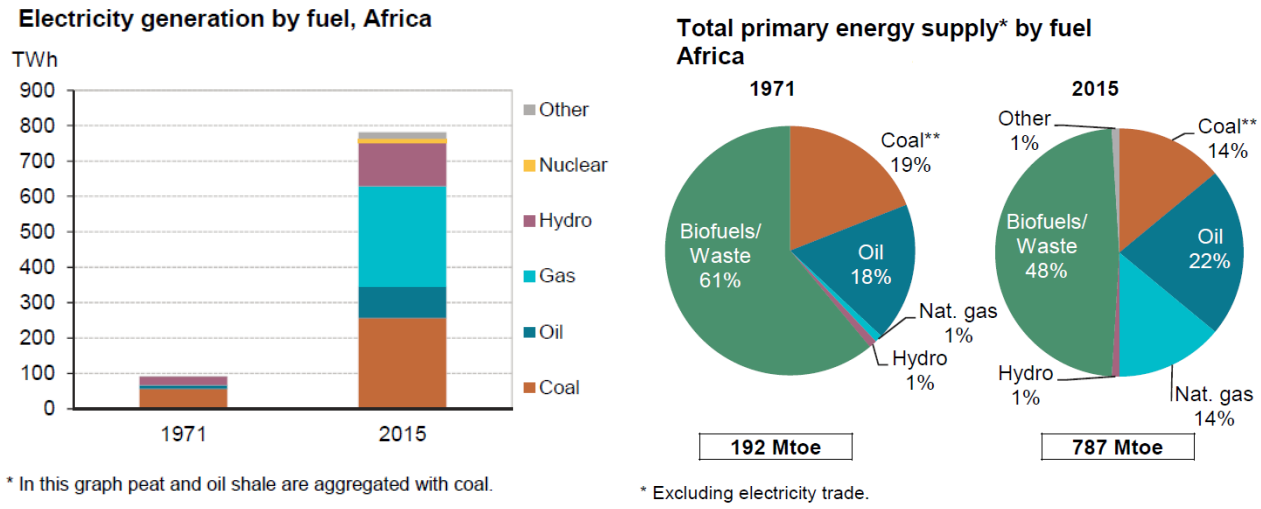


Figure 41: Electricity Generation by Fuel Type and Primary Energy Fuel (Africa)[43]

It is imperative to point out that, as a continent, Africa has seen a phenomenal change in its energy supply mix with a share of gas increasing over the last few years eroding both bio-fuel and oil-based energy generation. This increase in gas-based energy production is aligned with the way the global markets have been developing where gas shares in the overall energy mix have been on the rise (25% by 2035).

The global energy production contribution by fuel type shows that by the year 2035, gas, renewables and hydro will see the main bulk of the increase in shares rising from 32% in 2015 to 41% in 2035. The 4 selected countries are already leading the trend with more upcoming shifts to renewables as sources of energy production. This is in sharp contrast to West African countries where the major source of energy generation continues to be biomass followed by oil and gas based energy generation (especially for residential and industrial cooking – see Annex-2).

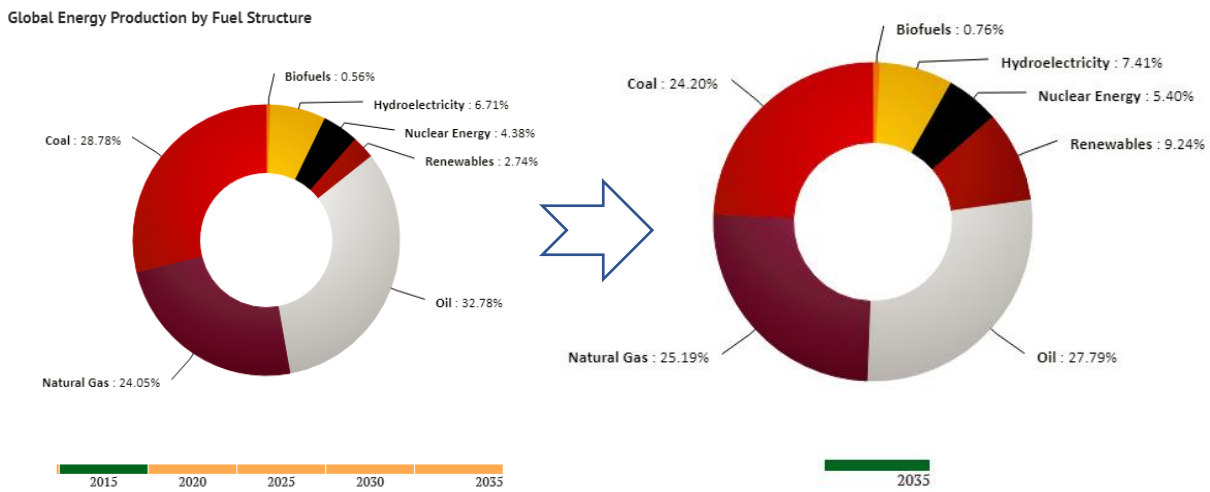


Figure 42: Future Evolution of Energy Generation by Fuel Type[44]

Overall, the demand for gas will continue to grow globally so countries like Nigeria, Côte d'Ivoire, and Ghana will keep building capacities both for exporting larger quantities of gas as well as selling it

[43] IEA (2017) 'World energy balances: an overview of global trends', *WORLD ENERGY BALANCES: AN OVERVIEW Global trends*, p. 21. doi: https://www.iea.org/publications/freepublications/publication/world-energy-balances---2017-edition---overview.html.

[44] World Energy Council (2016) 'World Energy Resources 2016', *World Energy Resources 2016*, pp. 1–33. doi: http://www.worldenergy.org/wp-content/uploads/2013/09/Complete_WER_2013_Survey.pdf.

domestically. West Africa will continue to lead (or at least follow) the trend in the use of renewable energy and energy-efficient technologies for energy generation (including electricity generation where West African countries lead compared to other developing countries).

4.1.3. Demographic changes

The demographics are drivers of present and future demand for electricity, and we see that Nigeria's population is 72% of the total population of selected four countries (Figure 43: Electricity Access). Nigeria has the fastest growing demographics which is slightly below the average population growth rate for West Africa, i.e. 2.7% per year[45]. The data from ECREEE WAPP projections highlights that total consumption of electricity will almost double by 2020 and triple by 2030 for these selected four countries put together.

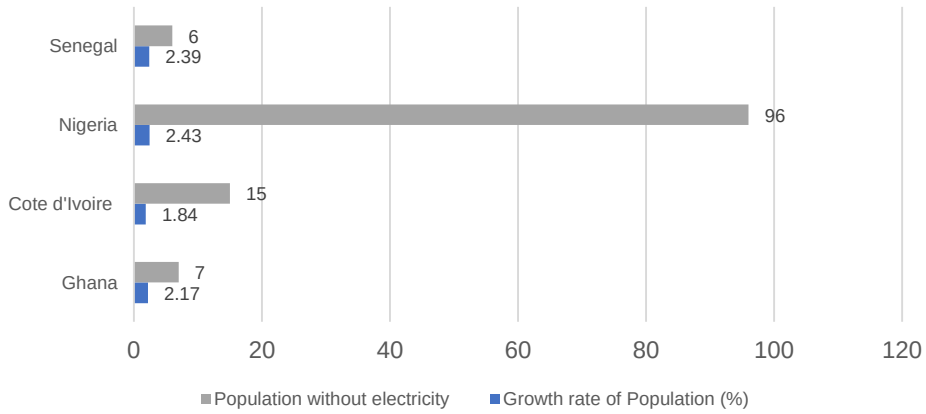


Figure 43: Electricity Access & Population Growth Rates

Source: IMF and CIA Databases 2016

Demographic pressures will continue to exert a demand for an energy value chain thereby affecting generation, transmission, storage, and distribution dynamics. Population without access to electricity averages around 48% in the 4 selected countries. Almost 60% population in Côte d'Ivoire and almost 51% in Nigeria have no access to electricity. These figures highlight the significant size of the untapped electricity demand that is not being met by the present electricity production and distribution companies, which offers a phenomenal potential for off-grid distribution of electricity as well as the entire range of new electricity generation, storage, and consumption products and services. Access to electricity shows higher scores in Ghana (75%) and Senegal (62%) therefore these markets offer the potential for energy efficiency and demand management services.

[45] http://www.worldometers.info/world-population/western-africa-population/

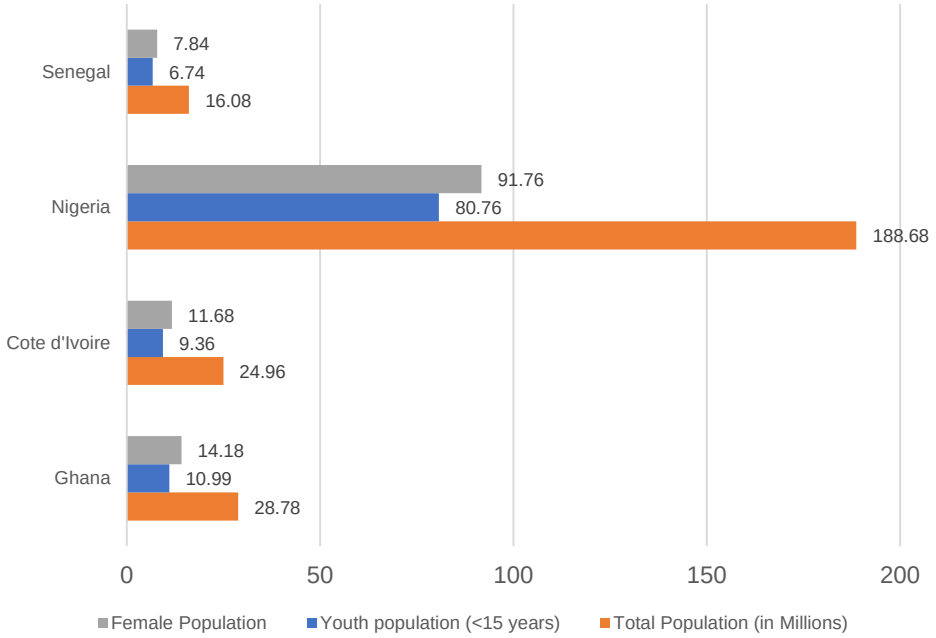


Figure 44: Youth and Female Population

Moreover, with its high youth population, creating energy solutions to drive their entrepreneurial needs will be crucial to engaging this segment of the population economically. Also, attention needs to be paid to the energy needs of the female population, which accounts for 50% in some of the countries. Access to modern, safe and affordable cooking energy solutions continue to be a major concern for women in rural, peri-urban and urban areas. Attention needs to be paid to women in agriculture, specifically in the rural areas, who make up the larger share of people employed in subsistence agriculture.

It is worth mentioning that, based on the SEforALL action agendas, ECOWAS countries are expected to see a significant level of electricity access expansion to larger proportion of its population by 2030 (as per targets contained in the Action Agendas).

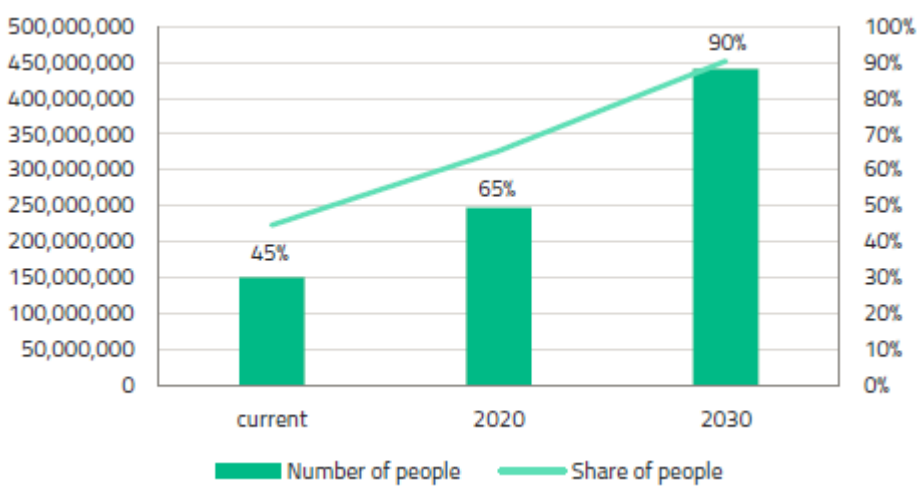


Figure 45: Expected Access to Electricity by 2030 (as per AA)[46]

[46] Energy, R., Plans, A. and Ef-, N. E. (September 2017) 'From Vision to Coordinated Action', ECREEE

4.1.4. The shift in economic power

"The focus of global growth has shifted. If looked at historically, we realize that western economic strength is a relatively recent phenomenon and the current developments are essentially a rebalancing of the global economies. As fast-growing economies become exporters of capital, talent, and innovation, the direction of capital flows is being adjusted in a way that is quite different from the traditional routes in developed-to emerging and developed-to-developed countries. We already see significant East-West, and East-South investment flows in power markets."[47]

The largest among the 4 selected is Nigeria, which constitutes almost 80% of the total GDP of the 4 selected countries combined. Incidentally, Ghana is fastest growing economy followed by Côte d'Ivoire. One of the key economic aspects to consider is the consumer price index which represents the inflation[48] produced by the economy. Nigeria followed by Ghana has the highest inflation among the 4 selected countries, which indicates an elevated level of activity (and possibly economic overheating). This high inflation results in high revenue turnovers for businesses but erodes company profitability (due to higher costs including higher borrowing costs). Intensive cost cutting due to higher borrowing costs results in business model transformations in some companies, affecting their products and services. During primary research, this was found to be true –extremely high lending rates in Ghana and Nigeria discourage businesses from borrowing money from commercial banks. On the other hand, excessive cost structures create pressure to innovate and find solutions that reduce costs and create efficiencies in the present business operations. Côte d'Ivoire and Senegal have low inflation rates and a high GDP growth rate which offers good possibilities for businesses to increase operations, especially for high scalability products which are commoditized in nature and are driven by low borrowing costs.

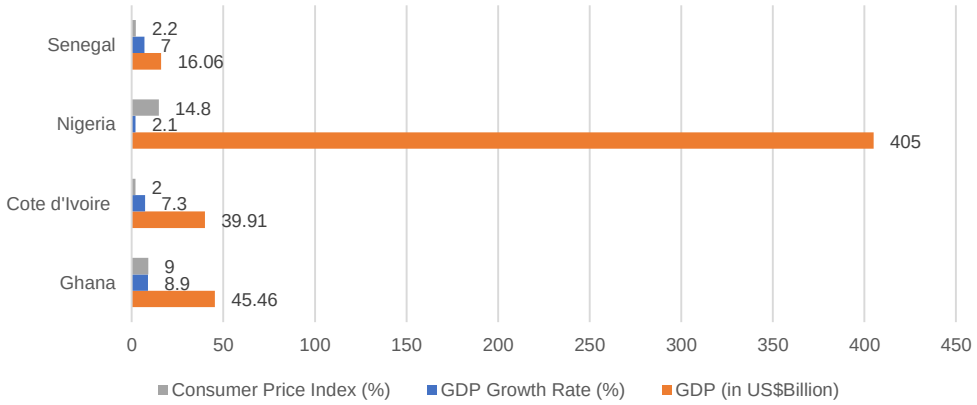


Figure 46: Economy, Growth rate, and Consumer Prices Index

Source: IMF & CIA Database 2017

[47] PricewaterhouseCoopers (2014) 'The road ahead - Gaining momentum from energy transformation', *Pwc*, pp. 1–32. Available at: http://www.pwc.com/en_GX/gx/utilities/publications/assets/pwc-the-road-ahead.pdf

[48] A **consumer price index** (**CPI**) measures changes in the price level of market basket of consumer goods and services purchased by households. CPI is a statistical estimate constructed using the prices in a sample of representative items whose prices are collected periodically. Sub-indices and sub-sub-indices are computed for different categories and sub-categories of goods and services, being combined to produce the overall index with weights reflecting their shares in the total of the consumer expenditures covered by the index. It is one of several price indices calculated by most national statistical agencies. The annual percentage change in a CPI is used as a measure of inflation. A CPI can be used to index (i.e., adjust for the effect of inflation) the real value of wages, salaries, and pensions, for regulating prices and for deflating monetary magnitudes to show changes in real values. In most countries, the CPI, along with the population census, is one of the most closely watched national economic statistics.

Data on financial infrastructures was used to understand the availability of finance for entrepreneurs and businesses. This data on financial infrastructure shows that both Nigeria and Ghana offer a sizable number of branches per 1000 adults (indicates the penetration of banks distribution networks) compared to other countries among the 4 selected countries. However, domestic credit from financial institutions is extremely low for the private sector[49] (Nigeria being the lowest at 15.6% of GDP which is way below the average for sub-Saharan Africa at 45.6% of GDP[50]). Even though the number of depositors is quite high in both Nigeria and Ghana extending credit to the private sector is quite low in both countries. However, in Senegal and Côte d'Ivoire deposits are low while domestic credit to the private sector is better than in Ghana and Nigeria.

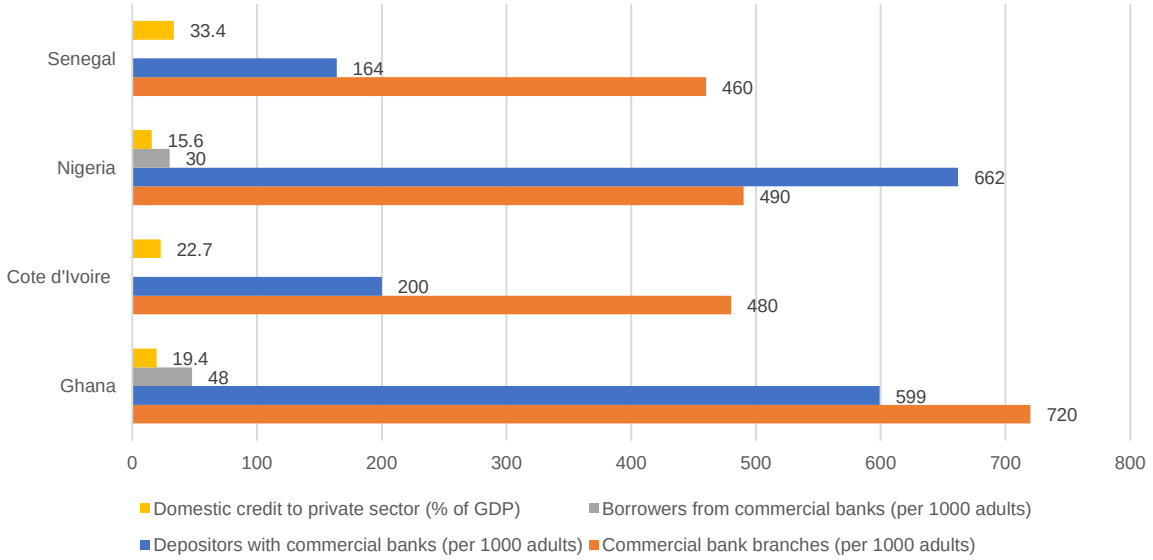


Figure 47: Commercial Bank Branches, Depositors, Borrowers and Private Sector Credit

Source: http://wdi.worldbank.org/table/5.5

To understand the size of foreign inflows happening in the form of equity, debt or developmental assistance to these selected 4 countries (Figure 48: FDI Equity, Debt and Development Assistance Flows), it was observed that there are some equity inflows into Nigeria and Ghana (but these are very small in terms of the size of the economy in Nigeria). The total equity flows into the 4 selected countries are around 1.7% of total GDP in these countries, total debt flows into the 4 selected countries are around 0.3% of total GDP in these countries, and total grant flows into the 4 selected countries are around 1.1% of total GDP in these countries. These are small numbers in relation to the size and potential of these economies, and there is a strong desire to push more funding into these countries. Regarding value of equity flows, Ghana and Nigeria offer a better incentive to equity-based funding than the other two of the 4 selected countries. Technologies that are innovative will have more probabilities to get funded in a country where there are higher equity inflows and, as such, service technologies for energy value chain, developed by women entrepreneurs requiring equity-based funding should look at Ghana and then Nigeria for maximizing their chances of

[49] Domestic credit to the private sector refers to financial resources provided to the private sector by financial corporations, such as loans, purchases of non-equity securities, and trade credits and other accounts receivable, which establish a claim for repayment. For some countries these claims include credit to public enterprises. Financial corporations include monetary authorities and money deposit banks, as well as other financial corporations where data are available (including corporations that do not accept transferable deposits but do incur such liabilities as time and savings deposits). (http://data.worldbank.org/indicator/FS.AST.PRVT.GD.ZS)

[50] https://data.worldbank.org/indicator/FS.AST.PRVT.GD.ZS?name_desc=true

success. Senegal, on the other hand, is driven by grant-based funding, and this was clearly seen during the field meetings with women entrepreneurs who mentioned that the only access to finance they have in Senegal is through grants from international donors and funds.

With increasing population, better regulations, stringent governance and improved legal systems there exists a sizeable potential to fund energy value chain related projects across the West African region. The present level of funding across the 4 selected countries is low and unlikely to help entrepreneurs grow their businesses.

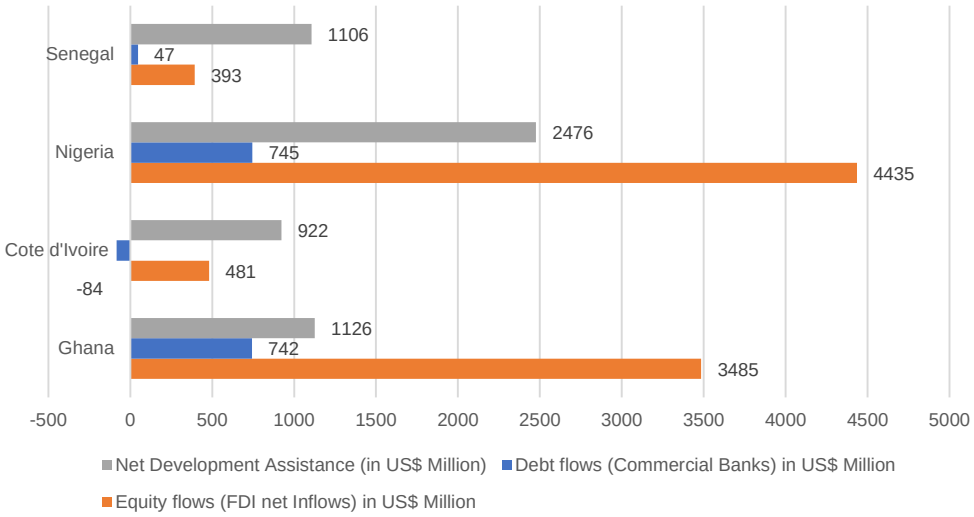
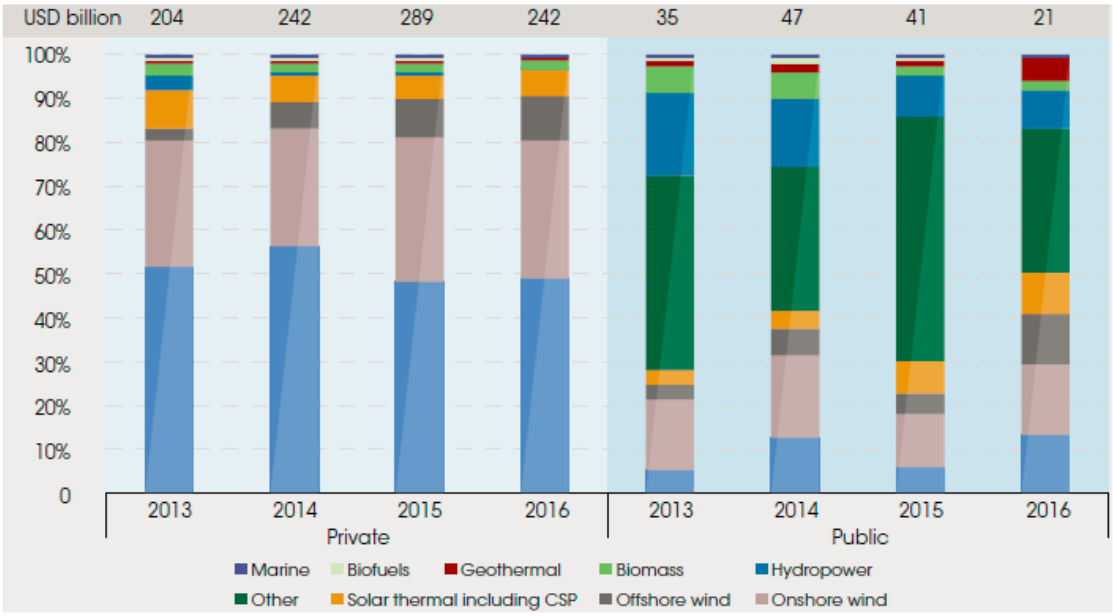


Figure 48: FDI Equity, Debt and Development Assistance Flows

Source: http://wdi.worldbank.org/table/5.5, http://data.un.org/Data.aspx?d=WDI&f=Indicator_Code%3aDT.ODA.ALLD.CD

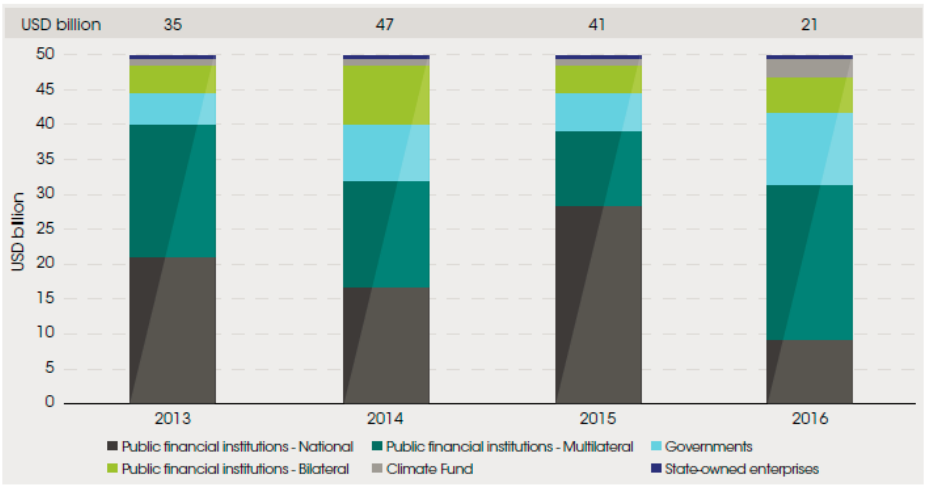
To get a global perspective on how renewable energy technologies were getting financed data from IRENA was used, which shows that the major source of funding for renewable energy projects comes from private sources followed by development financial institutions (DFIs). The DFIs include public financial institutions – national, bilateral, and multi-lateral.



Note: The "other" category in public finance represents a range of projects including advisory work in support of building renewable energy infrastructure, investment in community programmes, upgrades to grid infrastructure and mixed renewable technologies.

Figure 49: Source of Financing for Renewable Energy Projects[51]

The principal sources of funding for grid infrastructures, hybrid renewables and solar come from public institutions while for hydro and on-shore wind is through private sources. The DFI funding has shown a drastic decrease in 2016 compared with the level in 2014, but the private funding sources have remained static. DFI plays a significant role to kick-start innovative technologies, which are otherwise difficult to fund by private companies, and there is a need to further encourage funding especially from multilateral organizations to boost women entrepreneur owned projects.



Note: Figure includes only enterprises that are more than 50% owned by the state; enterprises with state ownership levels of 50% and below are excluded.

Figure 50: Public Investments in Renewable Energy by source[52]

[51] IRENA database 2017
[52] IRENA (2018), Global Landscape Of Renewable Energy Finance

Within public sources, public financial institutions – multi-laterals continue to increase their share along with government sources, and these will also be likely sources for women entrepreneurs on the energy value chain. The only possible problem is that these institutions cannot do small business financing and most women entrepreneurs are involved in companies worth less than US$1.3 Million (Figure 113: Project Finance Requirements). A possible solution would be to establish a separate fund for women entrepreneurs in the energy sector.

Investments coming from private sources have been a significant source of financing and have been led by project developers (growing continuously over the last 4 years) followed by commercial financial institutions. Associations with project developers in developed markets could offer women entrepreneurs the opportunity to seek financial assistance for their projects.

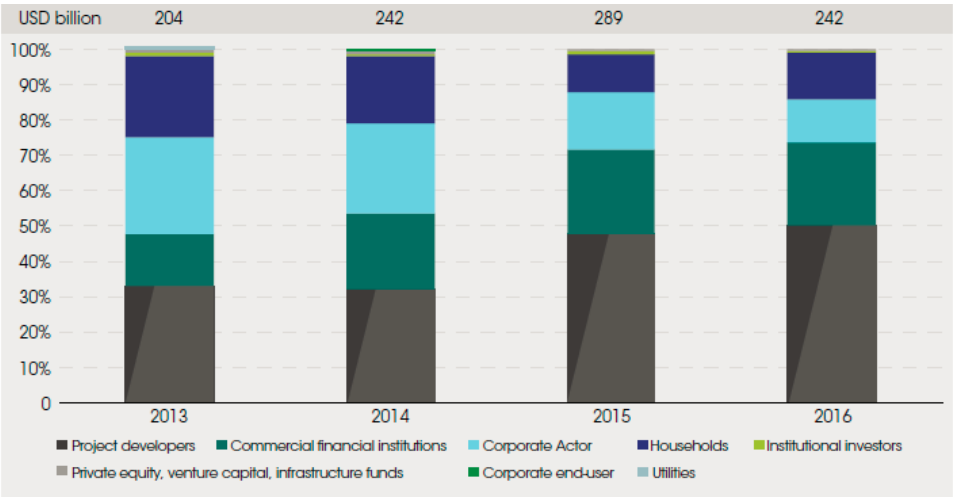


Figure 51: Private Investments in Renewable Energy by source[40]

The global renewable energy-based electricity generation has been witnessing a significant shift in renewable sector investments where the renewable energy-based investments are more than double than in thermal power generation (Figure 52: Global Electricity Investments by Region and Technology Type). Comparatively, investment proportions (renewable to thermal power generation) in Africa are significantly lower and need to be further increased to support the growth of renewable energy based electricity production.

Electricity sector investment by region and technology

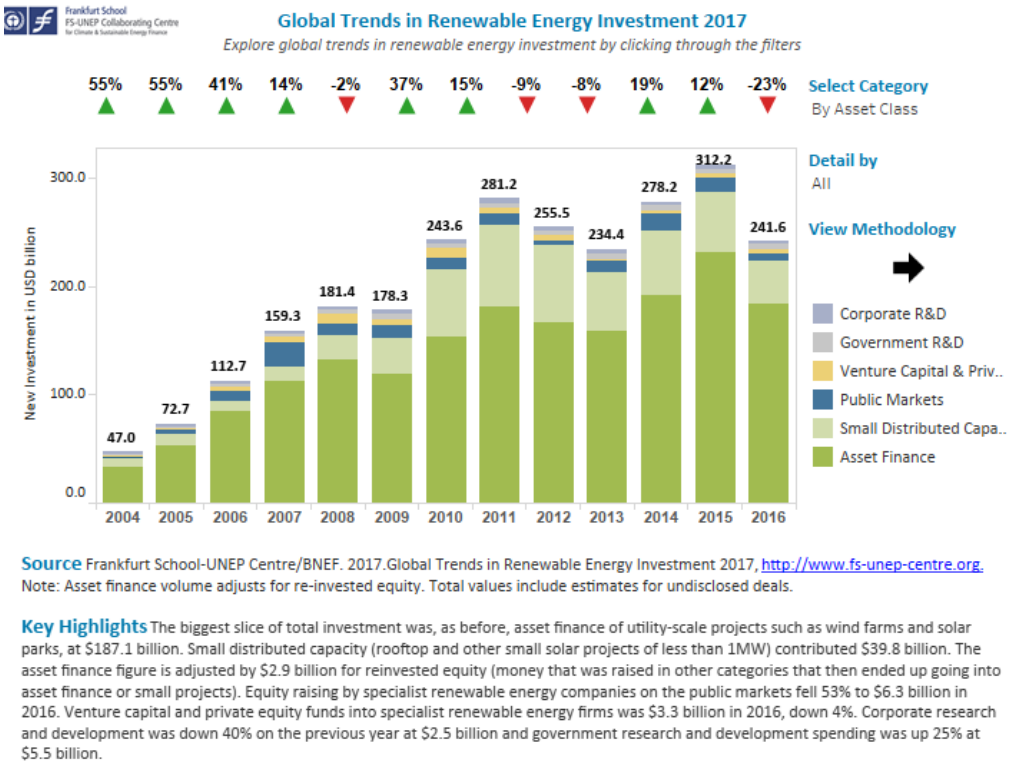
USD (2015) billion	Thermal power generation				Renewable generation				Electricity networks		Total
	Coal	Gas	Oil	Nuclear	Hydro	Wind	Solar PV	Other renewables	Transmission	Distribution	Power sector
OECD	9	13	0	2	14	54	68	16	28	84	289
Americas	0	6	0	0	6	19	24	4	21	37	117
United States	0	5	0	0	1	15	21	2	18	31	93
Europe	9	2	0	0	7	34	12	11	5	34	114
Asia Oceania	0	4	0	2	1	2	32	2	2	14	58
Japan	0	1	0	0	1	1	27	1	1	6	38
Non-OECD	69	18	2	19	45	53	29	8	31	118	393
Europe/Eurasia	2	1	0	5	1	1	1	0	4	12	26
Russia	1	1	0	5	0	0	0	0	3	7	17
Non-OECD Asia	65	8	0	15	34	45	26	4	21	87	306
China	38	5	0	15	25	41	22	2	15	51	214
India	18	1	0	0	3	4	3	1	4	17	48
Southeast Asia	9	2	0	0	4	1	1	1	1	9	28
Middle East	0	5	0	0	2	0	0	0	2	6	15
Africa	1	3	1	0	1	2	1	1	1	6	17
Latin America	0	1	0	0	8	5	1	3	3	7	29
Brazil	0	0	0	0	4	4	0	2	2	4	15
World	78	31	2	21	59	107	98	24	60	202	682
European Union	7	1	0	0	2	33	11	10	5	30	99

Note: Electricity networks include grid-scale battery storage.

Figure 52: Global Electricity Investments by Region and Technology Type[53]

Within the shift in economic power, this study also looked at how global investment trends have behaved in renewable energy technologies to get an insight on how these might affect investments in the 4 selected countries. Major investments in the renewable energy sector are through asset finance and the most invested projects are in utility-scale followed by small-distributed capacity. These investment trends are already shaping the fund allocation at a global scale, and West Africa is expected to see a similar pattern of funding availability. When it was compared to an earlier chart on major funding sources (Figure 51: Private Investments in Renewable Energy by source40,Figure 53: Global Trends in Renewable Energy Investments by Investor Type) it shows that private project developers would be the target segment to attract more funding into West Africa and the projects they might be interested in will be utility-scale followed by small-distributed capacity (based on solar and wind technologies).

[53] World Energy Council (2016) 'World Energy Resources 2016', *World Energy Resources 2016*, pp. 1–33. doi: http://www.worldenergy.org/wp-content/uploads/2013/09/Complete_WER_2013_Survey.pdf.



Source Frankfurt School-UNEP Centre/BNEF. 2017.Global Trends in Renewable Energy Investment 2017, http://www.fs-unep-centre.org.
Note: Asset finance volume adjusts for re-invested equity. Total values include estimates for undisclosed deals.

Key Highlights The biggest slice of total investment was, as before, asset finance of utility-scale projects such as wind farms and solar parks, at $187.1 billion. Small distributed capacity (rooftop and other small solar projects of less than 1MW) contributed $39.8 billion. The asset finance figure is adjusted by $2.9 billion for reinvested equity (money that was raised in other categories that then ended up going into asset finance or small projects). Equity raising by specialist renewable energy companies on the public markets fell 53% to $6.3 billion in 2016. Venture capital and private equity funds into specialist renewable energy firms was $3.3 billion in 2016, down 4%. Corporate research and development was down 40% on the previous year at $2.5 billion and government research and development spending was up 25% at $5.5 billion.

Figure 53: Global Trends in Renewable Energy Investments by Investor Type

The lowest amount of financing came from venture capital and private equity funds. Significant entrepreneurial activity is now happening across the region with a maximum number of businesses formed in Nigeria followed by Ghana, but the deal sizes for most of these entrepreneurial projects are quite low (Figure 115: Entrepreneurial Ecosystem for innovative technologies in West Africa103).

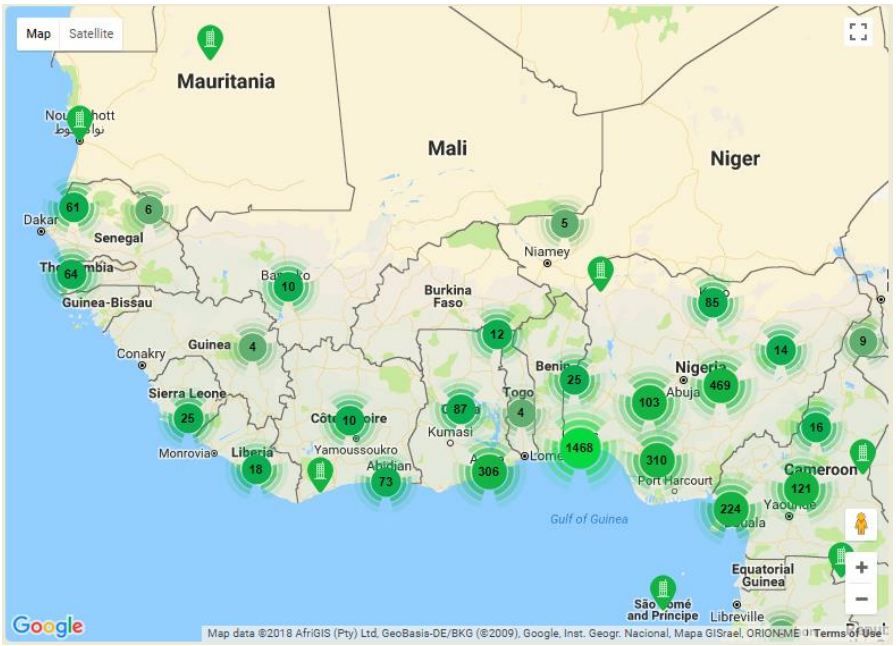


Figure 54: Start-Up Entrepreneurs across West Africa (as listed on vc4a.com)[54]

[54] https://vc4a.com/ventures/

The reason for these small deal sizes is low VC/PE appetite in renewable energy space as shown by Figure-50 and Figure-49, both pointing to a lower investment contributions investments from the VC/PE community. After interviewing women entrepreneurs, it was found that most women entrepreneurs have not received any equity investments from VC/PE while some others tried but were not successful. Based on this it can be concluded that access to funding from VC/PE for projects is a difficult barrier to cross. The possibility to get VC/PE involved can be through a joint program with private project developers, DFI or government funds – where VC/PE jointly invests with these parties in either debt or equity-based transactions.

4.1.5. Accelerating urbanization

"By 2050, the urban population will increase by at least 2.5 billion, reaching two-thirds of the global population. Fast urban expansion presents a major challenge and an opportunity for power utility companies. The speed of urban growth puts a big strain on infrastructure development. In Africa, already large cities such as Lagos, Kinshasa, and Cairo are going to become megacities, with more than 15 million people. Power companies can play a pivotal role in ensuring future cities become 'urban smart' rather than 'urban sprawl'. They have the potential to be lead players at the heart of future city infrastructure, but it will require a new mindset and the development of new partnerships."[55]

As seen in the data on urbanization (Figure 55: Urban Population (%) and Rate **of Urbanization**) of the 4 selected countries Senegal has the lowest urban population (against the global average of 54% of the total global population, sub-Saharan average of 38% of the total sub-Saharan population[56] and the average of the 4 selected countries is 51% of the total 4 selected countries population). The average urbanization rates in the 4 selected countries are around 3.5% while Nigeria has the highest urbanization rate with 4.3%. The rate at which the population growth and urbanization are happening, electricity distribution and waste accumulation will be some of the biggest challenges in urban planning for cities of the future, and this will open opportunities for technologies that can convert waste to electricity. During the interviews it was found that some women entrepreneurs share their interest in waste-to- energy technologies, but all of these were start-up ideas.

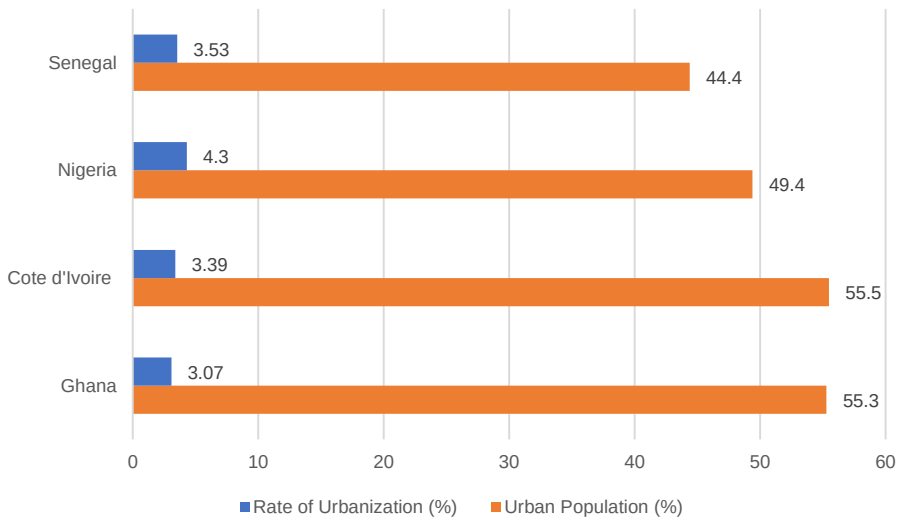


Figure 55: Urban Population (%) and Rate of Urbanization (%)

Source: CIA Database 2017

[55] PricewaterhouseCoopers (2014) 'The road ahead - Gaining momentum from energy transformation', *Pwc*, pp. 1–32. Available at: http://www.pwc.com/en_GX/gx/utilities/publications/assets/pwc-the-road-ahead.pdf

[56] https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?name_desc=true

4.2. Disruption Factors

"Disruption is defined as the radical change in an industry, business strategy, etc., especially involving the introduction of a new product or service that creates a new market." The factors that facilitate disruption are referred to as disruption factors. "The disruption taking hold of the power sector is just the beginning of an energy transformation. It is not a question of whether the business models pursued in the sector will change but rather what new forms they will take and how rapidly companies will have to alter course. Companies need to be sure they have fully factored into their strategic planning the megatrends and changes"[57]. The disruption factors that are covered here include – *customer behavior, competition, production service* models*, distribution channels and government and* regulations. These disruption factors are considered as external forces that are impacting women entrepreneurs forcing them to transform their business models and their products and services.

The pace of this change is different across the 4 selected countries and across the West African region but it seems that the direction of change is the same. The fundamental disruption factors, as mentioned above, remain the same for all the countries including the selected four countries. These changes are real; they are fast and are already forcing entrepreneurs to provide better energy products and services to their customers at competitive prices. To understand the disruption factors it was necessary to use the secondary as well as the primary data collected through interviews with women entrepreneurs and other stakeholders in the energy value chain.

4.2.1. Customer behavior

"Consumer behavior is the study of individuals, groups, or organizations and all the activities associated with the purchase, use, and disposal of goods and services, including the consumer's emotional, mental and behavioral responses that precede or follow these activities." This analysis considered consumer behavior and not customer behavior[58] since it is the consumer that drives the demand while customers just channel that demand and act as a supplier of products or services. The changing energy value chain is resulting in new products and services being provided to both current and new customers that are coming on-board the energy value chain due to increases in access to electricity. The availability of new mini-grids and off-grid electricity is resulting in the introduction of new solar or energy-efficient products. These changes have resulted in further diversification of mature businesses and the establishment of innovative technology-driven enterprises that not only sell these products and services but also install, maintain, and finance them.

[57] PricewaterhouseCoopers (2014) 'The road ahead - Gaining momentum from energy transformation', *Pwc*, pp. 1–32. Available at: http://www.pwc.com/en_GX/gx/utilities/publications/assets/pwc-the-road-ahead.pdf

[58] The terms "consumer" and "customer" are often used interchangeably, but a consumer and customer are not always the same entity. In essence, consumers use products while customers buy them. A consumer may also be a customer and a customer can also be a consumer, but there are situations where this is not the case (http://smallbusiness.chron.com/customer-consumer-definitions-5048.html)

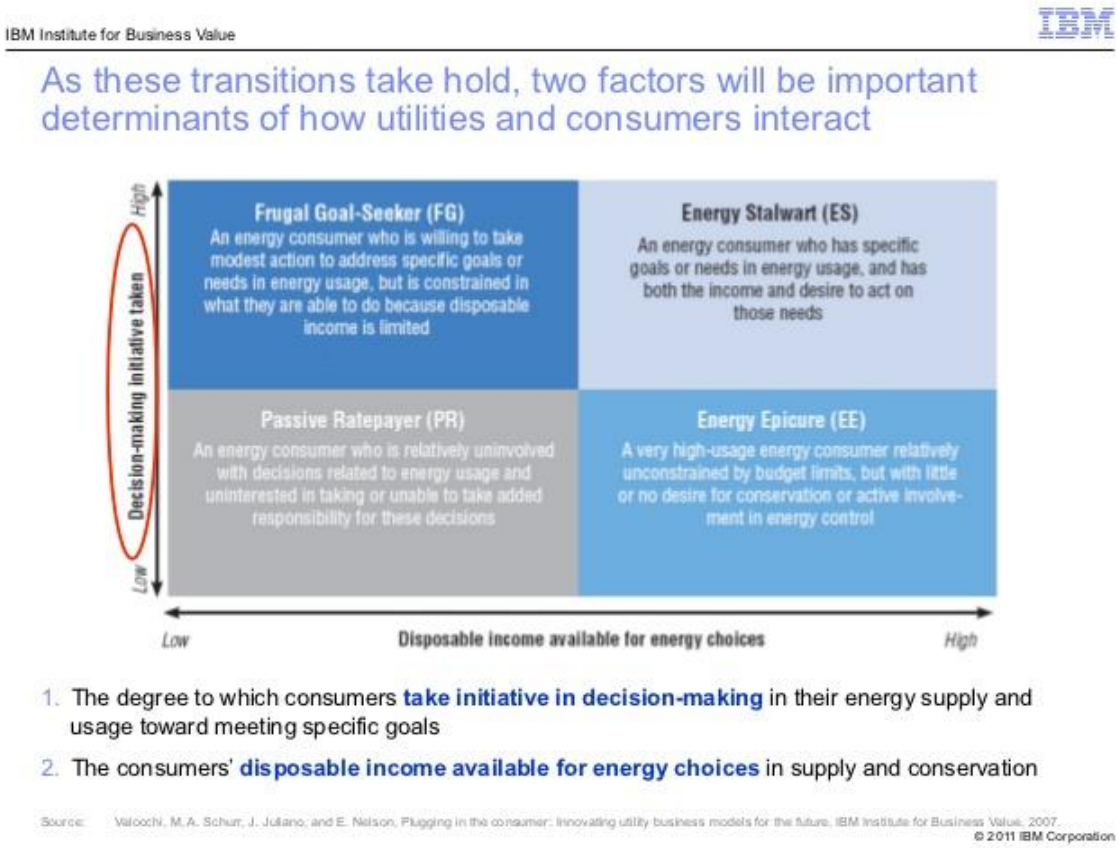


Figure 56: Consumer Types and their interaction with Utility Providers[59]

We have evaluated the customer or consumer behavior with the futuristic matrix developed by IBM that classes the consumers based on their disposable income and the decision-making initiative that they can undertake in energy supply and usage. The classification applies differently to residential or industrial electricity users. Applying this to individual consumers in selected four countries we see them moving from passive ratepayer (the basic level at which most consumers get the first electricity connection) to frugal goal seeker, where the energy consumer is willing to take modest action but what they do is constrained by their income. While for the industrial consumers we see them in the energy epicure segment which has consumers with high-usage of energy but not the desire or active involvement in energy control.

We can infer based on the discussions with different stakeholders that as service technologies are diffusing into the selected four countries, consumers are becoming rational and would like to control their usage patterns. With high connectivity (mobile and internet) it is becoming increasingly possible for consumers to get real-time information on their usage pattern and accordingly apply smart applications for controlling energy consumptions products. We have seen that digitalization has played a crucial role in facilitating controlling both energy demand and supply. Furthermore, Nigeria looks to be the most promising from this perspective, where the customer and utility companies are moving towards greater control, closely followed by Senegal and Ghana (Figure 21: Digitalization Infrastructure-1 (out of 100))

[59] IBM (2010) 'Switching perspectives', *Business*, pp. 1–20. doi: 10.1007/978-1-4471-6281-0_9.

4.2.2. Competition

"Energy transformation is shifting the opportunity for good margins into new parts of the value chain. However, lower barriers to entry in these areas of the value chain and the need for new capabilities mean there is the prospect of existing companies being outflanked and outpaced as more nimble and able competitors seize key revenue segments. New roles for companies come into view. In a distributed energy community with its own micro-grid, players other than power utilities can play an energy management role. This could be for local systems such as transport networks, residential communities, or industrial communities. For example, distributed energy is a key focus both for incumbent power utility companies and for new entrants. It is a big market space, worth tens of billions. It covers a wide spectrum of opportunities, from energy controls and demand management activities that save energy, to local generation, both small-scale and larger-scale, embedded in own use or local networks, through to distributed storage that can shift loads or, ultimately, end grid dependency."[60]. Competition in the energy value chain in the 4 selected countries was determined by incorporating elements of Porters' Five Forces Model which is an established model to evaluate the competitive profile of any industry. The factors that this model considers are:

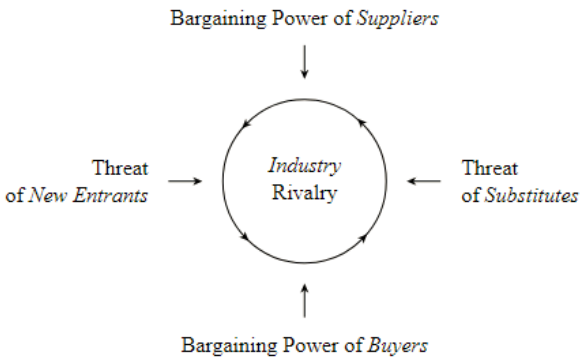


Figure 57: Porter's Five Forces Model[61]

Competition varies according to the product or service type and country under consideration. The interplays between the players in the industry as shown in Porters' Five Forces Model have an effect the profitability and sustainability of businesses. When looking at various products and services, it shows that products that are commoditized have a lower profit margin, larger scale and emulate consumer durables supply chains. These include solar lighting products (e.g., pico products, lanterns, chargers, etc.), storage batteries and solar SHS generators. These high-scalability products are products that face high competition (high threat of substitutes, new entrants, less bargaining power of suppliers and buyers and high industry rivalries). While products that belong to other non-conventional energy sources like wind and hydro face less competition because they have high entry barriers due to technical, regulatory and financial complexities (low threat of substitutes, new entrants, more bargaining power of suppliers and less industry rivalries).

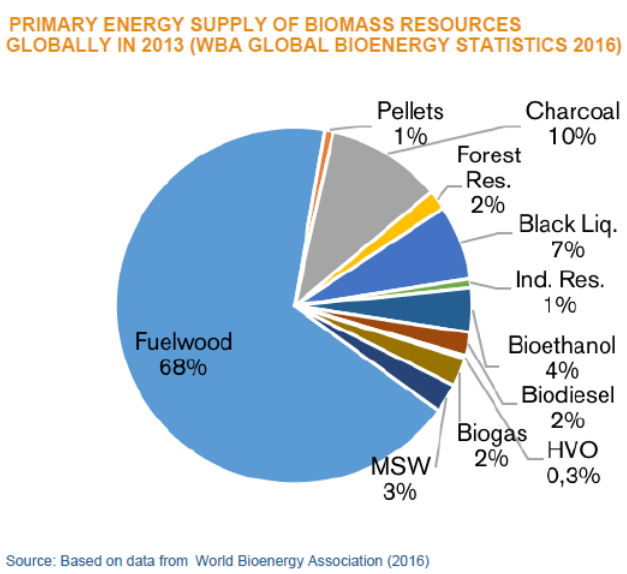
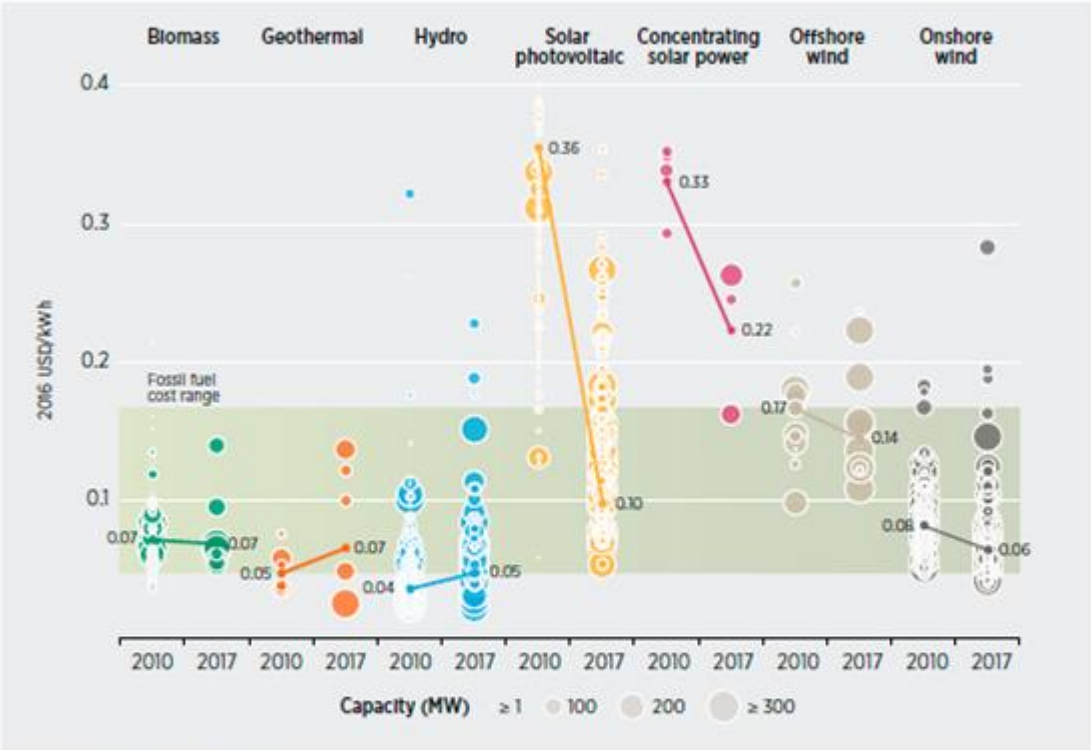


Figure 58: Global Primary Energy Supply (Biomass)

[60] Ibid
[61] Porter, M.E. (January 2008) The Five Competitive Forces That Shape Strategy, Harvard Business Review

Biomass is another source of energy where the competition is high at feedstock level (which is an agricultural raw material and commoditized). Due to the proximity of several agricultural suppliers competition is high and margins low but as we move to biogas or waste-to-energy plants. competition is lower and margins increase. Entrepreneurs in biomass-based energy generation face competition on either side of the energy value chain – on one side, raw material origination is competition from suppliers which can affect procurement costs and, on the other side, is selling the value-added energy generation products like briquettes which face stiff competition from conventional coal.

Another example is the level of competition that exists for a wind turbine based mini-grid operator is much less than that of a trader that buys and sells solar lighting or solar generation units to households. Value addition is the only way to increase margins and get a competitive or comparative advantage concerning other entrepreneurs in the same ecosystem. Furthermore, as the LCOE for new renewable technologies keeps on going down and is reaching grid parity, the level of competition is intensifying and resulting in several entrepreneurs and established companies to diversify into the energy sector.



Source: IRENA Renewable Cost Database.

Note: The diameter of the circle represents the size of the project, with its centre the value for the cost of each project on the Y axis. The thick lines are the global weighted average LCOE value for plants commissioned in each year. Real weighted average cost of capital is 7.5% for OECD countries and China and 10% for the rest of the world. The band represents the fossil fuel-fired power generation cost range.

Figure 58: Evolution of LCOE over time

The areas that are experiencing significant expansion across the 4 selected countries are micro-grids and mini-grids, these are undergoing a stage of increasing competition as more players are entering these new areas of private electricity generation and distribution. Mini-grids are presently in form of grid-tied and off-grid systems and both forms of grids are attracting interest from local and international entrepreneurs and investors.

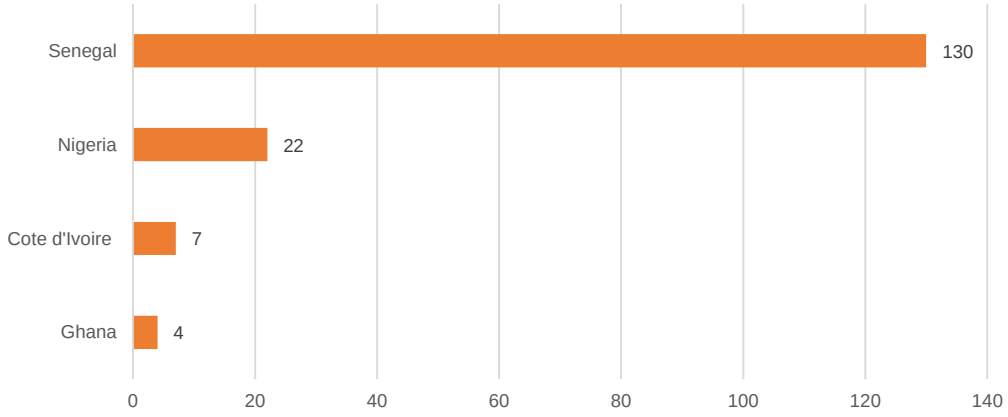


Figure 59: Number of Mini-Grids

Source: ECOWREX, 2017

	Minigrids served only by Renewable Energy (MW)			Mini-Grids RE and hybrid (MW)			Rural PV and Pico-Hydro systems (MW)		
	Current	2020	2030	Current	2020	2030	Current	2020	2030
Benin	0.0	4.5	9.5	0.0	0.0	0.0	0.0	2.0	4.0
Burkina	0.1	1.8	5.0	0.0	0.0	0.0	0.3	1.8	5.0
Cabo Verde	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Côte d'Ivoire	n.a.	n.a.	n.a.	n.a.	5,4	0,0	n.a.	n.a.	n.a.
Gambia	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Ghana	n.a.	n.a.	n.a.	40	50	60	1,100	1,200	1,300
Guinea	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Guinea-Bissau	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Liberia	4.6	4.6	4.6	n.a.	n.a.	n.a.	n.a.	26.4	52.8
Mali	0.6	118.3	355	2.9	8.1	8.1	12.9	47.2	106.6
Niger	n.a.	n.a.	n.a.	0.0	15	40.0	4.0	19.0	60.0
Nigeria	0.0	11	673	0.0	4.0	171	0.3	3.5	60.0
Senegal	0.6	7.6	10.1	0.0	0.0	0.0	1,4	2,9	3,9
Sierra Leone	n.a.	n.a.	n.a.	0.3	70.0	134.0	0.0	16.0	44.0
Togo	n.a.	n.a.	n.a.	0.0	1.5	4.0	0.0	1.5	4.0
	5.8	**147.8**	**1,057**	**43.2**	**154**	**417**	**1,119**	**1,320**	**1,640**

Figure 60: Off-grid Renewable Energy based capacities through pure RE Mini-grids, Hybrid Mini-grids and Rural PV or Pico-Hydro Systems[62]

It can be clearly seen that the electricity generation capacities through pure renewable energy-based min-grids will be led by Nigeria and Mali (and Senegal), in hybrid mini-grids again its Nigeria followed by Sierra Leone and in rural PV and pico-hydro systems Ghana (leads now) will lead the way followed by Mali and Nigeria. In terms of largest growth, it will be pure renewable energy based mini-grids but in terms of highest capacities it will be rural PV and pico-hydro systems.

[62] Energy, R., Plans, A. and E.f-, N. E. (no date) 'From Vision to Coordinated Action'.ECREEE

Finally, it can be concluded that the level of competition varies by products and countries and each country out of the 4 selected countries offers different competitive profiles for women entrepreneurs to consider and transform accordingly to gain an advantage over their competitors.

4.2.3. Production Service Model

Electricity systems are radically changing, thanks to the new emerging technologies from the production sector through consumption. The cost reduction of solar and wind power facilities is shifting the course towards a more evenly distributed energy generation. As pointed out by IBM in their energy transformation report there is convergence that is happening between information technology and operations technology. Nigeria has taken the lead among the 4 selected countries by being able to generate and provide information related to consumer off-take and usage. Many additional data driven technology companies in the energy value chain are getting access to real-time information in their consumer usage patterns and based on these, supply adjustments can be made within a matter of minutes.

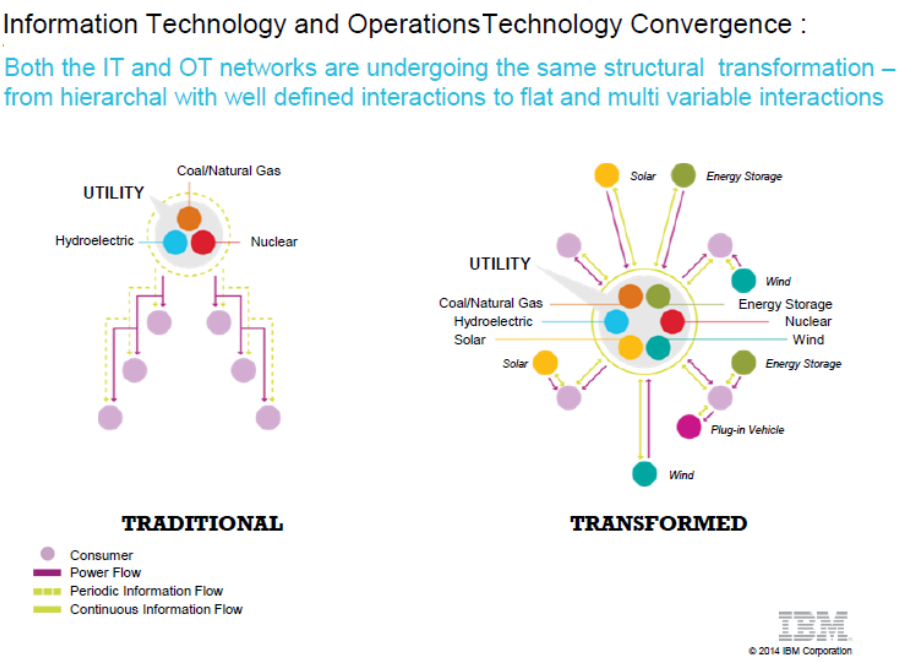


Figure 61: Convergence of IT and OT in Future Energy Markets

"According to the EC proposals, the future energy markets should reward flexible generation, demand, and storage at the equal footprint. Additionally, market rules must be adapted to make renewable producers participate both in the energy and services markets (procured from primary, secondary, tertiary, and balancing reserve). This will facilitate innovation and digitalization and will make European businesses responsible for providing greater energy efficiency and low-emission technologies. The increasing complexity of networks implies a higher need for coordination among different grid users to better identify threats to secure system operations and to adjust measures to mitigate these risks. The European Commission is supporting initiatives organized by transmission system operators at the regional level, with the scope of strengthening their cooperation in assisting their task of maintaining the operational security of the electricity system. The areas of collaboration cover several initiatives: sharing existing tools, methods, and procedures, operating services alternately or cooperatively and jointly optimizing services and tools for TSOs as well as developing new ones." "A strong coordination between TSO[63] and DSO[64] is necessary, concerning the planning of grid development, to face local congestion on the medium and low voltage grids, as well as to

[63] Transmission system operator
[64] Distribution system operator

face the need for voltage control. Thus, they should contribute to the formation of an integrated European energy market. They enable the energy transition and empower prosumers' contribution by ensuring transparency, confidentiality, and neutrality in data management, no matter which data governance is established. TSOs and DSOs should contribute to social welfare maximization with fair costs and benefit allocations". [65]

The pace of technological diffusion and its penetration will result in grid edge technologies reaching maximum penetration by 2040, which will result in dramatic shifts to the way the TSO and DSOs operate. The DSO will need to become more dynamic and analytical integrating operational capacities with demand movements, thereby reducing electric outages. Familiarity with consumers and fast and intelligent data exchange system (based on mobile and internet) will provide both the consumer and the utility company control over the generation, transmission, and distribution of assets.

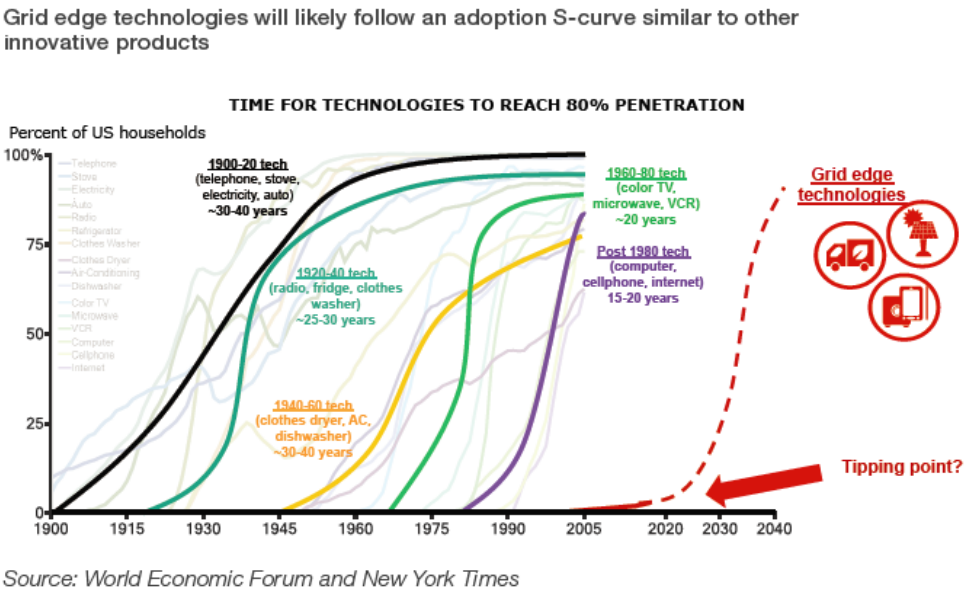


Figure 62: Grid Edge Technologies Adoption Curve compared with other Technologies

By applying the matrix developed by IBM for Utility Industry Models it was noted that the 4 selected countries are moving from the traditional passive persistence to operations transformation. Operations transformation is a combination of grid and network technology, which enables shared responsibilities and is a departure from centralized one-way network to a more distributed and dynamic network. There is also some degree of movement regarding consumer control, but it is still in the beginning stages of development in the 4 selected countries – for example - Supervisory Control and Data Acquisition Systems (SCADA) that has been introduced in the Nigeria Power System by PHCN for data collection and monitoring of the generating station[66]. Also, worth mentioning – "Huawei, the global tech giant, was brought in to reduce power waste and increase power using the Internet of Things technology. After collaborating with Huawei in 2015, Ikeja Electric has introduced a new system using such IoT technology as smart meters, as well as an electricity operation and management system"[67] in Nigeria.

[65] Role of regional interconnection in fostering RE Integration in Eastern Africa Power Pool - Bruno Cova, CESI – Paolo Pacciarini, Pöyry – Michael Pascucci, Pöyry – Andrea Renzulli, Pöyry – Riccardo Siliprandi, Pöyry - Modesto Gabrieli Francescato, Terna – Fabio Genoese, Terna

[66] Patrick, O., Tolulolope, O. and Sunny, O. (2013) 'Smart Grid Technology and Its Possible Applications to the Nigeria 330 kV Power System', *Smart Grid and Renewable Energy*, 2013(August), pp. 391–397. doi: 10.4236/sgre.2013.45045.

[67] http://uk.businessinsider.com/sc/these-smart-meters-are-revolutionising-nigeria-power-supply-2016-9

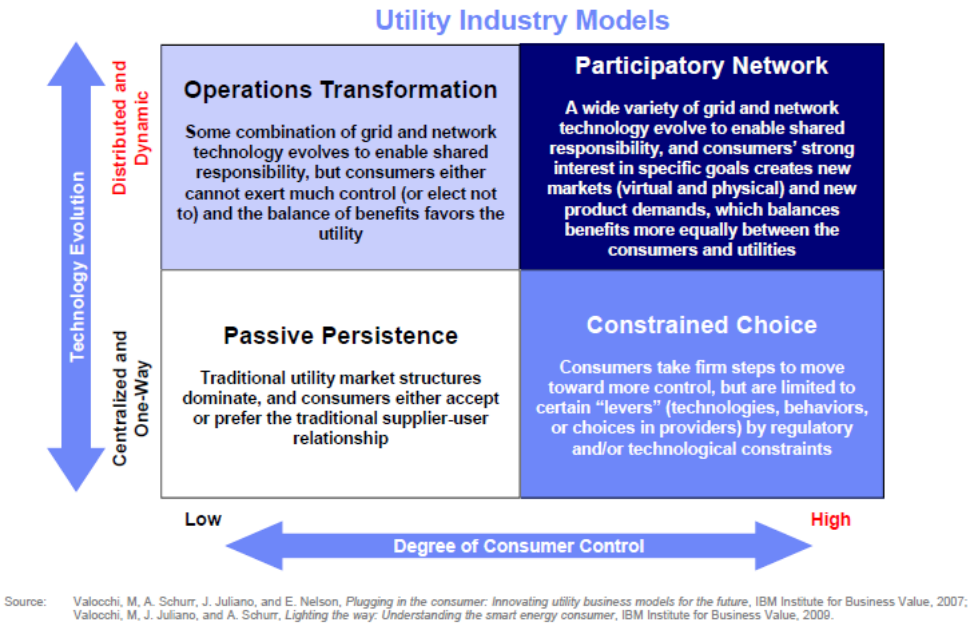


Figure 63: Future Utility Industry Models[68]

Côte d'Ivoire is aggressively looking at developing mobile-based app technologies for electricity demand management – "M2M and IoT –The government of Côte d'Ivoire and the Compagnie Ivoirienne d'Electricité (CIE), the national utility company, have developed a strategy to leverage smart meters to improve the country's electricity management. Orange has developed an M2M platform connecting smart electricity meters. This service aims to help customers monitor their electricity bills on a more regular basis while helping utility companies reduce the cost of reading meters and the risk of fraud or billing errors"[69].

4.2.4. Distribution channels

"Smart grids, micro-grids, local generation and local storage all create opportunities to engage customers in new ways. Increasingly, we are seeing interest in the power sector from companies in the online, digital and data management world who are looking at media and entertainment, home automation, energy saving and data aggregation opportunities. In a grid-connected but distributed power system, there are roles for intermediaries who can match supply and demand rather than meet demand itself."[70]

Figure 64: Evolving electricity value chain[71]

The electricity value chain is evolving and now it has two parts - product value chain and service value chain. Electricity products are electric devices and appliances (equipment, machinery, and instruments) that are used for energy generation, transmission, storage, distribution, and consumption. These products flow through the conventional physical supply chain. The service part of the supply chain includes the application of technologies for procurement, logistics, finance, distribution, and sales.

[68] Schurr, A. and Energy, V. P. (2011) 'Emerging Technology Transforming the Energy Value Chain and Customer Engagement'.
[69] 'Country overview: Côte d'Ivoire Driving mobile-enabled digital transformation' (2017), GSM Association
[70] PricewaterhouseCoopers (2014) 'The road ahead - Gaining momentum from energy transformation', *Pwc*, pp. 1–32. Available at: http://www.pwc.com/en_GX/gx/utilities/publications/assets/pwc-the-road-ahead.pdf
[71] Ibm (2010) 'Switching perspectives', *Business*, pp. 1–20. doi: 10.1007/978-1-4471-6281-0_9.

Distribution channels are evolving from physical to digital, but there are still conventional distribution channels where a physical product or equipment passes through transportation and logistics before finally being sold to the consumer. The front-end demand management model is becoming more virtual, and the smart services are being developed to bridge the gap between energy generation and energy consumption.

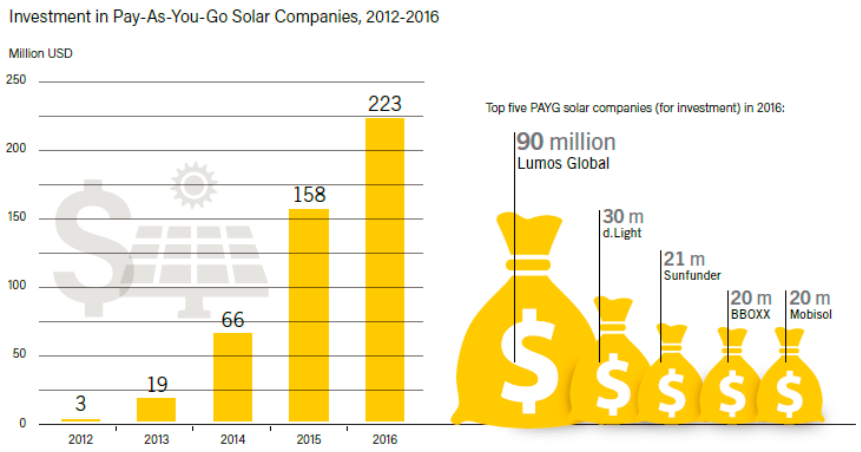


Figure 65: Investments in of Pay-As-You-Go Payment cum Distribution Model[72]

All the 4 selected countries have entrepreneurs and companies that have implemented and used technologies for all functions in the supply chain. Especially distribution related technological innovations in payment collection that has had remarkable application in Nigeria, Ghana, and Senegal and to some extent in Côte d'Ivoire.

4.2.5. Government & regulation

"Government policies and new business models are having a profound impact in the way investments in electricity are funded. In 2016, 94% of the global power generation investment was made by companies operating under fully regulated revenues or regulatory mechanisms to manage the revenue risks associated with variable wholesale market pricing. However, significant changes are occurring in some sectors and markets. Over 35% of utility-scale renewable investments took place in markets where prices for power purchase were set by auctions, contracts with corporate buyers and other competitive mechanisms, up from 28% in 2011. In wholesale markets, funding new thermal generation increasingly depends on capacity payments or other revenues beyond wholesale markets. While virtually all network investments have a regulated business model, unbundled grid companies accounted for only 40% of grid investments, with the large majority of this funding based on regulated network tariffs, compared with 50% in 2011. Policies that help to reduce the cost of capital and improve the cost-reflectiveness of electricity pricing are especially important in countries such as India and Indonesia where electricity demand is growing rapidly and where utilities face financing constraints."[73]

This is one area which can support or restrict the growth of businesses and fortunately for the West African region there has been a focus to streamline and align regulatory processes and arrive at a consensus to facilitate private sector participation in the energy value chain in all aspects. "Innovative, sustainable decentralized energy solutions represent the most efficient instrument to promote access to electricity in areas of low load density or very far from existing national grid.

[72] REN21 (2017) *Renewables 2017: global status report*, *Renewable and Sustainable Energy Reviews*. doi: 10.1016/j.rser.2016.09.082.
[73] International Energy Agency (2016) 'World Energy Investment 2016', *International Energy Agency*.

Fostering productive uses of energy is essential to ignite a virtuous cycle of demand growth built on an inclusive business model. However, the cycle jump-start requires many different inputs. Having a holistic point of view and strong partnerships will be important to activate all the inputs simultaneously to achieve the most efficient and sustainable business model, which will be beneficial both for local communities and investors. Systematic knowledge dissemination, a consistent regulatory framework for decentralized energy systems, and an open mind towards entrepreneurship in the energy sector are fundamental elements of an effective energy policy for emerging economies."[74]

Government involvement in facilitating investments from international stakeholders will play a key role in attracting investments. Green bonds being launched in Nigeria with $60 Million backing is very good initiative but it also required sovereign backed programs to attract FDI in this sector. A good example of private sector and government institutions coming together and creating a funding model that attracts foreign funding for renewable projects can be found in Senegal – "Santhiou Mékhé—The Santhiou Mékhé project was originally developed by the Senegalese-born American Sam Wébé whose company Senergy SUARL entered into a partnership with Senegal's Fonds Souverain d'Investissement Strategique (FONSIS) and the private investment company Meridiam in February 2015. FONSIS was created in 2012 by current President Macky Sall to promote the role of the State as an investor. As a result, this project can also be referred to as a PPP. In total at least 32% of the funds came from Senegal."[75]

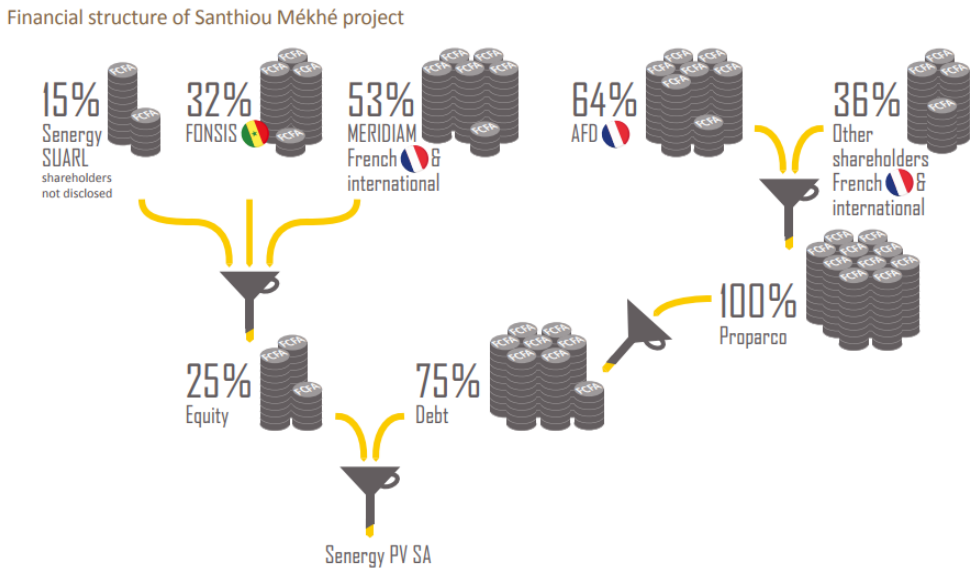


Figure 66: Financial Structuring of Santhiou Mekhe Project in Senegal[61]

The auction and carbon bond programs (second most issued by supranational and sovereign agencies after private corporations) are areas of development in the renewable energy sector and have gained traction across the US and European markets. Globally, SSA (supranational, sovereign and agency) and corporate play key roles in the green bond issuance and this can be achieved in the 4 selected countries through government support. The program should also consider smaller deal sizes for women projects under a special green bond category dedicated to women entrepreneur driven projects in renewable energy and energy efficiency.

[74] Decentralized renewable energy solutions to foster economic development - Giuseppe Artizzu, EPS - Ilaria Rosso, EPS - Anna Paola Minervini, EGP - Edoardo Patriarca, EGP – Emi Bertoli, EGP - Antonio Bonanni, Enertronica - Giovanni Pediconi, Enertronica - Tunde Morakinyo, ERM - Rachel Cochran, ERM - Alberto Berizzi, Politecnico di Milano

[75] Facts, K. E. Y. (2017) 're Flagship Projects in the ECOWAS Region Background Case Study FIRST THREE SOLAR PV INDEPENDENT POWER PRODUCERS IN SENEGAL'.

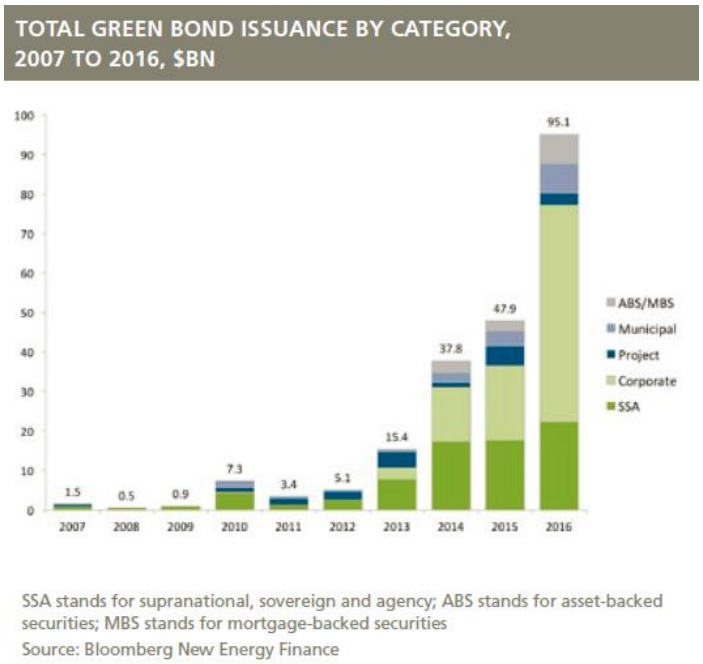


Figure 67: Global Green Bond Issuance over time

There are several tools by which governments can cooperate with financial institutions to facilitate financing of renewable energy projects, some of which are now being used in all 4 selected countries. IRENA came up with a list of measures that can be undertaken at a policy development and financial institution levels to help mitigate the existing risks for renewable energy projects. If these risks can be reduced it can open up the complete value chain for funding and thereby attract more women entrepreneurs and facilitate diffusion and penetration of new, more efficient renewable and efficient energy technologies across West Africa. Multi-lateral banks and

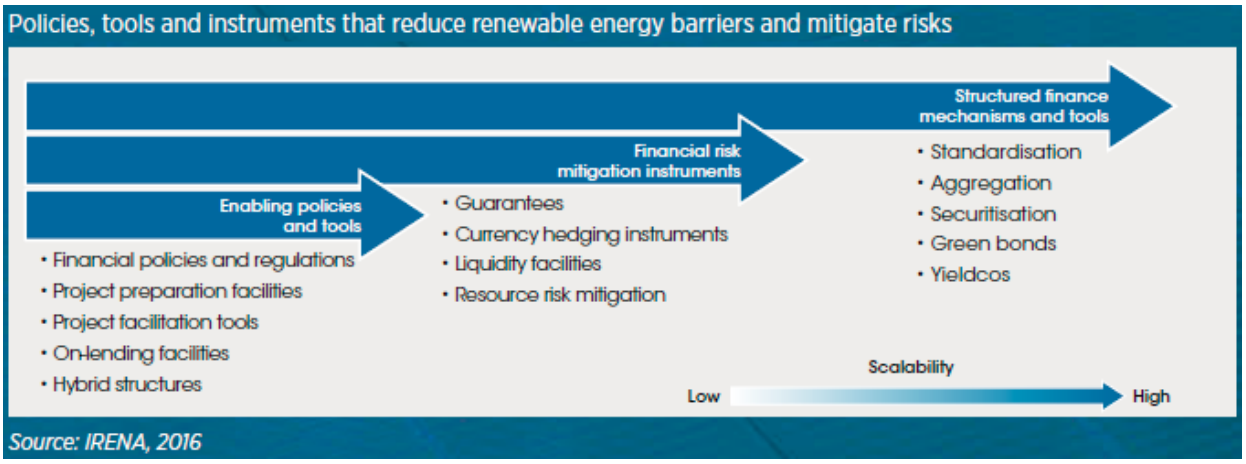


Figure 68: Policies, Tools, and Instruments to mitigate Renewable Energy Project Risks

donor organizations can also play a critical role here when it comes to providing the government institutions with technical expertise for structuring these products and financial institutions can help by attracting commercial financial institutions to participate under risk-sharing structures.

4.3. Future market models

The future market models refer to the new models that will evolve which will define the interplay between the participants that constitute the market such as: utilities, private power producers, government institutions, consumers, and other stakeholders.

4.3.1. Green command and control

"The Green Command and Control market scenario represents a market in which government owns and operates the energy sector and mandates the adoption of renewable generation and digital technology. In this scenario, we see vertical integration as the norm (particularly between generation and retail), and investment decisions made as a response to regulatory direction. It is a market in which renewables may be cost-competitive or supported under renewable policy initiatives, while stranded thermal assets may remain operational even when private sector owners would have taken closure decisions. The ongoing capital investment would be subject to policy approval and would feed into regulated tariffs."[76] The green command and control scenario includes aspects like rural electrification initiatives and development of off-grid electricity generation and distribution, this allows small local entrepreneurs to participate in domestic energy market.

This scenario already exists in the 4 selected countries, primarily in Nigeria and Ghana where demand-side management technologies and mini-grids have entered the market. Similarly, in Senegal and Côte d'Ivoire mini-grids are being installed, which has resulted in the development of a private-sector driven electricity generation and distribution market. The primary indicator of whether the green command and control market model is in existence is if renewable energy and energy efficiency enabling policies and regulations are in place or not.

The Nigerian Electricity Regulatory Commission (NERC) has committed to stimulating investment in renewable energy generation in Nigeria. With Nigeria's vast and mostly untapped potential in renewable energy resources, the Commission has set a target of generating a minimum of 2,000MW of electricity from renewables by the year 2020. The main features of this policy are:

- Guaranteed price & access to grid
- Feed-In – Tariff for Solar, Wind, Biomass & Small Hydro
- Power Purchase Agreement (PPA) based on plant life cycle of 20 years
- Electricity distribution companies (DisCos) to procure minimum of 1000MW (50 per cent of the total projected renewable sourced electricity)
- Nigerian Bulk Electricity Trading Company (NBET) to procure minimum of 1000MW (50 per cent of the total projected renewable sourced electricity)

In line with the National Policy on Renewable Energy and Energy Efficiency, the Commission has approved three windows for grid connected renewable energy projects.

1. Net-metering for very small capacities (typically below 1MW)
2. Feed-in tariff for capacities up to

    - 5 MW of solar,
    - 10 MW of wind,
    - 10 MW of Biomass and
    - 30MW of small hydro

3. Competitive tender for capacities above these thresholds to be procured through NBET.

Pursuant to its regulatory mandates, NERC established in 2015, a feed-in tariff for renewable energy-based power generation in Nigeria.[77]

An assessment of the renewable energy related policies that are currently in places in the 4 selected countries reveal that all the 4 countries have taken steps in this direction, and deserving special recognition are Ghana and Nigeria, which have both taken strides to develop policy framework that

[76] PricewaterhouseCoopers (2014) 'The road ahead - Gaining momentum from energy transformation', *Pwc*, pp. 1–32. Available at: http://www.pwc.com/en_GX/gx/utilities/publications/assets/pwc-the-road-ahead.pdf

[77] http://www.nercng.org/index.php/home/operators/renewable-energy

facilitates private sector participation. Cote d'Ivoire has taken some steps but does lag behind the other countries.

These policies are presented below:

Title	Year	Policy Status	Policy Type	Policy Target
Rural Electrification Strategy and Implementation Plan of Nigeria	2006	In Force	Policy Support>Strategic planning	Multiple RE Sources>Power
Nigerian Electricity Regulatory Commission Mini-Grid Regulation 2016	2016	In Force	Regulatory Instruments	Multiple RE Sources>Power
Nigeria Renewable Energy Master Plan	2011	In Force	Economic Instruments>Direct investment>Infrastructure investments, Economic Instruments>Fiscal/financial incentives>Tax relief, Policy Support>Strategic planning	Wind, Bioenergy>Biomass for power, Solar>Solar photovoltaic, Hydropower, Multiple RE Sources
Nigeria Feed-in Tariff for Renewable Energy Sourced Electricity	2016 (Feb)	In Force	Economic Instruments>Fiscal/financial incentives>Feed-in tariffs/premiums	Bioenergy, Solar, Wind
National Renewable Energy and Energy Efficiency Policy for Nigeria	2015	Planned	Policy Support>Strategic planning	Multiple RE Sources>All
Multi-Year Tariff Order (MYTO) II (2012-2017)	2012 (June 1st)	Superseded	Economic Instruments>Fiscal/financial incentives>Feed-in tariffs/premiums	Multiple RE Sources>Power, Multiple RE Sources, Wind>Onshore, Solar>Solar photovoltaic, Hydropower, Bioenergy>Biomass for power

Multi-Year Tariff Order (MYTO) I (2008-2013)	2008	Superseded	Economic Instruments>Fiscal/financial incentives>Feed-in tariffs/premiums	Multiple RE Sources, Multiple RE Sources>Power
Biofuels blending mandate	2013 (Dec 31st)	In Force	Regulatory Instruments>Codes and standards>Product standards, Regulatory Instruments>Codes and standards>Vehicle fuel-economy and emissions standards	Bioenergy>Biofuels for transport, Bioenergy>Biofuels for transport>Biodiesel, Bioenergy>Biofuels for transport>Bioethanol

Figure 69: Nigeria renewable energy policies[78]

Ghana has shown progress in the area of developing a green command and control market, as can be seen from the table data below. So far, enabling environment policies have been enforced while others are being developed:

Title	Year	Policy Status	Policy Type	Policy Target
Net Metering Code	2015	Planned	Regulatory Instruments>Codes and standards, Economic Instruments>Fiscal/financial incentives>User charges	Multiple RE Sources>Power, Multiple RE Sources
Feed-in tariff for electricity generated from renewable energy sources	2013 (last amended 2014)	In Force	Economic Instruments>Fiscal/financial incentives>Feed-in tariffs/premiums	Multiple RE Sources, Multiple RE Sources>Power, Wind, Solar, Hydropower, Bioenergy
Renewable Energy Act 2011	2011	In Force	Policy Support>Strategic planning, Policy Support	Multiple RE Sources
Ghana National Energy Policy	2010	In Force	Policy Support>Strategic planning, Policy Support	Solar, Hydropower, Geothermal, Multiple RE Sources>Power, Bioenergy>Biofuels for transport
National Electrification Scheme	2007-2020	In Force	Research, Development and Deployment (RD&D)>Research programme >Technology deployment and diffusion, Economic Instruments>Fiscal/financial incentives>Grants and subsidies,	Wind>Onshore, Bioenergy>Biomass for power, Multiple RE Sources>Power, Solar, Wind

[78] Organization for Economic Co-operation and Development/International Energy Agency (www.iea.org) , 31-35 rue de la Fédération, 75739 Paris Cedex 15, France and International Renewable Energy Agency (www.irena.org), IRENA Headquarters, Masdar City, PO Box 236, Abu Dhabi, United Arab Emirates

			Research, Development and Deployment (RD&D)>Research programme	
Ghana Energy Development and Access Project (GEDAP)	2007	In Force	Economic Instruments>Fiscal/financial incentives>Loans, Economic Instruments>Fiscal/financial incentives>Grants and subsidies, Economic Instruments>Fiscal/financial incentives>Tax relief	Wind, Solar>Solar photovoltaic
Strategic National Energy Plan (SNEP) 2006-2020	2006	In Force	Policy Support>Strategic planning	Multiple RE Sources>Power, Multiple RE Sources>Heating
Renewable Energy Services Programme (RESPRO)	1999	In Force	Economic Instruments>Direct investment>Infrastructure investments	Solar>Solar photovoltaic
Tax and duty exemptions	1998	In Force	Economic Instruments>Fiscal/financial incentives>Tax relief, Economic Instruments>Fiscal/financial incentives>Taxes	Wind

Figure 70: Ghana renewable energy policies[79]

Senegal has developed the following enabling framework[80] , which shows the country's willingness to develop its green energy market:

Title	Year	Policy Status	Policy Type	Policy Target
Renewable Energy Law	2010 (December)	In Force	Regulatory Instruments, Regulatory Instruments>Codes and standards>Sectoral standards, Policy Support	Multiple RE Sources, Multiple RE Sources>Power, Multiple RE Sources>All

[79] Organization for Economic Co-operation and Development/International Energy Agency (www.iea.org) , 31-35 rue de la Fédération, 75739 Paris Cedex 15, France and International Renewable Energy Agency (www.irena.org), IRENA Headquarters, Masdar City, PO Box 236, Abu Dhabi, United Arab Emirates

[80] Senegal is working on feed-in tariff structure and regulations which are expected to be launched soon

Senegalese National Biogas Programme Phase I	2009	In Force	Economic Instruments>Direct investment>Infrastructure investments, Economic Instruments>Fiscal/financial incentives>Grants and subsidies, Policy Support>Institutional creation	Bioenergy>Biomass for power, Bioenergy>Biomass for heat
2007-2012 Special Programme for Biofuels	2007	In Force	Economic Instruments>Direct investment>Infrastructure investments, Policy Support>Institutional creation	Bioenergy>Biomass for power, Bioenergy, Bioenergy>Biofuels for transport
Program for the promotion of renewable energies, rural electrification and sustainable supply in domestic fuel (PERACOD)	2004-2015	In Force	Economic Instruments>Fiscal/financial incentives>Grants and subsidies	Solar, Multiple RE Sources, Multiple RE Sources>All

Figure 71: Senegal renewable energy policies[81]

In Cote d'Ivoire the renewable energy policy[82] was adopted in 2013 and is in effect, with the following three objectives:

- Increase renewable energy share in the national energy mix from 1% in 2015 to 16% in 2030
- Diversify energy production sources from 80 % fossil fuel and 20 % renewables in 2015, to 66 % fossil fuel and 34 % renewable in 2020

4.3.2. Ultra-distributed generation

"The Ultra Distributed Generation (DG) market scenario represents a market in which generators have invested in distributed renewable generation, with investment decisions based on policy incentives and economic business cases. It is a market with full unbundling and strong customer engagement, both in retail and as micro-generators. Market operation becomes more complex for both transmission and distribution operators, given the increased volume of distributed and renewable generation and the continued operation of large-scale thermal generation, but remains centrally operated and does not fragment. Regulatory oversight and revenue price controls are likely to address the efficiency of system operation and equitable treatment of generation in dispatch and system support. Determining which market participants pay for the central transmission grid becomes a critical regulatory question."[83]

It shows that there exists significant potential (Figure 72: Estimates of Renewable Energy Potential in West Africa) to develop renewable projects over and above the present large capacities in West Africa. It is worthwhile to note that there are countries within each renewable energy technology type

[81] Organization for Economic Co-operation and Development/International Energy Agency (www.iea.org) , 31-35 rue de la Fédération, 75739 Paris Cedex 15, France and International Renewable Energy Agency (www.irena.org), IRENA Headquarters, Masdar City, PO Box 236, Abu Dhabi, United Arab Emirates

[82] http://www.africabv.com/blog/starting-as-an-independent-power-producer-in-cote-divoire/

[83] PricewaterhouseCoopers (2014) 'The road ahead - Gaining momentum from energy transformation', *Pwc*, pp. 1–32. Available at: http://www.pwc.com/en_GX/gx/utilities/publications/assets/pwc-the-road-ahead.pdf

[83] http://www.nercng.org/index.php/home/operators/renewable-energy

that have the potential for development. When looking at the 4 selected 4 countries – Nigeria offers potential in almost all renewable technologies, Ghana in solar PV and wind, Côte d'Ivoire in mini-hydro, biomass, and wind and Senegal in wind, solar PV and biomass. With these new potential areas identified the prospect for developing ultra-distributed generation capacities seem to be very achievable within a brief period.

Estimates of other Renewable Energy Potential

Country	Mini Hydro	CSP	Solar PV	Biomass	Wind 20%	Wind 30%
	MW	TWh	TWh	MW	MW	MW
Burkina Faso	140	18.1	77.4	2,250	4,742	29
Cote d'Ivoire	242	2.2	103	1,530	491	0
Gambia	12	3.2	4.74	23.75	197	5
Ghana	1	2.3	76.4	1,133	691	9
Guinea	332	4.7	52.0	656	2.4	0
Guinea-Bissau	2	9.0	14.9	71	142	0
Liberia	1,000	0.0	6.67	459	0	0
Mali	67	36.2	79.1	1,031	2,195	0
Niger	50	88.3	157	1,115	16,698	5,015
Nigeria	3,500	100	325	10,000	14,689	363
Senegal	104	15.4	75.2	475	6,226	1,243
Sierra Leone	85	2.0	15.0	166	0	0
Togo/Benin	336	0.0	51.6	957	551	0

[3] HelioClim-3, developed by Mines ParisTech and operated by Transvalor, is a satellite-based database with a long history, where data and maps are offered via the SoDa online portal. Read more at: www.pv-magazine.com/archive/articles/beitrag/solar-resource-mapping-in-africa-_100009438/501/#ixzz2JNDgfV6q

[4] Solar potential would correspond to 2-100 times larger than the projected total electricity demand in each country in 2030, and only 3% of solar potential would be utilised in the Renewable Promotion Scenario.

Figure 72: Estimates of Renewable Energy Potential in West Africa[84]

4.3.3. Local energy systems

"The Local Energy Systems market scenario represents a market in which we see significant fragmentation of the existing transmission and distribution grids and local communities demand greater control over their energy supply or a market in which a local approach is adopted for serving remote communities. The development of local energy systems depends on the local potential of renewable resources that can be used to produce electricity"[85] It is well understood that the 4 selected countries have good potential for solar and wind potential: the charts show clearly that Nigeria offers immense potential for both off-grid solar and wind technologies with Senegal following closely.

[84] IRENA (2013) 'Southern African Power Pool: Planning and Prospects for Renewable Energy', pp. 1–91. Available at: www.irena.http://www.irena.org/documentdownloads/publications/sapp.pdforg.

[85] PricewaterhouseCoopers (2014) 'The road ahead - Gaining momentum from energy transformation', *Pwc*, pp. 1–32. Available at: http://www.pwc.com/en_GX/gx/utilities/publications/assets/pwc-the-road-ahead.pdf

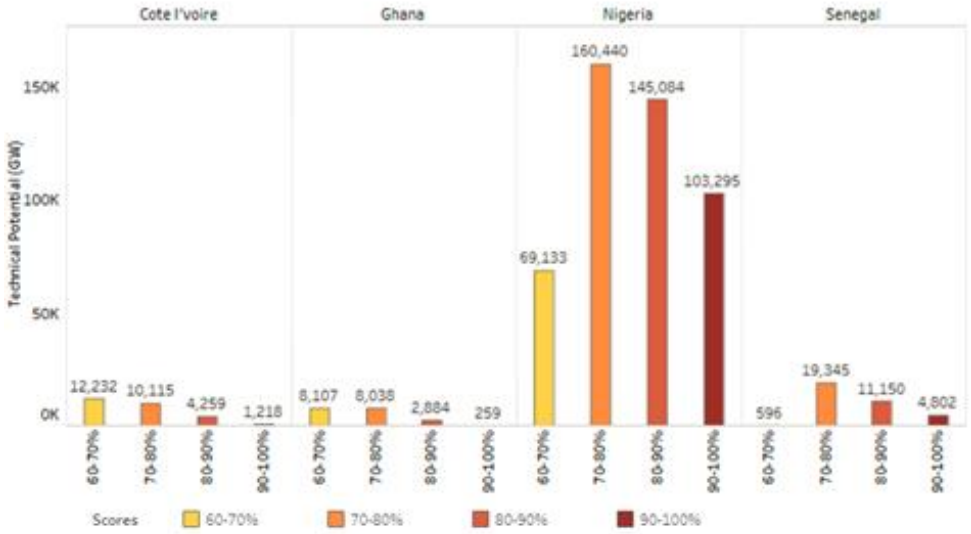


Figure 73: Technical Potential of Solar PV (Off-grid)[66]

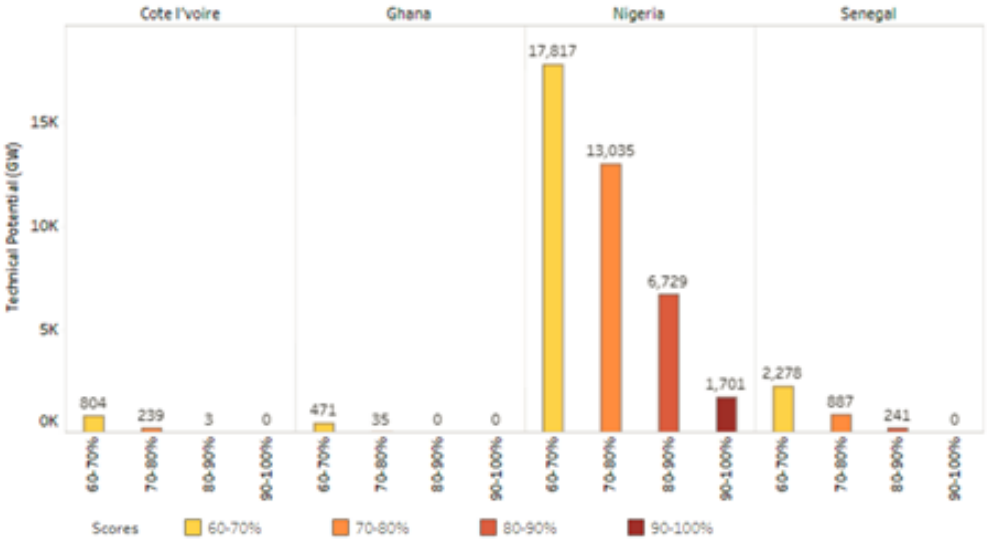


Figure 74: Technical Potential for Wind Energy (Off-grid)[66]

"The market is likely to have undergone full unbundling and experienced strong customer engagement, both as consumers and micro-generators, but recognizes the benefits of vertical integration for off-grid solutions. Financial viability of distributed generation and distributed grids are a prerequisite. Strong policy support for fragmentation is required, either to allow local initiatives or to encourage and incentivize local communities and businesses to take control and build and operate their own local energy systems."[86]

This scenario is now underway in all 4 selected countries in off-grid communities where clean mini-grid based standalone solar, oil based and wind systems are providing local communities with continuous electricity, and regulators are working out feed-in tariffs where the grid proximity is available. Still, strong policy support is required to re-sell and trade excess electricity, which is one area for government policy intervention.

[86] PricewaterhouseCoopers (2014) 'The road ahead - Gaining momentum from energy transformation', *Pwc*, pp. 1–32. Available at: http://www.pwc.com/en_GX/gx/utilities/publications/assets/pwc-the-road-ahead.pdf

4.3.4. Regional super grid

"The Regional Super-grid market scenario represents a market which is pan-national and designed to transmit renewable energy over long distances. It is likely to embrace some degree of unbundling and customer choice. It requires large-scale renewable generation, interconnectors, large-scale storage and significant levels of transmission capacity."[87]

This scenario is already underway through the West African Power Pool (WAPP) project[88] which will bring the producers and exporters of electricity and consumers and importers of electricity together to trade and transmit energy. The WAPP project will further open opportunities for IPP to feed-in and trade excess energy or buy energy from this regionally integrated electricity sharing pool.

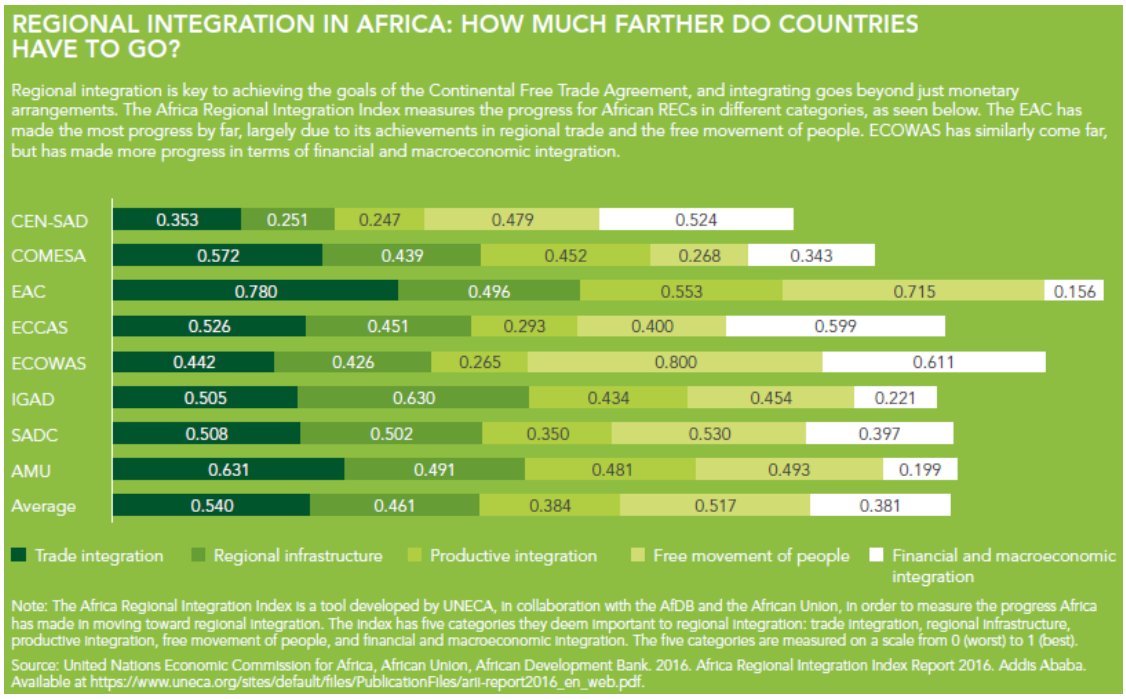


Figure 75: Regional Integration Comparisons across Africa

The illustration from UNEC for Africa that regional integration in ECOWAS is strongly positioned and it continues getting stronger with the cooperation and joint efforts of the 15 countries. The regional WAPP is a notable example of this effort to push the electricity agenda across the West African region.

4.4. Inferences from the Secondary Research and Analysis

The overall evaluation of the secondary research data provides a complete overview of the megatrends and disruptions that are shaping the energy landscape across the West African region. It is visible that the disruptions have already started affected these markets in a manner that is creating both challenges and opportunities for women entrepreneurs. The summaries of findings from the secondary research include:

1. Global megatrends in energy generation, storage, transmission and distribution are impacting all stakeholders on the energy value chain, which include public utility companies, women entrepreneurs, government agencies and financial institutions

[87] Ibid

[88] The **West African Power Pool** (**WAPP**) is a cooperation of the national electricity companies in Western Africa under the auspices of the Economic Community of West African States (ECOWAS). The members of WAPP are working to establish a reliable power grid in the region and a common electricity market. It was founded in 2000

2. The disruptions are happening across the energy supply chain i.e. upstream, midstream and downstream, affecting how energy is produced and consumed.
3. Low rural electrification rates in countries like Cote d'Ivoire and Senegal offer high potential for off-grid electricity generation, distribution, and consumption.
4. Nigeria and Ghana are leading the way in sales of high-scalability products for decentralization while Senegal leads on the chart in sales of low-scalability products for decentralization.
5. For off-grid technologies that are being used across the 4 selected countries, Senegal leads the group. We see that big wins for off-grid solutions has happened in solar-based generation systems followed by oil-based generation systems (in kWp- kilowattpeak) resulting in development of hybrid systems.
6. Senegal and Cote d'Ivoire are gradually moving towards 'innovation achiever' levels within Sub-Saharan Africa and leading the West African region.
7. Globally there has been a significant investment growth in solar, wind and biomass areas and these will continue to be areas of opportunity within the West Africa energy innovation landscape.
8. Technologies that will make the bulk of future energy generation will include solar, wind and bio-energy based technologies, hence these will see the fastest commoditization, regulatory compliance, consumer diffusion and commercial funding.
9. The CO_2 emission profile demonstrated that all the 4 selected countries contributed a small portion of global CO_2 emissions, but compared with each other Nigeria produces the highest proportion of the regional emissions
10. Demographics are drivers of present and future demand for electricity, and we see that Nigeria's population is 72% of the total population of the 4 countries selected.
11. Nigeria has the largest economy, constituting almost 80% of the total GDP of the 4 selected countries while Ghana is the fastest growing economy followed by Cote d'Ivoire.
12. Nigeria and Ghana offered the lowest domestic credit at 15.6% of GDP which is way below the average for sub-Saharan Africa at 45.6% of GDP
13. Ghana and Nigeria offer a better route to equity-based funding than in the other two of the 4 selected countries
14. We see that globally:
    a. The major chunk of funding for grid infrastructure, hybrid renewable and solar comes from public institutions while for hydro and on-shore wind is through private sources
    b. Within public sources, i.e. public financial institutions – multi-laterals continue to increase their share along with government sources, and these are also likely sources for women entrepreneurs on the energy value chain
    c. Knowledge Tie-ups with project developers in developed markets could offer women entrepreneurs the opportunity to establish as well as finance their projects
    d. The lowest sources of financing in renewable energy projects comes from venture capital and private equity funds
15. The rate of population growth and urbanization means that universal electricity access and waste accumulation will be some of the biggest challenges in urban planning for cities of the future, and this will open opportunities for technologies that can convert waste to electricity.
16. Individual consumers in the 4 selected countries are moving from passive ratepayer (the basic level at which most consumers get the first electricity connection) to frugal goal seeker, where the energy consumer is willing to take modest action, but how much they do is constrained by their income
17. Products that are commoditized have a lower profit margin, larger scale and imitate consumer durable type supply chains. These include solar lighting products (e.g., pico-products, lanterns, chargers, etc.), storage batteries and solar SHS generators
18. High-scalability products are products that face high competition (high threat of substitution, new entrants, less bargaining power of suppliers and buyers and high industry rivalry).
19. Products that belong to other non-conventional energy sources like wind and hydro face less competition because they have high entry barriers` due to technical, regulatory and financial complexities (low threat of substitutes, new entrants, more bargaining power of suppliers and less industry rivalry).

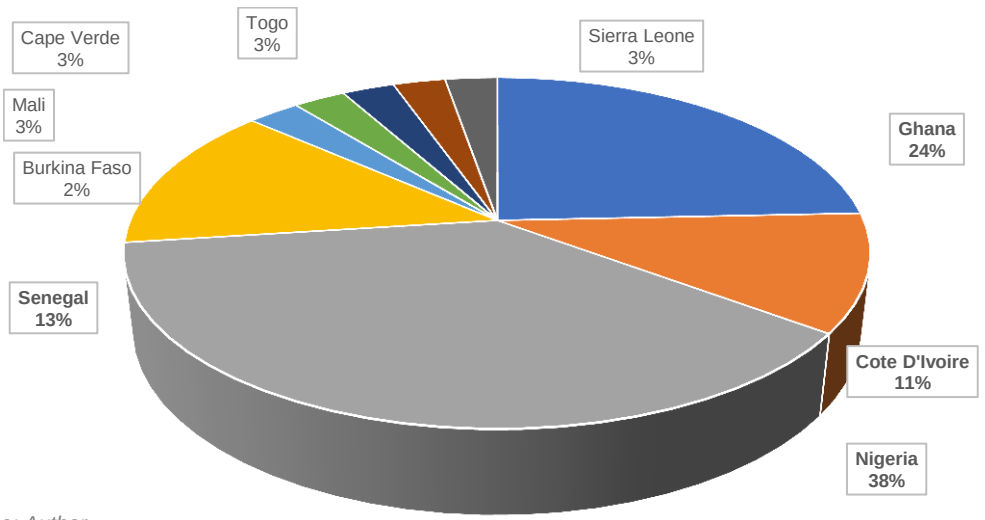
20. Biomass is another source of energy where the competition is high at feedstock level (which is an agricultural raw material and commoditized). Due to proximity to several agricultural suppliers the competition is high and margins low but as we move to biogas or waste to electricity plants the competition reduces, and margins increase.
21. LCOE for new renewable technologies is gradually decreasing which is attracting more competition (Hydro<Onshore Wind<Geothermal<Solar & Biomass)
22. A convergence is happening between information technology and operations technology. Nigeria has taken the lead among the 4 selected countries by being able to generate and provide information related to consumer electricity offtake and usage.
23. The 4 selected countries show that their utility industry model is moving from the traditional passive persistence to operations transformation.
24. Distribution channels are evolving from physical to digital, but there is still the conventional distribution channel where a physical product or equipment passes through transportation and logistics before finally being sold to the consumer.
25. The front-end demand management model is becoming more virtual, and smart services are being developed to bridge the gap between energy generation, payment, and energy consumption.
26. There are several tools by which governments can collaborate with financial institutions to facilitate financing of renewable energy projects, some of which are now being used in all the 4 selected countries, these include Financial policies and regulations, guarantees, hybrid structures for project funding, green bonds, etc.
27. The green command and control market model is already in existence in the selected countries with predominance in Nigeria and Ghana where demand-side management technologies and mini-grids have entered the market. Similarly, in Senegal and Cote d'Ivoire mini-grids are increasingly being installed, resulting in development of a private-sector led electricity generation and distribution market.
28. It is worth mentioning that there are countries, within each renewable energy technology type, that have the potential for development into ultra-distributed system – especially for off-grid.
29. Nigeria has potential in all renewable technologies, Ghana in solar PV and wind, Cote d'Ivoire in mini-hydro, biomass, and wind and Senegal in the wind, solar PV and biomass.
30. The Local Energy Systems market model is also present to some extent – i.e. which is a situation where there is significant fragmentation of the existing transmission and distribution grids and local communities demand greater control over their energy supply or a market in which a local approach is adopted for serving remote communities.
31. We are seeing off-grid communities where clean mini-grid based standalone solar or oil based as well as wind systems are providing local communities with control over their energy generation.
32. We observe a growing regional Super-grid market model via WAPP. This is a market which is pan-regional and designed to transmit renewable energy over long distances. It is likely to embrace some degree of unbundling and customer choice. It needs large-scale renewable generation, interconnectors, large-scale storage and significant levels of transmission capacity.

5. Primary Research and Analysis

This assignment is part of a project which seeks to ensure that the region meets its goal of universal energy access for over 300 million people, by developing a high quality, **gender responsive**, regional energy market development strategy that taps into the innate **entrepreneurial capacity of ECOWAS women.** Harnessing this capacity to increase the establishment of energy businesses and deployment of energy technologies to meet the energy needs of the region's largely unserved population. The Project on Feasibility Study on Business Opportunities for Women in a Changing Energy Value Chain in West Africa is a product of the ECOWAS Policy for Gender Mainstreaming in Energy Access which aims, among other things, to increase women participation in energy-related fields in the private sector by 25% by 2020 and 50% by 2030.

The primary research and analysis involved in-depth interviews with women entrepreneurs across the 4 selected West African countries, but before conducting the interviews, it was necessary to identify and formalize the database of women entrepreneurs in the 4 selected countries. It was revealed that there is a very small structured database of women entrepreneurs working in the energy value chain in the 4 selected countries. The process for identifying women entrepreneurs was time-consuming since very few women entrepreneurs are involved in the energy sector in the 4 selected countries. One of this project's achievements has been to document and compile a list of women entrepreneurs, which can be used, not only for research purposes, but also for establishing specific economic empowerment activities and events designed for women owners.

Thanks to the research conducted by contacting almost a dozen agencies, the research team successfully and, for the first time, *formally documented a list of 54*[89] *women entrepreneurs involved in renewable energy and energy efficiency businesses* (having **personally interviewed 37 women entrepreneurs**). The profile of these aspiring and successful women business leaders is diverse ranging from start-ups to highly structured businesses. The focus of this study was to interview women entrepreneurs from the 4 selected countries, but also included were successful women entrepreneurs from other countries in the West African region, e.g. Sierra Leone, Togo, Cape Verde, Mali and Burkina Faso.



Source: Author

Figure 76: Women Entrepreneur Geographic Representation (Interviewed)

We conducted in-depth 60 minutes interviews with women entrepreneurs to understand the:

a) purpose (of their business),
b) business model,
c) operating model/capabilities,
d) human resources model,
e) financial performance

We have structured our interview (and questionnaire) to not only identify explicit challenges that are stated by women entrepreneurs but also look through their business operations and identify the implicit challenges that are dwell in their businesses. We have also looked at what prospects these women entrepreneurs view for their businesses and how do they see the disruptions and transformations in the energy value chain affecting them. These interviews gave us in-field perspective of how women operate, interact, and deliver their products and service to their

[89] Browsing through the vast expanse on secondary data and after discussions with several stakeholders of the energy ecosystem, it has been understood that 2% of all entrepreneurs in the energy value chain might be women.

customers and operational, labor, and financial challenges they face in their environment. The findings of the study are as below:

5.1. Purpose

The purpose of existence of the company is to profit and sustain those profits for eternity. To quantify this aspect for evaluating the women held businesses we inquired about different indicators which were - years in existence, their product, and services range, what sources of energy they are involved with and what their aspirations were for the future.
Most women-owned businesses in our survey (59% of respondents) are more than three years old and we have start-ups (around 19% of respondents) which are pre-dominantly based on ideas with commercial success in other countries or regions which these women entrepreneurs are keen to launch in the West African region. At present these women start-ups do not have tie-ups with foreign companies for knowledge or technology transfer, but these women are open to the idea of a tie-up with a commercially successful start-ups from other countries.

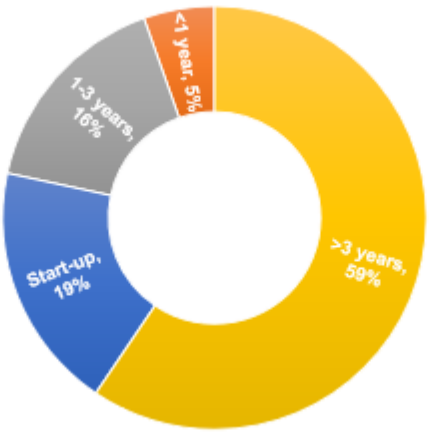


Figure 77: Period of Existence

Source: Author

The criteria for selecting a 3-year period were chosen because banks require that businesses have been in operation for at least 3-years in order to fund any business. The goal was to find out how many of these businesses had been established for 3 or more years and had taken loans from banks and whether or not they could be helped with banking institutions and getting loans. It is worthwhile mentioning that businesses established for more than three years have better chances of qualifying for credit than if they have been in business for less than three years or are start-ups. However, it is essential to understand that the longevity of a company is just one of the criteria that banks consider when providing credit limits.

The profiles of products and services of women entrepreneurs were examined and it was found that the majority of women-owned businesses are in – Energy Generation Products[90] (15% of respondents), Maintenance (16% of respondents) and Installation (16% of respondents) which together form around ~47% of the total women-owned businesses. Whereas, when looking at the revenue mix of women businesses, it was found that 70% of revenue comes from product sales while 30% comes from service sales. When the total product based items within energy products were looked at, including energy generation, product based businesses rose up to 40% (Figure 78: Product & Service Profile (present)). Based on the consolidation of product based items it can be concluded that women-led energy businesses in the 4 selected countries are primarily product based businesses with services tightly wrapped around them. This insight implies that anything that

will affect the product will, in turn, affect the growth, profitability, and sustainability of the majority of women-owned businesses in the 4 selected countries.

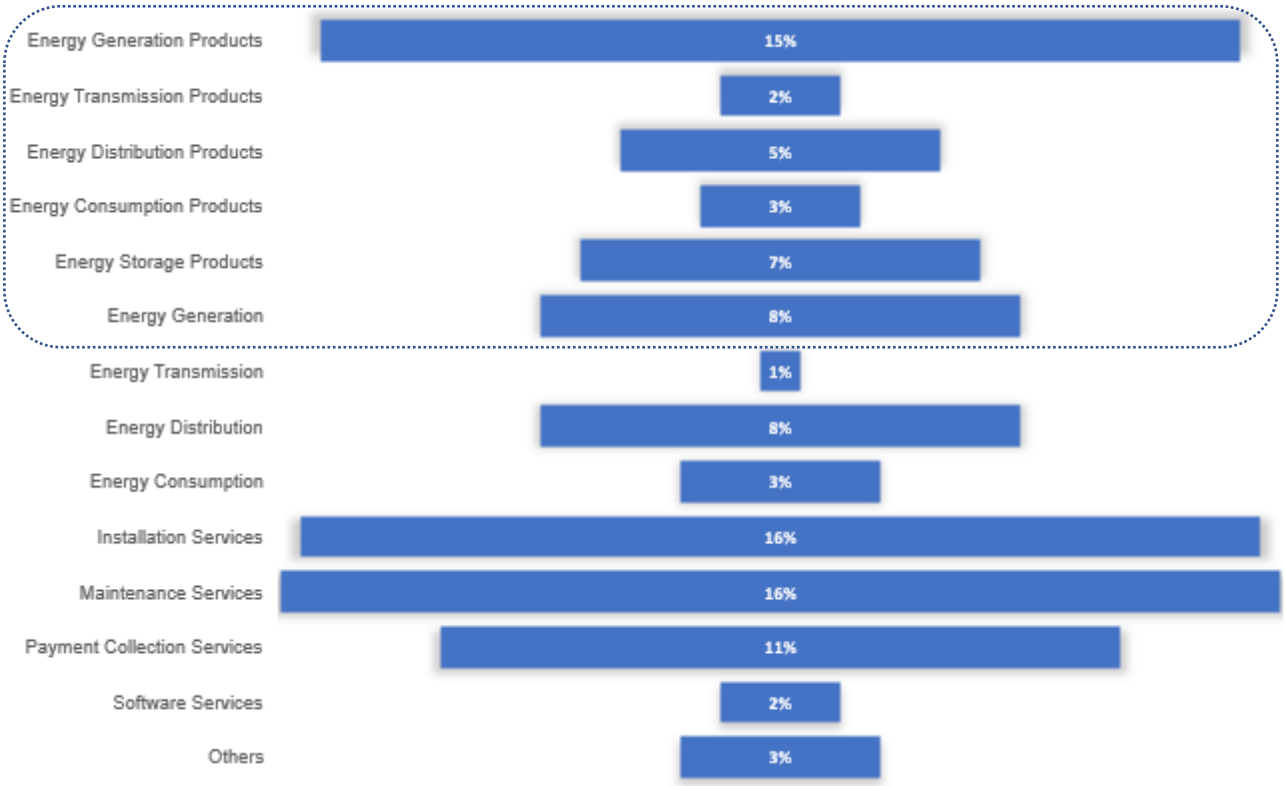


Figure 78: Product & Service Profile (present)

Source: Author

Product & Service Profile description

Energy Generation Products	These are products that are used for energy generation like solar panels, wind turbines, hydro power plants, etc.
Energy Transmission Products	These are products that are required for transmission of energy or electricity like – high-voltage wires, substations, etc.
Energy Distribution Products	These are products that help in distribution of energy or electricity and include – low and medium voltage wires, transformers, circuit breakers, distribution boards, etc.
Energy Consumption Products	These products are involved in helping consumers to transform energy or electricity to heat or light which they can use to address their needs, and these include – lighting products (lanterns), stoves, etc.
Energy Storage Products	These products are used for energy storage and include products like batteries, back-ups, etc.
Energy Generation	This is a service where a company acts as a producer of energy or electricity and supplies it to customers or consumers
Energy Transmission	This is a service where by a company acts as a transmission provider of energy or electricity to customers or consumers utilizing either their own or other companies transmission lines/resources
Energy Distribution	This is a service where by a company acts as a distributor of energy or electricity to customers or consumers utilizing either their own or other companies transmission lines/resources
Energy Consumption	This is a service where by a company consumes energy or electricity to produce value added products and services which can then be sold to customers or consumers e.g. agricultural co-operatives, industrial processors, etc.
Installation Services	This is a service where by an installation company installs the energy products at the customers' or consumers' site
Maintenance Services	This is a service where by a maintenance company maintains (and repairs) the energy products for the customers or consumers over a contracted period of time e.g. annual maintenance contracts
Payment Collection Services	This is a service where by a payment collection company collects the payments from the customers or consumers on behalf of the client - either physically or through a software applications

Software Services	This is a service where by a software company designs, deploys and provides software based services that include – smart solutions, energy demand management solutions, applications, etc.
Others	Any products and services that are not covered in above mentioned heads.

After examining the product and services provided by women entrepreneurs and bank facilities, it was found that software services have positive relations with bank institutions. However, if this data is compared with the data about women entrepreneurs involved in software services, it showed that a mere 2% of respondents are in the software business, this might be an area of opportunity for women held businesses to diversify (especially for businesses that are already more than 3 years old).

Women entrepreneurs focus on specific energy sectors, which are determined by their understanding of customers, technical knowledge and professional background. Most women entrepreneurs (42% of respondents) work with easy to trade and maintain solar-based products and close-to-home agricultural related biomass-based products (30% of respondents). Gas based products have been an area of interest for women entrepreneurs, but they have not been able to capitalize on this opportunity due to cultural, technical, and financial access issues.

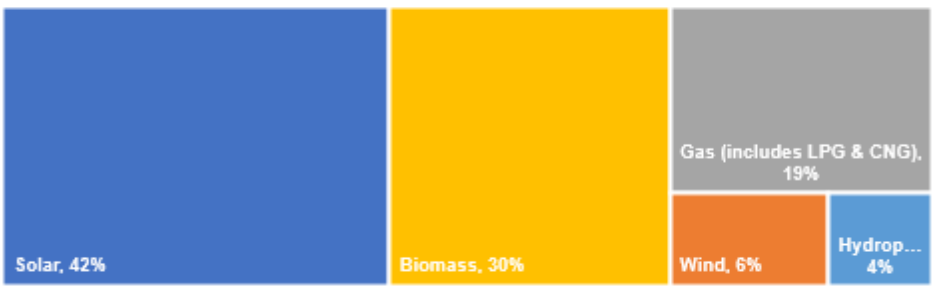
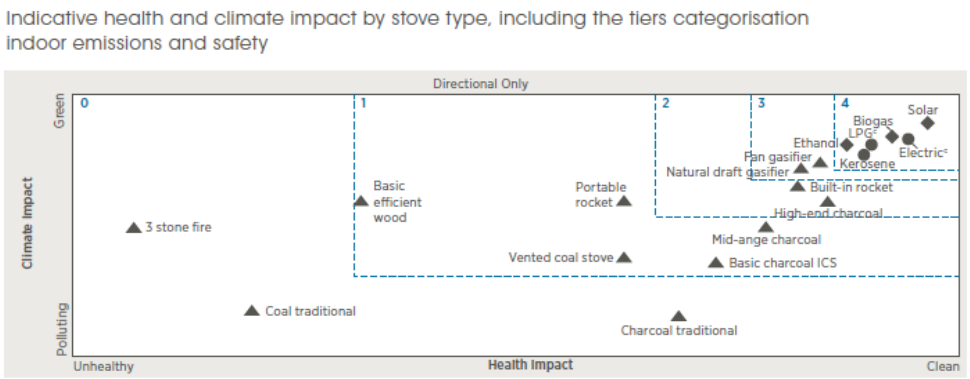


Figure 79: Energy sectors of Women Entrepreneurs (present)

Source: Author

Energy products for wind and hydro sources are low on women-owned businesses areas of involvement due to limited opportunities (larger deal sizes), low awareness and low technical expertise in these technologies. Dealing with commoditized energy products offers lower profit margins, but due to the service aspects, women can get better margins and offer better services (Figure 98: Profitability Drivers for Women Entrepreneurs). Moreover, since women entrepreneurs operate in commoditized energy products, it is extremely difficult to sustain healthy profit margins and possible ways to enhance the margin exist either by accessing new innovative products where they can demand better price or by diversifying into other energy products where there's less competition. Women entrepreneurs have lacked access to innovative technologies in the wind and in biomass areas, which, if provided, will open an exciting opportunity for them to expand their present businesses as well as venture into new energy sectors.



Source: Putti et al., 2015

Figure 80: Climate and Health Impact of different cooking technologies

Women entrepreneurs have been involved in the area of energy efficiency by developing cookstove businesses. Comparing the tier-level of products against the source of energy women entrepreneurs are involved in, Tier-1 and Tier-2 and are now gradually migrating to Tier-4 products like biogas stoves and solar. We see that Senegal (Figure 81: Access to Clean Cooking) has been successful in providing access to clean cooking to urban populations (80%), whereas other countries like Nigeria, with proportionately higher urban populations, penetration has been lower. Even Ghana and Côte d'Ivoire show very low urban access to clean cooking. The presence of gas reserves in Nigeria, Ghana, and Côte d'Ivoire has strong potential to introduce gas stoves as an efficient and clean source of energy. Rural areas are still facing difficulties in accessing clean cooking technologies across all 4 selected countries.

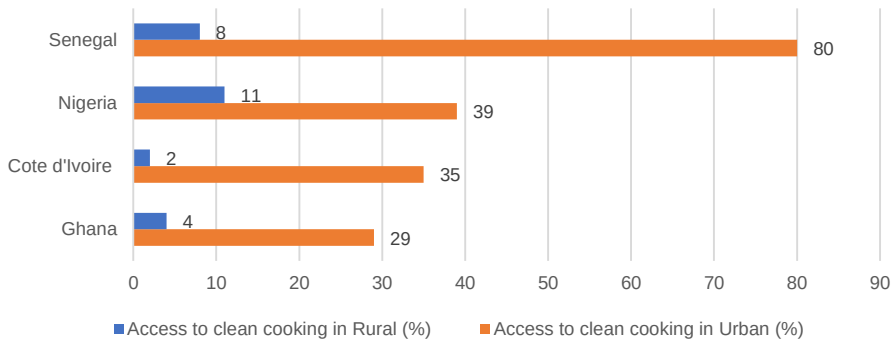
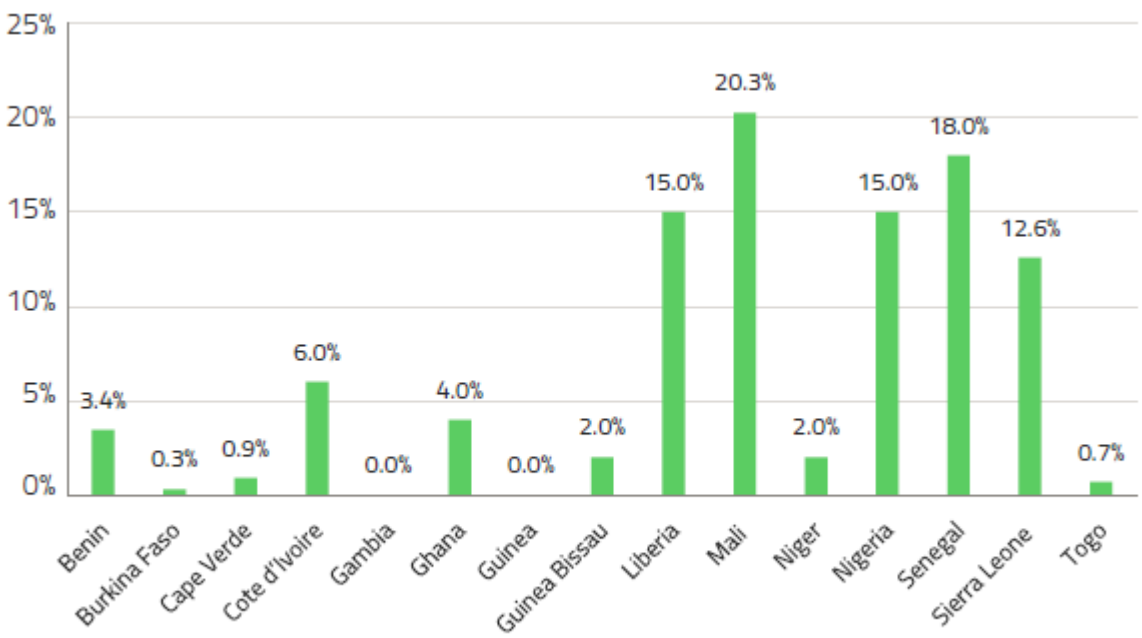


Figure 81: Access to Clean Cooking

Source: https://trilemma.worldenergy.org/#!/country-profile?country=Senegal&year=2017

Based on ECOWAS SEforALL Action Agendas and the NREAPs, the current population using efficient cookstoves or alternative cooking fuels amounts to approximately 75 million people, out of which approximately 40 million use efficient cookstoves and approximately 35 million use alternative cooking fuels, namely LPG, biogas, solar cookers, ethanol, etc.

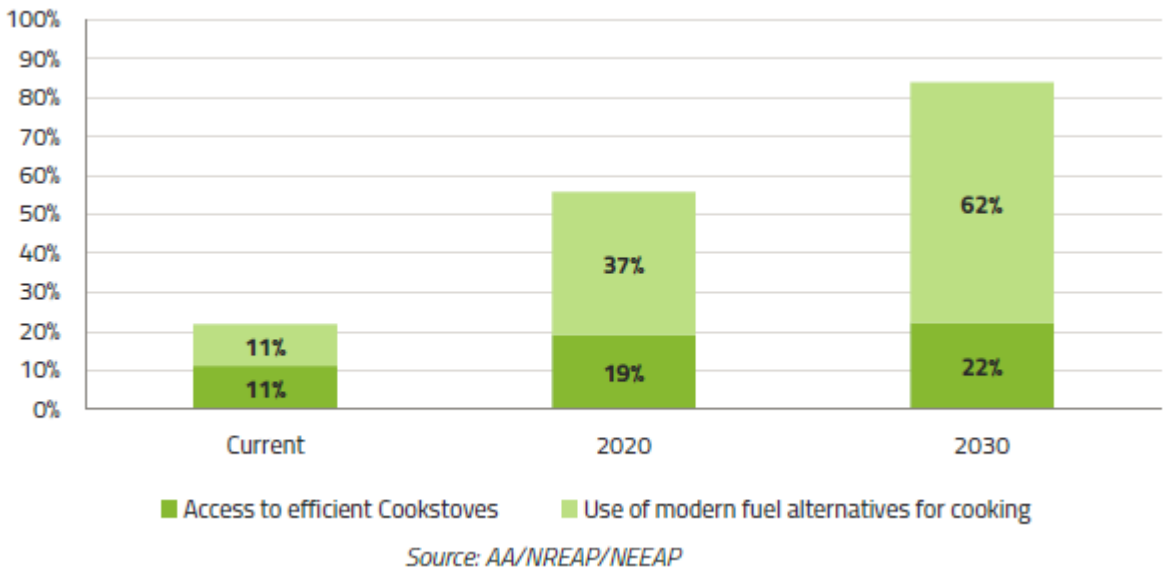


Source: ECOWAS country and AAs and NREAPs

Figure 82: Current access to Efficient Stoves

It is important to mention that across the West African region access to efficient stoves remains very low. Among the 4 selected countries, Nigeria and Senegal which have been successful in reaching above average penetration rates for the region. It is expected that by 2030 the population utilizing

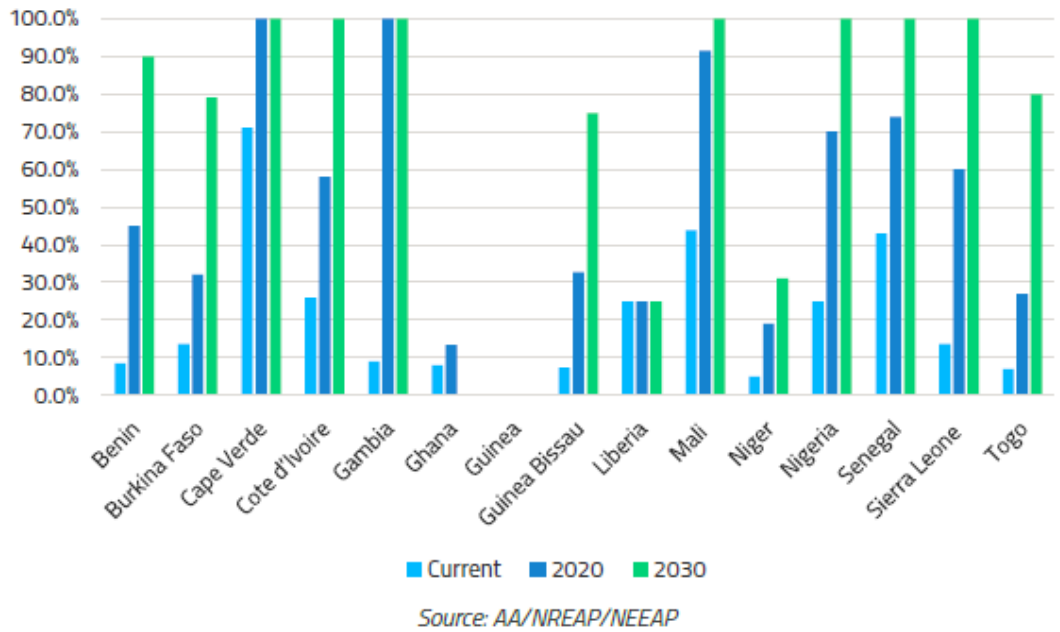
efficient cookstoves and alternatives fuel (including LPG) will grow to 84% from present level of 22% (Figure 83: Share of Population Using Efficient Cooking).



Source: AA/NREAP/NEEAP

Figure 83: Share of Population Using Efficient Cooking

Considering that clean and sustainable cooking solutions is a component of the renewable energy and efficient energy ecosystem and directly impacts a significant proportion of the population, West African countries have set a targets to be achieved by year 2020 and 2030. We see that Nigeria, Senegal and Cote d'Ivoire intend to provide 100% of their population with efficient cooking technologies by 2030.

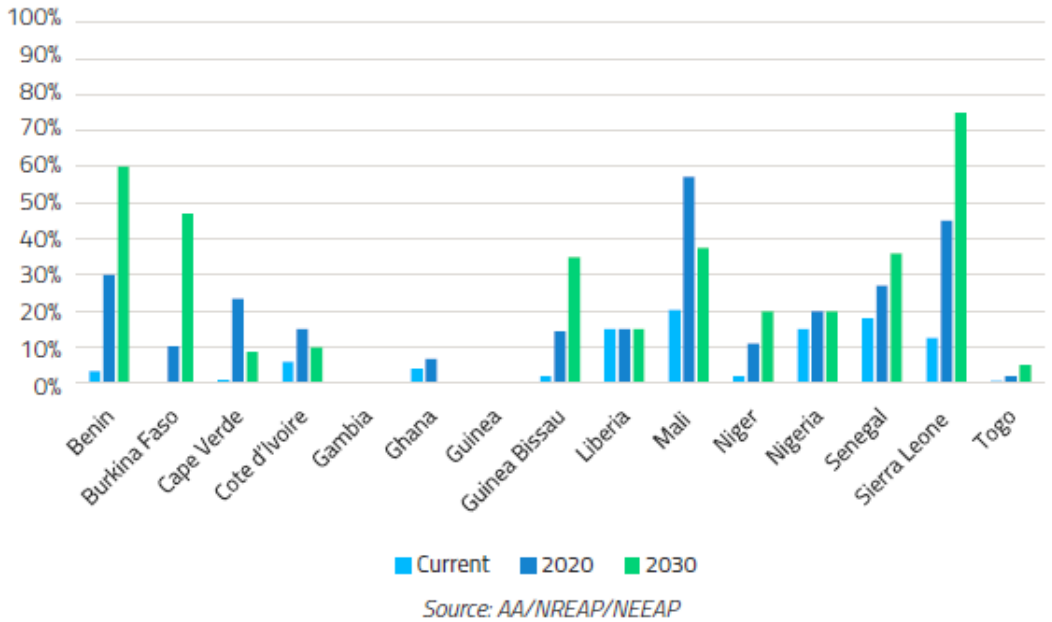


Source: AA/NREAP/NEEAP

Figure 84: Efficient Cooking Targets (% of Population)

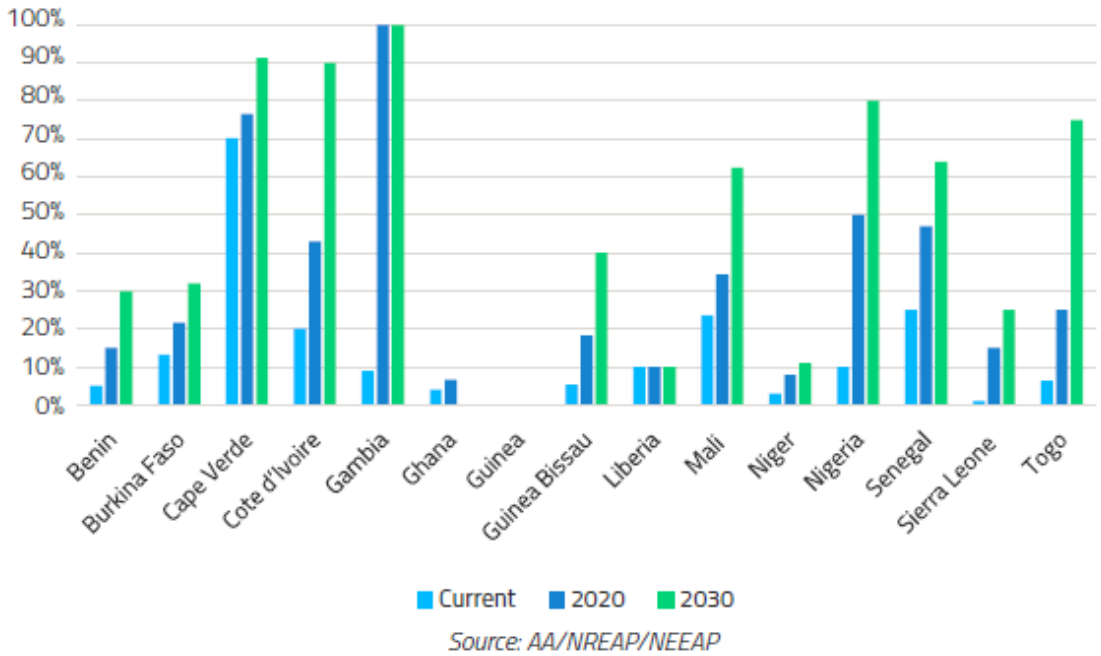
Providing universal access to modern cooking solutions, involves two elements – improved cooked stoves and clean cooking fuels. Both of these elements are being promoted by local entrepreneurs across the West African region, specifically by women entrepreneurs. The main customers of cooking stoves and deployers of alternative fuels for cooking purposes, as we mentioned before in this report, are women. When we look at the targets that have been proposed to be achieved, in terms of percentage of population using efficient cooking stoves, we see that Senegal and Nigeria

will lead among the 4 selected countries. And for alternative fuels (this includes LPG) we see that Cote d'Ivoire and Nigeria will lead the way among the 4 selected countries. Nigeria offers the best opportunity for women entrepreneurs to develop a bundled cookstove and fuel supply business (i.e. vertically integrated energy efficient business).



Source: AA/NREAP/NEEAP

Figure 85: Targets for Efficient Cookstoves (% of Population)



Source: AA/NREAP/NEEAP

Figure 86: Targets for Alternative Fuels (% of Population)

From interviewing the women entrpreneurs it can be predicted that the next commoditized energy source that will be accessible to women will be Gas (including LPG) (Figure 87: Energy sector (Future) of Women Entrepreneurs) as it qualifies in the same category as solar and biomass in terms of supply chain dynamics with end-users being women themselves for gas consumption (limited only by difficulties to source or originate). It was interesting to notice that some women in Senegal are involved in running bio-gas generation plants that are intimately tied-up with the agricultural

processing industry.The present agricultural processing[91] supply chain for millet involves usage of electricity and biomass for drying and cooking; some women entrepreneurs have set up biodigesters to supply gas to these agricultural processing units. Moreover, some agricultural processing women entrepreneurs have designed and are now investing in deploying solar-powered dryers for processing which will help them to go off-grid. This is, in turn, will also allow more women to join agricultural processing (in off-grid rural areas) while women entrepreneurs units that are already producing excess solar energy can start selling it to other agricultural co-operatives in their vicinity. These women-owned energy & agriculture (E&A) businesses are companies where women are either energy generators and or consumers, and work very closely in rural markets. These E&A type women businesses provide value addition to both the energy and agricultural value chains. Interestingly, the future energy sources the women entrepreneurs would like to get involved is not very different from what they do now (with more shift visible into biomass and solar in the future[92]), but it is a clear indication of how well women understand their market and see it evolving from their perspective of an evolving energy value chain.

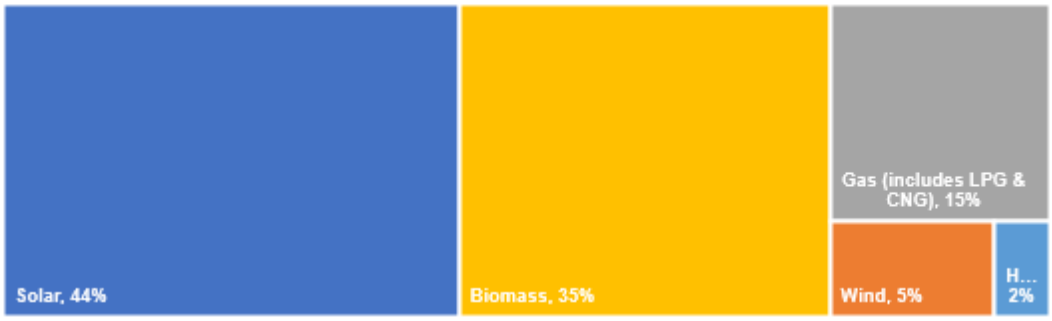


Figure 87: Energy sector (Future) of Women Entrepreneurs

Source: Author

Energy Source	*Sum of Score (Present)*	*Sum of Score (Future)*	*Growth Areas*
Biomass	18	23	5
Gas (includes LPG & CNG)	10	9	-1
Hydropower	2	1	-1
Solar	24	28	4
Wind	3	3	0

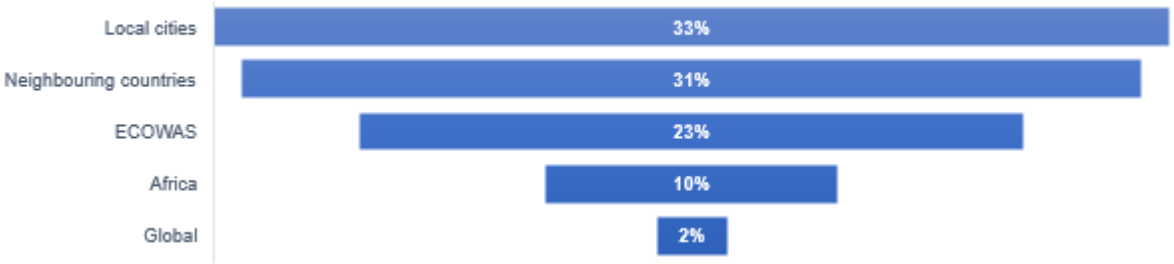
Table 1: Future growth areas by Energy source

Source: Author

The next aspect for evaluating company purpose was to find out how women entrepreneurs perceive the future. This involved understanding their plans for geographic expansion, product and service diversification, energy sector diversification and their reasons for expansion.

[91] These agricultural processing co-operatives are predominately women held, have significant market shares and have high women employee compositions. Some of them are large enough to export their processed food commodities to other countries in West Africa and to Europe and the US.

[92] This seems to be the reason as women have very low access to new technologies in other energy sources like gas and wind power which are fast evolving into fuel feedstock of the near future



Source: Author

Figure 88: Future Geographical Expansion

The total rankings of variables based on the total scores point out that women entrepreneurs expressed their interest in geographic expansion prioritized by their local cities followed by neighboring and ECOWAS countries (54% of respondents), which clearly illustrates their local and regional preferences for future geographical expansion. A rating of 3 (which is the highest priority) was given by 11 respondents (almost 30% of respondents) for expansion into ECOWAS and neighboring markets which further highlights the importance of regional markets for women entrepreneurs:

	3 (Highest Priority)	***2 (Medium Priority)***	***1 (Lowest Priority)***	***Total Count***[93]
Local cities	23	0	0	23
Neighboring countries	7	23	0	30
ECOWAS	4	9	19	32
Africa	2	3	9	14
Global	0	0	4	4

Table 2: Number of Women Entrepreneurs based on prioritization for Future Geographical Expansion

Source: Author

This is also an indication of their understanding of the market and where they envision their future markets, very few women-owned businesses indicated global ambitions (2% of respondents) to expand outside Africa.

Another area for future expansion for women-owned businesses is through adoption and development of new products and services (Figure 89: Future Product & Service Expansion) – and we saw that almost 57% of respondents indicated that they would like to look at new products and services (33% of respondents for new products and 27% of respondents for new services). Within the selection of the new product and services, it is evident that there is more focus on energy generation products, installation, and maintenance, and on the pure service side its more on payment collection services, energy generation, and distribution, which is the same as their present portfolio.

[93] Number of women entrepreneurs that stated the asked variable as their highest (3) or lowest priority (1)

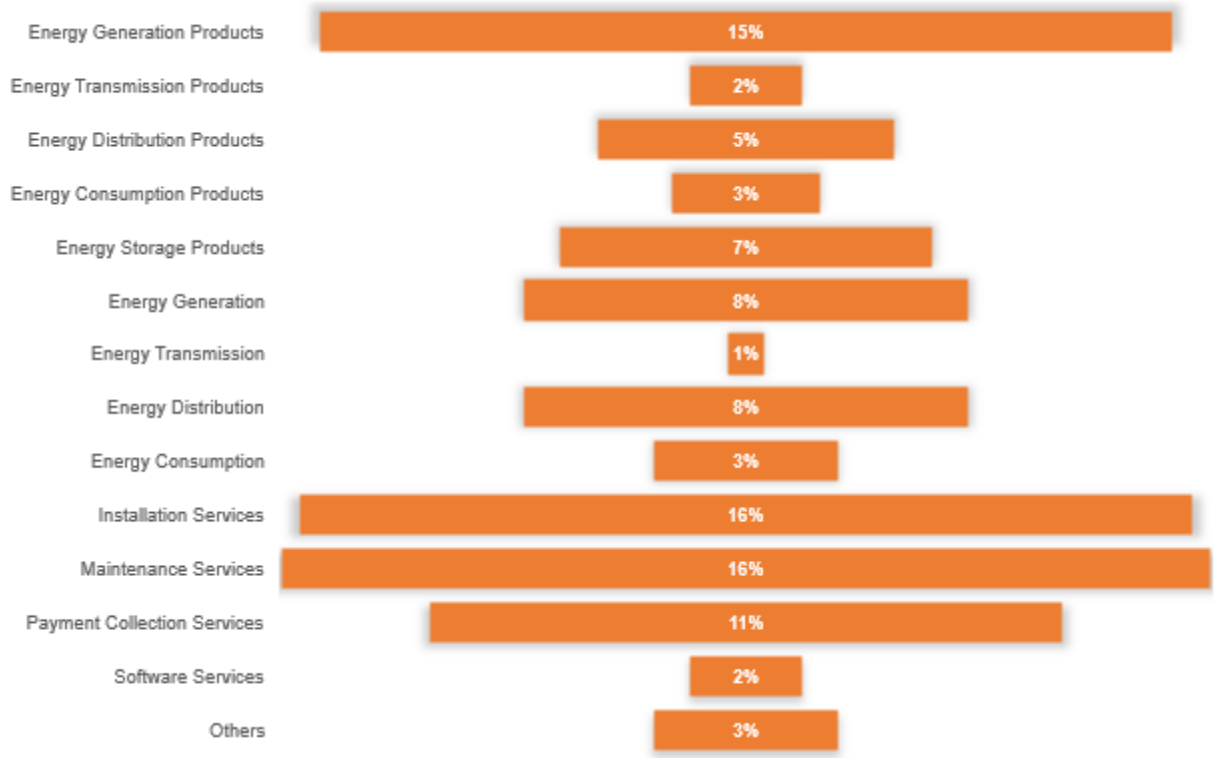


Figure 89: Future Product & Service Expansion

Source: Author

However, if we look at future growth areas based on individual scores, women entrepreneurs are more interested in some products and services in the future.

Products & Services	***Sum of Score (Present)***	***Sum of Score (Future)***	***Future Growth Areas***
Energy Consumption	5	1	-4
Energy Consumption Products	5	2	-3
Energy Distribution	12	13	1
Energy Distribution Products	8	8	0
Energy Generation	12	20	8
Energy Generation Products	24	16	-8
Energy Storage Products	11	5	-6
Energy Transmission	1	1	0
Energy Transmission Products	3	2	-1
Installation Services	25	13	-12
Maintenance Services	26	17	-9
Others	5	4	-1
Payment Collection Services	18	21	3
Software Services	3	7	4

Table 3: Future growth areas on products and services

Source: Author

And these are – *energy generation, energy distribution, payment collection services and software services*. When asked about which energy sector they viewed as the best opportunity for their business and the majority of women indicated – solar, biomass and gas in that order of preference, which shows that commoditized energy feedstock and sources will continue to expand further for women entrepreneurs, and they will continue to develop businesses that utilize these resources.

The final factor to understand the complete strategic thought behind the aspirations of women businesses is to evaluate what variables are motivating women-owned businesses to look at new opportunities in geographies and in their product and services portfolio (Figure 90: Reasons for Future Expansion). They pointed out that the biggest reason for them to look at expanding into new geographies and changing their present portfolio is because: technologies are more efficient (25% of the sum scores) and these technologies can be acquired and added to their present portfolio[94]. The other two most important reasons stated were - to diversify their market risks (from their present market due to localization effects[95] which can be regionalized to reduce the business risk profile by making it more sustainable), and add the offer to a basket of new products and services to the existing customer portfolio (already established credibility and relationships with present customers making it easy to launch new products and solutions to these customers thereby reducing the risks of failure).

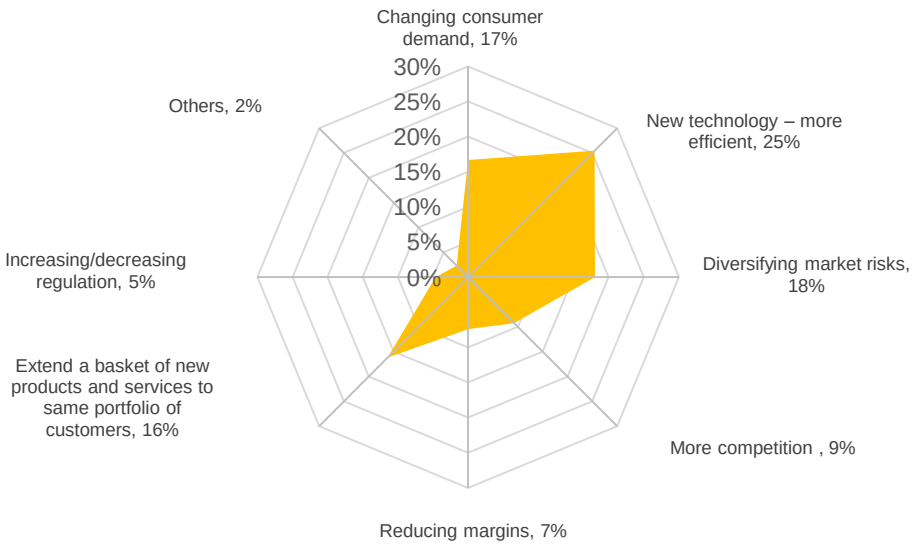


Figure 90: Reasons for Future Expansion

Source: Author

The present and future purpose of women entrepreneurs is to grow their businesses within and across the local and regional markets and achieve profitability and sustainability by continuously innovating their products and service offerings through the application of new more efficient technologies.

5.2. Business Model

There are various definitions of a company's business model, e.g. "Joan Magretta, cites Drucker when she defines what a business model is in "Why Business Models Matter," partly as a corrective to Lewis. Writing in 2002, during the crash of the dot.com, she said that business models are "at heart, stories —that explain how enterprises work. A good business model answers Peter Drucker's age-old questions, 'Who is the customer? Moreover, what does the customer value?' It also answers the fundamental questions every manager must ask: How will we make money in this business?

[94] Women entrepreneurs cited difficulties in identifying and acquiring innovative technologies due to limited exposure (low awareness) to new global technological developments.
[95] Localization is the adaptation of a product or service to meet the needs of a language, culture or desired population's "look-and-feel." http://searchcio.techtarget.com/definition/localization

What is the underlying economic logic that explains how we can deliver value to customers at an appropriate cost?"[96]

A set of questions was designed to determine the business model of women-owned businesses. *First*, to find out what kind of value-added activities are involved within women-owned businesses and it was observed that the majority of value-added activities included trading, coordination, transportation, installation, and maintenance. This is because energy-related products that women had to deal with needed to be bought or traded (imported from China, India, Germany, Spain, and the US, or procured locally and then sold to rural or semi-urban markets), and required storage in warehouses, had to be transported to rural or remote locations for installation and then needed maintenance (under annual maintenance contracts).

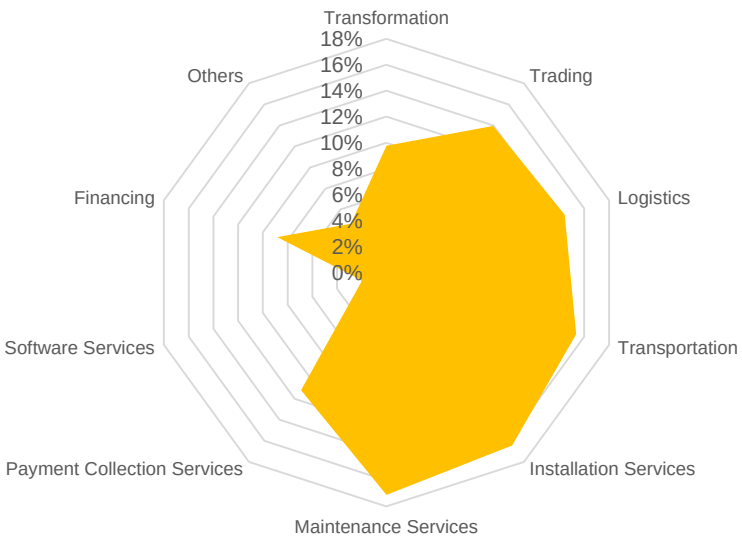


Figure 91: Value Addition Activities

Source: Author

Second, to look at women entrepreneurs from the perspective of the customers they deal with – thereby understanding the kind of customer mix women needed to satisfy in order to generate business (this is a key element of their sales and marketing strategies). It showed that women-owned businesses are more of a mix of B2B[97] and B2C[98] (55% of respondents) then of only one kind, i.e. either B2B (21% of respondents) or B2C (24% of respondents).

The *market* in which women entrepreneurs operate and compete is defined and quantified by – the *number of customers and consumers, market size regarding value, number of competitors and market share*. A clear understanding of the *market* in which these women entrepreneurs operate was necessary, and it was observed that all women entrepreneurs understood their market and had a fair knowledge of the space and who they are competing with but they lacked the skills and tools to quantify these market evaluation parameters[99].

It was observed that most women entrepreneurs are competing in a market with customer and consumer numbers below 5 million. Almost 41% of respondents stated that they deal with a population of fewer than 1 million customers and/or consumers. There is a disparity based on whether the respondents' business is B2B or B2C; if it is B2B then the buyers are other businesses which are usually smaller in number than if the respondents' business is B2C where the buyers are

[96] https://hbr.org/2015/01/what-is-a-business-model
[97] Business to Business – where products and services are supplied to a company
[98] Business to Consumer – where products and services are supplied to end user
[99] These figures were extremely difficult to figure out because most women entrepreneurs find it difficult to quantify the customers and/or consumer market size and by value

end-users. Irrespective of the nature of customer/consumer orientation these numbers define the customer and consumer space in which most women-owned businesses operate and compete in.

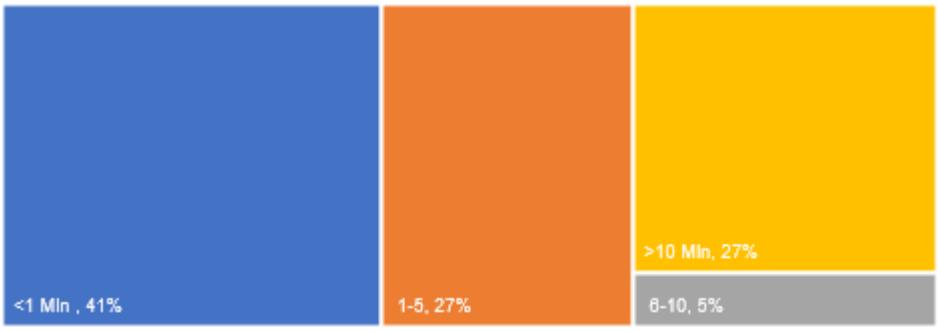


Figure 92: Market-size (in number of customers and/or consumers)

Source: Author

Another area for understanding the market for women entrepreneurs was to look at the value of the market, this was essential to understand the size of existing opportunities [100] (and how much of this market has been tapped, which is called market share – which is the next most important indicator of women entrepreneur's business profiles).
It was found that most women entrepreneurs see the size of the market at more than $500 Million (30% of respondents,Figure 93: Market-size (in value US$)) and if the range is further widened 57% of respondents indicated their market size by value of more than $101 Million, which looks sizeable with respect to the size and operations of these women-owned businesses. The question about how much of this market is being tapped by these women entrepreneurs was answered when these women were asked about their market share in % (Figure 94: Market-share of Women Entrepreneurs).

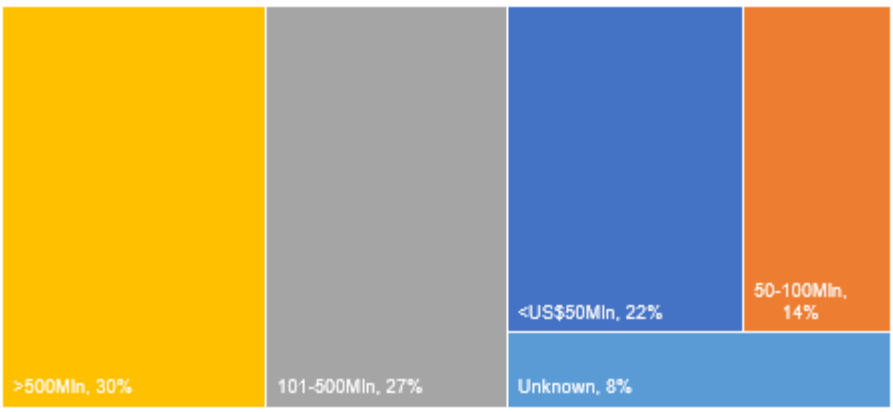


Figure 93: Market-size (in value US$)

Source: Author

Third, to find out the space in which women entrepreneurs competed. Respondents were asked if they knew women entrepreneurs in their industry and it was found to be extremely low with more than half of the respondents (59% of respondents) indicating less than three women entrepreneurs in the entrepreneurial ecosystem[101]. When asked about the broader market, which included both men and women competing for the same consumer wallet, it came out that a large share of respondents (56% of respondents) agreed that there were more than 8 competitors in their market

[101] This number for women entrepreneurs was seen as standard across different energy products and services, but in case of women businesses operating in the agricultural space it was found there were more women entrepreneurs and in some places some at par with men e.g. in agricultural processing sector in Senegalese women.

space (this number related to highly commoditized energy products like solar panels could see competitors going up to the thousands in countries like Nigeria and Ghana).

To understand the present status of women-owned businesses and their position in the market, it was necessary to find out their market share – this parameter was helpful in understanding their present position and scope of growth in their market to enhance their operations by achieving efficiencies. From their responses most of the women-owned businesses, a significant 61%, are below 10% market share and surprisingly there are 25% who hold more that 30% of market share.

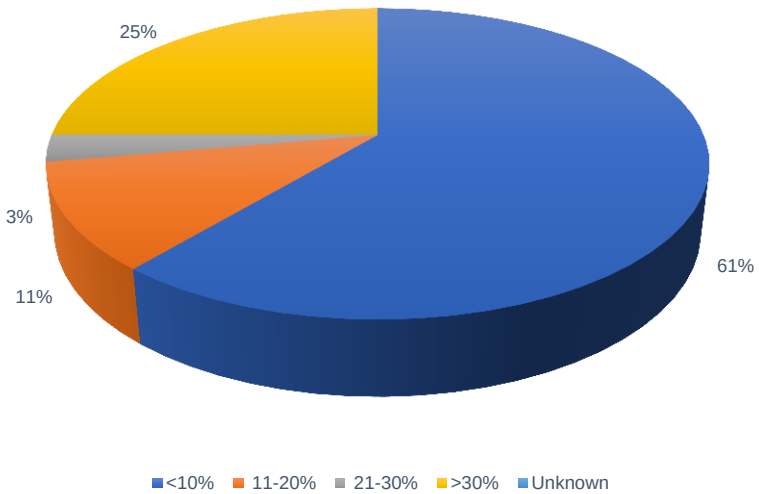


Figure 94: Market-share of Women Entrepreneurs

Source: Author

The presence of both women and men competitors in an entrepreneurial ecosystem illustrates the market's margin, sustainability, and vibrancy, which allows benefits to be passed to consumers and allows innovative technologies to migrate and diffuse along the value chain. Furthermore, the lower market shares held by the majority of women illustrates that either there is more market to be captured (which women are not able to capture due to certain challenges) or the market is highly fractured which might be gradually maturing/entering a consolidation phase offering opportunities for mergers and acquisitions.

Fourth, it is well understood that every business should produce returns that justify the risks taken for running a business; this return or profitability metric also points out to sustainability and intrinsic value in the energy value chain for women entrepreneurs.

Exploring this question resulted in encouraging results whereby the majority of women entrepreneurs could consistently achieve a range of 15-25% on their net margin realization (for 77% of respondents). Again, this varies depending on the product or service the entrepreneurs are involved in, but overall the margin structure is quite attractive.

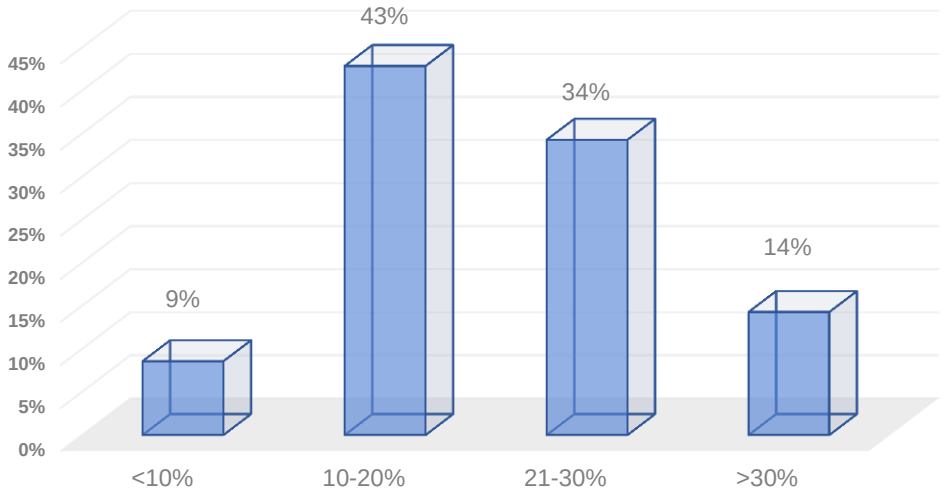


Figure 95: Margins in Women-owned businesses

Source: Author

This indicates that not only the majority of women-owned businesses are profitable, but also that they can provide healthy returns to potential investors and financiers. Worth mentioning is that the majority of women entrepreneurs bootstrapped and run their business with their own equity or low-level borrowing from lenders thereby restricting their capacity to expand or invest in their business.

Fifth, when looking at the growth rate of these women-owned businesses in last 3 years and for the next year and it was concluded that most businesses have grown between 10-50% in the last 3 years and expect to grow by 10-50% in the next year, indicating a growing market demand and women entrepreneurs' sense of optimism in their markets. It was clear that even commoditized businesses like solar systems, solar lighting, etc. saw growths of more than 10% per year.

	5 >100%	4 (50-100%)	3 (50%)	2 (10-50%)	1 (<10%)
Last 3years	10	5	3	11	3
Next year	8	5	4	16	2

Table 4: Number of Women Entrepreneurs citing their past and future business growth

Source: Author

Finally, but most importantly, women were about the low representation of women entrepreneurs in the energy value chain to understand the soft factors that restricted women participation. This low participation of women in the energy sector is a perspective that requires being incorporated into the policy-building tool to achieve targets for gender mainstreaming.

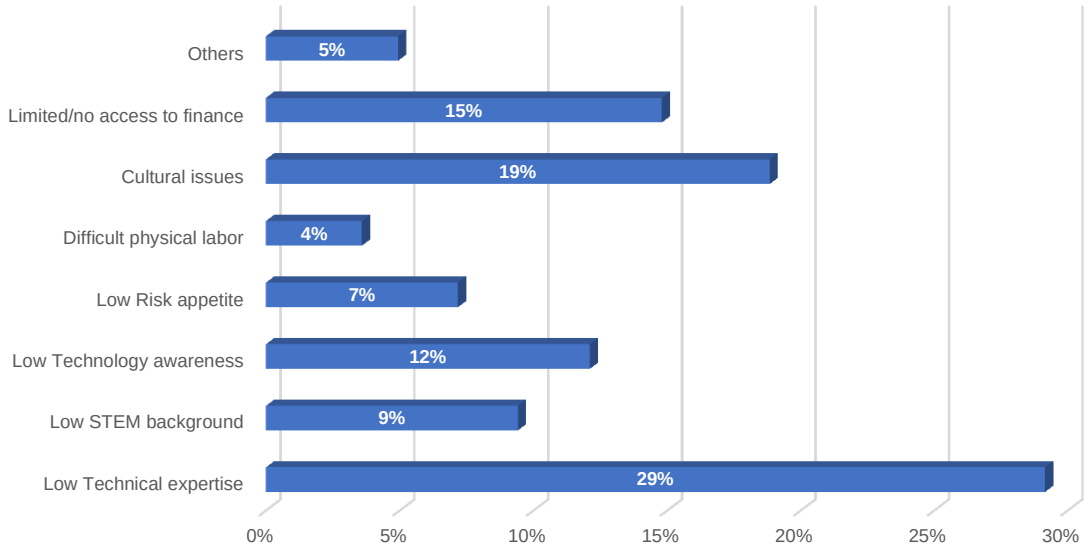


Figure 96: Reason for less Women Entrepreneurs

Source: Author

It is interesting that the major reason 29% of respondents pointed out was related to low technical expertise, if STEM education, technical expertise, and technology are taken into account, 50% of the respondents would point out that technical aspects (Technical expertise, STEM background and Technology awareness) are a significant barrier for women to participate in the energy business. "The gender education gap is magnified in the fields of science, engineering, technology and mathematics (STEM). Even in countries with very advanced gender equality, women still encounter resistance to studying STEM fields in technical and vocational education and training (TVET) programs where many are corralled into traditional female disciplines such as food, garment, and other sectors (UNESCO-UNEVOC, 2011)."[102]

"The real disadvantage is that, overall, fewer women have the necessary educational and work experience to be able to enter the energy sector at the same rates as men. The same finding was reported for female technical staff at the agencies represented by the ECOW-GEN Technical Advisory Group (TAG): that the female candidate selection pool was simply too small"[103]. The findings from this research as well as from other sources, clearly point out that entrepreneurship for women in the energy value chain is a symptom of a problem which is more fundamental in nature and that there are less number of women participating in STEM education. This would require a policy intervention to incentivize and subsidize women entry into TVET programs by means of scholarships (from public and private enterprises), educational loans from commercial banks and public enterprises on zero or subsidized rates, and preferential admission quotas for women in STEM courses at national and private colleges and universities.

Also worth mentioning is that cultural issues play a significant secondary deterrent and with access to finance following closely as the third deterrent which discourage women from getting into energy related businesses.

[102] ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREE) (2015) 'Situation Analysis of Energy and Gender Issues in ECOWAS Member States 2015'.
[103] Ibid

Considering that cultural issues were consistently mentioned during the interviews we felt it was necessary to see how these countries actually ranked on gender gap, based on the World Gender Gap Rankings[104] as shown in **Error! Reference source not found.**, with the objective of having a good understanding of the gender ecosystem as it exists in the 4 selected countries (from third party perspective). Based on the ranking of gender gaps, it is fair to say there are lots of obstacles for women to grow in any sector in these countries (even though Ghana offers a much more conducive environment vis-à-vis, it still has long way to go to be part of the top-50 in the world gender gap rankings).

SUB-SAHARAN AFRICA

Country	Overall rank	Overall score
Rwanda	4	0.822
Namibia	13	0.777
South Africa	19	0.756
Burundi	22	0.755
Mozambique	29	0.741
Uganda	45	0.721
Botswana	46	0.720
Zimbabwe	50	0.717
Tanzania	68	0.700
Ghana	72	0.695
Lesotho	73	0.695
Kenya	76	0.694
Madagascar	80	0.692
Cameroon	87	0.689
Cape Verde	89	0.686
Senegal	91	0.684
Malawi	101	0.672
Swaziland	105	0.670
Liberia	107	0.669
Mauritius	112	0.664
Guinea	113	0.659
Ethiopia	115	0.656
Benin	116	0.652
Gambia, The	119	0.649
Burkina Faso	121	0.646
Nigeria	122	0.641
Angola	123	0.6402
Côte d'Ivoire	133	0.6114
Mali	139	0.5831
Chad	141	0.5750

Figure 97: Gender Gap Ranking (Africa)

We also observed that cultural issues was the next key issue restricting women's participation in the energy value chain – "Outside of the workplace, other social norms related to childcare, care for the elderly, and domestic work impinge disproportionately on women's time management, flexibility, and mobility, capabilities arguably needed in certain clean energy subsectors"[105]. The third crucial factor which limits women's participation in the energy value chain is limited access to finance, and the reasons for this are covered separately in this report.

However, the main factor that restricts women from getting funding from commercial banks or funds is due to the absence of tangible collaterals, which women entrepreneurs find particularly difficult to provide due to social and cultural standards of paternal inheritance norms and male-dominated ownership of family assets. However, discussions with both women entrepreneurs and banking institutions show that both are skeptical about approaching each other - women entrepreneurs are not familiar with banking products and collateralization procedures while commercial banks find energy based technologies comparatively new and risky (with respect to conventional trading products like – agricultural, consumer goods, etc.) and would primarily resort to asset based lending[106] which is difficult for women entrepreneurs to qualify.

The World Energy Investment Report 2017 mentioned that "In many cases, it is unclear whether the business models in place are conducive to encouraging adequate investment in flexible electricity assets, raising concerns about electricity security. Continuous investment in flexible assets to ensure system adequacy during periods of peak demand and to help integrate higher shares of wind and solar PV capacity into the system is essential. The bulk of the flexibility that has been introduced so far has come from existing assets, primarily dispatchable capacities (mainly gas-fired plants and hydropower) and transmission interconnections. In 2016, the amount of new flexible generation capacity plus grid-scale storage that was sanctioned worldwide fell to around 130 GW – its lowest level in over a decade, reflecting weaker price signals for investment stemming from ongoing regulatory uncertainty and flawed market designs. For the first time, this capacity was virtually matched by the 125 GW of variable renewables capacity (solar PV and wind) commissioned in 2016, whose construction times are generally a lot shorter. *The 6% increase in electricity network investments in 2016, with a larger role for digital technologies, supports grid modernization and the ongoing integration of variable renewables. However, new policies and regulatory reforms are needed to strengthen market signals for investment in all forms of flexibility*."

[104] Terjesen, S. and Llyod, A. (2015) 'The Female Entrepreneurship Index ((FEI)', (Global Entrepreneurship and Development Institute).
[105] ECOWAS Center for Renewable Energy and Energy Efficiency (ECREE) (2015) 'Situation Analysis of Energy and Gender Issues in ECOWAS Member States 2015'.
[106] The bank evaluates the credit risk based on the balance sheet of the borrower looking into elements like –: assets, net worth, liabilities, sales turnover and sales growth

Overall, the business model of women entrepreneurs can be summed up to be 'product-based innovative service delivery model' that charges premiums to customers for providing them access to these products and services in their area.

5.3. Operating model/capabilities

Company operations involve daily business functions, tactical maneuvers, commercial contracting, and overall supply chain challenges. We tried to evaluate this aspect by looking at business to identify both explicit and implicit challenges, and strengths in women-led businesses.

Most respondents highlighted that top drivers of their business were – a strong relationship with buyers and suppliers, innovative products, and innovative service. These three aspects allowed women entrepreneurs to drive their profitability and allowed them to access a pool of suppliers and buyers that offered them a premium for their products and services.

Figure 98: Profitability Drivers for Women Entrepreneurs

Source: Author

Even though these women entrepreneurs have tried to overcome the hurdles and are established and continue to grow their businesses, they face external hardships that are not allowing them to grow. The main challenges that affect women entrepreneurs are: access to finance, supply chain management, and labor availability.

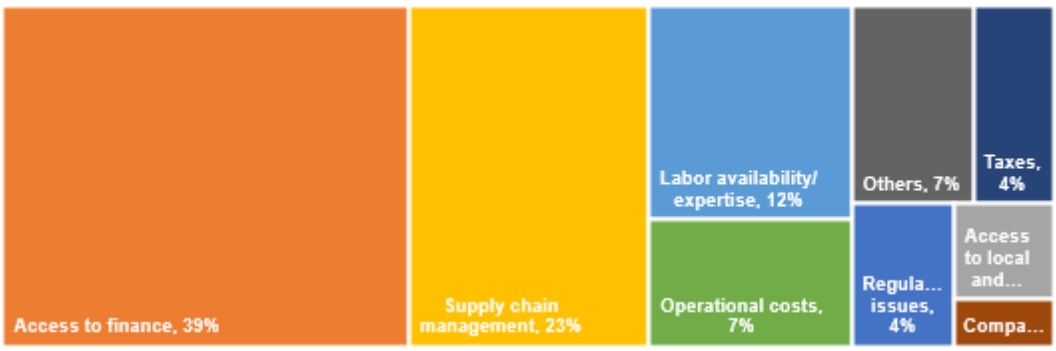


Figure 99: Operational Challenges for Women Entrepreneurs

Source: Author

- Access to finance – this challenge has been very difficult for women entrepreneurs, and they find it increasingly difficult to tackle. This is driven by both, the lending institutions (banks and funds), as well as the women entrepreneurs themselves. The comprehensive understanding of this aspect is discussed in detail under the financial challenges section in this report Figure 108: Challenges for accessing finance by Women Entrepreneurs.

- Supply chain management – this is more an operational issue and is driven by operational capabilities within the company in order to manage and mitigate supply chain risks. Most of the women-owned companies face problems with recruiting a qualified labor force that can help them manage supply chain challenges.
- Labor availability – there is difficulty getting trained and technically qualified workers, which if available is expensive and most women-owned businesses find it difficult to recruit these experts. They usually hire low expertise labor and then try to train them on-the-job which results in high training costs and employee error risks.

Most women, 46% of respondents, believe that if the challenges they have cited are resolved they can grow their business by at least 50% over the next three years and 43% of respondents expect to employ more than 35 new employees over their present employee strength.

5.4. Human resources model

An organization is made of employees, and their skills and attitudes configure the core of organizational capabilities – which are its strengths and weaknesses. Not only do employees strengthen company execution capabilities but also, they help the company fight internal and external forces to deliver consistent product and services to customers. They are regarded as drivers of culture and performance within the company. An evaluation consisted of enumerating total employees, women employees and identifying the labor challenges women business owners face in hiring, training, and retaining employees.

It was seen that most of the women businesses have around 11-20 employees (43% of respondents) who are predominantly technical experienced to deliver the installation and maintenance services for the company. Another small number of employees is in administration and documentation.

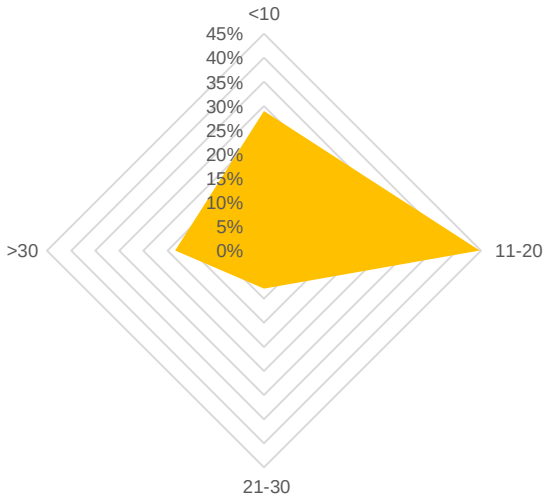


Figure 100: Employee Profile of Women-owned businesses

Source: Author

It is interesting to note that women entrepreneurs tend to hire a sizable portion of women employees (46% of respondents) within their team, and actively coach and train them on-the-job. When comparing this data with the results from the World Bank Enterprise survey[107] for the 4 selected countries, it showed very similar results to what was discovered during the interviews with women entrepreneurs.

[107] http://www.enterprisesurveys.org/Custom-Query#hReprtpreview

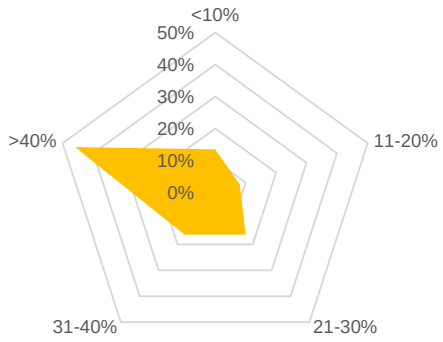


Figure 101: Women Employees in Women-owned businesses

Source: Author

Women find it difficult to get suitably skilled women employees due to low availability of technical expertise among women. Another interesting observation is that women-owned businesses recruit a higher proportion of women for both production (technical) and non-production, but in men owned businesses this was not the case – men consistently recruited fewer women employees irrespective of the business function.

Country	Female/Male - Owner or Top Manager	The proportion of permanent full-time workers that are female (%)
Côte d'Ivoire	Female	53.3
Côte d'Ivoire	Male	17.3
Ghana	Female	50.8
Ghana	Male	19.8
Nigeria	Female	48.6
Nigeria	Male	20.1
Senegal	Female	50.0
Senegal	Male	15.6
	Average if Female (%)	**50.7**
	Average if Male (%)	**18.2**

Table 5: Proportion of Women Employees in Female/Male owned/led businesses-1

Source: World Bank Enterprise Survey 2017

After looking at the World Bank Enterprise survey numbers and comparing them with the world and regional averages it was found that all 4 selected countries did not fare well in the proportion of female employees in those countries' companies.

Economy	The proportion of permanent full-time workers that are female (%)	The proportion of permanent full-time production workers[108] that are female (%)*	The proportion of permanent full-time non-production workers that are female (%)*
All Countries	**32.4**	**25.4**	**35.2**
Sub-Saharan Africa	**28.2**	**19.4**	**30.4**
Côte d'Ivoire	22.7	17.1	26.0
Ghana	24.7	18.0	32.8
Nigeria	24.3	24.2	19.3
Senegal	20.7	9.3	25.3

Table 6: Proportion of Women Employees in Female/Male owned/led businesses-2

Source: World Bank Enterprise Survey 2017

[108] This data is for manufacturing companies only while our survey data is for energy sector, but the similarities are quite astonishing

When these results from World Bank Enterprises survey are compared with our findings from interviewing the women entrepreneurs we see that energy business that were women-owned had significantly higher number of women employees then the national averages.

Among the labor challenges that women entrepreneurs faced the biggest challenge concerns training employees. Employees are mostly trained on the job with two implications – the efforts used in training these employees have the effect of shifting the focus of the business to training rather than on core business development activities. Furthermore, since these employees are in the learning phase, there is a higher occurrence of mistakes and lapses affecting product or service delivery to customers. These, of course, increase the working capital costs of women entrepreneurs. Eventually, the result is that the business owner is herself involved in training the new employees.

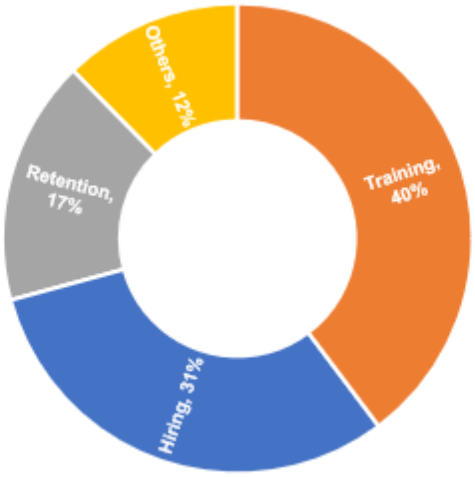


Figure 102: Labor Challenges for Women Entrepreneurs

Source: Author

The second challenge is hiring the right employees. It is always difficult to get a technically qualified workforce, and due to cultural aspects, men do not like to work for a woman entrepreneur as head of the company. Moreover, it is difficult to get suitably technically qualified women due to fewer women engineers, or vocational trained graduates. Because of these two labor challenges, most women entrepreneurs end up incurring in high labor costs.

5.5. Financial performance

"Financial performance is a subjective measure of how well a firm can use assets from its primary mode of business and generate revenues. This term is also used as a general measure of a firm's overall financial health over a given period and can be used to compare similar firms across the same industry or to compare industries or sectors in aggregation."[109]

Financial management is at the heart of a company and allows it to grow, operate and be sustainable; without strong finances a company is liable to fail and disintegrate. This meant looking at the financial aspects a company, taking a deep dive into its financial health and its linkages with company operations to identify areas that can illustrate the true functioning of women-owned businesses. The revenue and cost structure of women entrepreneurs were evaluated to understand the scale and size of their operations. Most of the women entrepreneurs had revenues of more than $50,000 per annum, and geographically, based on the revenue size of women held business, we observed larger revenue sized businesses in Nigeria, followed by Cote D'Ivoire, Ghana and Senegal.

[109] https://www.investopedia.com/terms/f/financialperformance.asp

While evaluating the costs, it was found that 78% of the women-owned businesses have costs of more than US$50,000 per year so a lower profit scale would have a detrimental effect on their margins. This is also clear from the fact that the larger costs are in inventory (42% of the total according to respondents) and other significant costs are in labor and transportation.

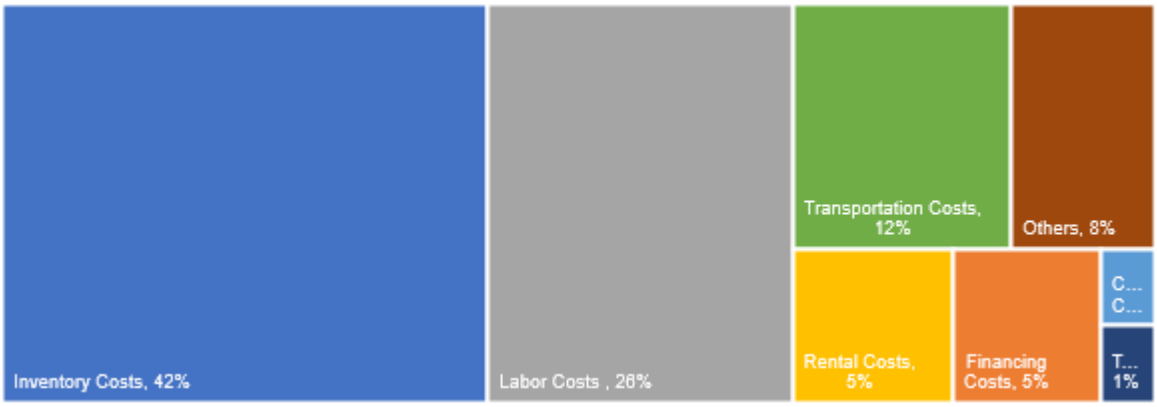


Figure 103: Cost drivers for Women-owned businesses

Source: Author

"Inventory costs are the costs associated with the procurement, storage, and management of inventory. It includes costs like ordering costs, carrying costs and shortage/stock out costs. Inventory costs can be categorized into three sub-headings-

a) **Ordering cost** of inventory refers to the cost incurred for procuring inventory. It includes the cost of purchase and the cost of inbound coordination. To minimize the ordering cost of inventory this study used of the concept of EOQ or Economic Order Quantity[110].

b) **Carrying cost** of inventory refers to the cost incurred towards inventory storage and maintenance. Inventory storage costs typically include the cost of renting a building and other infrastructures that are needed to preserve inventory. The inventory carrying cost is dependent and varies with management's decision to manage inventory in-house or through outsourced vendors and third-party service providers.

c) **Shortage or stock out** costs and cost of replenishment are the costs incurred due to unusual circumstances. They usually form a very small part of the total inventory cost"[111]

Being a product-driven business, a huge amount of women's business capital is stuck with inventory that is either stored or transported which means high inventory costs.

Solutions: Ways to reduce inventory costs involve –

1. better sales forecasting,
2. supplier tie-ups for extended payments and no or low advance payments,
3. just in time inventory levels,
4. reducing inventory by faster sales liquidation of finished goods from a warehouse or in-transit sales

The second major cost is labor cost (26% of the total according to respondents) which is: wages paid to workers during an accounting period on daily, weekly, monthly, or job basis, plus payroll and related taxes and benefits (if any).[112]

Solutions: Ways to reduce labor costs involve –

1. proper labor allocation,

[110] economic order quantity (EOQ) is the order quantity that minimizes the total holding and ordering costs. It is one of the oldest traditional production scheduling models.

[111] https://www.mbaskool.com/business-concepts/operations-logistics-supply-chain-terms/15039-inventory-costs.html

[112] http://www.businessdictionary.com/definition/labor-cost.html

2. matching skills with job requirements,
3. hiring project-based labor from third-party companies and
4. evaluating labor performance against profitability

The third significant cost is transportation costs (12% of the total according to respondents) which refers to expenses involved in moving products or assets to a different place, which costs are often passed on to consumers. For example, a business would generally incur in transportation costs if it needs to bring its products to retailers to have them sold to consumers[113]

Solutions: Ways to reduce transportation costs involve –

1. optimization of transport planning by utilizing 3PL companies,
2. transport contracting for annual contracts under fixed pricing and
3. predictable vehicular allocation and
4. load sharing

"Working capital is a common measure of a company's liquidity, efficiency, and overall health. Because it includes cash, inventory, accounts receivable, accounts payable, the portion of the debt due within one year, and other short-term accounts, a company's working capital reflects the results of a host of company activities, including inventory management, debt management, revenue collection, and payments to suppliers. Positive working capital generally indicates that a company can pay off its short-term liabilities almost immediately. Negative working capital generally indicates a company is unable to do so. Therefore, analysts are sensitive to decreases in working capital; they suggest a company is becoming overleveraged, is struggling to maintain or grow sales, is paying bills too quickly, or is collecting receivables too slowly. Increases in working capital, on the other hand, suggest the opposite. There are several ways to further evaluate a company's working capital, including calculating the inventory-turnover ratio, the receivables ratio, days payable, the current ratio, and the quick ratio.
One of the most significant uses of working capital is inventory. The longer an inventory sits on the shelf or in the warehouse, the longer the company's working capital is tied up.
When not managed carefully, businesses can grow themselves out of cash by needing more working capital to fulfill expansion plans than they can generate in their current state. This usually occurs when a company has used cash to pay for everything, rather than seeking financing that would smooth out the payments and make cash available for other uses. As a result, working capital shortages cause many businesses to fail even though they may turn a profit. The most efficient companies invest wisely to avoid these situations.
Analysts commonly point out that the level and timing of a company's cash flows are what really determine whether a company can pay its liabilities when due. The working-capital formula assumes that a company really would liquidate its current assets to pay current liabilities, which is not always realistic considering some cash is always needed to meet payroll obligations and maintain operations."[114]

The working capital cycle of companies was evaluated to understand the heart of their operations[115]. There are two aspects of the working capital cycle that were analyzed:

1. Components of the working capital cycle and the contribution of each component to the total working capital cycle (composition) and

2. The average number of days in each part of the average working capital cycle.

[113] http://www.businessdictionary.com/definition/transportation-cost.html
[114] http://www.investinganswers.com/financial-dictionary/financial-statement-analysis/working-capital-869
[115] The limited scope of this project did not allow us to undertake detailed working capital analysis which would have required analyzing businesses financial statements so we took a different approach to get the right perspective of working capital cycles of women-owned businesses

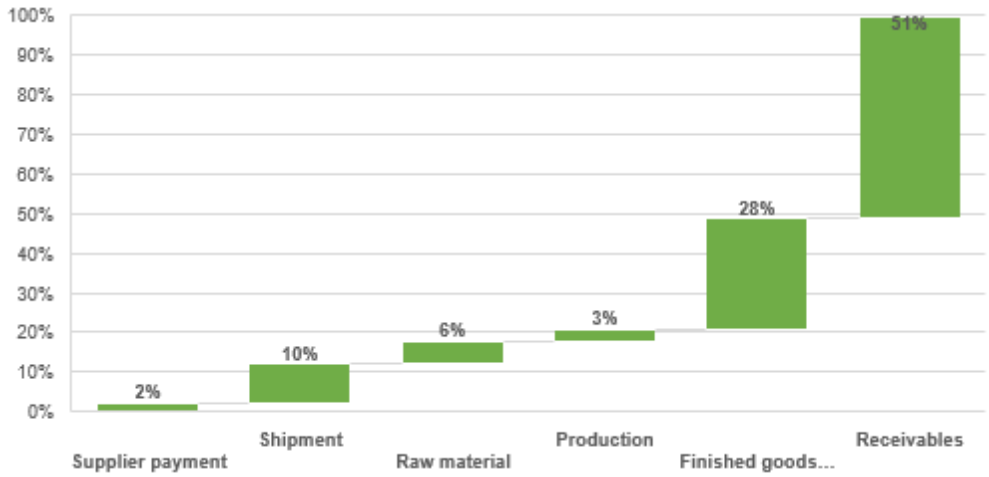


Figure 104: Working Capital Cycle (Composition)

Source: Author

It was found that the last step in the supply chain transaction is where women entrepreneurs faced a huge jump in working capital requirements and this jump had a ripple effect across the complete working capital cycle and impacted their procurement and processing/installation activities. Receivables and Finished Goods Inventory + Installation accounted for almost 79% of their working capital cycle requirements which can be easily bridged with short-term borrowing or structured trade finance instruments from banks.

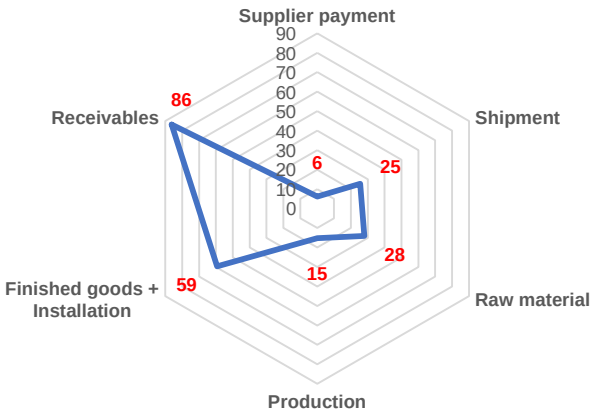


Figure 105: Average Working Capital Cycle

Source: Author

The same jump in receivables and finished goods + installation in an average number of days was noticed which contributed to 126 days out of 161 days (or around 79% of average working capital cycle). The average working capital needs be seen from both operational and financial perspectives – from an operational standpoint, structure operational activities like reducing inventory holdings, decreasing installation times, etc., and from a financial standpoint, reduce credit periods to customers, obtain bank financing, etc.

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Solutions: Ways to reduce working cycle time involve –

1. optimization of supply chain planning by utilizing forecasting inventory needs,
2. reduced lead times,
3. longer and larger supplier credit,
4. inventory as an-asset backed financing from banks or structured trade financing,
5. lower inventory levels by faster sales,
6. reduced market receivables by faster collection or selling the receivables to third party collection agencies

After estimating the working capital, it was imperative to understand how the company funds the present business cycles, and it was learned that almost 65% of women-owned businesses are funded with their own equity (42% of respondents) and grants/developmental finance (23% of respondents). Both these sources provide them with limited financial resources to grow their businesses. Hence, women businesses are smaller in size and are difficult to grow from their present level of operations.

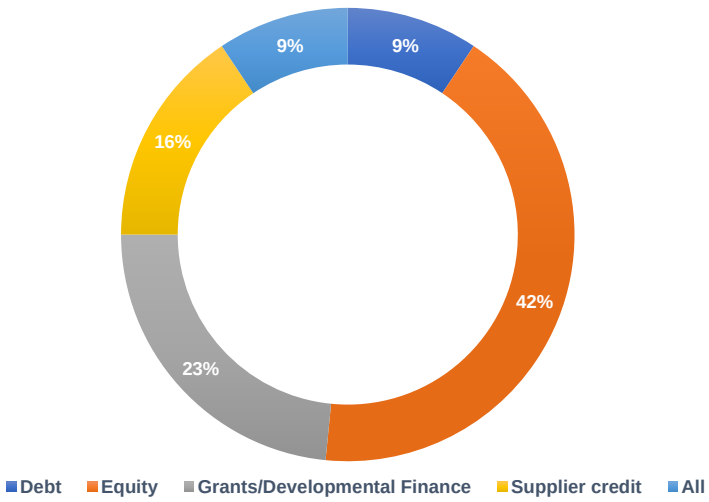


Figure 106: Financing of Women-owned businesses

Source: Author

Almost all women entrepreneurs have approached banks, micro-finance institutions, developmental institutions and funding organizations either directly or indirectly seeking finance but have found it extremely difficult to get the desired funding. “Female-backed digital businesses are proving to be good for the Continent as well as investors. According to a study by First Round Capital, founding teams that include women, out-perform their all-male peers by 63 percent. Funds such as Alethia Identity Managers and WDB Investment Holdings are focused on investing in women-led businesses or the social or economic empowerment of women in the Continent”[116] . However, if we look at the present status of funding for these entrepreneurs, it paints a dismal picture - with only 2% women getting funding from commercial banks.

[116] https://www.entrepreneur.com/article/299590

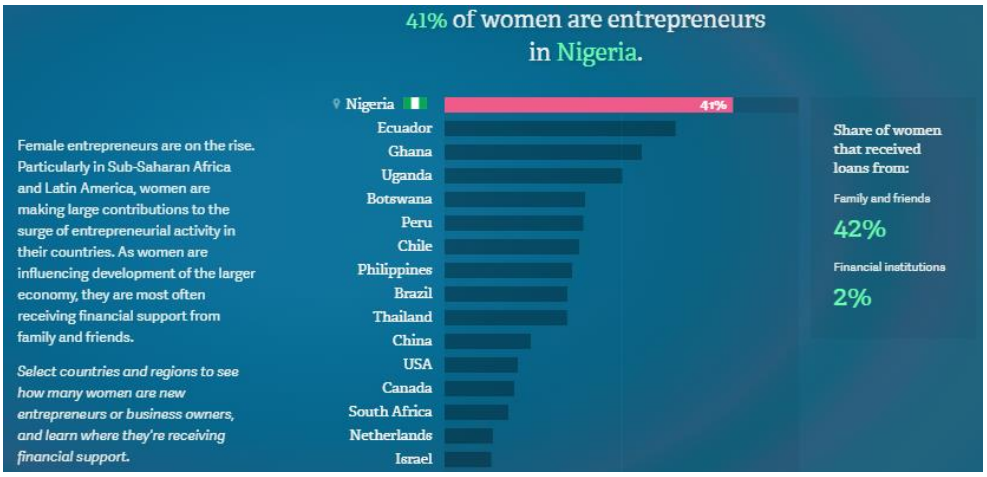


Figure 107: Women Entrepreneurs and Access to Finance from Financial Institutions (Nigeria)[117]

When this study evaluated women entrepreneurs' present relations with commercial banks, it was found that all women maintain at least two current accounts with their bankers and only 31% of women-owned businesses have a loan with a commercial bank, micro-finance institution or private lending institution. Almost all these facilities are 3-5year term loans with interest rates of around 15% p.a.

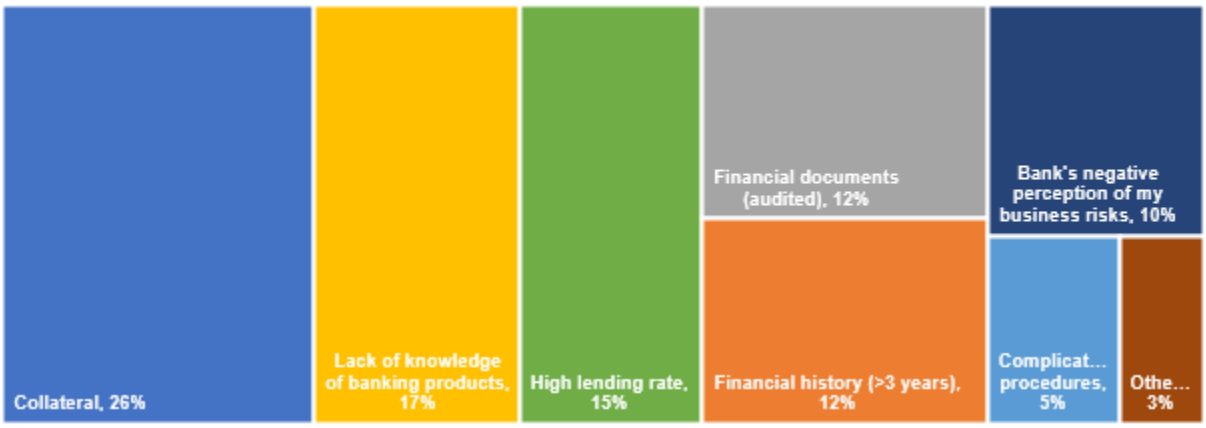


Figure 108: Challenges for accessing finance by Women Entrepreneurs

Source: Author

Three top factors that restricted women entrepreneurs from accessing funding from banks include: the requirement of collaterals from banks , women entrepreneurs' inadequate knowledge of banking products and high lending rates. All these three factors need to be addressed with the involvement of both banks and women entrepreneurs and might require a two ways communication to be established between the two parties. This can be achieved if:

- Banks are
  - helped to understand women entrepreneur's businesses where inventory assets may be collateralized
  - product knowledge is disseminated by banks to prospective women entrepreneurs and
  - government and multi-lateral support may be used to reduce high lending rates
- Women entrepreneurs
  - evaluate and quantify their business risks and rewards
  - start with small commercial borrowing and gradually increasing their debt-equity mix

[117] First Round Capital

- partner with investors that provide them with exposure and credibility to borrow and get trained in managing working and financial capital

Furthermore, they need to understand bank requirements to be able to approach them with the right type of information in order to get credit approval. As discussed with bankers in the four countries it was clear that they follow the 5C principles for credit evaluation - character, capacity, capital, collateral, and conditions. "The five C's of credit is a system used by lenders to gauge the creditworthiness of potential borrowers. The system weighs five characteristics of the borrower and conditions of the loan, attempting to estimate the chance of default. The five C's of credit method of evaluating a borrower incorporates both qualitative and quantitative measures. Lenders look at a borrower's credit reports, credit score, income statements and other documents relevant to the borrower's financial situation, and they also consider information about the loan itself.

a) **Character**
   Sometimes called credit history, the first C refers to a borrower's reputation or record of accomplishment for repaying debts. This information appears on the borrower's credit reports these credit reports contain detailed information about how much an applicant has borrowed in the past and whether he has repaid his loans on time. These reports also contain information on collection accounts, judgments, liens, and bankruptcies

b) **Capacity**
   Capacity measures a borrower's ability to repay a loan by comparing income against recurring debts and assessing the borrower's debt-to-income (DTI) ratio. In addition to examining income, lenders look at the length of time an applicant has been at his job and job stability.
c) **Capital**
   Lenders also consider any capital the borrower puts toward a potential investment. A large contribution by the borrower decreases the chance of default. Down payments indicate the borrower's level of seriousness, which can make lenders more comfortable in extending credit.
d) **Collateral**
   Collateral can help a secure borrower loans. It assures the lender that if the borrower defaults on the loan, the lender can repossess the collateral. For example, car loans are secured by cars, and mortgages are secured by homes.
e) **Conditions**
   The conditions of the loan, such as its interest rate and amount of principal, influence the lender's desire to finance the borrower. Conditions refer to how a borrower intends to use the money. For example, if a borrower applies for a car loan or a home improvement loan, a lender may be more likely to approve those loans because of their specific purpose, rather than a signature loan that could be used for anything."[118]

Out of the 5C's listed above most women entrepreneurs will not be able to qualify for all factors except a few women entrepreneurs who have the financial credit history, capital, and collateral to borrow.
When looking at the collaterals (tangible) women entrepreneurs are able to provide – 29% can provide land, 19% can provide building, 29% can provide movables and the remaining 23% can provide deposits. It is rare to find women entrepreneurs who can provide all of these collaterals; mostly they can only provide one. Another requirement that banks usually require is a personal guarantee, which is quite difficult to estimate and exercise, and the majority of women entrepreneurs do not wish to provide such a document as they do not understand the consequences and fear getting in problems.
Because of the limitations of bank funding, most women entrepreneurs would like to have a mix of all types of funding options (50% of respondents) to create a diversified financing pool.

[118] https://www.investopedia.com/terms/f/five-c-credit.asp

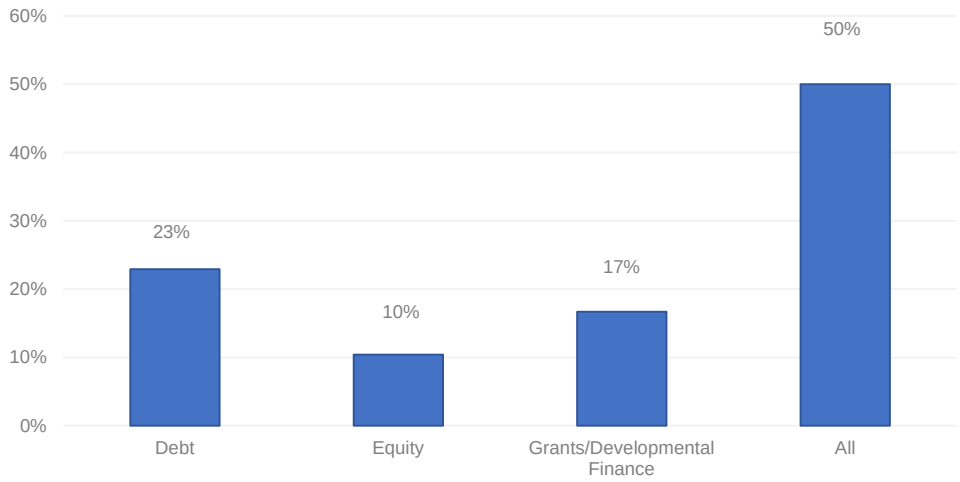


Figure 109: Desired Financing Types

Source: Author

Creating a funding mix with inclusion of debt is extremely important for renewable energy projects specially when looking at setting-up off-grid solar/PV projects – the illustration below shows the impact of borrowing costs and over LCOE of the project (this is an example of global model comparing two environments – High Financing Cost and Low Financing Cost) – if these are tested for women-owned businesses, they might show some variations but the impact will be more or less the same (e.g., cost of debt in most of the 4 selected countries is around 15-20% (or High Financing Cost Environment) and factual equity is more expensive than debt so if this model is applied to the 4 selected countries-based businesses, the impact is going to be substantial).

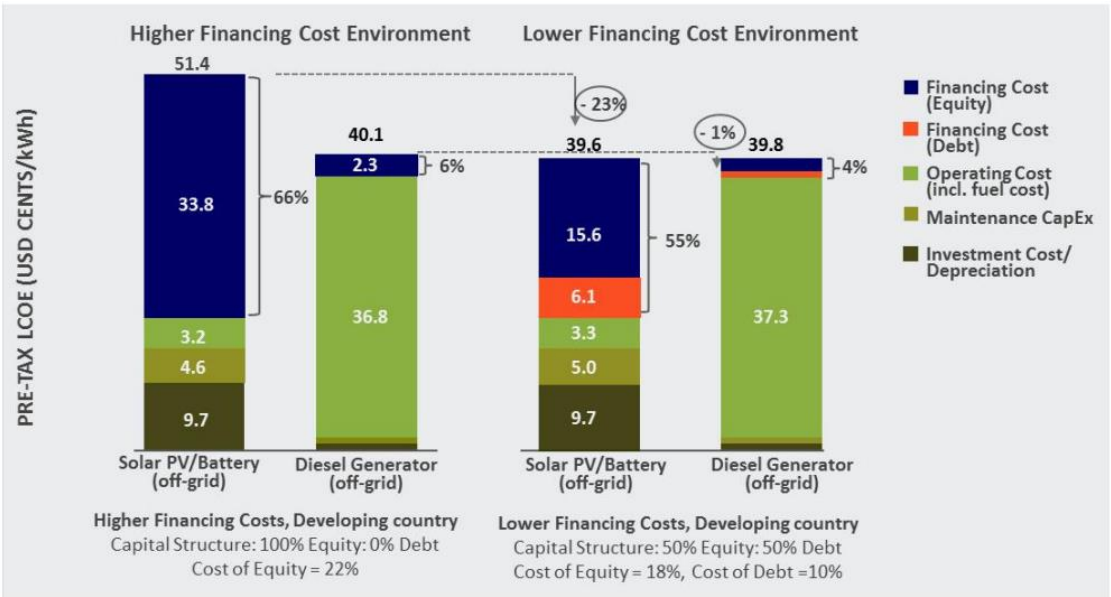


Figure 110: Impact of Cost of Borrowing on LCOE of Project[119]

Within asset finance investments, the major form of security continues to be the balance-based sheet followed by project financing and bonds, and the main focus for financing has been in the areas of Wind, Solar and Biomass technologies.

[119] Glemarec, Y., Bayat-Renoux, F. and Waissbein, O. (2016) 'Removing barriers to women entrepreneurs' engagement in decentralized sustainable energy solutions for the poor', *AIMS Energy*, 4(1), pp. 136–172. doi: 10.3934/energy.2016.1.136.

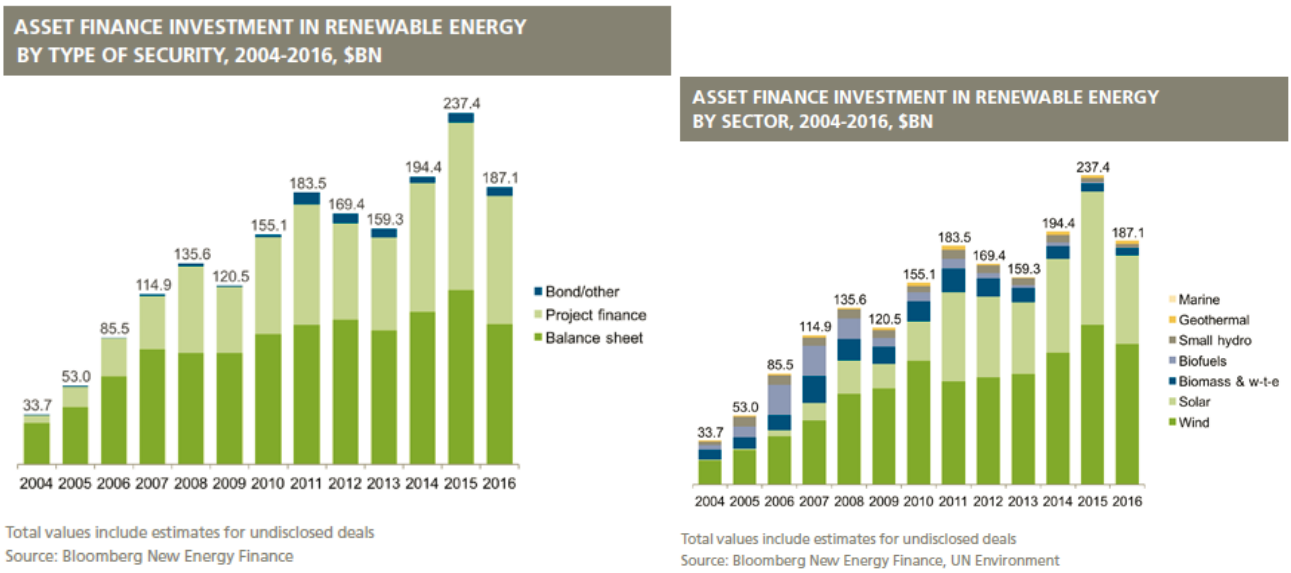


Figure 111: Trends in Asset Finance Investment in Renewable Energy by Security and Sector

The funding requirements for women entrepreneurs are in two areas – their working capital requirements and their project financing requirements. The majority is looking for funds higher than US$150,000 to fund their operations in any form (term loans or structured trade finance arrangements).

Average Total Funding Requirement:
Immediate US$3 Million
Next 3 years: US$11 Million

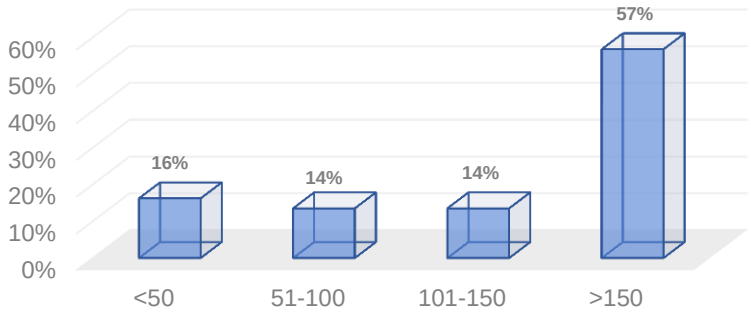


Figure 112: Working Capital Requirements

Source: Author

The working capital requirement for most women owned businesses are over US$150,000 and can go up to US$3 Million depending on the size of the business. For project financing, women entrepreneurs are looking at funding between US$150,000 – US$ 450,000 (around 40% of respondents) and, in some cases, larger ticket sizes of over $1.3 Million (20% of respondents). These projects vary in nature. First, on the solar products side, the funding needs are related to asset development for logistics and transportation. Second, on the generation side it is more into setting up mini and micro-grid community networks and setting up electricity generation plants from biomass and solar technologies. Third, on the smart services side is on data storage and processing.

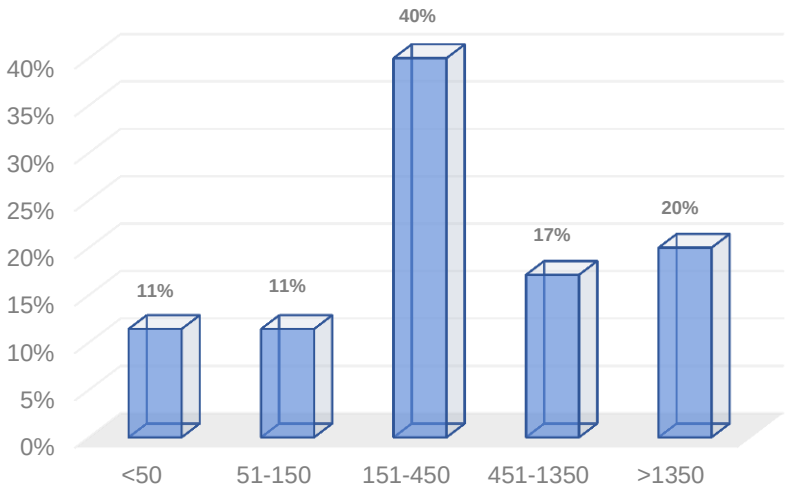


Figure 113: Project Finance Requirements

Source: Author

Equity-based financing is a conventional tool to access financing (primarily at the early or late stages of ventures), so this study also asked if women entrepreneurs were interested to dilute part of their ownership to get access to a pool of funds from funding organizations and private equity funds. We saw that 86% of women entrepreneurs responded positively and would like to see foreign or local investors/funds participate as partners in their growth. They are ready to reduce up to 30% (68% of respondents) of their ownership within the company. The venture capital ('VC') funding has been primarily focused on solar, wind and some biomass and bio-fuels – which makes it possible to project women entrepreneurs in these sectors for VC funding.

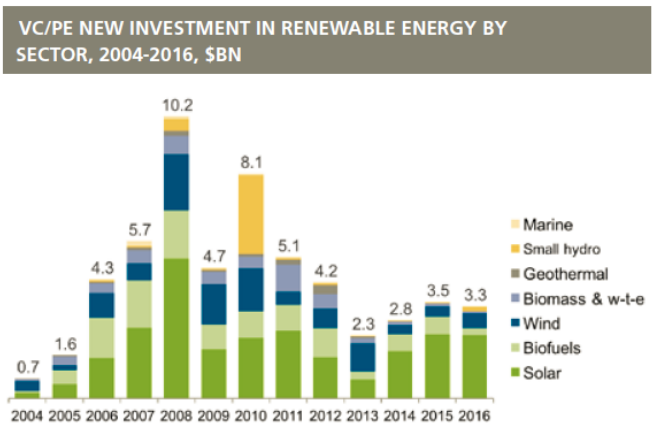
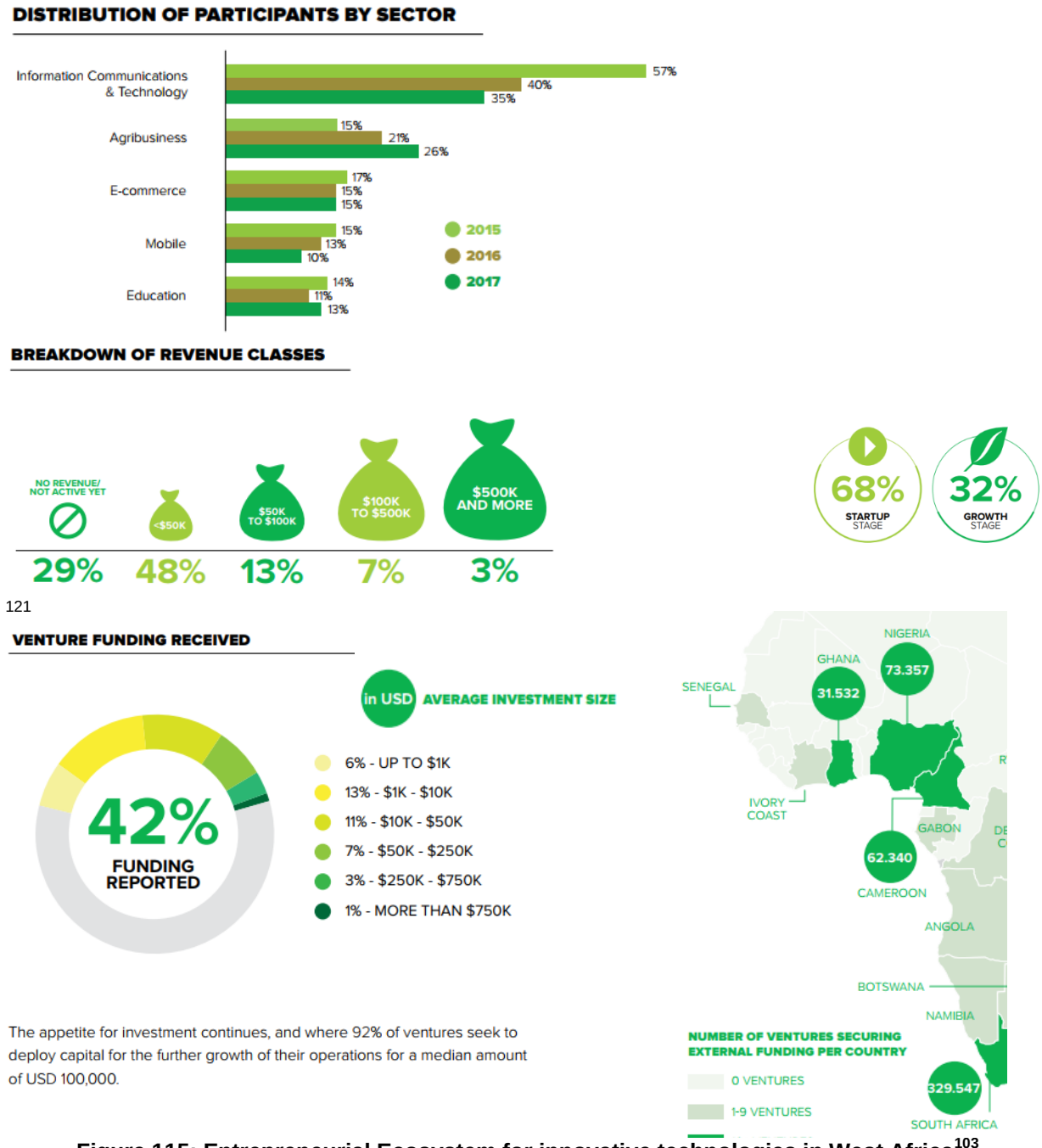


Figure 114: Trend of VC and PE Investments into Renewable Energy[101]

The World Energy Investment Report 2017 mentions: "More than 90% of energy investment is financed from the balance sheets of investors, suggesting the importance of sustainable industry earnings, which are based on energy markets and policies, in funding the energy sector. This share has barely changed in recent years, though sources of finance are changing in some sectors. While the overall share of project finance, which depends on cash flows for a given asset, remains small, its use in power generation investment – especially renewables – has grown rapidly in the past five years, by 50%, reflecting lower project risks in some emerging economies and the maturation of certain technologies. Newer mechanisms for raising equity and debt, such as green bonds and project bonds, are enabling investors to tap into larger financing pools, especially for refinancing assets and funding investments in smaller-scale projects such as energy efficiency and distributed generation."[120]

Looking at the incubation platform was helpful in understanding what kind of entrepreneurs are getting listed for funding, what sectors they represent, what is the size of their business and what kind of funding they have managed to secure.

[120] World Energy Council (2016) 'World Energy Resources 2016', *World Energy Resources 2016*, pp. 1–33. doi: http://www.worldenergy.org/wp-content/uploads/2013/09/Complete_WER_2013_Survey.pdf.



121

Figure 115: Entrepreneurial Ecosystem for innovative technologies in West Africa[103]

Finally, under financial performance, the business risks that exist in women-owned businesses operating within the energy value chain. was evaluated. “Business risk is the possibility that a company will have lower than anticipated profits or experience a loss rather than taking a profit. Business risk is influenced by numerous factors, including sales volume, per-unit price, input costs, competition, the overall economic climate, and government regulations. A company with a higher business risk should choose a capital structure that has a lower debt ratio to ensure it can meet its financial obligations at all times.”[122]

The evaluation included the existing risks for women-owned businesses, but these factors are gender neutral so they would exist in any energy-related business. The largest risk in the value chain is due to price variations (which includes exchange rate fluctuations affecting procurement and sales

[121] Africa, V. C. F. (2015) ‘Venture finance in africa’.
[122] https://www.investopedia.com/terms/b/businessrisk.asp

prices), supply chain disruptions and credit that is extended to buyers. Most of these risks can be mitigated by insurance and bank instruments, which women entrepreneurs do not know or cannot access in their countries.

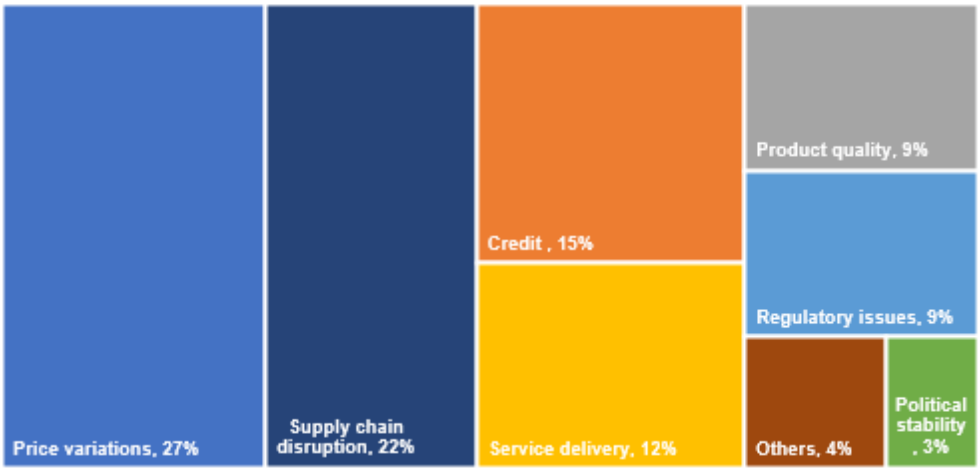


Figure 116: Risks in Women-owned businesses

Price variation risks come into play due to volatilities in price from the point of purchase to the point of sale. These variations might result because of changes in supply and demand, operational and financial costs (including exchange rate fluctuations, interest rates and other price affecting changes).

Supply chain disruptions are due to volatilities in the supply chain such as delay in delivery from suppliers, shipment, transportation, and logistical challenges.

Credit risk is the risk of default on a debt obligation that may arise from a borrower failing to make required payments. On the first point, the risk is the lenders and includes lost principal, interest, disruption to cash flows, and increased collection costs.

Factors that influence biomass price

Factor	Sub-factor
Increasing demand	• Population, diet changes and economic growth • Importer policies (hoarding) • Rapid expansion of biofuels • (Future: bio-based economy)
Increased production costs	• Oil and gas prices • Fertiliser • Immature logistics for biomass feedstock
Decreased supply	• Harvest failures (droughts and floods) • Decrease in subsidised exports and food aid
Low stocks	• Global market integration reduces the need for domestic stocks • Demand growth exceeding production increase • Lagging investments in agriculture • Low commodity prices in earlier years • Commodity prices below costs (dumping) • Yield gap • Food waste
Market dynamics	• Speculation • Trade restrictions (export bans, stockpiling) • Currency exchange rates (weak dollar)

Source: Hamelinck (2013)

Figure 117: Factors influencing Biomass Prices

Solutions: Ways to reduce these risks include - risk policies and utilization of tools for risk mitigation. Price variation risks can be mitigated with utilizing price hedging tools e.g. if procurement is of tradeable commodities like some type of biomass (proxies can be developed utilizing the exchange traded commodities to offset price risks on biomass). For interest rate or foreign exchange volatilities, swaps or derivatives can be purchased from banks. For credit risk there is the possibility of utilizing credit insurance products which can be structured within the debt borrowed from the bank.

5.6. Business Model Evolution

After thoroughly analyzing the data collected and comprehensive meetings and discussions with women entrepreneurs and other stakeholders, it can be concluded that for women-owned company's strategic capabilities, based on Pricewaterhouse Coopers' report most women entrepreneurs have a business model that closely relates to either enabler (56% of respondents) or energy supplier (31% of respondents). It was also interesting to see that a few women-owned businesses have a hybrid model which is mix of two roles e.g. enabler and optimizer or energy supplier and integrator.

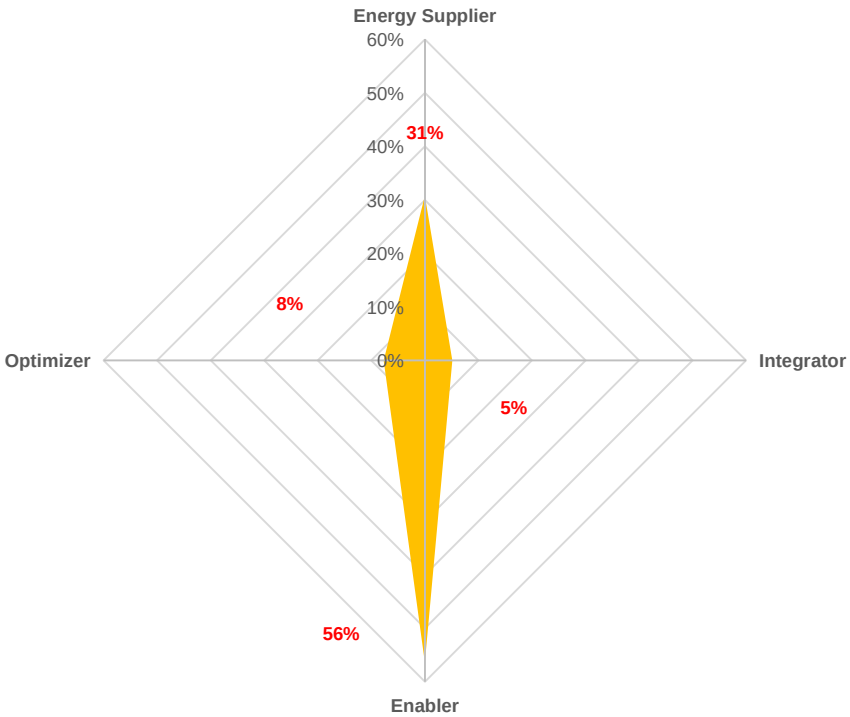


Figure 118: Current roles for Women Entrepreneurs on the energy value chain

As the energy value chain is being disrupted, and changes are happening, it is foreseeable that many or all these women-owned businesses will be impacted and will evolve into new and more efficient business models. Currently, most women entrepreneurs are (36% of respondents) acting as partners of partners who are primarily trading and distributing energy products. Product innovators (19% of respondents) are involved in manufacturing and installation of energy generation systems. Pure-play merchants (17% of respondents) are actively involved in producing and distributing energy across present transmission networks, and grid developers (14% of respondents) are involved in setting-up and operating grid businesses for predominantly off-grid communities.

"The future role of digital technologies for generating, handling, and communicating data has taken center stage in energy discussions. It has been estimated that US$47 billion was spent in 2016 on infrastructure and software directed towards digitalization of the electricity sector to facilitate more flexible network operation, demand management and integration of renewable resources."[123]

[123] International Energy Agency (2016) 'World Energy Investment 2016', *International Energy Agency*.

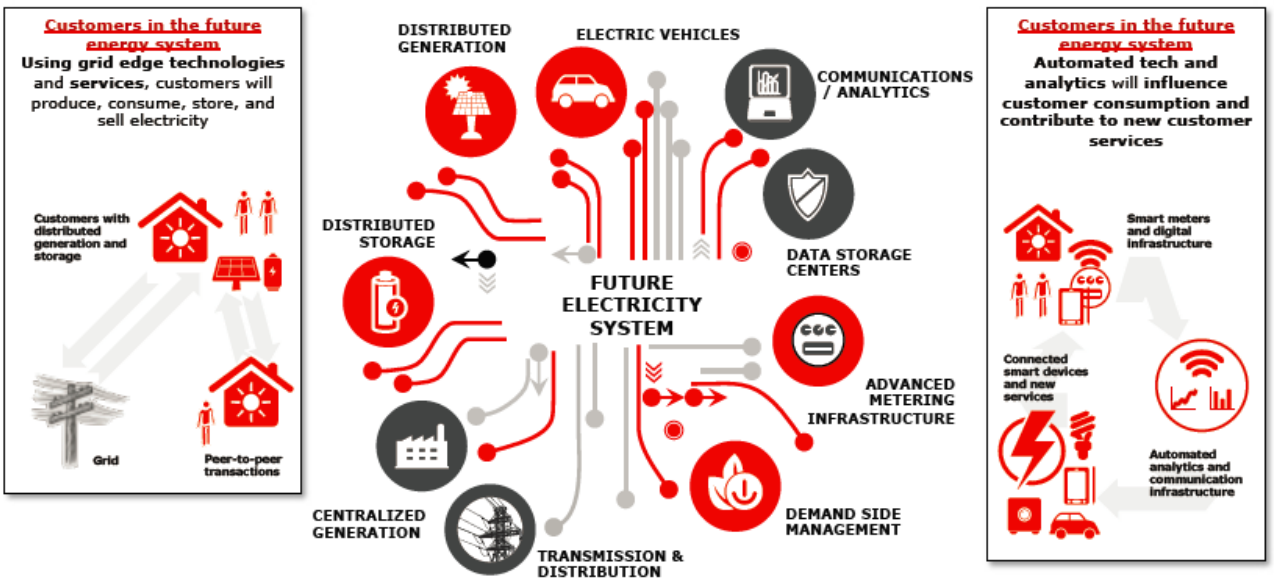


Figure 119: Future Digital Technologies[124]

Digital technology businesses offer women entrepreneurs an important opportunity to enter and scale – it also offers an opportunity for already established businesses to diversify and create a new product mix.

In the new model, the focus will be to make margins by commanding better premiums, i.e. a higher price rather than reducing costs to get higher profits[125]. The general scenario is when a new innovative technology is introduced it commands a premium because it does not have a direct benchmark hence the sales price is a number that is much higher than the cost price providing the seller with significant profitability on a per unit basis, but lower total profit due to low scalability and high customer acquisition cost. As the competitors start entering the market the prices fall, and the focus of the seller changes from market creation to market share retention and expansion– which involves scaling so the profit per unit is lower but high total profit – here the costs need to be reduced, i.e. operational efficiency becomes imperative for sustainability (commoditized). The entrepreneurs try to balance the above extreme scenarios by rapidly developing new products and introducing them to their present customers and as the product matures add new customers and simultaneously keep developing and adding new products – products or services that lose profitability are removed, and the cycle goes on.

[124] Astarloa, B. *et al.* (2017) 'The Future of Electricity: New Technologies Transforming the Grid Edge', *World Economic forum*, (March), p. 32. Available at: https://www.weforum.org/reports/the-future-of-electricity-new-technologies-transforming-the-grid-edge.

[125] PricewaterhouseCoopers (2014) 'The road ahead - Gaining momentum from energy transformation', *Pwc*, pp. 1–32. Available at: http://www.pwc.com/en_GX/gx/utilities/publications/assets/pwc-the-road-ahead.pdf

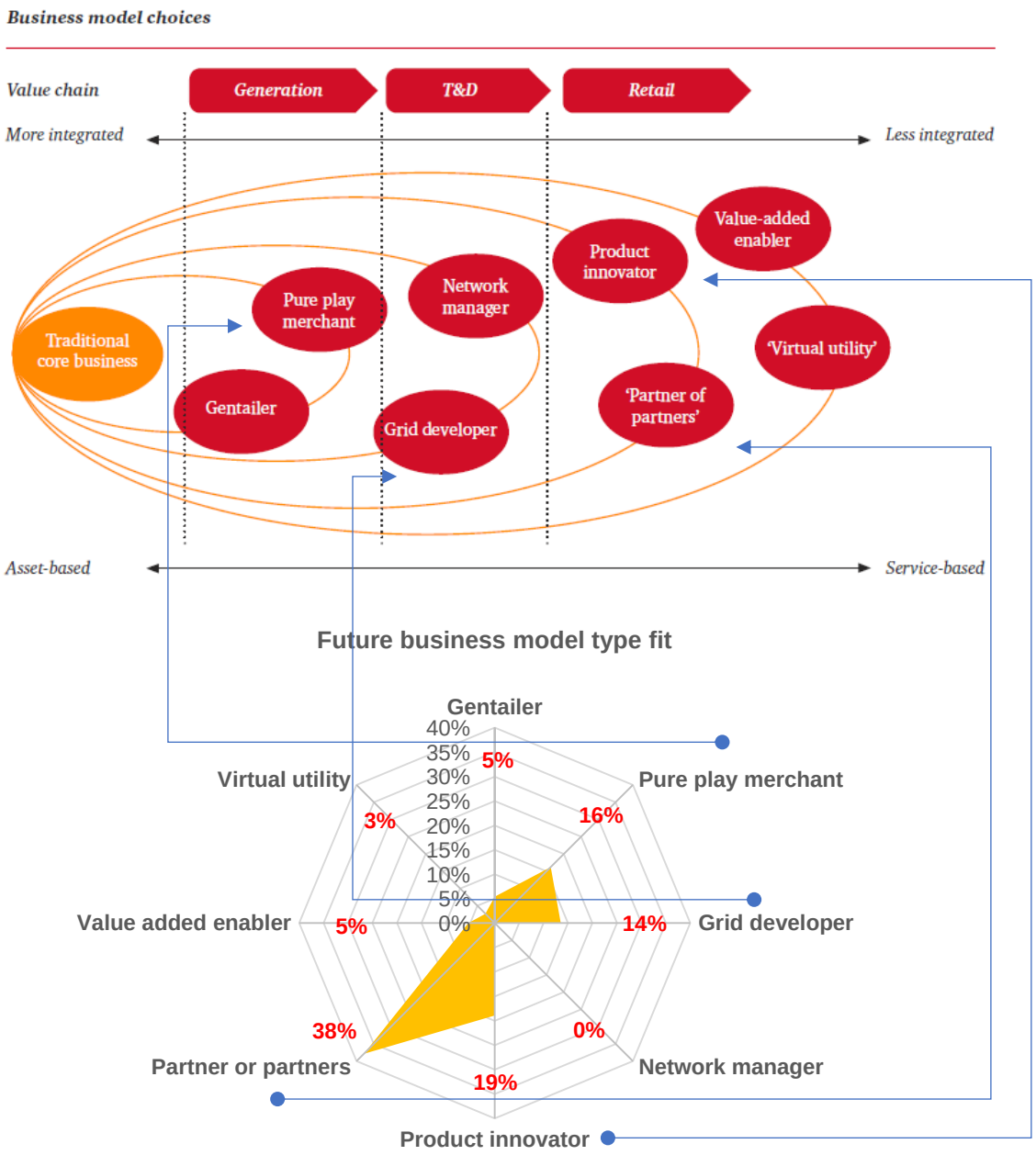


Figure 120: Best fit for Women Entrepreneurs in West Africa in future energy value chains and business models

Evaluating and understanding the fit between model and reality is not only interesting but helpful predicting the transformations that will happen in the future concerning the 4 most prominent business models for women entrepreneurs.

For partner of partners, there is a wide variety of solar based (panels, lighting, inverter, storage, pico, kiosks) and biomass based (cookstoves) energy related product companies that are involved in buying and selling these products. These value chains are commoditized and require strong working capital resources to maintain and manage their competitiveness. Due to extreme competition and eroding margins combined with high capital requirements, there is alignment of partnerships for extracting margins and penetrating uncovered markets.

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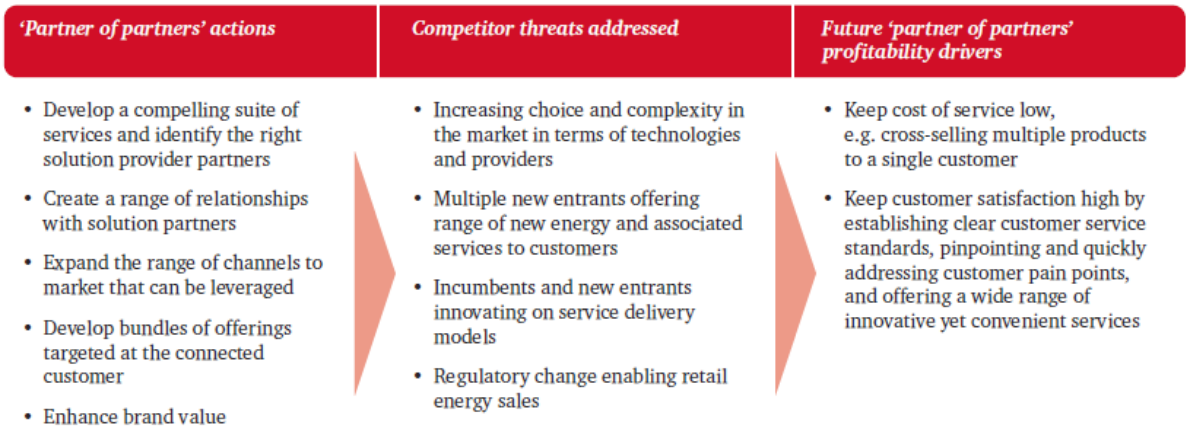


Figure 121: Partner of Partners Business Model[126]

The next type is product innovator where we see women entrepreneurs being involved with the manufacturing of products (smart meters, cookstoves, biogas plants, etc.) and service innovation (payment platforms, consumption analytics, etc.).

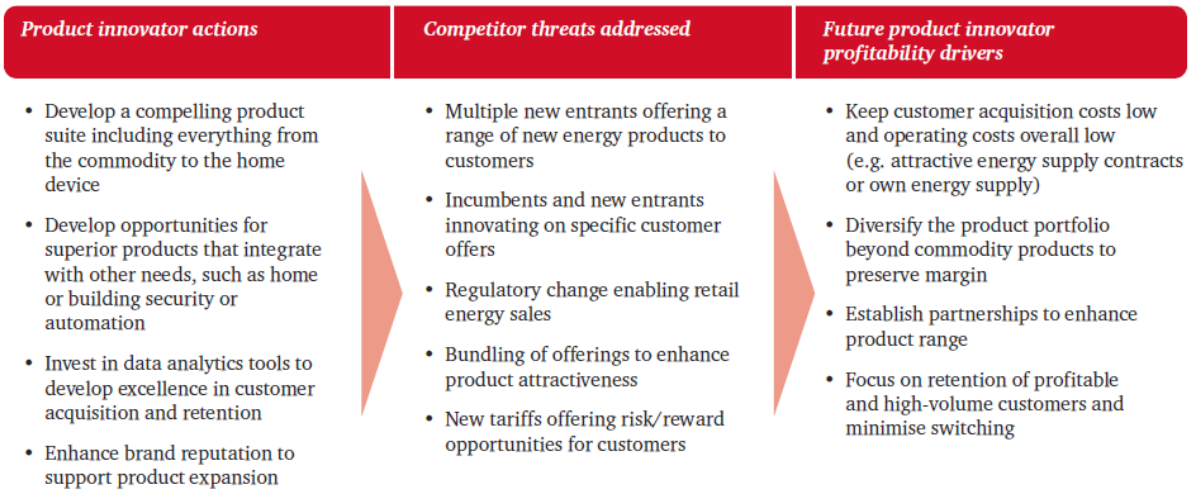


Figure 122: Product Innovators Business Model[127]

Grid developers are the third most prominent business models for women-owned businesses and this is one area that is not only growing very fast across the West African region but across most developing markets. Innovation is not only driving grids to efficiency but also creating smart technologies that allow grids to operate and optimize loads with real time demand flows and opening opportunities to sell excess loads into other grids (opening possibilities to trade and optimize energy distribution).

[126] PricewaterhouseCoopers (2014) 'The road ahead - Gaining momentum from energy transformation', *Pwc*, pp. 1–32. Available at: http://www.pwc.com/en_GX/gx/utilities/publications/assets/pwc-the-road-ahead.pdf
[127] Ibid

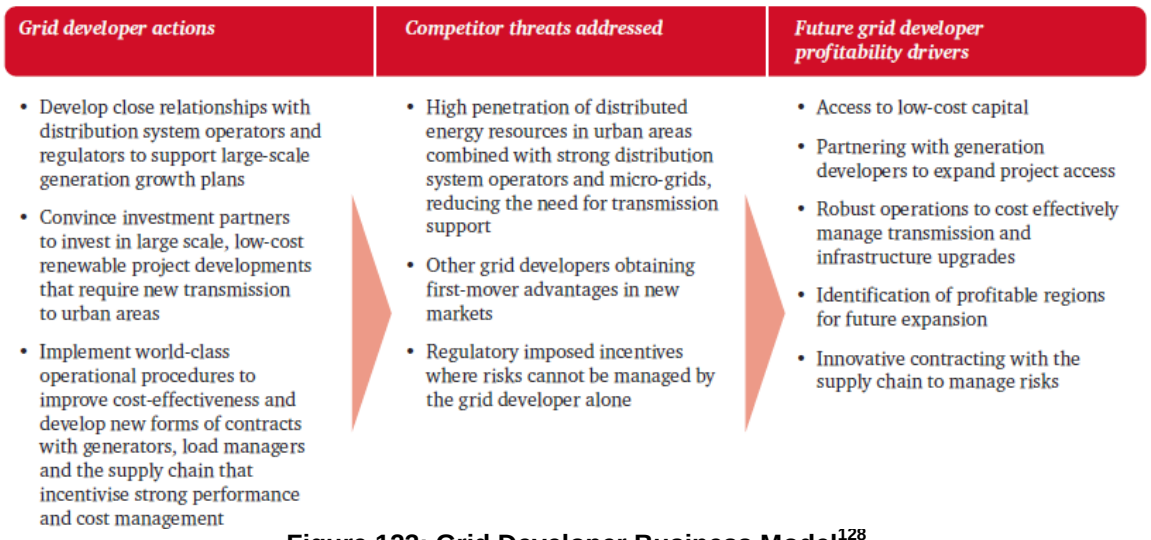


Figure 123: Grid Developer Business Model[128]

In the pure-play merchant models, gas-based energy generation will play a key role. The introduction of more efficient LPG distributors that are not only involved with distribution but also play a role in smart analytics to manage and control demand flows on a close to real time basis is already happening. These new gas distributors are integrating service and building on asset deploying technologies to optimize and streamline gas flows across the supply chain – it is clear that these efficient players will soon take a significant share of traditional vertically integrated gas processors and distributors and non-organized gas suppliers.

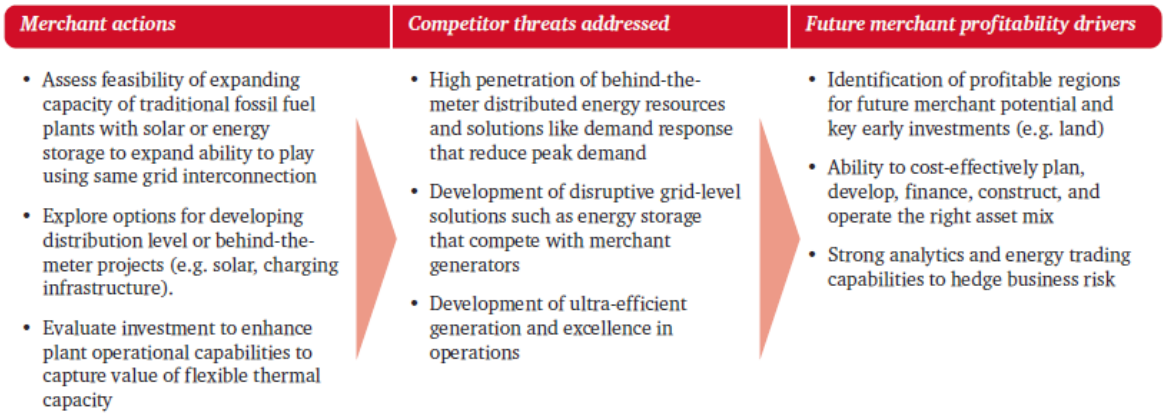


Figure 124: Merchant Business Model[129]

5.7. Transformations necessary for Women Entrepreneurs

This research has provided invaluable insights into the present position of women-owned businesses, the challenges they face, and prospects for their future growth. Assimilating all the gathered information through primary and secondary data collection techniques, has resulted in a set of recommendations that are based on both the internal factors that are driven by the capabilities and dynamics of the women businesses and the external environmental factors that affect the capabilities and dynamics of women businesses to result in volatilities in their profitability and sustainability.

[128] Ibid
[129] Ibid

Before going into the recommendations, it is worth mentioning that the new energy market is already opening the possibilities for women entrepreneurs to participate at different points on the energy value chain. Right now the margins and sustainability will be not only in product-based businesses but also in service-based ventures. Many women shared their thoughts about migrating or diversifying into more service-based businesses but due to lack of technical and technological expertise they find it difficult to understand and venture into these fields. Out of the new market paradigm and looking at their involvement, women entrepreneurs are facing 7 types of paradigms in the 4 selected countries in West Africa.

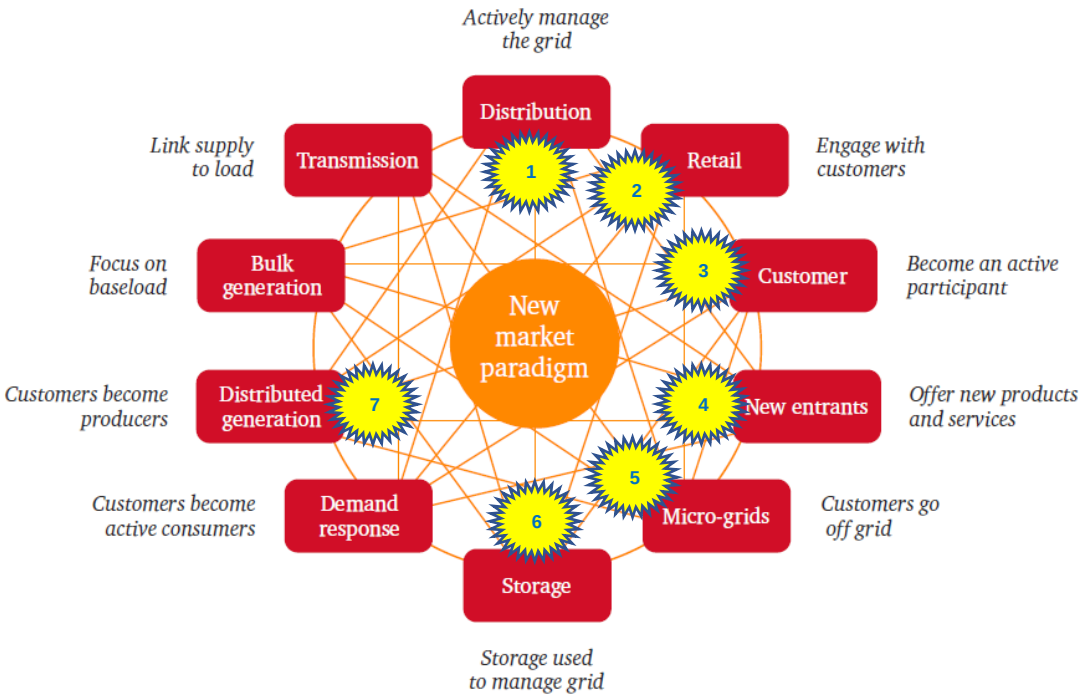


Figure 125: The New Market Paradigm and role of women entrepreneurs as agents of change

The complete electricity value chain is transforming from a traditional single forward-flow value chain with one or two types of fuel generation facilities, to a more dynamic multi- flow value chain driven by information exchange and originating from multiple renewable sources and fossil fuel generation facilities.

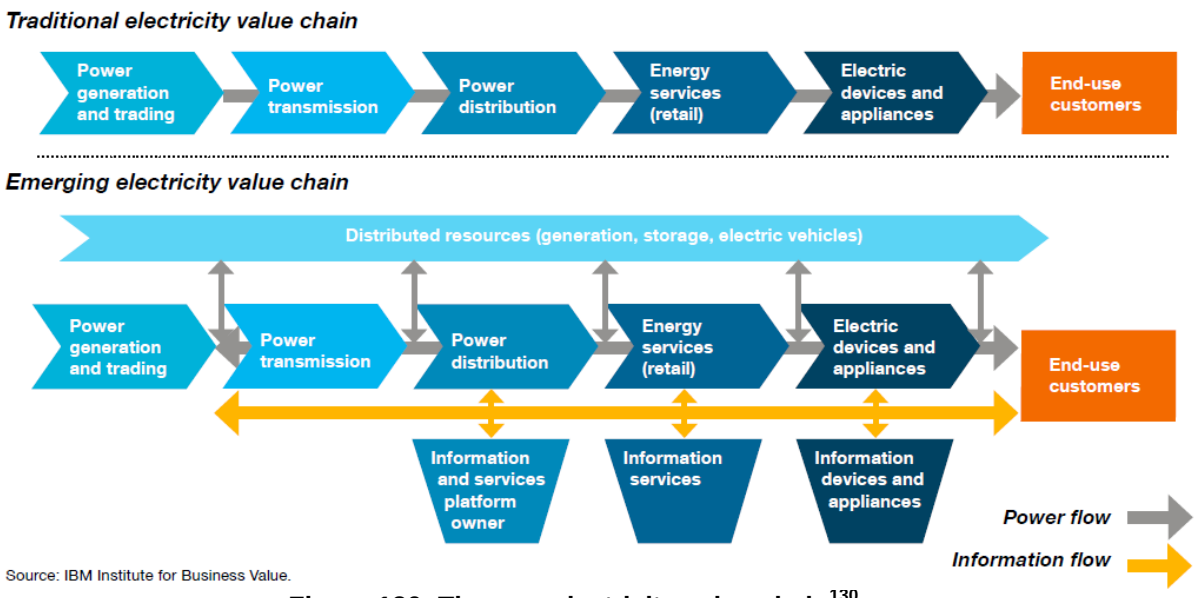


Figure 126: The new electricity value chain[130]

[130] Ibm (2010) 'Switching perspectives', *Business*, pp. 1–20. doi: 10.1007/978-1-4471-6281-0_9.

From a perspective of women entrepreneurship, there are differences, which allow us to understand why there is more entrepreneurship in one country when compared to the rest, and how more women can participate in the energy value chain in its present and future form. This data comes from the index developed by GEDI[131] called Global Entrepreneurship Index (GEI) which uses a methodology to collect data on entrepreneurial attitudes, abilities and aspirations of the local population and then weights these against the prevailing social and economic 'infrastructure' – this includes aspects such as broadband connectivity and the transport links to external markets. This process creates 14 'pillars' which GEDI uses to measure the health of the regional ecosystem.

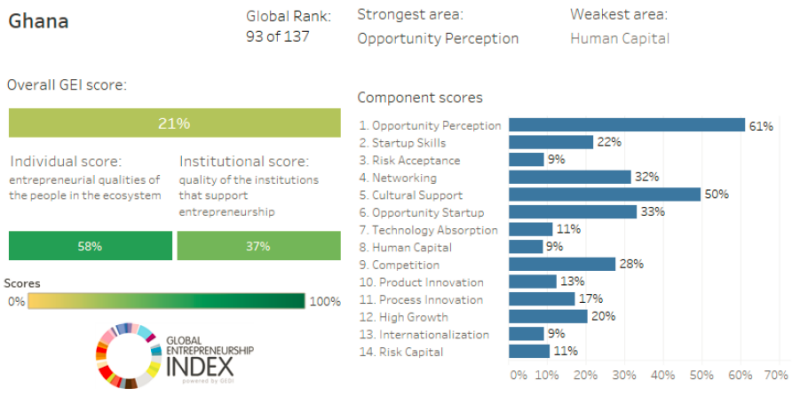
Pillars (Component of Entrepreneurial Ecosystem)	What do they measure?
Pillar 1: Opportunity Perception	Can the population identify opportunities to start a business and does the institutional environment make it possible to act on those opportunities?
Pillar 2: Startup Skills	Does the population have the skills necessary to start a business based on their own perceptions and the availability of tertiary education?
Pillar 3: Risk Acceptance	Are individuals willing to take the risk of starting a business? Is the environment relatively minimal risk or do unstable institutions add additional risk to starting a business?
Pillar 4: Networking	Do entrepreneurs know each other and how geographically concentrated are their networks?
Pillar 5: Cultural Support	How does the country view entrepreneurship? Is it easy to choose entrepreneurship or does corruption make entrepreneurship difficult relative to other career paths?
Pillar 6: Opportunity Perception	Are entrepreneurs motivated by opportunity rather than necessity and does governance make the choice to be an entrepreneur easy?
Pillar 7: Technology Absorption	Is the technology sector large and can businesses rapidly absorb innovative technology?
Pillar 8: Human Capital	Are entrepreneurs highly educated, well trained in business and able to move freely in the labor market?
Pillar 9: Competition	Are entrepreneurs creating unique products and services and able to enter the market with them?
Pillar 10: Product Innovation	Is the country able to develop new products and integrate innovative technology?
Pillar 11: Process Innovation	Do businesses use innovative technology and are they able access high quality human capital in STEM fields?
Pillar 12: High Growth	Do businesses intend to grow and have the strategic capacity to achieve this growth?
Pillar 13: Internationalization	Do entrepreneurs want to enter global markets and is the economy complex enough to produce ideas that are valuable globally?
Pillar 14: Risk Capital	Is capital available from both individual and institutional investors?

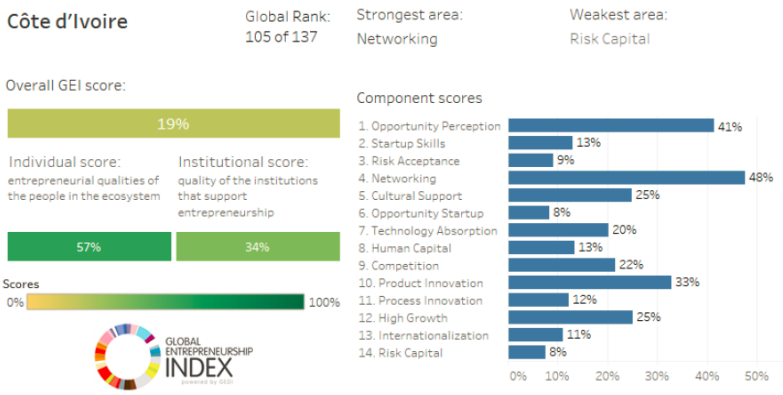
Based on the rankings, the following selection identifies the strengths and weaknesses of the 4 selected countries which help us understand the entrepreneurial pros and cons and will help in structuring the recommendations to help women entrepreneurs to build their businesses.

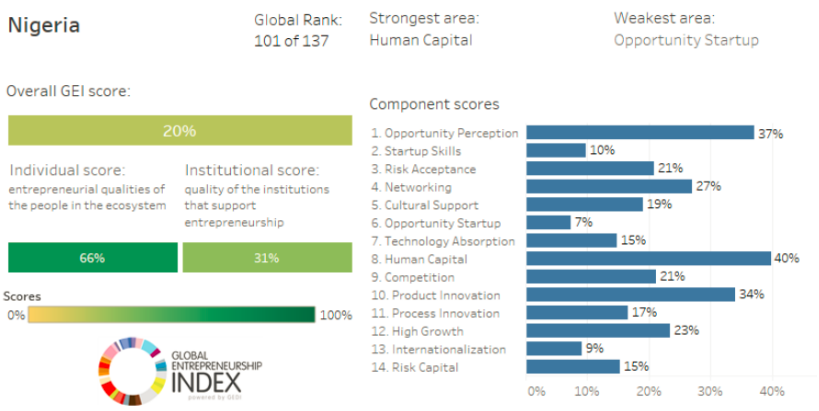
	Country	GEI Rank (out of 137)	Strong areas	Weak areas
1	Ghana	93	Opportunity perception & Cultural support	Human capital, Internationalization & Risk acceptance

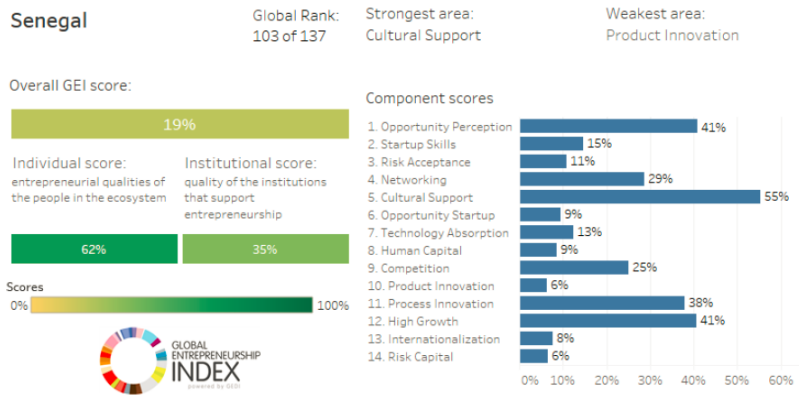
[131] Autio, E. (2015) 'Zoltán J. Ács László Szerb'. The Global Entrepreneurship and Development Institute (The GEDI Institute) is a non-profit organization that advances research on links between entrepreneurship, economic development and prosperity. The institute was founded by world-leading entrepreneurship scholars from the LSE, George Mason University, University of Pécs and Imperial College London.

2	Cote d'Ivoire	105	Networking & Opportunity perception	Risk capital, Risk acceptance & Opportunity start-up
3	Nigeria	101	Human capital, Opportunity perception and Product innovation	Opportunity startup, internationalization, and Start-up skills
4	Senegal	103	Cultural support, Opportunity perception and High growth	Product innovation, Risk capital and Opportunity start-up









6. Recommendations

Based on a detailed review of the primary and secondary data and its analysis the following recommendations are provided and are divided into six areas of relevance for women entrepreneurs, which, if addressed, can result in fast and supportive change for women-owned businesses. The expectation is that these recommendations improve women-owned businesses in short to medium term.

Area of relevance	***Measures***
1. Policy & Regulatory	a) Public procurement system with preferential allocation for women entrepreneurs b) Renewable and Energy Efficient Industrial Area or Special Economic Zone (cluster) with benefits like: a. Assembly and manufacturing of renewable energy and energy efficient products and services b. Taxation benefits c. One stop shops for easy company statutory processes d. International standards aligned processes, legal and regulations for investors e. Incentives for attracting foreign investments (on rent, lease, and taxes) f. Repatriation of funds for foreign investors c) Women representation for international delegations led by Ministry of Energy (Renewable) to energy innovation events d) Tie- up with foreign research labs and national energy commission to identify and introduce new renewable technologies for women entrepreneurs eg. with MIT/Stanford Labs e) Initiative for women SME preferential licensing mechanism (with standardized process, cost, and time deadlines) f) Develop energy auction program for connecting public sector and investors in emerging RE markets g) Develop carbon trading for Certified Emission Reduction (CER) issued out of West Africa based clean energy projects – by setting up a carbon trading exchange as an extension of European Union **Emissions Trading** System (EU ETS) based trading mechanism h) Launch quality standards for renewable energy and energy efficient products/equipment at regional level i) Further research to identify women in energy and agriculture (E&A) projects for funding through government and AfDB channel j) Setting up of an agency within the Ministry of Economy to allow foreign investors a one stop shop to acquire shares in local women-owned businesses – also act as sole source of information in all

	issues related to foreign investments in local companies
2. Operational	a) Supply chain related training program for women entrepreneurs b) Provide supply chain software/s at subsidized prices for women entrepreneurs c) Develop an operating manual for women business that can offer a blueprint of operations and can be used to train employees
3. Commercial	a) Contracting and public vendor participation training b) Comprehensive training on legal aspects of company operations – registration, operation, franchising/agency, and financials c) Training on tax planning for SMEs
4. Technological	a) Setting up an energy focused incubation center with a regional and women focus b) International tie-ups to knowledge transfer private commercialized technologies c) Setting up of stringent patent regime to allow women entrepreneurs to register patents
5. Human Resource	a) Technical training on different energy system – installation and maintenance b) Financial training on managing financial accounts c) Create entrepreneurial universities focusing on women in energy and adjacent other sectors (like smart technologies, software, e-commerce, etc.) d) Peer to peer mentorship program can be launched whereby some successful women entrepreneurs can act as mentors to other women entrepreneurs
6. Financial	a) Set-up a quarterly bank and women entrepreneurs network event b) Banks to provide training on banking products and their application to women-owned businesses c) Provide multi-lateral banks backed facility to commercial banks for risk shared provisions (AfDB/bi-lateral or multi-lateral bank backed facility) d) Provide structured products that can lift the risk from balance sheet to inventory and receivables e) Set-up credit rating agency (CRA) for energy related companies f) Create a partnership of local commercial banks with export credit agency in the exporting country focused at women-owned businesses g) Commercial banks may open specialized women banking branch to focus and extend funding solutions created for women entrepreneurs[132]

[132] https://www.abl.com/personal-banking/theme-branches/women-banking/, https://www.rblbank.com/category/Small-Business-Loans, http://www.womensbank.co.tz, http://www.covenantbank.co.tz/bank/about, http://www.akdn.org/press-release/first-microfinance-bank-fmfb-opens-branch-women-only-first-country, https://www.sewabank.com, https://www.kwftbank.com, http://www.wwbg.com.gh/products.php

7. Selection of Four Feasibility Studies

The key end-product of the pre-feasibility study was the selection of four projects for feasibility study which, if implemented, will position West African women entrepreneurs as primary contributors to the development of the region's energy infrastructure. The objective of selecting these projects or businesses for feasibility study is to develop four bankable product or service related feasibility study templates (information memorandums), that can be used by women entrepreneurs, either working or interested in working with that product or service, to approach a commercial bank or fund to access funding. *A key requirement of the feasibility study is that it must be oriented towards gender mainstreaming, focused on the needs of women and men across the supply chain, specifically on empowering them as stakeholders and beneficiaries of throughout the project's supply chain.*

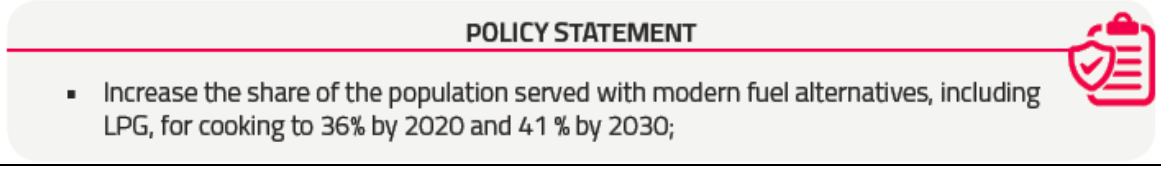
Thus, the four product and/or service related projects selected for further study will either support women entrepreneurs to:

a) streamline their present businesses in line with that product or service,
b) diversify into that product or service,
c) set-up a new entrepreneurial venture in line with that product or service.

Presented below are the four projects for feasibility study:

	Feasibility Study	***Reason for Selection***	***Impact***
1	Development of *Liquefied Petroleum Gas Distribution business in Nigeria with possibilities to replicate the same model in Côte d'Ivoire, Ghana, and Senegal*	1) Feedstock: Readily available either locally or imported from neighboring countries 2) Demand: Wide potential demand base 3) Competition: Low 4) Price: High affordability 5) Model: Commodity supply chain type 6) Cost of development: Medium to high 7) Maintenance cost: Low 8) Scalability: High 9) Technology complexity: Low	1) Consumer lifestyle: High 2) Carbon footprint: Very low

Description:
LPG has been gaining ground regionally as a key form of fuel, that is clean and efficient, used in cooking both for residential and industrial purposes and has been growing in its share across the African continent (Figure 42: Future Evolution of Energy Generation by Fuel Type). Gas deposits are vast and spread across West Africa (world rankings[133] Nigeria – No.9, Ghana – No.51, Cote d'Ivoire – No.72). The supply chain disruptions have been a major constraint for expansion of this form of fuel and this sector has seen a very low involvement of women entrepreneurs while on the demand side majority of women act as consumers of gas**.** Expanding the share of the population that uses alternative fuels (including LPG) for cooking to 36% by 2020 and 41% by 2030 is a key target for West African countries, as stated in the ECOWAS Renewable Energy Policy.



[133] https://en.wikipedia.org/wiki/List_of_countries_by_natural_gas_proven_reserves

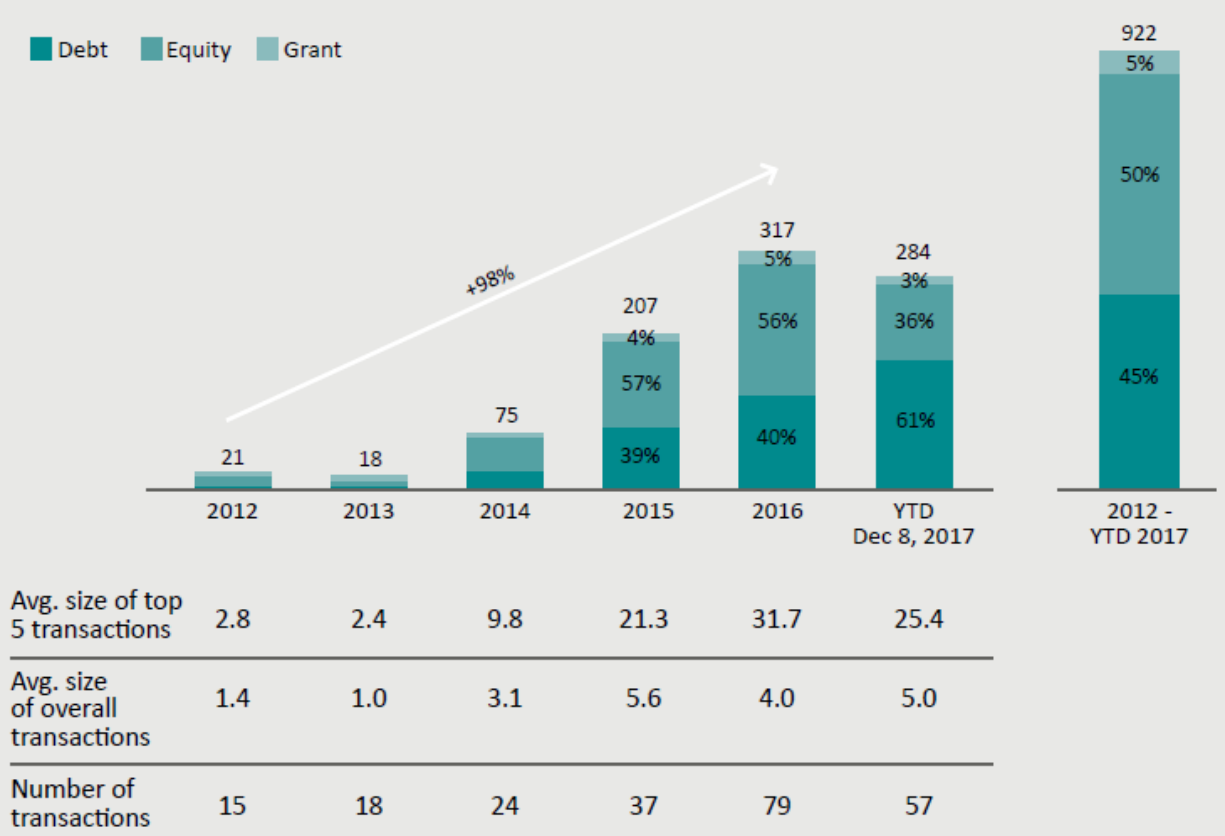
The primary research at the pre-feasibility stage shows that women are interested in developing LPG businesses (with it being the third preferable energy source) but are not aware of the operational, technological and financial challenges associated with the business. There are also women entrepreneurs that have already ventured into manufacturing LPG stoves and participating (at a limited scale) in LPG distribution. These women and others see a business opportunity in the vertical integration of LPG into their present LPG stove distribution business. Already working closely with the primary present and future consumers of LPG, which are also women, these women entrepreneurs are well-equipped to understand the consumer demand. However, they need support in managing the intricacies of an LPG distribution business.

Scope:
The scope of this feasibility study is to evaluate the complete supply chain of LPG from production to distribution. This will involve in-depth profiling of product, supply chain, margins, business model, organizational capabilities and structure, complexities, investment opportunities on the supply chain, risks, and financials for setting up and running an LPG distribution business. The geographic focus of the study will be Nigeria (as Nigeria is presently the largest producer, exporter, and consumer of gas in the West African region with the highest potential for demand growth) but it should also look into how similar businesses can be replicated in the other three countries, i.e. Senegal, Ghana, and Cote d'Ivoire. The study should also look at possibilities of expanding into the selling of gas stoves and gas cylinders alongwith gas filling. On the project development side it should look at investments for setting up gas filling and storage sites.

Deliverable:
A bankable document - 'Information Memorandum' that can be presented to banks or funds for lending or participation.

	Feasibility Study	***Reason for Selection***	***Impact***
2	Development of a *Solar based electricity generation system and solar lighting product distribution* business in Ghana with possibilities to replicate in Nigeria, Cote d'Ivoire, and Senegal	1) Product: Import 2) Demand: Wide potential demand base 3) Competition: High 4) Price: High affordability 5) Model: Commodity supply chain type 6) Cost of development: Low 7) Maintenance cost: Low 8) Scalability: High 9) Technology complexity: Low	1) Consumer lifestyle: Medium 2) Carbon footprint: Very low

Description:
Solar based electricity generation systems (solar panels, storage batteries, inverters and converters) and solar lighting has been gaining ground regionally as a key form of renewable energy source, that is freely and widely available, used for both electricity generation and lighting across residential and industrial purposes (Figure 72: Estimates of Renewable Energy Potential in West Africa). Solar based electricity generation systems and solar lighting products have been gaining imports and penetrated across West Africa providing the best off-grid and on-grid electricity.



	2012	2013	2014	2015	2016	YTD Dec 8, 2017
Avg. size of top 5 transactions	2.8	2.4	9.8	21.3	31.7	25.4
Avg. size of overall transactions	1.4	1.0	3.1	5.6	4.0	5.0
Number of transactions	15	18	24	37	79	57

Figure 127: Annual Investments in Off-grid Solar over time[134]

The supply chain disruptions have been a major constraint for expansion of this form of energy and this sector has seen a good involvement of women entrepreneurs (which is still very low when looked at as a percentage of women to total entrepreneurs in this sector) while on the demand side women continue to be the biggest consumers and decision-makers. These products have reached commoditizable volumes but suffer from operational, commercial, and financial challenges and women find it difficult to get them financed and hence scale up.

	2016			2022 Est.		
	Sales units CAGR (2010-2016)	Annual unit sales	Annual revenue (USD)	Sales units CAGR (2017-2022)	Annual unit sales	Annual revenue (USD)
Pico	~99%	26 Mn	$600-650 Mn	~16%	47 Mn	$1-1.5 Bn
PnP SHS	~125%[40]	<1 Mn	$150-200 Mn	~87%	24 Mn	$6-7 Bn
Open-market component[41]	n/a	2-2.5 Mn	$200-250 Mn	n/a	2-2.5 Mn	$200-250 Mn
TOTAL	**~100%**	**~30 Mn**	**~$1 Bn**	**~25%**	**~72 Mn**	**~$8 Bn**

Figure 128: Estimated sales and revenues across OGS segments[135]

Ghana has been leading in importing solar panels from China and continues to increase its import size due to increasing market demand.

[134] 'Off-Grid Solar Market Trends Report 2018' (2018), (January),GOGLA
[135] Ibid

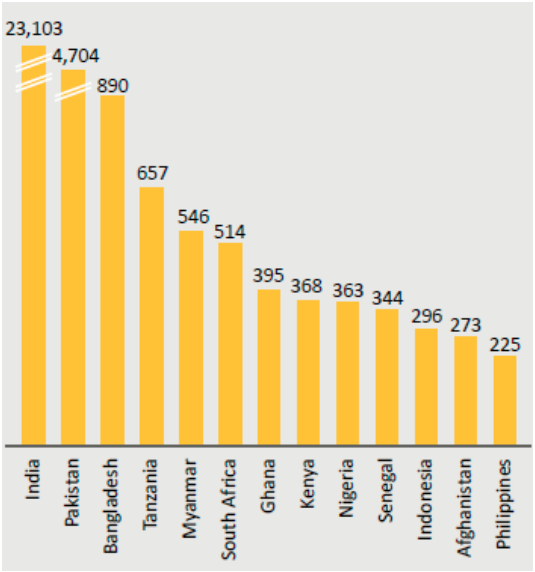


Figure 129: Solar Panel Imports from China in thousand units (Q42016-Q32017)

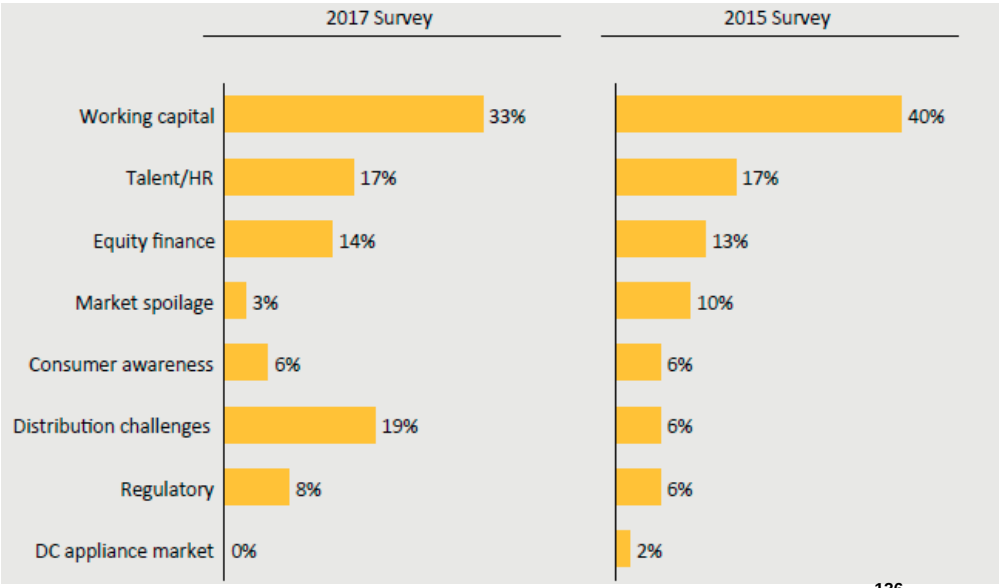


Figure 130: Survey of Key Barriers to growth of OGS industry[136]

Scope:

The scope of this feasibility study is to evaluate the complete supply chain of solar based electricity production systems and solar lighting products from manufacturing, import, storage to distribution. This will involve in-depth profiling of product, supply chain, margins, business model, organizational capabilities and structure, complexities, investment opportunities on the supply chain (including assembly facilities within Ghana), risks and financials for setting up and running a Solar based electricity generation systems and solar lighting products distribution business. The geographic focus of the study will be Ghana. However the study will also look into how similar businesses can be replicated in the other three countries i.e. Senegal, Nigeria, and Cote d'Ivoire.

Deliverable:
A bankable document - 'Information Memorandum' that can be presented to banks or funds for lending or participation.

[136] 'Off-Grid Solar Market Trends Report 2018' (2018), (January),GOGLA

	Feasibility Study	*Reason for Selection*	*Impact*
3	Development of a *Clean Energy Powered Mini and Micro Grid electricity generation and distribution business* in Senegal with provision for development in Nigeria, Cote d'Ivoire, and Ghana	1) Feedstock: Readily available (Solar/Wind/Hydro) 2) Demand: Community based demand 3) Competition: Very Low 4) Price: Medium affordability 5) Model: Electricity generation and distribution 6) Cost of development: Medium 7) Maintenance cost: Medium 8) Scalability: Medium to high 9) Technology complexity: Medium	1) Consumer lifestyle: High 2) Carbon footprint: Very low

Description:

Clean Energy Powered Mini and Micro Grid have been gaining ground regionally as a key form of off-grid electricity generation and distribution system supplying to residential and industrial purposes. Clean Energy Powered Mini and Micro Grid products have been gaining imports and penetrated across West Africa providing a new opportunity for privately held businesses to expand into electricity generation and distribution business. Technological understanding, technical expertise and access to finance have been major constraints for expansion of this form of energy business and this sector is seeing interest of women entrepreneurs across the region.

Total off-grid installed renewable energy (MW)

	Current	2020	2030
Benin			
Burkina			
Cabo Verde			
Côte d'Ivoire	n.a.	94	0
Gambia			
Ghana		50	
Guinea			
Guinea-Bissau	0	6	15
Liberia	0	23	30
Mali	2	189	250
Niger			
Nigeria			
Senegal	27	783	783
Sierra Leone	2	25	65
Togo	0	5	15
		1,175	1,158

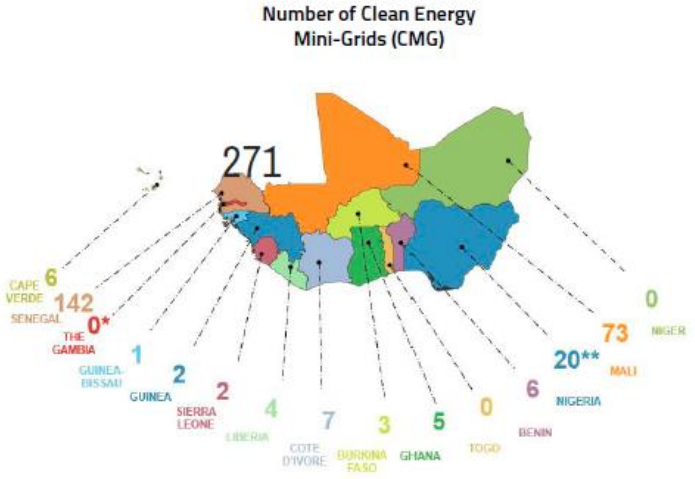


Figure 131: Installed Off-grid Capacities and CMGs in West Africa

This type of business is seeing social impact and helping other women-based businesses become efficient but suffer from operational, commercial, technological, and financial challenges and women find it difficult to get them financed.

Scope:

The scope of this feasibility study is an in-depth profiling of product (including single and multiple/hybrid types), sources of feedstock (solar, wind, hydro and biomass), supply chain, margins, business model, organizational capabilities and structure, complexities, investment opportunities on the supply chain (including assembly facilities in Senegal), risks and financials for setting up and running this type of electricity generation and distribution business. The geographic focus of the study will be Senegal (Figure 59: Number of Mini-Grids) but it should also cover how similar business can be replicated in

other three countries i.e. Ghana, Nigeria and Cote d'Ivoire.
Deliverable:
A bankable document - 'Information Memorandum' that can be presented to banks or funds for lending or participation.

	Feasibility Study	***Reason for Selection***	***Impact***
4	Identification and development of *Smart Applications for Energy Consumers* in Cote d'Ivoire with possibilities to replicate in Senegal, Nigeria, and Ghana	1) Product: Locally developed 2) Demand: Wide potential demand base 3) Competition: Low 4) Price: High affordability 5) Model: Payment on transaction and advertisement revenue 6) Cost of development: Low 7) Maintenance cost: Low 8) Scalability: High 9) Technology complexity: High	1) Consumer lifestyle: High 2) Carbon footprint: No

Description:

Smart applications[137] have been gaining ground as provider and integrator of value addition services between generation, transmission, storage, and distribution system involving residential and industrial customers. Smart applications are expanding very fast due to digitalization infrastructure growth and penetration (Figure 21: Digitalization Infrastructure-1 (out of 100)Figure 22: Digitalization Infrastructure-2Figure 23: Digitalization Infrastructure-3) across West Africa. There has been entry of technically sound and enterprising new generation of entrepreneurs (Figure 54: Start-Up Entrepreneurs across West Africa (as listed on vc4a.com)) and they are materializing opportunities on the energy value chain by utilizing ICT and impacting businesses

Figure 24: Innovation Achievers in Sub-Saharan Africa, Figure 25: Innovation Profile (rankings out of 127)) and electricity flows. These kind of smart applications are primarily structured around demand side of the energy value chain providing services like – data analytics, payment mechanics, electricity trading and demand planning. The business model of this kind of business will involve coding (developing), deploying and running a smart app or platform that will target either B2B customers like power distribution companies or B2C consumers that are residential and industrial electricity consumers.

[137] The term **smart process application** was coined by analysts at Forrester Research Inc. As the demand for business agility -- and therefore business process software -- increases, smart process applications are expected to change the way employees create, manage and interact with business rules.
To be considered a smart process application, the software must have five key attributes:

- Imported or embedded awareness data relevant to the business activity.
- A collaboration platform on which people can create content needed for the activity.
- BPM tools for executing the steps involved in a business process.
- Document capture, document output and document management capabilities.
- Embedded analytical tools.

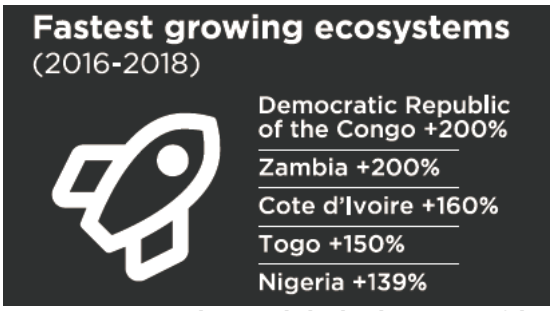


Figure 132: Fastest growing tech hubs in West Africa (2018)[138]

Abidjan in Cote d'Ivoire has gradually positioned itself as the new catalyst of innovation across Francophone Africa and has seen its number of active tech hubs double[139]. Since 2016, a number of new mobile operators-backed tech hubs were launched including MTN-Y'ello, an incubator programme active in Congo and Cote d'Ivoire, Orange Fabin Cote d'Ivoire and Orange Start on in Morocco and Djezzy's ENP Incubator in Algeria.

This type of business is creating social impact and helping other women-based businesses become efficient but suffer from operational, commercial, technological, and financial challenges and women find it difficult to get them financed Table 3: Future growth areas on products and services.

Scope:
The scope of this feasibility study is an in-depth profiling of solutions (including types of smart applications – available and that can be migrated to the region from other developed markets), supply chain, margins, business model, organizational capabilities and structure, complexities, investment opportunities (including software development, archiving, processing, etc.), risks and financials for setting up and running this type of smart applications production and processing business. The geographic focus of the study will be Cote d'Ivoire, but it should also cover how similar business can be replicated in other three countries i.e. Ghana, Nigeria, and Senegal.

Deliverable:
A bankable document - 'Information Memorandum' that can be presented to banks or funds for lending or participation.

[138] https://www.gsma.com/mobilefordevelopment/programme/ecosystem-accelerator/africa-a-look-at-the-442-active-tech-hubs-of-the-continent/
[139] Ibid

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13. Appendices

Annex-1: Questionnaire

Name :

Company:

1) How old is your business in years?

Start-up	<1	1-3	>3

2) What do you buy and sell?

SN	Area	Rate
1	Energy Generation Products	
2	Energy Transmission Products	
3	Energy Distribution Products	
4	Energy Storage Products	
5	Energy Consumption Products	
6	Energy Generation	
7	Energy Transmission	
8	Energy Distribution	
9	Energy Consumption	
10	Installation Services	
11	Maintenance Services	
12	Payment Collection Services	
13	Software Services	
14	Other services	

3) Which energy source/s are you associated with?

SN	Area	Rate
1	Solar	
2	Wind	
3	Gas (includes LPG & CNG)	
4	Biomass	
5	Hydropower	

4) What is the value addition do you do to your products and services?

SN	Area	Rate
1	Transformation	
2	Trading	
4	Logistics	
5	Transportation	
6	Installation Services	
7	Maintenance Services	
8	Payment Collection Services	
9	Software Services	
10	Financing	
11	Others	

5) What kind of business are you involved in?

B2C	B2B	Both

6) How many employees do you employ (full time)?

<10	11-20	21-30	>30

7) How many women employees do you have in %?

<10%	11-20%	21-30%	31-40%	>40%

8) Why do you think there are so less women entrepreneurs? *(where 3-highest and 1-lowest)*

SN	Area	Rate
1	Low Technical expertise	
2	Low STEM background	
3	Low Technology awareness	
4	Low Risk appetite	
5	Difficult physical labor	
6	Cultural issues	
7	Limited/no access to finance	
8	Others	

9) How many women entrepreneurs are there in your sector (with similar business size/type)?

<3	3-5	>5

10) How many competitors do you have for your business?

<3	3-5	6-8	>8

11) What is total size of your market-size (in number of consumers)?

<1 Million	1-5	6-10	>10	Unknown

12) What is total size of your market-size (in US$)?

<50 Mln	51-100 Mln	101-500 Mln	>500 Mln	Unknown

13) What is your market share?

<10%	11-20%	21-30%	>30%	Unknown

14) What is the NET margin do you realize on your sales?

<10%	10-20%	21-30%	>30%

15) What is growth of your business in % average per year? *(5=>100%, 4=50-100%, 3=50%, 2=10-50%, 1=<10%)*

Last3years	Next year

16) What makes your business profitable and sustainable? *(where 3-highest and 1-lowest)*

SN	Area	Rate
1	Niche/new market category	
2	Innovated product	
3	Innovated service	
4	Lower pricing	
5	Fast response time	
6	Strong relationship with buyers and suppliers	
7	Skilled employees	
8	Easy to buy our product/service	
9	Product quality	
10	Others	

17) What challenges do you face in your business? *(where 3-highest and 1-lowest)*

SN	Area	Rate
1	Regulatory issues	
2	Access to finance	
4	Access to local and regional markets	
5	Supply chain management	
6	Labor availability/expertise	
7	Operational costs	
8	Taxes	
9	Company management (financial, technical,etc.)	
10	Others	

18) What kind of challenges do you face with your people? *(where 3-highest and 1-lowest)*

SN	Activity	Rate
1	Hiring	
2	Training	
3	Retention	
4	Others	

19) Are you looking for finance?

SN	Type	Tick
1	Debt	
2	Equity	
3	Grants/Developmental Finance	
4	All	

20) How much funding do you need?

Immediate	Next 3years

21) How much working capital is required in **US$ thousand**?

<50	51-100	101-150	>150

22) How much project finance is required in **US$ thousand**?

<50	51-150	151-450	451-1350	>1350

23) How long is you working capital cycle in days?

Supplier Payment	Shipment	Raw material	Production	Finished goods+ installation	Receivables

24) How do you finance your business?

SN	Type	Tick
1	Debt	
2	Equity	
3	Grants/Developmental Finance	
4	Supplier credit	
5	All	

25) With how many banks do you work - current account facilities and in case of loan facilities - how many facilities, average value, average tenor and average pricing?

Institution (Bank/NBFI/ Micro/ Private)	Current Accounts	Facility Type (CL/ LC/ LCTR/ BG/ IF/ RF/PF)	Value	Tenor	Pricing

26) What are difficulties you face to get funding from above sources? *(where 3-highest and 1-lowest)*

SN	Area	Rate
1	Collateral	
2	Financial history (>3years)	
3	Financial documents (audited)	
4	Lack of knowledge of banking products	
5	Complicated procedures	
6	High lending rate	
7	Bank's negative perception of my business risks	
8	Others	

27) What collaterals do you have?

SN.	Collateral	Yes/No
1	Land	
2	Building	
3	Movables	
4	Deposits	

28) How much equity do you/women have in this company?

<30%	31-50%	>50%

29) Have you looked at selling your equity?

Yes		No	

30) How much value? and what % share?

<30%	31-50%	>50%

31) What is your revenue per annum in **US$ thousands**?

<50	50	>50

32) What is composition of your revenue?

SN	Area	%
1	Product	
2	Service	

33) What are cost drivers for your business? *(where 3-highest and 1-lowest)*

SN	Area	Rate
1	Inventory Costs	
2	Financing Costs	
3	Labor Costs	
4	Rental Costs	
5	Compliance Costs	
6	Transportation Costs	
7	Taxes	
8	Others	

34) What is your cost per annum in **US$ thousands**?

<50	50	>50

35) What are the risks in your business? *(where 3-highest and 1-lowest)*

SN	Risks	Rate
1	Price variations	
2	Credit	
3	Product quality	
4	Service delivery	
5	Regulatory compliances	
6	Political stability	
7	Supply chain disruption	
8	Others	

36) How much can grow your business from its present revenue (if above mentioned challenges are answered) in next 3years?

<20%	21-50%	51-100%	>100%

37) How many employees you expect to employ in next 3years?

<6	6-15	16-25	26-35	>35

38) Which other markets you would like to expand in immediate future? *(where 3-highest and 1-lowest)*

Local Cities	Neighboring countries	ECOWAS	Africa	Global

39) What opportunities do you see in future for your business? why?

	Same	New
Product		
Service		

40) In which areas do you see new opportunities?

SN	Area	Rate
1	Energy Generation Products	
2	Energy Transmission Products	
3	Energy Distribution Products	
4	Energy Storage Products	
5	Energy Consumption Products	
6	Energy Generation	
7	Energy Transmission	
8	Energy Distribution	
9	Energy Consumption	
10	Installation Services	
11	Maintenance Services	
12	Payment Collection Services	
13	Software Services	
14	Others	

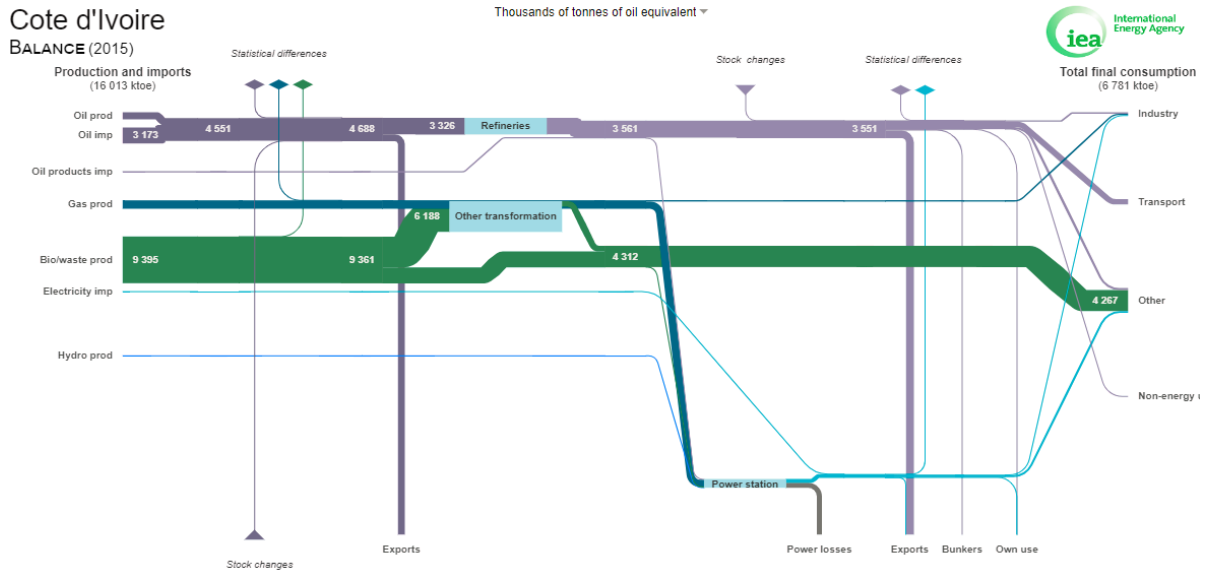
41) Which energy source/s areas will be prospective for your business?

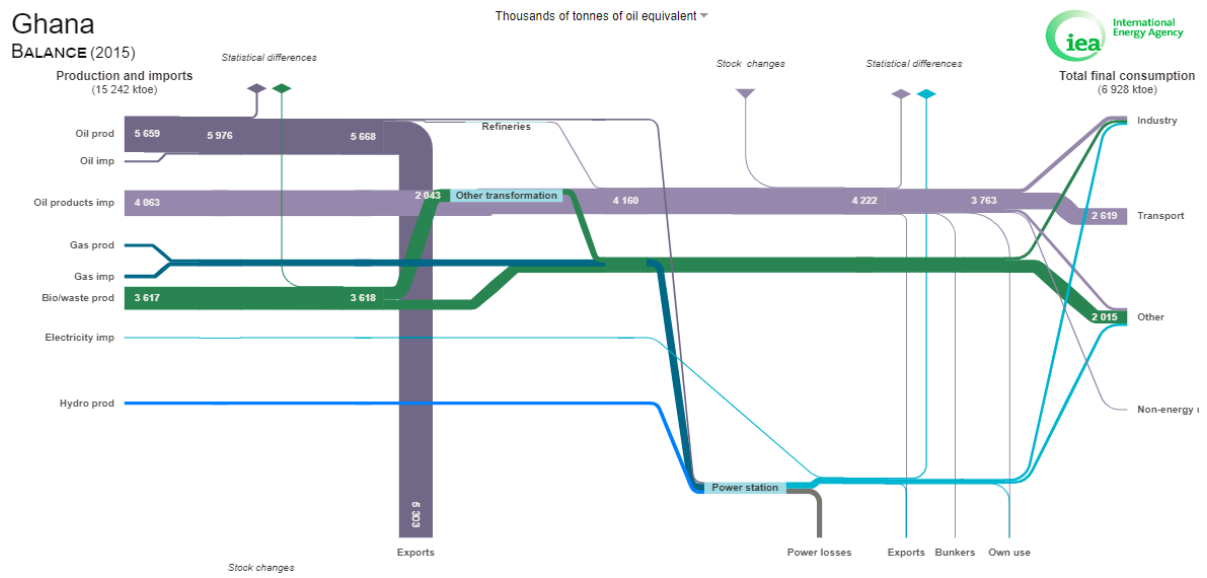
SN	Area	Rate
1	Solar	
2	Wind	
3	Gas (includes LPG & CNG)	
4	Biomass	
5	Hydropower	

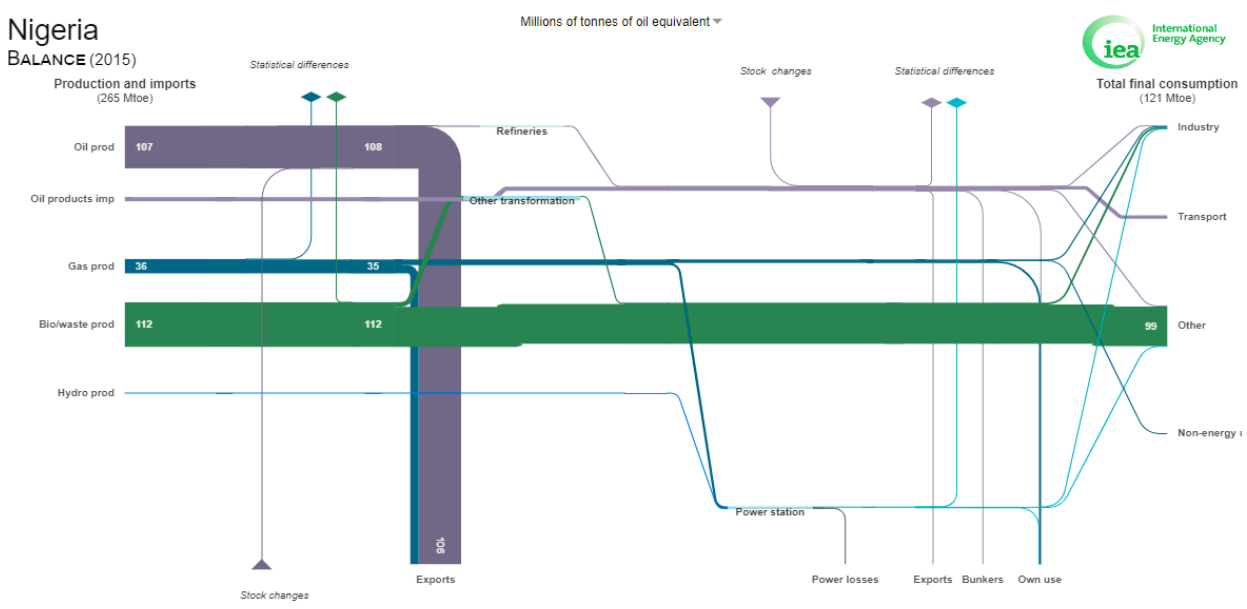
42) Why do you see need to develop new products and/or services? *(where 3-highest and 1-lowest)*

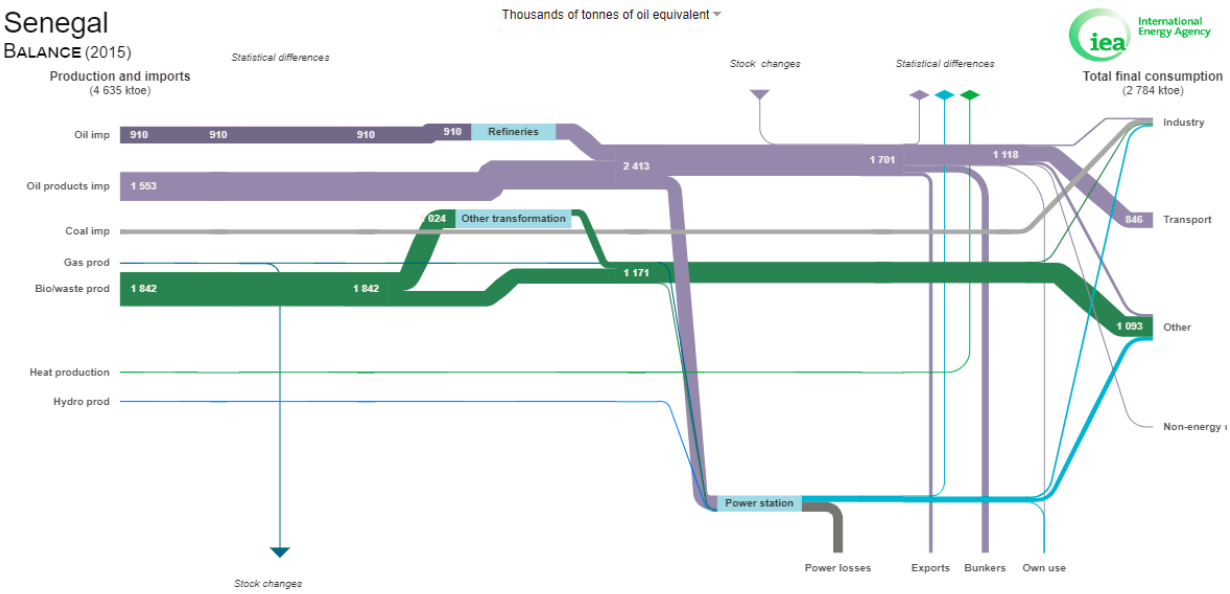
SN	Area	Rate
1	Changing consumer demand	
2	New technology – more efficient	
3	Diversifying market risks	
4	More competition	
5	Reducing margins	
6	Extend a basket of new products and services to same portfolio of customers	
7	Increasing/decreasing regulation	
8	Others	

Annex-2: Energy Production & Consumption, 2017

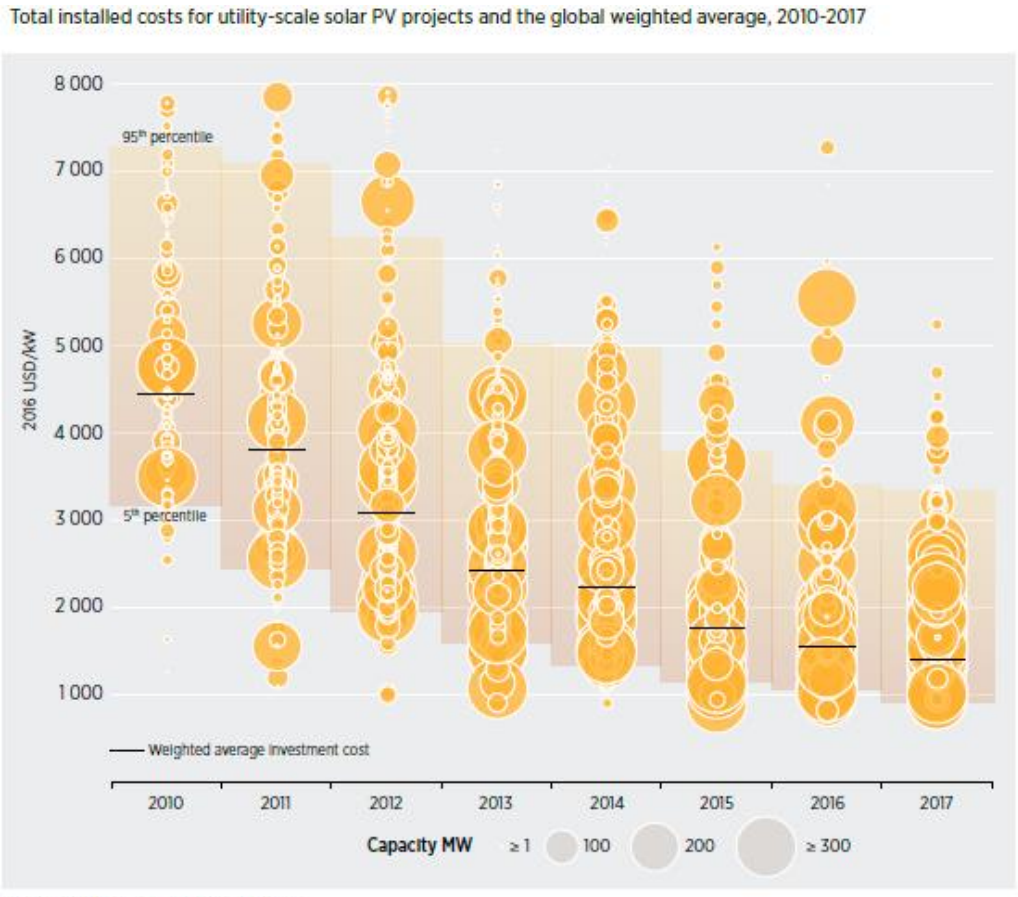






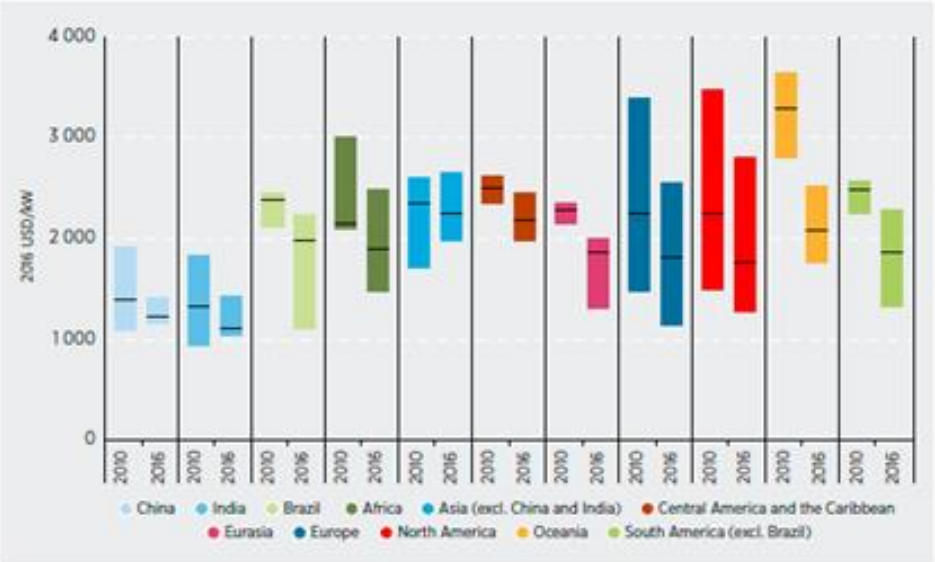


Annex-3: Total Installed Cost for Utility Scale Solar PV Projects and the global average, 2010-2017



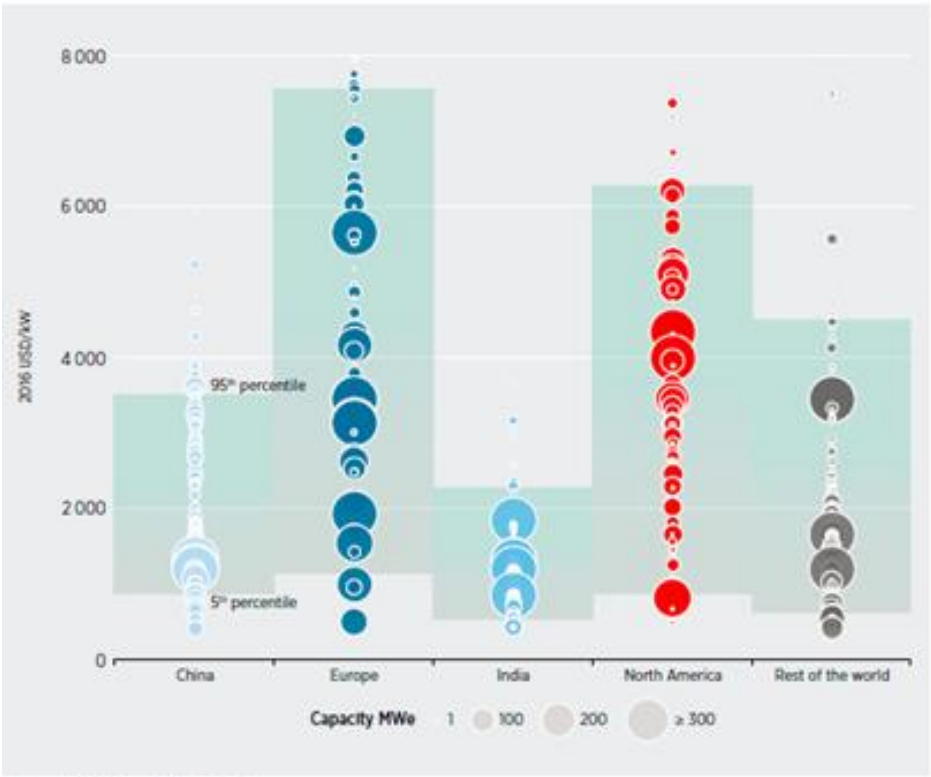
Source: IRENA Renewable Cost Database.

Annex-4: Total Installed cost ranges and weighted averages for on-shore wind farms (by country/region, 2010-2016)



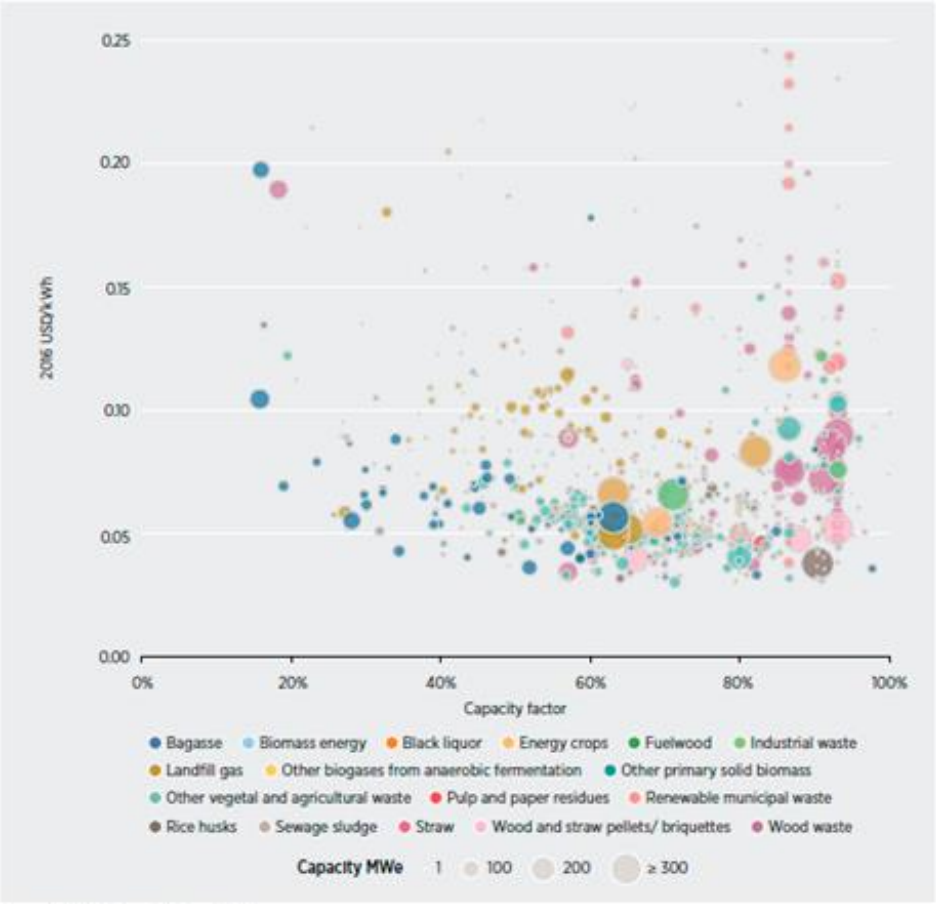
Source: IRENA Renewable Cost Database.

Annex-5: Total installed costs of bio-mass-fired generation technologies (by country/region)



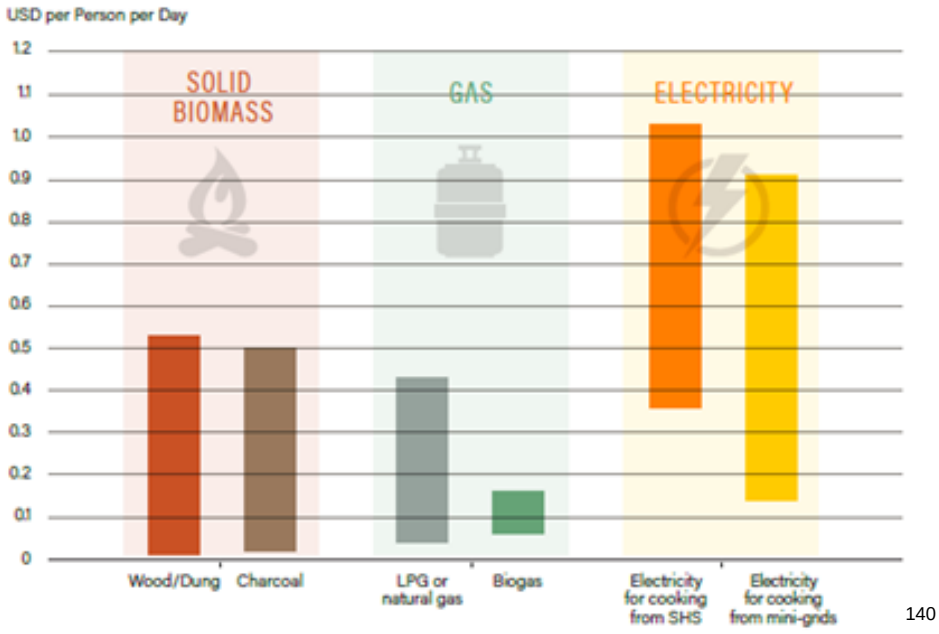
Source: IRENA Renewable Cost Database.

Annex-6: Levelized cost of electricity by capacity factor of bio-energy fired projects (2000-2016)



Source: IRENA Renewable Cost Database.

Annex-7: Cost of Various Cooking Technologies by source



[140]

[140] http://www.ren21.net/status-of-renewables/global-status-report/