The Federal Government

Enabling PV Nigeria

AHK Delegation der Deutschen Wirtschaft in Nigeria
Delegation of German Industry and Commerce in Nigeria

BSW German Solar Association

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intec
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Nigerian-German Business Association

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List of Acronyms

Acronym	Definition
AA	All-Action Agenda
AC	Alternating Current
BP	British Petroleum
BSW	Bundesverband Solarwirtschaft (German Solar Industry Association)
CAC	Corporate Affairs Commission
CAPDAN	Computer and Allied Products Dealers Association of Nigeria
CAPEX	Capital Expenditures
CBN	Central Bank of Nigeria
CET	Common External Tariff
CFTZ	Calabar Free Trade Zone
CREN	Council for Renewable Energy Nigeria
DC	Direct Current
DisCo	Electricity Distribution Company
ECN	Electricity Commission of Nigeria
ECOWAS	Economic Community of West Africa
EFCC	Economic and Financial Crimes Commission
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMSL	Electricity Management Services Limited
EPC	Engineering, Procurement and Construction
EPIC	Electrical Power Implementation Committee
EPSR(A)	Electric Power Sector Reform Act
EPZ	Export Processing Zone Authority
ESI	Electricity Supply Industry
ESIA	Environmental and Social Impact Assessment
ESMAP	Energy Sector Management Assistance Program
EU	European Union
FCT	Federal Capital Territory
FGN	Federal Government of Nigeria
FiT	Feed-in Tariff
FKZ	Förderkennzeichen (project funding reference number)
FMENV	Federal Ministry of Environment
FMPWH	Federal Ministry of Power, Works and Housing

Acronym	Definition
FTZ	Free Trade Zone
FZ	Free Zone
GDP	Gross Domestic Product
GIZ	Gesellschaft für Internationale Zusammenarbeit
GRML	General Reuse Markup Language
GW	Giga Watt
HV	High Voltage
ICPC	Independent Corrupt Practices Commission
ICT	Information and Communication Technology
IEA	International Energy Agency
IEDN	Independent Electricity Distribution Networks
IFC	International Finance Corporation
IMF	International Monetary Fund
IRR	Internal Rate of Return
kV	Kilo volt
LCOE	Levelized Costs of Electricity
MFN	Most Favoured Nation
MSME	Micro, Small and Medium Enterprises
MW	Mega Watt
MYTO	Multi-Year Tariff Order
NAHCO	Nigeria Aviation Handing Company
NAPSAS	National Power Sector Apprenticeship Scheme
NAPTIN	National Power Training Institute of Nigeria
NBET	Nigerian Bulk Electricity Trading
NBS	Nigeria Bureau of Statistics
NCS	Nigeria Customs Service
NDPHC	Niger Delta Power Holding Company
NEEAP	National Energy Efficiency Action Plans
NEMSA	Nigerian Electricity Management Services Agency
NEP	National Energy Policy
NEPA	National Electric Power Authority
NEPP	National Electric Power Policy
NEPZA	Nigerian Export Processing Zone Authority
NERC	Nigerian Electricity Regulatory Commission
NESI	Nigeria Electricity Supply Industry

Acronym	Definition
NESP	Nigerian Energy Support Programme
NGN	Nigerian Naira
NGSDP	National Graduate Skill Development Programme
NIPC	Nigerian Investment Promotion Commission
NIPP	National Independent Power Program
NIRP	Nigeria Industrial Revolution Plan
NOI	Country Specific Polling Services in the West Africa
NREAP	National Renewable Energy Action Plans
NREDA	National Renewable Energy Development Agency
NREEEP	National Renewable Energy and Energy Efficiency Policy
OEM	Original Equipment Manufacturer
OPEX	Operational Expenditure
PEBEC	Presidential Enabling Business Environment Council
PHCN	Power Holding Company of Nigeria
PPA	Power Purchase Agreement
PPP	Private Power Project
PSI	Pioneer Status Incentive
PTFP	Presidential Task Force on Power
PV	Photovoltaics
PVPS	Photovoltaic Power Systems Program
RE	Renewable Energy
REA	Rural Electrification Agency
REAP	Renewable Electricity Action Programme
REF	Rural Electrification Fund
REMP	Renewable Energy Master Plan
REPG	Renewable Electricity Policy Guidelines
RESP	Rural Electrification Strategy and Plan
RETF	Rural Electrification Trust Funds
ROI	Return on Investment
SHS	Smart Home Systems
SO	National Electric System Operator abbreviated as System Operation
TCN	Transmission company of Nigeria
TEM	Transitional Electricity Market
UAE	United Arab Emirate
UN	United Nation

Acronym	Definition
UNDESA	UN Department for Economic and Social Affair
UNDP	United Nations Development Programme
USA	United States of America
USD	United States Dollar
VAT	Value Added Tax

0. Executive Summary

Nigeria's current electrification rate is only 59% and energy demand is expected to grow steadily due to a fast-growing population and economy. Approximately 80% of Nigerians use alternative sources of electricity supply, particularly diesel generators, which have an installed capacity of 8–14 GW.

Looking at the market segments it should be noted that residential usage accounts for almost 58% of overall electricity consumption, while the industrial sector only accounts for 17%. The relatively low industrial energy consumption is an indicator of the ongoing energy crisis in Nigeria and its consequences. To ensure further economic development and to adopt a growing population into a strong labour force, Nigeria needs a strong industrial sector, which in turn needs a reliable and stable supply of electricity, which has not been provided to the extent necessary in the past. Renewable energies, in particular solar PV, can substantially contribute to the improvement of energy supply in Nigeria – and this is being recognized by policymakers. The *National Renewable Energy Action Plans* (NREAP) of Nigeria supports the adopting of 30,000 MW in installed capacity, with a share of at least 30% in renewable energies. The targets for the installed capacity of solar PV are 2,000 MW by 2020 and 5,000 MW by 2030.

The question now is: how to best realize these capacities and which obstacles need to be removed to appreciate Nigeria's undisputedly huge solar-PV potential? Solar-PV has succumbed to a bad image based on the poor quality of the systems, due to unprofessional installations. A number of initiatives and a few Nigerian solar pioneers however, are working hard to resolve this image. Another more palpable, and probably the most relevant practical constraint for the growth of solar-PV today, is the lack of financing. Due to the low capital resources and purchasing power of large parts of the population, high inflation rates and the lack of experience with solar-PV, banks are less willing to provide loans for solar projects, and if they do, they do so at rates that make solar-PV plants unprofitable.

Therefore, it is important to define business models that can work. Standardising business models is always a challenge, and this may be more so the case in Nigeria, where creativity is paramount in developing models that create win-win situations for all parties involved in realizing a solar-PV project. This ENABLING PV report presents different business models that each give direction as to how PV can be exploited in different segments and installation sizes.

In this study the German Solar Association (BSW-Solar) in cooperation with the GOPA-International Energy Consultants GmbH (GOPA Intec), the Delegation of German Industry and Commerce in Nigeria (AHK Nigeria), and eclareon GmbH analyse and describe the process of investment and project development of PV power plants in Nigeria. This includes the description of the legal and administrative framework and of import, trade and investment conditions, as well as the presentation of selected business cases.

1. Status of the Nigerian Power Sector

When 76 million Nigerians are living without electricity something needs to change: this statement is a call to action for a change in the way Nigeria generates its power. Of the overall population of Nigeria, only 59% [1] have access to electricity supply. More than 80% of the high operating costs (over NGN 8bn / USD 53m), goes into staff salaries, pensions and welfare contributions. The national electricity grid is characterized by high energy losses (technical and non-technical) and by inadequate expertise to manage the distribution and transmission network. Moreover, the transmission and distribution network has only grown at a rate of about 16% yearly showing its inherent disability to handle the necessary power park capacity. Taking these numbers and facts into consideration, it becomes clear that the power sector needs to be strengthened and that renewable energy sources, in particular solar energy, can be an important contributor to this.

1.1 Power Market Policy

The Nigerian power sector cannot be wholly analysed without considering the market policy, strategy and development plans. It must be noted that some of these policies and measures are fully implemented while others are awaiting the final approval and implementation by Nigerian authorities.

1.1.1 General Power Market Policy

The Nigerian power market has been governed by a series of regulations that have undergone transformations in the last decades. Thus, the state-owned utility *Power Holding Company of Nigeria* (PHCN), known as *National Electric Power Authority* (NEPA) before the unbundling of the sector, was divided into six (6) Generation Companies of Nigeria (GenCos), eleven (11) Distribution Companies (DisCos) and the *Transmission Company of Nigeria* (TCN). This unbundling was done by the federal government, following the energy crisis of 2001, through the formulation of the *Electric Power Sector Reform Act* (ESPRA) (2005) that provided the legal basis for this process.

In the hope of addressing the poor electricity service in Nigeria, which is plagued by constant power outages, a new investor-friendly environment with a strong central regulatory framework was created.

The objective was to **transform the Nigerian power sector into a private-sector driven market** ("The Reform Objective") by introducing transparent and responsible management, limiting political and governmental interference in utility management, and encouraging private investment in power generation (privatization of PHCN and *Niger Delta Power Holding Company* (NDPHC)) assets. The reform process intends to support and improve service maintenance and delivery to the Nigerian energy consumers ("The Service Delivery Objective"). [1]

National Electric Power Policy (NEPP), 2001

This policy statement was **the initial step towards the reformation of the electricity sector**. It is the result of the consultations of the *Electrical Power Implementation Committee* (EPIC), the central body tasked to elaborate, coordinate and monitor all activities relating to the reform, restructuring and privatization of the power sector [3]. It defines the principal phases for achieving the reform goal of a reliable system, which are:

- The **privatization of the vertically-integrated parastatal company** NEPA and the introduction of Independent Power Projects (IPPs) as well as of private emergency power producers.
- Focus on **increasing the competition between market participants**, reduction of subsidies (i.e. payment of full fuel prices) and sale of excess power to DisCos. [2]

National Energy Policy (NEP), 2003

The (NEP) 2003 was the **first overall framework** to help further develop the energy sector and guarantee that its contribution to Nigeria's economy improves. The broad framework covers the development, exploitation and supply of all energy resources and how they are utilized by various other sectors as well as the environment, energy efficiency and energy financing. It also entails plans regarding energy policy implementation [4].

Renewable energy: The NEP 2003 remarks that the efficient conversion of energy resources is vital to a growing development in the region.

Energy efficiency and conservation: The NEP 2003 acknowledges that the energy utilization in Nigeria is by no means efficient. To promote this the NEP promoted the efficient extraction of energy resources, however no specific targets were set, making the objective vague and toothless.

Rural electrification: The NEP 2003 recommended off-grid and stand-alone systems to increase the electricity supply to remote regions of Nigeria. [2]

Electric Power Sector Reform Act (EPSRA), 2005

The **Nigerian power sector was liberalized as a consequence of EPSRA in 2005 [5].** This in itself was a consequence of the NEPP which was adopted in 2001 providing a new legal and regulatory framework for the sector.

The act mandates that the *Nigerian Electricity Regulatory Commission* (NERC) ensure that **all electricity generated is efficiently sourced and delivered to the consumers using the grid**. NERC, being the Nigerian power sector's principal regulator, is responsible for setting cost-reflective tariffs, issuing licenses, and determining operating codes and standards.

Recommendations in EPSRA include: the creation of the *Rural Electrification Agency* (REA) and proposals regarding the expansion of the main grid, the development of isolated and mini-grid systems and renewable energy power generation be prepared for the President of Nigeria. The act also mandated that the REA prepare a strategic plan regarding the expansion of access to electricity using renewable energy. [2]

Renewable Electricity Policy Guidelines (REPG), 2006

The Renewable Electricity Policy Guidelines issued by the Federal Ministry of Power and Steel made it a condition that the federal government **expand the share of renewable**

electricity to at least 5% of total national electricity generation and a minimum of 5 TWh of electric power production by 2017 [5].

The document examined the electricity sector and analysed the progress of renewable energies under previous energy policies, thereby evaluating the effectiveness of existing and preceding policies and their targets. The document also set the following policy objectives to promote the use of renewable energies in the power sector:

1. Expansion of the market for renewable electricity to at least five percent of total electricity generating capacity and a minimum of 5 TWh of electric power production;
2. Establishment of stable and long-term favourable pricing mechanisms and ensuring unhindered access to the grid with guaranteed purchase and transmission of all electricity produced by renewable electricity producers and obliging the grid operators to upgrade the system accordingly;
3. Construction of independent renewable electricity systems in areas not covered by the electricity grid;
4. Development of innovative, cost-effective and practical measures to accelerate access to electricity services in rural areas through renewable energy sources;
5. Setting up of a Renewable Electricity Trust Fund to be governed by the Rural Electrification Fund;
6. Creation of a multi-stakeholder partnership for the delivery of renewable electricity to meet national development goals;
7. Broadening international cooperation in expanding the role of renewable electricity for meeting national development goals and contributing to global efforts in addressing climate change.

The REPG facilitated that the *Rural Electrification Trust Funds* (RETF) be set up to promote, support and provide renewable electricity through private and public-sector participation. [2]

Renewable Electricity Action Programme (REAP), 2006

The REAP set out a roadmap for implementing the Renewable Electricity Policy Guidelines. The focus was to promote the use of all forms of renewable energy sources in electricity generation by highlighting the disparities between policy guidelines and the realities of implementation. The REAP highlighted the great potential that renewable energies have and the newest technologies that are making them even more attractive. The REAP also laid out the strategies developed to achieve the targets set for each form of renewable technology. [6]

National Renewable Energy and Energy Efficiency Policy (NREEEP), 2015

The NREEEP outlined the policies and measures to be implemented to promote renewable energy and energy efficiency in Nigeria [7]. NREEEP sought to bring policymakers' attention to the great economic, political and social potential of renewable energy. It recommended that strategies be developed to harness the great potential of renewable energies and to propel the ongoing changes in Nigeria's power sector even further. It is an umbrella that streamlined the other aforementioned policies and strategies into one document.

The policies laid out in the NREEEP led to development of the *National Renewable Energy Action Plan* [8] which put in writing how the objectives are to be achieved step-by-step. The NREEEP's overall objective is the optimal utilization of the nation's energy resources for a more sustainable development. [2]

1.1.2 Strategy and Plans

Roadmap for Power Sector Reform, 2010/2013 – Plans

In December 2012, the *Presidential Task Force on Power* (PTFP) presented its *Roadmap for Power Sector Reform* [9], an updated edition of the *Roadmap for Power Sector Reform 2010* [10]. The new roadmap reviewed and calibrated plans and strategies for Nigeria's power sector to produce clean and efficient electricity at competitive rates. [2]

Renewable Energy Master Plan (REMP), 2005/2012

The *Renewable Energy Master Plan* (REMP), drafted by the Energy Commission of Nigeria and the United Nations Development Programme (UNDP) in 2005 and updated in 2012, highlights Nigeria's vision for a sustainable future and how renewable energies can help enable faster progress on this front [10]. The REMP **recommended integrating renewable energies into buildings, electricity grids and "other distribution systems" [9]**.

While promoting the increased use of renewable energy the REMP also set the following targets to increase electrification rates in Nigeria: **from 42% in 2005 to 60% in 2015 and 75% by 2025**.

The plan includes issues that are common to all sub-sector programmes:

- The legal, regulatory and institutional framework,
- Incentives (financial and fiscal, e.g. tax exemptions),
- Capacity building (human and infrastructural),
- Inter-agency/governmental collaboration,
- Research and development,
- Monitoring and evaluation,

Renewable energy portfolios and feed-in-tariffs. [2]

Draft Rural Electrification Strategy and Implementation Plan (RESIP), 2016

In Nigeria plans for rural electrification are coordinated at the federal level, whereas the implementation of these plans is carried out by the states. RESIP is a document that tells states and local government that: "The primary objective of the *Nigerian Rural Electrification Policy* and by extension this Rural Electrification Strategy and Implementation Plan is to expand access to electricity as rapidly as possible in a cost-effective manner. This implies full use of both grid and off-grid approaches, with subsidies being primarily **focused on expanding access rather than consumption**." It seeks to do so by "**promoting a full menu of rural electrification options, grid, off-grid (mini-grid and stand-alone)" systems.** [11]

National Renewable Energy Action Plans (NREAP) (2015-2030)

In July 2016, the Federal Government of Nigeria, supported by the European Union (EU) and the German Government, adopted the following four documents [12]:

- the National Energy Efficiency Action Plans (NEEAP),
- the National Renewable Energy Action Plans (NREAP),
- the Sustainable Energy for All-Action Agenda (SE4ALL-AA), and
- the Nigerian Power Sector Investment, Opportunities and Guidelines.

The NREAP supports an electricity vision of attaining 30,000 MW of power (on/off-grid) by the year 2030 with at least 30% RE in the electricity mix. Three development phases are intended: attaining a stable, then sustainable and finally uninterrupted power supply in Nigeria.

The NREAP provides useful information on the renewable energy potential and market in Nigeria, the relevant policies and barriers to overcome, and is a useful tool for the development, implementation and promotion of renewable energy measures. The 30% goals were supposed to be supported by installation of grid connected solar PV plants. The targets for installed capacity from solar PV are 2,000 MW by 2020 and 5,000 MW by 2030.

A good portion of the electricity vision can be achieved by means of renewable energy as shown in Table 1.

Table 1: Targets for Grid Connected RE

Installed Capacity	2010	2020	2030
RE installed capacity [MW] (including large and medium scale hydro)	916	5,325	13,800
RE share of the total installed capacity [%] (including medium and large hydro)	21	52	43
Total RE generation [GWh] (including medium and large hydro)	4,749	20,031	49,766
RE share in the electricity mix [%] (including medium and large hydro)	17	38	29

Source: National Renewable Energy Action Plans (2015–2030) [13]

1.2 Electricity Generation

1.2.1 Status of Generation Capacities

The Nigerian electrical power system has four basic power generation options:

1. Transmission based on-grid generation
2. Embedded generation
3. Off-grid generation and
4. Captive generation.

While licenses are needed to operate options 1, 2 and 3, captive generation only requires a permit from NERC. [14]

The existing regulations only apply to electricity generation exceeding 1 MW of installed capacity. Captive generation implies that electricity generated is consumed by the generator itself, as is the case in households or companies that run their own diesel generators. **Captive generation** is off-grid, meaning that it is not connected to the national or a distribution grid.

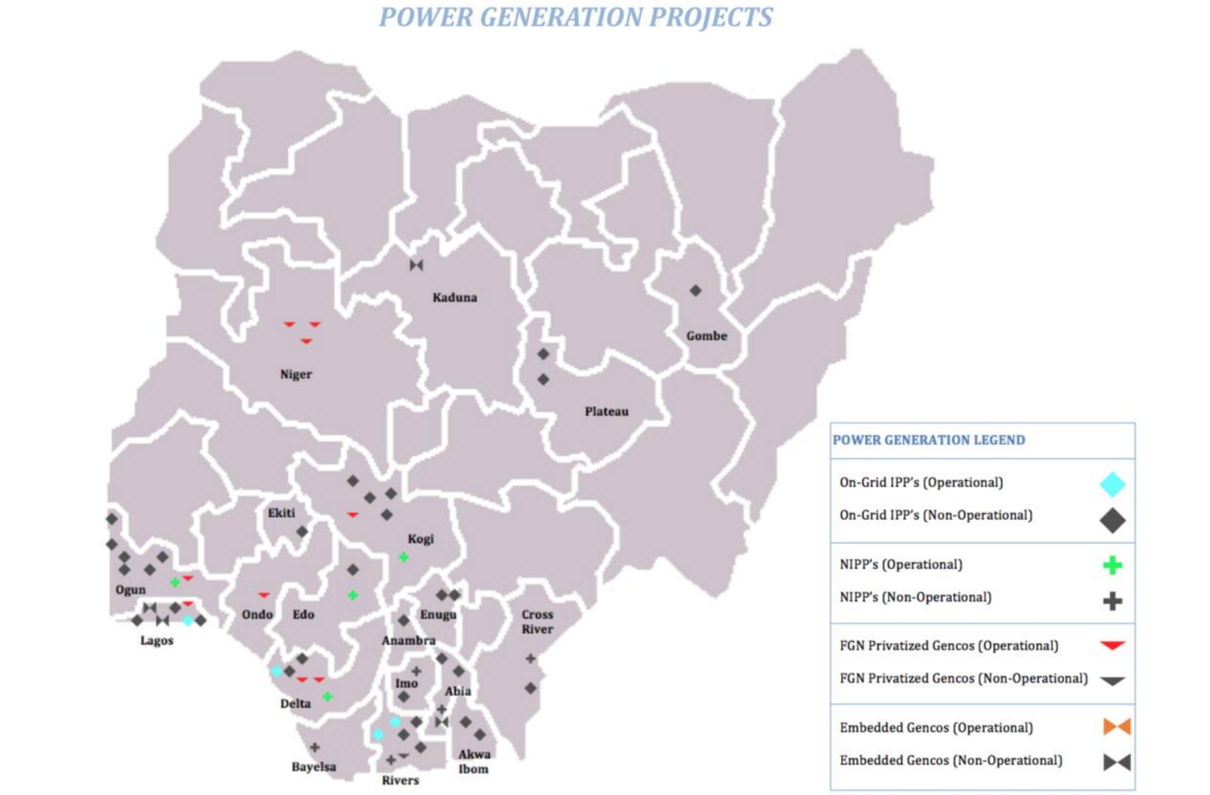
Power generation with **off-grid generation** licenses require external off-takers. These are traditionally households in remote villages, public facilities (for example schools or health stations) and/or businesses

Power generated from **embedded generation** is distributed using an external distribution company. Embedded generators are therefore usually connected to the distribution grid.

On-grid generation licenses are necessary for all power plants which distribute their power on the national transmission grid. [2]

Figure 1 shows all large, on grid power generation sites in Nigeria, including those owned by NIPP, Federal Government of Nigeria (FGN) and privatized plants. The figure also shows embedded power generation sites. These power generation plants are mainly depending on fossil fuel, which is well available in the southern parts of Nigeria. The northern parts of Nigeria do not have large power generation facilities. Those parts of Nigeria are supplied with electricity by means of high-voltage transmission lines.

Figure 1: Power Generation Sites in Nigeria



Source: Detail Solicitors; 2015 [15]

1.2.2 On-grid power Generation

Table 2 shows how electricity was generated in Nigeria from 2007 to 2014. As stated by NERC, the licenses for on-grid power plants amounted to 19,407 MW in 2014, while off-grid licences cover a production capacity of only 305 MW and embedded generation capacity covers 49 MW. At this point it should be noted that electrical power from captive power generation is much higher than that provided by power plants with off-grid licenses and embedded generators. [2]

Table 2: Electricity Generation Profile

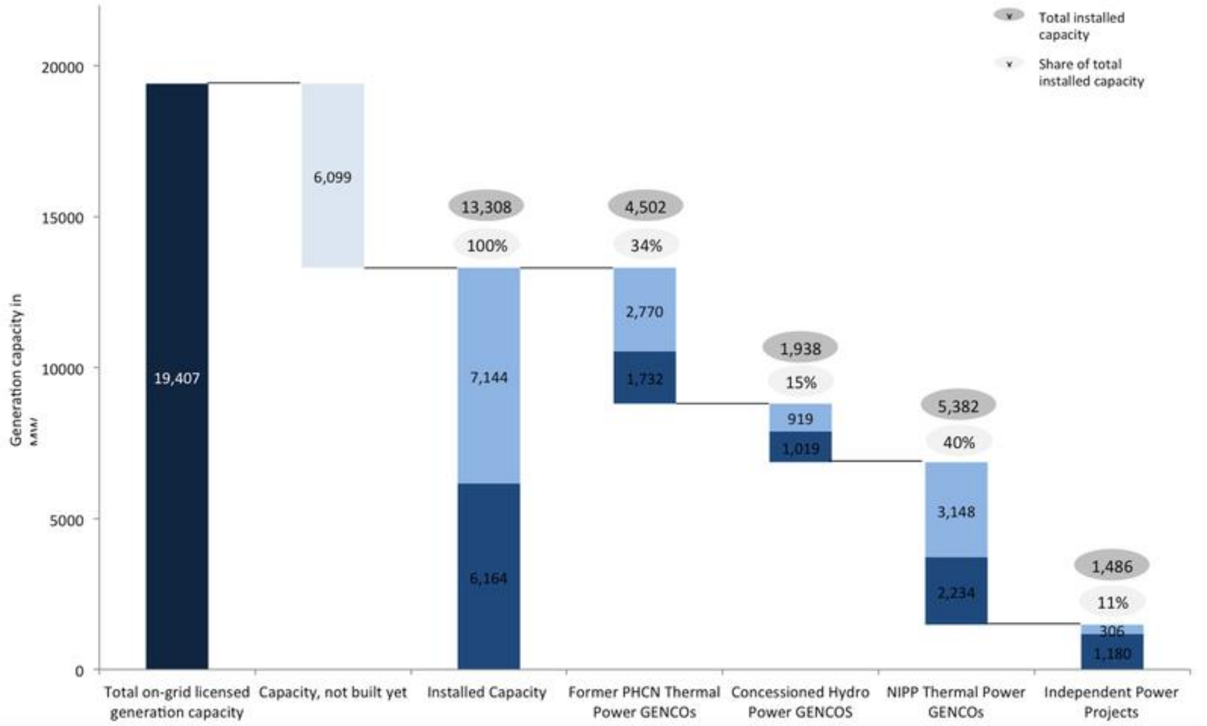
Year	Ave. Gen. availability (MW)	Maximum peak generation (MW)	Maximum daily energy generated (MWh)	Total energy generated (MWh)	Total energy sent out (MWh)	Per Capita Energy Supply (kWh)
2007	3,781.3	3,599.6	77,322.3	22,519,330.5	21,546,192.2	155.3
2008	3,917.8	3,595.9	86,564.9	18,058,894.9	17,545,382.5	120.4
2009	4,401.8	3,710.0	82,652.3	18,904,588.9	18,342,034.7	122.0
2010	4,030.5	4,333.0	85,457.5	24,556,331.5	23,939,898.9	153.5
2011	4,435.8	4,089.3	90,315.3	27,521,772.5	26,766,992.0	165.8
2012	5,251.6	4,517.6	97,781.0	29,240,239.2	28,699,300.8	176.4
2013	5,150.6	4,458.2	98,619.0	29,537,539.4	28,837,199.8	181.4
2014	6,158.4	4,395.2	98,893.8	29,697,360.1	29,013,501.0	167.6

Source: NERC Archive [16]

Figure 2 illustrates how the licenses for grid-connected generation capacity (options 1 and 2) are combined. Dark blue represents ‘available capacity’ and light blue ‘non-operational installed capacity’. 13,308 MW installed capacity is attributable to the main power plant fleet, the remainder (~31% of licensed capacity) has not yet been built or is under development. Within the existing power plant fleet, NIPP thermal power plants (~40%) and former PHCN thermal power plants (~34%) are contributing the most to the installed capacity. According to NERC statistics, 80% of actual generation capacity in 2015 came from gas-based power plants, while the remaining energy came from hydro power plants. A detailed overview of the existing power plant fleet in Nigeria is as shown in figure 2 above.

The *Presidential Task Force on Power* regularly publishes the estimated peak demand and peak generation, whereby the former was with 12,800 MW regularly close to four times the latter. The only way the shortfall can be made up is by relying on off grid electricity generation. [2]

Figure 2: Break-Down of On-Grid Licensed Power Generation in Nigeria, 2012



Source: GOPA International Energy Consultants GmbH; 2015 [2](dark blue = available capacity, light blue = non-operational installed capacity)

1.2.3 Off-Grid Power Generation

As already mentioned in the previous chapter, off-grid licenses cover a production capacity of only 305 MW, while licensed embedded generation capacity only represents 49 MW.

Most private investors invest in captive generation to guarantee sustainable and stable power supply for manufacturing facilities. **The figures listed above do not account for the generation capacities of privately-owned diesel or gas generators**.

According to a 2013 survey, approx. 80% of Nigerians use alternative sources of energy to get a steady supply of electricity. Of these alternative energy sources generators are used by a much higher margin than solar PV systems. Estimates suggest that decentralized diesel generators generate between 8 and 14 GW of total capacity currently installed in Nigeria. About 86% of companies in Nigeria own or share a generator and about 48% of their total electricity demand is covered by these captive power generators. With several million privately operated diesel generators, Nigeria is Africa's leading importer of generators and one of the leading worldwide importers. Total annual imports amount to NGN 17.9 billion (USD 112 million).

Captive generation offers some distinct advantages for the Nigerian power system. These advantages include: industrial consumers being able to generate the power needed for their operations, getting **permits for captive generation is less risky financially** and captive generation permits the effective use of electric power because no technical transmission or commercial losses occur. [2]

1.3 Electricity Consumption and Demand

1.3.1 Electricity Demand

Households account for almost 58% of electricity consumption in Nigeria and it is the residential sector that will account for the highest increase of energy consumption in the next twenty-year period.

Energy consumption is expected to increase quite dramatically in the next years because of a growing population and strong economic growth. Demand for on-grid electricity is expected to increase more than demand for off-grid electricity. The World Bank projected that **total electricity demand will grow by a factor of 5 by 2035 to almost 530 TWh**. Generators with a capacity of 65 GW could satisfy this demand if they run throughout the year at their maximum output level. [2]

Table 3: Comparison of Electricity Demand Projections (MW)

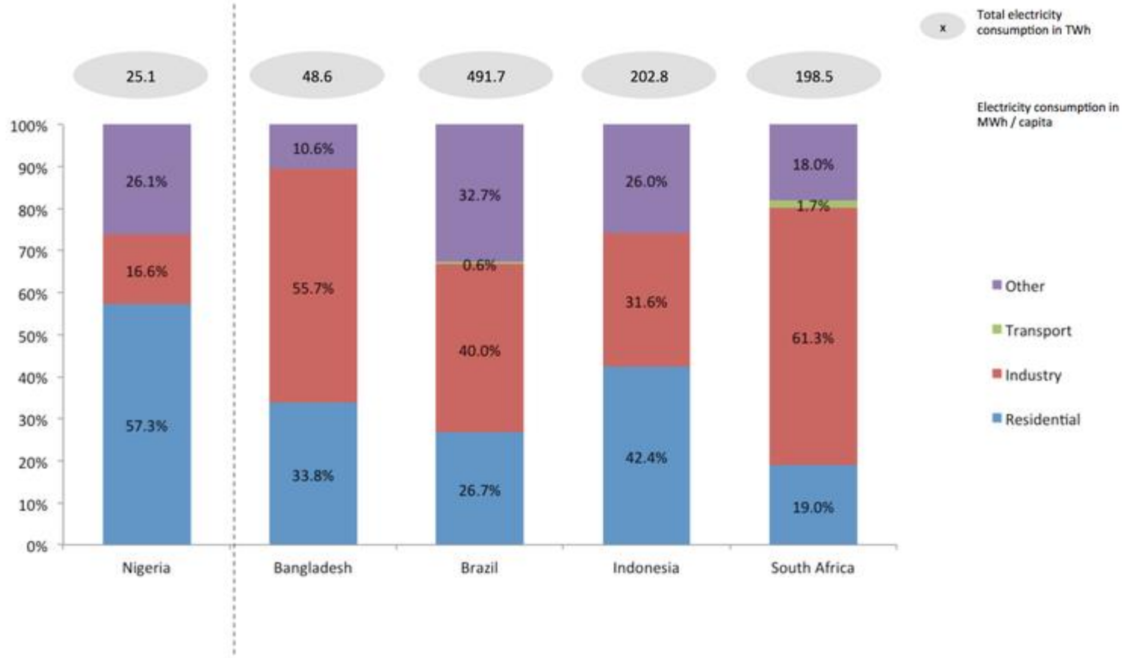
	2014	2015	2020	2025	2030	2035	2040
Agusto & Co.	12,800	41,133	88,282	–	–	–	–
Renewable Energy Master Plan (reference growth 7%)	–	24,380	45,490	79,798	115,674	161,651	213,122
Presidential Task Force on Power (PTFP)	–	12,800*	–	–	–	–	–
PTFP, distribution capacity	10,648	–	32,774	–	–	–	–
Tractebel Engineering	–	–	11,433	–	24,208	–	–
NREEEP		2,483	8,188		23,134		

Source: Nigeria Power Reform; 2015 [17]

1.3.2 Electricity Consumption

Figure 3 compares the total electricity consumption by economic sector in Nigeria to selected emerging economies based on the most recent data from 2015.

Figure 3: Total Electricity Consumption by Economic Sectors and Consumption Per Capita for Nigeria and Peer Countries (2015)



Source: IEA; 2015 [18]

The Nigerian industry has a relatively low energy consumption of 16.6% when compared to other emerging countries. There are several reasons for this: (1.) the Nigerian industry is quite small due to an over-dependence on oil exports, which leads to a high import-dependent economy. This makes it cheaper to import goods rather than producing them locally because the cost for machinery and spare parts is high. (2.) It is difficult to gather reliable statistics because many industrial companies operate off-grid due to an unreliable or complete lack of a grid connection. This makes it difficult to calculate the energy consumption of companies that run their production using energy produced by diesel generators.

1.3.3 Power Outage Statistics

The failures of the power sector have resulted in a situation that has been hampering, if not damaging the economy and infrastructural development in Nigeria for decades. Among these challenges a few are: unconducive environments for investors, the general underfunding of the power sector and a lack of good regulations. The funding issue resulted in a face-off between the National Assembly and the Minister of Power, Works and Housing according to Mr. Babatunde Fashola. However, the non-compliance of electricity consumers to pay for power consumed, coupled with the inability of the DisCos to pay for the power delivered to the customers, have also affected the sector, especially since the generation and distribution components are being handled by private investors. The National Electric System Operator or System Operator (SO), an arm of the TCN, put the general national peak demand forecast at about 19,100 MW, while recent peak power levels generated hover between just 4,000 MW and 5,000 MW [19] . This translates into unavailable or unstable power supply in response to the effective demand.

With the aim of monitoring the progress made so far since the power sector reforms in Nigeria, NOI Polls introduced the Power Polls in 2013 to explore the perception of Nigerians towards the power sector reforms [20]. The polls were conducted on a monthly basis in order to analyse the daily amount of power supply delivered and the general state of power supply to households.

Erratic Power Supply

New aggregated power poll results released by NOI Polls for the first half of 2017 (January to June 2017) display an **average coverage of 30.5%**, revealing a decline in power supply to Nigerian households when compared to the second half of 2016 (July to December 2016) where the coverage was at an average of 41.5% [21]. This significant drop can be attributed to the reported shortage of gas supply experienced by the sector and grid instabilities caused by weak transmission infrastructures.

Quarterly Trend on Power Supply

The analysis of the poll series results revealed that only about 3 in 10 Nigerians nationwide experienced an improvement in power supply in the first semester 2017. The more detailed quarterly evaluation revealed that only 31% of adult Nigerians reported a minimal increase in power supply to their households in quarter two (Q2), 2017. This merely represents a 1% increase in absolute numbers when compared to Q1, 2017. [22]

Quarterly Average Daily Cumulative Power Supply to Nigerian Households

The analysis of survey findings also revealed that the average cumulative power supply to nationwide Nigerian households for Q1 2017 was 8.9 hours compared to 9.3 hours in Q2 2017, reflecting at best a fractional improvement.

Average Monthly Improvement in Power Supply

Monthly analysis has further shown that the highest improvement in nationwide power supply was in the month of March 2017 with 35% while the month of January displayed a negative development with only 21%. January's minimum is likely connected to the decline in power generation during quarter four (Q4) of 2016 since Nigeria's generation statistics show that a total average of just 2,159 MW of power was generated by power stations during the fourth quarter of 2016. Despite a 14%-point surge from 21% in January to 35% in March, the power supply fluctuates tremendously throughout the year. [23]

Average Monthly Daily Cumulative Power Supply to Nigerian Households

The analysis of survey results also revealed that the month of February recorded the highest average daily cumulative power supply to Nigerian households with 9.8 hours while January displayed the lowest supply with 7.5 hours.

1.4 Transmission and Distribution Grid

1.4.1 Transmission Grid

Nigeria's national grid operates at 330 kV and 132 kV high voltage level (HV) [24]. Nigeria's transmission network consists of 159 high voltage substations with a total (theoretical) transformation capacity of 19,000 MW and over 15,022 km of transmission lines. Nigeria's transmission wheeling capacity of 5,338 MW is higher than average operational generation capacity of 3,879 MW but it is far below the total installed generation capacity of 12,522 MW [25]. The national grid configuration has an installed capacity of 6,500 MW but can handle a wheeling capacity of maximum 4,500 MW [26]. The long-term planning of TCN is to further improve the grid capacity - thereby topping the installed generation capacity to 20 GW by 2020. Already approved TCN and NIPP transmission projects could increase transmission lines to a total length of 21,035 km and the grid wheeling capacity to 7,230 MW. [27]

1.4.2 Distribution Grid

In the process of the privatisation programme, the PHCN distribution network was broken up into 11 regional distribution grids. Those distribution grids were sold to foreign investors with a minority stake held by the FGN. The distribution grids vary in geographic area, capacity and served customers. The Nigerian DisCos are: Abuja, Benin, Eko, Enugu, Ibadan, Ikeja, Jos, Kaduna, Kano, Port Harcourt and Yola.

The distribution grid operates mainly on 33 kV and 11 kV voltage. A major problem of the distribution companies are 46% losses of energy due to technical, commercial and collection losses. This affects the companies' financial stability as the revenue is insufficient to cover the full market costs. [27]

1.5 Electrification

1.5.1 Electrification Rate

Nigerian generation facilities are heavily concentrated in Southern Nigeria, resulting in high losses and load shedding within the transmission system when electricity is transported north. Nigeria's geography makes delivering energy to smaller towns difficult without the appropriate infrastructure. Theft from illegal connections to the grid is another challenge that needs to be addressed. The reasons for the relatively low levels of electricity access and frequent blackouts in Nigeria are reported in the *General Household Survey* conducted between 2015–2016 [28]. Over 60% of surveyed **rural households attributed the reason for lack of electricity access to frequent grid failures and high connection costs**. The unreliability of services was also reported as one of the reasons for low electrification rates in Nigeria. [29] [2]

In 2016, the **overall electrification rate in Nigeria was 59%**, but still higher than the 43% average electrification rate in Sub-Saharan Africa. As further detailed in Table 4, there is a sharp discrepancy between cities and rural areas, as **the rate of urban electrification in Nigeria is 86% compared to a rural electrification rate of just 41%**. According to government plans, an overall electrification rate of 75% shall be achieved by 2025, as emphasized in the *Nigeria Vision 20:2000* and in the *Draft Rural Electrification Strategy and Plan* [30].

Table 4: Electrification Rates in Nigeria and Sub-Saharan Africa

Region	Sub-Saharan Africa	Nigeria
Population without electricity	591 million	76 million
Overall Electrification rate (%)	42	59
Urban Electrification rate (%)	76	86
Rural Electrification rate (%)	25	41

Source: World Bank; 2016 [31]

Table 5 shows the distribution of households with access to electricity in Nigeria. The table distinguishes electricity supply from PHCN, private generators and solar panels and electricity supply from rural electrification (i.e. mini-grids). As shown in the table, the type of electricity supply varies significantly by state. There is a clear North/South divide, that can be attributed to the location of the thermal power stations in the South and the distance involved when wheeling out the power to the North. Figures for the states that have made the most progress in rural electrification are marked yellow, while green highlights states where the reliance on diesel generation was considered exceptionally high. It should be remarked that minus a few states **little progress has been made in rural electrification in the time period considered**.

The varying electrification rates in the states can also be regarded as indications of market opportunities, because the states with the lowest grid-electrification, are the states where there is the greatest need and therefore the greatest potential for investments in rural electrification. Rural areas that did not have any connection to the grid until 2010 were left to use their own generators. In other words, **rural electrification is neither regulated nor structured in a planned manner**. [2]

Table 5: Distribution of Household with Access to Electricity by Type of Electricity Supply in %, 2016

State	PHCN (NEPA) only	Rural Electrification*	Private Generator	PHCN/ Generator	Rural Electricity/ Generator	Solar Panel
Abia	89.6	0.9	0.5	5.0	4.1	0.0
Adamawa	89.5	2.9	1.9	4.8	1.0	0.0
Akwa Ibom	82.8	0.4	2.9	13.1	0.8	0.0
Anambra	81.0	1.7	1.0	15.6	0.7	0.0
Bauchi	77.5	8.0	1.4	9.4	3.6	0.0
Bayelsa	33.1	36.1	2.3	2.3	26.3	0.0
Benue	68.5	14.4	2.7	10.8	3.6	0.0
Borno	87.9	6.1	0.0	6.1	0.0	0.0
Cross River	91.7	6.2	0.5	1.6	0.0	0.0
Delta	93.6	2.7	1.5	1.5	0.8	0.0

State	PHCN (NEPA) only	Rural Electrification*	Private Generator	PHCN/ Generator	Rural Electricity/ Generator	Solar Panel
Ebonyi	78.9	12.7	0.0	1.4	7.0	0.0
Edo	93.1	2.1	1.2	2.7	0.9	0.0
Ekiti	91.1	1.0	0.8	6.9	0.3	0.0
Enugu	75.0	16.9	1.3	5.9	0.8	0.0
Gombe	94.7	3.2	0.0	2.1	0.0	0.0
Imo	85.4	5.0	2.1	7.5	0.0	0.0
Jigawa	93.2	0.9	0.0	4.3	0.9	0.9
Kaduna	84.8	5.1	2.0	7.6	0.5	0.0
Kano	87.0	6.0	0.0	4.0	3.0	0.0
Katsina	80.4	14.7	0.0	4.3	0.0	0.6
Kebbi	86.4	1.6	3.8	7.1	1.1	0.0
Kogi	79.2	3.3	0.4	15.8	1.3	0.0
Kwara	92.8	1.8	0.3	2.4	2.7	0.0
Lagos	67.9	1.2	1.2	25.9	3.5	0.2
Nasarawa	76.0	0.6	7.2	13.2	3.0	0.0
Niger	75.2	1.8	0.9	21.7	0.0	0.4
Ogun	94.5	0.3	0.0	5.2	0.0	0.0
Ondo	87.5	0.8	2.9	2.9	5.8	0.0
Osun	90.5	0.0	0.4	7.1	2.0	0.0
Oyo	97.7	0.9	0.5	0.9	0.0	0.0
Plateau	92.5	1.3	1.3	3.8	1.3	0.0
Rivers	66.0	26.3	6.7	1.0	0.0	0.0
Sokoto	90.4	6.6	0.6	1.8	0.6	0.0
Taraba	85.7	0.0	0.0	14.3	0.0	0.0
Yobe	77.0	6.9	1.1	11.5	3.4	0.0
Zamfara	87.0	6.9	0.0	3.8	1.5	0.8
FCT Abuja	67.4	0.9	1.9	27.6	2.2	0.0
Sector						
Urban	83.2	2.7	0.8	11.3	2.1	0.0
Rural	81.5	7.5	2.0	6.2	2.6	0.1
National	82.2	5.5	1.5	8.4	2.4	0.1

Source: NBS; 2014 [32]

1.5.2 Grid Development Plans

The Transmission Company of Nigeria developed a 5-year transmission system expansion plan that covers the period of 2016-2022. This plan is meant to bring the wheeling capacity from 5,300 MW to 20,000 MW by 2022 as part of short term measures and to urgently address the shortfall in the transmission sub-sector of the electricity supply industry (ESI).

1.6 Electricity Tariffs and Costs

1.6.1 Electricity Tariffs On-grid

The electricity prices are set centrally by the Nigerian Electricity Regulatory Commission in line with its *MYTO*. Within the electricity system, DisCos pay the Nigerian Bulk Electricity Trading (NBET) company, the central market intermediary between GenCos, DisCos and the TCN, for the electricity they receive from the GenCos. NBET then refunds GenCos for the bulk power sent to the grid. The respective prices are fixed per fuel source. The wholesale contract price for different power generation sources is provided in Table 6. [2]

Table 6: Wholesale Contract Prices for Different Power Generation Sources

Power generation sources	NBET Contract price USD/MWh (2013)	NBET Contract price NGN/MWh (2013)
Gas Power Plant	64.10	10,257
Hydro Power Plant	158.75	25,400
Solar PV Plant	458.13	73,300

Source: NBET; 2013 [37]

On the other hand, consumers pay DisCos for the electricity they consume. Here, **prices are fixed per region and consumer category**. The price to be paid by the end consumer for electricity in Nigeria is not to be confused with the price paid to GenCos.

The *MYTO* methodology combines the regulation of rates of return and price caps, which change by region and type of electricity customer. The regulators factor three modules into their calculations: the allowed return on investment (ROI), the allowed return of capital, as well as efficient operating costs and overheads. Hence, the costs factored into the prices were assessed individually for power generation, transmission, distribution and retail rates differ.

In order to attract investment in the sector, *MYTO* emphasizes cost recovery and financial viability, whereby the intention is to encourage efficient investments. The multi-year structure provides investors with a firmer basis for planning. Also, the tariffs foster an efficient use of the network, as tariffs are structured to reflect the marginal costs that users place on the system. It is worth mentioning that the tariff design by NERC was implemented for DisCos. It was intended to ensure that a distinction is made between private, commercial and industrial users with regard to electricity prices, while enabling DisCos to remain commercially viable. Each DisCo has tariffs reflecting its uniqueness in terms of cost, location and customer profile.

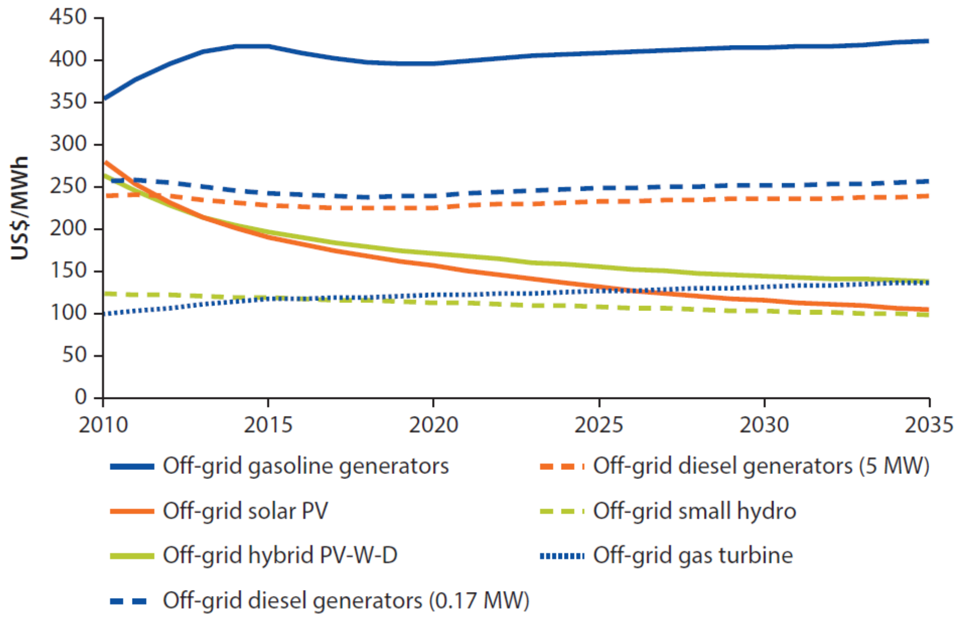
The Ministry of Finance has provided a maximum subsidy of NGN 50 billion (USD 312.5 million) for 2012 and 2013 and solely for residential customers. **NERC retained a minimum tariff at 4.00 NGN/kWh (0.025 USD/kWh) for all those consuming below 50 kWh/month**. Cross subsidies from large residential (category R), commercial (category C) and industrial (category D) customers to small residential customers are inherent to the tariff design because the Federal Government subsidy is not sufficient. [34] [2]

1.6.2 Electricity Tariffs Off-grid and Diesel-based

The following analysis was conducted as part of the Nigerian Energy Support Programme (NESP) and published in the GIZ study *The Nigerian Energy Sector*. [2]

The projected prices for off-grid electricity are shown in Figure 4. **In the set-up of the Nigerian electricity market, off-grid generation based on medium-sized diesel gensets is far more expensive for the consumer than on-grid supply of electricity**. **The World Bank estimates the cost for power generation with medium-sized diesel gensets at approx. 250 USD/MWh (corresponding to 40 NGN/kWh). This is significantly higher than the electricity prices for residential usage and higher than electricity prices of 19.89 to 29.58 NGN/kWh (0.124 – 0.185 USD/kWh) for industrial usage, purchased from the DisCos based on MYTO 2.1** [35]. Small scale businesses and families spend an average of NGN 3.5 trillion (USD 21.8 billion) a year to power their generating sets with diesel and petrol due to the unstable supply of electricity. [36]

Figure 4: Electricity Tariffs Off-grid and Diesel-based Projections



Sources: IEA; 2010 [37]

The interesting aspect in Figure 4 is the clearly projected decrease in price of electricity generated by solar PV. The price is expected to fall to the level of small hydropower plants, with the power generation costs of PV diesel hybrid systems falling at similar rates.

It can be noted that solar PV power is already substantially cheaper than electricity produced using diesel generator sets. This is especially the case in areas at long distances from diesel depots, thus mostly in northern Nigeria. This price trend is consistent with all international predictions on PV prices in relation to other means of power generation. **In Nigeria, more**

than in many other countries, fossil fuel prices are expected to rise disproportionately due to expected subsidy cuts. Taking this into consideration, solar PV plants outperformed diesel generator set much earlier than predicted in the *Energy Sector Management Assistance Program* (ESMAP) 2007 study [38]. Solar PV diesel hybrid systems can thus be clearly expected to take hold over time.

1.7 National Stakeholders

Federal Ministry of Power, Works and Housing (FMPWH)

In the power sector, the FMPWH is responsible to formulate and implement the policy of the FGN with respect to the generation, distribution and transmission of the nationwide power.

FMPWH has supported pilot solar projects in Ogun and Cross River states and built a pilot wind farm in Katsina [39]. The REA, NEMSA and NAPTIN are affiliated to the FMPWH, whereby the ministry oversees the independent regulator, NERC. [2]

Nigerian Electricity Regulatory Commission (NERC)

The Nigerian Electricity Regulatory Commission was established as an independent regulatory agency in 2005 under EPSRA 2005. Its mandate is to monitor and regulate the electricity industry of Nigeria and ensure compliance with market rules and operating guidelines.

Moreover, **NERC is responsible for assessing applications for licenses to operate independent power plants larger than 1 MW. In this process NERC supervises the eligibility of companies that apply for licenses and negotiates power purchasing agreements with the central off-taker in the transitional market, the NBET.**

To create a positive investment climate for rural electrification projects, NERC expanded the regulatory guidelines for mini-grids with less than 100 kW and light-handed regulation for mini-grids between 100 kW und 1 MW. [2]

Rural Electrification Agency of Nigeria (REA)

The Rural Electrification Agency was established as part of the ESPRA in 2006. The REA’s coordinates rural electrification activities in Nigeria and manages the Rural Electrification Fund (REF). The agency’s main function is to expand the reach of the electric power supply in rural areas.

The REA provides overall support and coordination of rural electrification activities to various stakeholders such as public-private partnerships, private investors and community owned/operated projects. REA through its offices in each of the six geopolitical zones, conducts feasibility surveys, market surveys, and willingness to pay surveys to ensure easy offtake. The REF Management Directorate of the REA is responsible for establishing and administering the REF and for providing capital subsidies in a transparent competitive process to qualified rural electrification schemes developed by public and private sector entities. [2]

National Power Training Institute of Nigeria (NAPTIN)

The National Power Training Institute of Nigeria (NAPTIN) was established in March 2009 to satisfy the high demand for training in the power sector. NAPTIN operates eight regional training centres in Afam, Akangba, Ijora, Jos, Kaduna, Kainji, Kano and Oji from its headquarters in Abuja.

NAPTIN's focus is government-funded technician training courses. Flagship programmes include the National Graduate Skill Development Programme (NGSDP) and the National Power Sector Apprenticeship Scheme (NAPSAS) which is aiming to train 7,400 graduates in a broad range of technical power professions. [2]

Nigerian Electricity Management Services Agency (NEMSA)

The Nigerian Electricity Management Services Agency (NEMSA) is a governmental agency under the jurisdiction of the FMP. The agency provides support services to Nigeria's electricity generation, transmission and distribution sector [40]. Its purpose is to guarantee efficient and reliable production and delivery of power and to ensure that safety standards are maintained in the electricity sector.

NEMSA inspects, tests and certifies the Nigerian power industry's electrical materials, equipment, power systems and electrical installations. All installations are tested against the technical standards and regulations that NEMSA sets. NEMSA also provides advanced training for technicians and licenses technical personnel. [2]

Federal Ministry of Environment (FMENV)

The Federal Ministry of Environment (FMENV) was established in 1999 and is responsible for protecting the environment against pollution and degradation and ensuring the conservation of natural resources for a more sustainable development in Nigeria [41]. FMENV's Department of Climate Change coordinates all matters regarding climate change and represents the Ministry at international climate negotiations.

The Department of Climate Change's objective is to better enable renewable energy and energy efficiency in Nigeria. Its focus is the sustainable use of biomass for cooking purposes and small-scale agricultural applications.

The FMENV is also the regulator for the Environmental and Social Impact Assessment (ESIA). ESIA are mandatory for all development projects as per the Nigerian EIA Act No. 86 of 1992. [2]

Energy Commission of Nigeria (ECN)

The Energy Commission of Nigeria (ECN), established in 1988, is "charged with the responsibility for strategic planning and co-ordination of national policies in the field of energy in all its ramifications" (ECN Act) [42]. This includes advisory services to the government regarding energy strategies, promoting research activities, development and training, and liaising with other international energy organisations.

Energy research, development and training related activities are organized in the six technical departments and the six energy research centres. Two centres, located at Nsukka and Sokoto, are responsible for new and renewable energy research. The centre in Lagos focuses on energy efficiency and conservation, while the centre in Benin City specialises in energy and environment. The two centres in Ilorin and Bauchi are responsible for research in the areas of hydropower and petroleum respectively.

The ECN was instrumental in launching the Renewable Energy Master Plan (2012). Another of its significant contributions was the preparation of the first National Energy Policy which was launched in 2003. This policy is currently undergoing revision. [2]

Nigerian Bulk Electricity Trading Plc (NBET)

The Nigerian Bulk Electricity Trading Plc (NBET) is a government owned public liability company [43]. The Bureau of Public Enterprises and the Ministry of Finance are its two shareholders of record with 80% and 20% stakes respectively.

NBET was established in 2010 to meet provisions of the *Electric Power Sector Reform Act* (EPSRA). Its mandate is to manage the purchase and resale of electricity from independent power producers.

NBET signs PPAs with privatised generation companies, greenfield IPPs and existing state-owned power plants. They resell power using vesting contracts with distribution companies and sign power sales agreements with eligible customers directly. **NBET's power purchase agreements (PPAs) with independent power producers are backed by credit enhancement instruments provided by the FGN.** [2]

Council for Renewable Energy Nigeria (CREN)

Launched in November 2014 at Energetic Solutions, the Council for Renewable Energy Nigeria (CREN) is a non-profit, multi-stakeholder association that promotes the appropriate use of renewable energy technology in Nigeria and the reduction of greenhouse gases through reduced consumption of fossil fuels [44]. CREN has a unique position in Nigeria to effectively build partnerships and facilitate the large-scale implementation of renewable energy. The Council for Renewable Energy Nigeria (CREN), **CREN aims to bring together the professional sector, government and civil servants, academics, associations, industry, financial institutions and services, the non-profit sector and end-users**. It acts as a forum where all stakeholders can work together for the efficient and appropriate implementation of renewable energies and to develop a comprehensive sustainable energy strategy for Nigeria. CREN strives to create public awareness and foster the emerging availability of reliable and economically viable renewable energy systems by supporting the policy implementation and research of these new renewable energy systems. [2]

2. Status of the Nigerian PV Sector

The following section gives an overview of the Nigerian PV Sector including its general acceptance, the regulatory and business framework as well as possible customer segments for Solar PV in Nigeria.

2.1 General Perception and Acceptance of PV

The awareness and information about opportunities offered by RE and their technologies are very low among public and private actors. This lack of information and awareness creates a market gap that results in an unnecessary higher risk perception for potential renewable energy projects. The general perception is that renewable energy technologies are not yet mature technologies in Nigeria and that they are only suited for niche markets and as such will require heavy subsidies. There is therefore, a need for dissemination of information on renewable energy resource availability, benefits and opportunity to the public to raise public awareness and trigger activities in this area. Such a process is paramount to building public confidence and acceptance of renewable energy technologies.

Consequently, providing information to selected stakeholder groups such as investors, can help mobilize financial resources needed to promote renewable energy technology projects. The R*enewable Energy Master Plan* proposes the setup of a *National Renewable Energy Development Agency* (NREDA) [45], which will assist in increasing public awareness and providing information and assistance to interested stakeholders. This will be done together with non-governmental organizations (NGOs).

With the level of awareness about the viability of RE, and in particular solar energy being very low in the country, most of schools' curricula lack adequate information on solar and other renewable energy sources. Mass media too has not helped in any way: hardly any information regarding solar, wind or biomass energy technologies and utilization can be seen in newspapers or experienced on television or radio. This lack of awareness has also led to a perception of technical ineptitude and it severely hampers the adoption of solar PV as a reliable source of power generation. The acceptance of solar PV gained momentum in Nigeria following the government's initiative to create the Council for Renewable Energy Nigeria (CREN) in 2004. CREN is a non-profit association with the objective to promote renewable energy technologies and to reduce greenhouse gas emissions by reducing the consumption of fossil fuels.

2.2 Regulatory and Business Framework

There are two areas where regulating on-grid renewable energy projects are crucial. First in the process of submitting a dossier to NERC to obtain a license for a renewable energy IPPs. (1.) Getting a license for conventional IPPs is the same process, even though the power purchase agreements (PPAs) are significantly different. Conventional PPAs require an analysis of feedstock prices and yet this does not apply to most renewable energy projects.

(2.) The second area relates to grid access and requirements, more specifically the grid code and potential entry points [46]. These are decided by NERC in consultation with the TCN. The grid code is a regulatory document initiated by NERC which delivers revalidation of aggregate technical, commercial and collection losses (ATC & C losses), and a minor tariff review.

In terms of policies, the development of RE is a central vector in the NEP. Amongst the strategy, acts, and main bye-laws, the following documents are the guiding principles for RE:

- Renewable Energy Policy Guidelines (REPG), 2006
- Renewable Energy Master Plan (REMP), 2012
- National Renewable Energy and Energy Efficiency Policy (NREEEP), 2015

In May 2015, the Federal Executive Council approved the NREEEP [47]. This policy paper would presumably replace the REMP. The NREEEP recognizes the importance of RE for on-grid and off-grid systems. The document notes that the use of energy in the nation is far from efficient at all levels including household, industry, and transport. It introduced the concept of energy efficiency as a source of energy and incorporated the need to promote energy conservation. [2]

2.2.1 PV Regulations

The Nigerian Electricity Market Rules are designed to establish and govern an efficient, competitive, transparent and reliable market for the sale and purchase of wholesale electricity and ancillary services in Nigeria and to ensure that the grid code and the market rules are synchronized to secure efficient co-ordination and adequate participation in the Nigerian electricity market. The main regulations applying to the development and operation of a PV plant in Nigeria are as follows:

- MYTO (Multi Year Tariff Order)
- Transmission, Distribution and Metering Codes
- Embedded Generation Regulations NERC, 2012
- Regulation for Independent Electricity Distribution Network (IEDN), 2012
- Regulations on the Procurement of Generation Capacities, 2014
- Regulations on National Content Development, 2014
- Mini Grid Regulations, 2017
- The Eligible Customer Regulation, 2017

2.2.2 Support Mechanisms

It is important to note that support mechanisms (e.g. incentives) play a large role in the economics of PV projects, especially since traditional power generating technologies are gratified with ample direct and indirect subsidies. Support mechanisms for solar and other types of RE can take many forms of direct subsidies, such as tax or investment credits or favourable feed-in tariffs (FiTs). Many countries set strict criteria for new renewable projects to qualify for financial support and Nigeria may not be an exemption.

Feed-in tariff (FiT) and MYTO

The FGN approved the FiT regulation in November 2015 and entered into force in February 2016. The tariff model was captured initially under the Multi-Year Tariff Order (MYTO) 2012 but has now been superseded by the Nigeria FiT for RE sourced electricity.

The FiT is **applicable to all solar and wind-based power plants, all biomass cogeneration power plants, irrespective of their sizes, and for small hydro schemes**

not exceeding 30 MW. Its purpose is the reduction of costs associated in the negotiation process of PPAs and to ensure a stable pricing policy. In addition, FiT provide added benefit by the government because NBET is obliged to purchase 50% of the power generated by RE plants and DisCos have the obligation to source the remaining 50%. While power plants smaller than 30 MW are integrated automatically, RE projects bigger than 30 MW take part in an auction (competitive bid process). Its procedures are defined by the FiT regulation.

Power Purchase Agreements

The involved authorities have developed an appropriate standard or model for PPAs. The PPA sets the terms by which power is marketed and/or exchanged. It determines the delivery location, power characteristics, price, quality, schedule, and terms of agreement and penalties for breach of contract. It will among other things, ensure that prices provide an adequate return on investments in renewable electricity; standardizes and simplifies contractual relationships; and protects investors, utilities and consumers.

Regulatory and policy changes in the Nigerian energy sector since 2005 culminated in the signing of 14 on-grid solar Power Purchase Agreements (PPAs) in 2016, between the Nigerian government and several private investors. The completion of these PPAs would add just about 1,200 MW to the national grid.

However, up to 2018 none of the 14 proposed projects have reached financial closure, which is largely believed to be due to delays on the part of the NBET, which concern an acceptable framework that satisfies financial houses and investors. [48]

On the potential of building on these PPAs and for more solar power companies to join the process, the state of Nigeria's transmission infrastructure has also been a major stumbling block to the completion of deals, since it is a concern for developers and investors that generated electricity may not be utilised, due to poor wheeling capacity of the transmission infrastructure. There is good potential that this would improve, given that in January 2018 Nigeria announced a World Bank financed 20-year transmission infrastructure development plan, which hopes to enhance the transmission infrastructure's wheeling capacity from its present capacity of 7,125 MW to 10,000 MW by the year 2020 and on to 28,000 MW by 2035. [49]

The 14 signed PPAs are listed in the table below:

Table 7: Solar Power Purchase Agreements signed in 2016

Company	Installed Capacity	State
Access Power (Quaint Abiba Solar Project)	50 MW	Kaduna
Afrinergia Power	50 MW	Nasarawa
Anjeed Innova	10 MW	Kaduna
CT Cosmo's	70 MW	Plateau
En Africa	50 MW	Kaduna
GreenWish Partners	100 MW	Enugu
Kvk Power's	100 MW	Sokoto
LR Aaron Power	100 MW	FCT-Abuja
Nova Scotia Power Development	80 MW	Jigawa

Company	Installed Capacity	State
Pan Africa Solar & JCM Power	75 MW	Katsina
Middle Band Solar One	100 MW	Kogi
Motir DuSable	100 MW	Nasarawa
Nigerian Solar Capital Partners	100 MW	Bauchi
Nova Solar 5	100 MW	Katsina

Source: Nigeria Electricity Hub; 2017 [50]

The procedure for tenders for PPAs is defined by NBET in a 5-step guide for competitive procurement [51]. NBET additionally offers a draft PPA for solar companies [52].

Tariff regulation

As per policy guideline, involved government authority must specify the terms and conditions for the determination of tariff, and in so doing shall be guided by the promotion of renewable energy sources in electricity production.

The process and calculation method for tariffs under the feed-in-tariffs are outlined by the NERC in the document *Regulations on Feed-in Tariff for Renewable Energy Sourced Electricity:*

For the Tariff Computation Method, the regulation stipulates:

a) The tariff schedule for the period starting from 2015 will be based on long range marginal cost
b) These tariffs, where awarded to licensees shall last for the duration of the Power Purchase Agreement (PPA)
c) The Commission (NERC) shall monitor uptake, considering the impact of each RE-FiT in an annual tariff review. The resulting tariffs shall only be applicable to new projects
d) New Generators shall be required to negotiate tariffs under market conditions applicable at the time, which shall be applicable till the end of the contracted Re-FiT tariff

For the Tariff Methodology, the Long Run Marginal Cost (LRMC) and Levelised Cost of Energy (LCOE) shall be the methodology used to set the RE-FiTs for the qualifying Re-FiT technologies. The methodology shall also allow the cost of capital and the operating cost of the project to be recovered over the term of the PPA based on reasonable level of output/capacity.

Regarding agreed tariffs under this model, the 14 PPA agreements signed with the NBET will last 20 years and sell the power generated at 0.115 USD/kWh. From a consumer's point of view the NBET-agreed tariff seems high (and has represented a stumbling block to the finalisation of the signed PPA agreements – see PPA chapter) but compared to the daily costs incurred by consumers who rely on generators it appears price competitive.

2.2.3 Codes and Standards

The Nigerian electricity networks are governed by two main codes, the *National Grid Code for the Transmission System* and the *Distribution Code*. For commercial operation of a power plant, the *Metering Code* is another important document and it provides details on the limits of supply and invoicing. All codes currently in force refer to related sections in the ESPRA [53].

Transmission Code

The *National Grid Code* stipulates the conditions for the electricity transmission system in Nigeria. According to the ESPRA of 2005 [54], the TCN is tasked to guarantee functioning transmission system operations of the HV network and is responsible for overseeing the operations. The code is the reference document for day-to-day operating procedures and principles governing the development, maintenance and operation. It was designed with two goals in mind: facilitating efficient production and supply of electricity for all users of the transmission system and TCN itself, on the one hand, and on the other hand, enable competition in the generation and supply of electricity in the country. Thus, it is mandatory for all users of the transmission system, including TCN, to comply with these prescriptions. The document was reviewed by the dedicated *Grid Code Review Panel* [55].

Distribution Code

Based on the EPSRA, the Distribution Code is the reference for all distribution networks operating in the range from 240 V to 33 kV that operated by the DisCos. DisCos are responsible for overseeing network operations and retail sales of electricity [56].

To support this function, the *Distribution Code* established a *Distribution Code Review Panel* and regulates how unforeseen circumstances are to be handled. The first chapter highlights the processes necessary during the distribution planning phase. These requirements include: relevant planning data, planning documents, load forecasting, exigencies on distribution planning and system studies. New additions or modifications of the grid are governed by section 3. This process includes: connection agreements and showing ownership boundaries (i.e. limits of supply). The most relevant part for the system designer is section 4, which states the details of the requirements of the grid connection point including frequency, voltage, protections and grounding, standards, requirements on generators with the definitions of the connection point. The *Distribution Code* regulates operations including planning, system texting and safety prescription and concludes with construction and maintenance provisions. [2]

Metering Code

The last document that is regarded as essential for the development of a commercial project is the *Metering Code* [57]. It covers metering in the transmission system and distribution networks. It defines the conditions and requirements for electricity meters in the country. The *Metering Code* defines the type and characteristics of the metering devices for developers and owners of energy projects. The location of the meter is vital as it marks the commercial limits of supply and defines where the responsibility for interconnection line losses lies. [2]

Any generation company with plans to sell electricity to the national grid or to DisCos will need to apply for a generation license with NERC and for a *Power Purchase Agreement* with NBET. Before a project reaches the license submission stage, a large quantity of studies will need to be completed; meaning that **the project developer or investor must be prepared to partly incur substantial costs ahead of license approval in the hope to gain such**. The studies must obviously include a **power evacuation study** (proving the viability of the grid connection) and an ***Environmental Impact Assessment* (EIA)**. The EIA shall be prepared by a registered Nigerian company. Moreover, evidence must be furnished that the TCN confirms that the proposed connection point has the capacity to take the load to be fed into the grid. Compiling the legal & regulatory studies and the financial modelling will also entail costs and time input.

2.2.4 Financing Situation for PV Power Plants

At present the funds available for PV power plants in Nigeria are so minimal that developers need to find equity investors for investments. Debt financing, especially with commercial banks and long-term loan tenors are difficult to find and expensive in Nigeria, which makes solar investment options unviable. A solid financing option is the Bank of Industry (BOI) which finances industrial and manufacturing projects at lower interest rates for Nigerian companies. For most companies it is probably easiest to finance investments with foreign loan credits.

Loan

The scheme described in Table 8, has been successfully used in the public and several industrial sectors. Large RE power plants require high investment volumes and are difficult to finance with private equity.

Table 8: Loan Conditions

Key Players	Financial institutions and banks
Financial Terms /Conditions	• Loan tenor: 15 (fifteen) years according to Bank's initiative (for large scale PV Plants) • Interest rate: 5% • Interest method: fixed • Debt/equity split: 25% equity.
Risks	In the case of a cost overrun, the company must pay for the extra costs without support through an additional loan.
Rights	Feed-in Tariff for 15 years according to contracting situations
Obligations	• Payment of loans • Collateral: mortgage, • PV systems itself usually are not perceived as collateral by banks due to the lack of reliable second-hand market for PV panels. Hence, instead of collateralization of PV panels, they prefer to collateralize investor's assets (on-balance sheet finance).

Key Players	Financial institutions and banks
Investment Criteria	• Confirmation of an EPC firm authorized by a partner bank • Technical feasibility study • Suitable site conditions for PV installation • Sufficient share of production to meet the planned energy demand • The participatory banks require documents such as the electricity consumptions and the income structure of the investor to approve the loan.
Legal Requirements	• Project permission from a DisCo

Table 9: Advantages and Challenges, Loans

Advantages	Challenges
• Diversification of loans: Loans for small investments and rehabilitation, reconstruction of houses and new buildings. • Endorsement of an EPC firm by a partner bank • Feed-in tariff • Payments on production basis	• Collateral: Financial condition of the investor • Volatility of Nigerian financial markets • Joint property rights lead to problems regarding the distribution of consumption and income rights.

Leasing

Leasing financing schemes involve two parties – the lessor (investor) and the lessee (user) – who will sign a long-term leasing contract. The lessor (usually an electricity supply company) purchases, installs and operates the PV system and the user (company) consumes the generated electricity at a certain price or fee. The investor retains ownership of the system throughout the duration of the contract.

Table 10: Leasing Financing Scheme

Key Players	Key Players are the lessor (investor, usually an electricity supply company), and the lessee (company)
Financial Terms / Conditions	Lease contract durations vary between 7 to 25 years, depending on the plant size and applicability. Leasing rate: in most cases, the lessee pays a fixed monthly fee for the PV electricity produced; yet, fees per consumed kWh are also possible. The leasing rate is usually fixed for the entire term of the lease, i.e. if power supply prices rise, the lessee has an advantage. At the end of the lease, the PV plant either becomes property of the lessee, can be bought by the lessee or the lease can be renewed; this depends on the terms of the initially negotiated contract.

Key Players	Key Players are the lessor (investor, usually an electricity supply company), and the lessee (company)
Risks	The risks for the lessee are rather low, as the responsibilities regarding the plant lie with the lessor (as laid out in the leasing contract). A risk that lies with the lessee is the possibility that he cannot maximize his self-consumption to the necessary level to exceed the leasing rate. Additionally, it is possible that the system does not perform as expected or that the maintenance service is of poor quality. In that case the lessee might face restrictions leading to termination of the contract. The lessor is responsible for planning, installing and running the plant and bears all associated risks. Additionally, the lessor is also responsible for service, insurance and maintenance and liable for any damage. Therefore, in the case of irregularities, the lessee has the right to demand for them to be fixed by the lessor
Obligations	The lessee must pay the fees as stipulated in the contract.
Investment Criteria	Fixed fee for the term of the contract (while the cost of power from the grid might rise); sometimes the leasing fee is higher than the cost of conventional electricity, but as the fee is guaranteed to remain stable, leasing still represents an attractive financing scheme for some lessees Use of PV electricity without having to raise the funds for purchasing a system
Legal Requirements	Requirements contract between lessor and lessee

Table 11: Advantages and Challenges, Leasing

Advantages	Challenges
• Low level of risk • Stable rate throughout the duration of the contract	• Forecasting the development of electricity prices

Maximizing the rate of self-consumption is the most economically viable business model.

2.2.5 Import conditions for PV

Following the federal government's plan to achieve an installed electricity capacity of 35 GW by 2020 and increase the share of renewable electricity generation to 36 % by 2030 [2], efforts are being made to provide the right conditions for the actualisation of these ambitious targets.

The National Renewable Energy and Energy Efficient Policy (NREEEP) as approved by the Federal Executive Council (FEC) in May 2015 earmarked 5 percent duty rate for renewable energy products with zero duty tariff. Notwithstanding, additional landing charges may apply when importing RE products into the country. It is also important to take into consideration the country's 20 percent most favoured nation (MFN) tariff rate.

The following tariff applies to imported photovoltaic products according to Common External Tariff (CET) Act No. 4 of the Nigeria Customs Service (NCS):

- **Solar cells**, whether in modules or not, or made up into panels: 0 percent import duty
- **Batteries**: 20 percent import duty / 5 percent VAT
- **Inverters**: 5 percent import duty / 0 percent VAT

As part of the ongoing reform to revamp the energy sector, in August 2017, FEC approved 27 new infant industries eligible to enjoy the pioneer status incentive (PSI) with tax holidays for a period not exceeding five years [58]. The PSI is a scheme to stimulate growth and diversify investments in infant or non-existent sectors. It is governed by the Industrial Development (Income Tax Relief) Act (IDIRA) which grants tax holidays to companies by exempting their profits from taxation under the Principal Act being the Companies Income Tax Act. The pioneer certification grants tax-free dividends and capital allowances after the expiration of the tax holiday.

2.2.6 Security and Business Climate

Nigeria as the seventh most populous country in the world with an estimated 186 million people, is steadily expanding at a 2.6 percent growth rate according to the International Monetary Fund [59]. The population is relatively young and youthful with an **average median age of 19.**

The UN Department for Economic and Social Affair (UNDESA) forecast that **Nigeria's population could reach 440m people by 2050** thus overtaking the United States as the third most populous country in the world. Given these realities, provision of adequate security for lives and properties, and creating an enabling environment for businesses to thrive are two major tasks that the current administration is saddled with.

Business Climate

According to the World Bank Doing Business Report 2017, **Nigeria ranks 169 out of 190 economies of the world and ranked 44 out of 60 in 2016 considering access to credit**.

The 1995 *Nigerian Investment Promotion Commission* (NIPC) Act permits foreign investors to partial or full ownership of businesses in Nigeria. In accordance to stipulated exchange control regulations and requirements, investors can import capital and freely repatriate profits. However, in some sectors of the economy namely: oil and gas, mining, telecommunications, aviation etc., specific ownership licenses and restrictions are required for operations:

NIPC was set-up with the mandate of promoting Nigeria as the ideal destination for foreign direct investments. It ensures a conducive business environment for potential investors by removing bottlenecks and simplifying administrative procedures involved with registering new entrants or businesses.

The Nigerian Export Processing Zone Authority (NEPZA) under the aegis of Federal Ministry for Industry, Trade and Investment (FMITI) has established 34 Free Trade Zones with over 300 licenced Free Zone enterprises spread across the nation e.g. Lekki Free Trade Zone, Tinapa Free Zone and Tourism Resort, Kano Free Zone, LADOL Free Zone, Olokola Free Trade Zone etc. to stimulate foreign direct investments and accelerate the pace of economic growth in the country. Privileges that registered Free Trade Zones enterprises enjoy includes: exemption from all federal, state, and local government taxes incl. levies and rates, 100 percent capital and profit repatriation, and waivers on customs and import duties.

The Office of the Presidency formed a Presidential Enabling Business Environment Council (PEBEC) chaired by the Vice-President with selected Heads of Ministries, Departments and Agencies (MDAs), the Central Bank of Nigeria (CBN) governor, Head of Civil Service of the Federation and other key stakeholders from the private sector in July 2016. Since inception, PEBEC has initiated various economic reforms – the most notable being a 60 Day National Action Plan on Ease of Doing Business in Nigeria – to ensure synergy and transparency among MDAs, improve product and service delivery, thereby creating a conducive business environment.

In February 2017, Nigeria's foreign missions commenced a 48-hour visa issuance and visa on arrival (i.e. business and tourism) programmes to ensure seamless entry and exit of potential investors and/or goods into the country, in compliance to a directive from the federal government.

Abuja and Lagos international airports have received infrastructural upgrades in recent times. **Several other projects are being implemented to develop the country's ailing infrastructure especially in power (off-grid and rural electrification), gas exploration, transportation and aviation.**

Business vehicles

Common business vehicles are sole proprietorship, partnership (from 2 – 20 partners), company (with USD 50,000 minimum capital share depending on the sector), free trade zones.

Established by the *Companies and Allied Matters Act 1991*, **the Corporate Affairs Commission (CAC) is the autonomous regulator and supervisor of companies' formation and incorporation in Nigeria.** It offers administrative services to new and existing businesses. In 2016, the commission included an online application feature on its website to fast-track the business registration process. This has helped to streamline the process and improve efficiency. In Lagos, a company would get registered in 25 days considering ongoing reforms, this should get done in two days [60].

Once a limited liability company is established, an official certificate of capital importation is required especially for repatriation of profit. Foreign investors must also obtain import-export licence from the Nigeria Customs Service (NCS).

Security

Conflict is a common occurrence in human society and Nigeria is no exception. Physical and structural conflicts raging from the jihadist Boko Haram insurgency, pipeline vandalism and indiscriminate kidnapping of oil-workers in Niger Delta, cattle rustling across the Benue, and to the agitation for secession in the South-East etc. are major threats to the nation's stability and economic wellness.

Piracy is another common occurrence along the Gulf of Guinea. The International Maritime Bureau stated that the number of pirate attacks off the coast of Nigeria has drastically increased in 2016.

In response to Boko Haram's inhumane operations in the Lake Chad Basin and the north-east regions: Borno, Yobe, and Adamawa states, the federal government has beefed up security measures in the region with military intervention and improved medical care and provision of shelters for displaced persons in the region.

In collaboration with its neighbouring countries, Nigeria has formed a military coalition called *"The Multinational Joint Task Force"* which includes soldiers from Benin, Chad, Nigeria, Niger and Cameroun to counter the onslaught of the terrorist group.

The Nigeria Airforce has seen increased advisory and machinery supports from the international community (Russia, the United States of America, Pakistan and the United Arab Emirates) and these have helped to boost its capacities and strengthen its ranks against the Boko Haram.

International aid agencies e.g. Doctors Without Border, the Red Cross etc. and the UN Security Council have pledged allegiance to supporting the government in the struggle for peace in the affected areas.

Anti-graft Campaign

The All Progressive Congress (APC) rode to victory in the 2015 general elections on a number of key campaign pledges among which good governance and anti-corruption stood tall and distinct [61]. Given this precedence, Buhari's administration has been characterized by efforts to curb corruption and organised crimes in the country using its anti-graft agencies particularly the Economic and Financial Crimes Commission (EFCC) and the Independent Corrupt Practices and other Related Offences Commission (ICPC).

Since he assumed office, he has introduced governance reforms to check graft at all levels of government with many high-profile figures in the public sector already been investigated and arrested for criminal charges such as money laundering, bribery etc. Among other things, however, his administration will also look at improving good governance and transparency among its various ministries, agencies and parastatals against the backdrop of the country's recent performance (ranked 136 out of 176 countries) in the 2016 Corruption Perception Index released by Transparency International.

In August 2017, his administration signed an Extradition Agreement with the United Arab Emirate (UAE) to expedite mutual legal assistance between both countries with respect to criminal cases and recovery of stolen public funds in the region [62].

In the same vein, the Federal Ministry of Finance launched a whistle-blowing programme to increase exposure of financial crimes, theft and fraud, mismanagement of public funds and assets, and other related financial malpractices through public engagement and participation in the fight against corruption.

2.3 Customer Segments for Solar PV

The potential of the Nigerian PV market is divided into the residential and industrial sector. Most private households are characterized by a low energy consumption, whereas many industrial companies have high energy consumption and are looking for a reliable energy supply for their production. RE technologies are characterized by high initial investment costs (CAPEX) and rather low operating costs (OPEX). Facilitating and securing financing is therefore perceived as one of the key challenges to the growth of RE technologies in Nigeria.

The lack of adequate public funding has been a major setback in the growth of PV and other renewable energy technologies in Nigeria. For example, the modest percentage of federal budget dedicated to the education, science and technology ministries is discouraging. Productive research and development activities could not be started or supported with the meagre budgets allocated to these ministries. Corporate actors also need to be encouraged to collaborate with research institutions in order to co-finance research aimed at developing solar energy. The required research includes the elaboration of an adequate national solar atlas providing crucial information for a nationwide solar energy resource assessment. Such a basic tool is urgently needed to determine the commercial feasibility and viability of solar energy generation and prerequisite to sound investment decision making. Furthermore, the efforts required to establish national solar PV testing and certification schemes also require public support because they overburden the small national solar industry's resources.

2.3.1 Industrial Clusters

Industrial conglomerates are perceived as promising targets for the development of PV in Nigeria: these clusters are made of companies whose main concern may less be a lack of capital but rather a reliable and stable access to electricity for securing stable production.

The *Nigeria Industrial Revolution Plan* (NIRP) was designed to facilitate the development of industrial cities, parks and clusters by focusing on making civil infrastructure available within these industrial zones. However, the development of these industrial zones requires the consideration of environmental protection measures to which RE can greatly contribute. Furthermore, most of these industrial zones are dominated by SMEs so that solar PV should thrive very well in these environments. Some relevant industrial clusters are presented below:

Nnewi Automotive Parts Industrial Cluster

Nnewi, the second largest city in Anambra State (South-East Nigeria), has positioned itself as a major manufacturing hub in Africa. It is home to many indigenous manufacturing companies such as Ibeto Group, Cutix Plc, Uru Industries Ltd, Omata Holdings, Innoson Group, Tomy Group, Chicason Group, and many more. The Nnewi Automotive Parts industrial cluster is a huge success story in Nigeria. Its key critical success factors include active participation of private industry associations such as Nnewi Chamber of Commerce, Industry, Mines and Agriculture and the Nigerian Association of Small-scale Industries, a social-cultural milieu characterized by competitiveness. Such industrial zones have a common challenge when it comes to electricity to drive their heavy-duty machines due to the unreliability of the grid. Hence, very paramount is the **need for a captive diesel hybrid solar PV or off grid solar PV**.

Firms in Nnewi grew despite major infrastructural and credit constraints. Electricity, for example, was only supplied through private generators and banks were reluctant to extend the level of credit offered to companies with high inventory costs. Despite all these limitations, Nnewi firms succeeded in innovating, growing and exporting their products to neighbouring communities. Much more success will be recorded if there is a huge deployment of solar PV technology to proffer a lasting solution to power supply in the zone.

Otigba Computer Village

The Otigba Computer Village was developed in 1995 in Ikeja, Lagos and provides for the sale, service and repair of Information and Communication Technology (ICT) products and components, particularly to the Lagos industrial base. Consequently, the need for a constant power supply cannot be overemphasized. **These SMEs require supply of electricity which will be most convenient via off-grid roof top solar home systems to power their computers and related equipment**. Increasingly, the Otigba cluster is meeting West African market demand with some 392 SMEs employing more than 3,000 people. The cluster development has been characterized by significant inter-firm cooperation and joint action.

In the meantime, co-operation has been particularly noticeable in dealing with government's treatment of the cluster, where the *Computer and Allied Products Association of Nigeria* (CAPDAN) has been very active. The support of government through property access, rental and licensing, as well as refrain from heavy handed inspection, licensing practices and other areas of significant cooperation relate to technology and market support, security, and infrastructure maintenance. With solar PV investors drive, the cluster will experience more business boom through improved electricity supply.

Onitsha Plastic Cluster

The plastic cluster in Onitsha is known as the Osakwe industrial cluster. It is situated at Awada layout in Onitsha and has about 75 businesses employing over 1,800 people. **Onitsha is a very dynamic city and has the highest concentration of manufacturers in Eastern Nigeria** with products ranging from plastic film extrusion, plastic pipe extrusion, plastic injection, plastic blow moulding, polythene bag making, and plastic waste recycling. It attracts trading partners from the rest of the country and different parts of the West African sub-region. This area will witness a huge development if solar PV technology is adopted for electricity supply infrastructures, be it off grid or embedded solar PV generation. Presently, the industries are managed by the Industrial Economy Development Agency, a local group that provides planning, research & development, infrastructure, security, and training to members of the cluster. There are also free services, workshops, machine development and building company in this cluster.

2.3.2 Free Trade Zones

In addition to industrial clusters, free trade zones may also be a promising target for the development of solar PV as they have similar needs as industrial clusters with regards to the provision of reliable power supply. A free trade zone is an area where goods may be landed, handled, manufactured or reconfigured, and re-exported without the intervention of the customs authorities. Only when the goods are moved to consumers within the country in which the zone is located, they become subject to the prevailing customs duties.

The Nigerian Export Processing Zones Authority is the agency responsible for promoting and facilitating local and international investments into free trade zones in Nigeria.

Table 12: Free Trade Zones in Nigeria

Name	Location	Developer	Land Size (ha)	Status
Calabar Free Trade Zone (CFTZ)	Cross River	Federal Government	220	Operational
Kano Free Trade Zone (KFTZ)	Kano	Federal Government	463	Operational
Tinapa Free Zone & Resort	Cross River	PPP	265	Operational
Snake Island	Lagos	Nigerdock Plc.	59.42	Operational
International Free Zone				
Maigatari Border Free Zone	Jigawa	State Government	214	Operational
Airline Services EPZ	Lagos	Private	n/a	Operational
Sebore Farms EPZ	Adamawa	Private	2,000	Operational

Name	Location	Developer	Land Size (ha)	Status
Ogun Guandong FTZ	Ogun	PPP	10,000	Operational
Lekki Free Zone	Lagos	State Government	n/a	Operational
Abuja Tech Village FZ	FCT Abuja	FCT	702	Under construction
Ibom Science & Tech FZ	Akwa Ibom	State Government	122.14	Operational
Lagos Free Trade Zone	Lagos	Eurochem Technology	218	Operational
Olokola Free Trade Zone	Ondo & Ogun	PPP	10,500	Operational
Living Spring Free Zone	Osun	State Government	1,607.86	Under construction
Badagary Creek Integrated Park	Lagos	Kaztec Engineering	531	Under construction
Ogindigbe Gas Revolution Industrial Park (GRIP)	Delta	Alpha GRIP Development Co.	2,506.03	Under construction
Nigeria Aviation Handing Co. (NAHCO)	Lagos	NAHCO	10	Under construction
Nigeria International Commerce City	Lagos	Eko Atlantic FZ Ltd	1,000	Under construction
Ogogoro Industrial Park	Lagos	Digisteel	52	Under construction
Ondo Industrial City	Ondo	State Government	2,771.2	Under construction

Source: Nigeria Export Processing Zones Authority; 2017 [63]

3. Selected PV Business Models

This section is dedicated to the profitability analysis of four selected PV business models. Sample calculations of typical projects include: cash-flow modelling and sensitivity analyses to provide an outlook of profitability changes related to changes in system prices, energy yield and remuneration.

3.1 Large Scale PV (25 – 50 MWp)

Large scale photovoltaic systems (PV systems). which also known as solar parks, are designed to supply power to the electricity grid. They are differentiated from most building-mounted and other decentralized solar power applications because they supply bulk power at the utility level, rather than to a local user. Large scale PV plants generally are the type of projects which most investors and developers invest in. The off-takers of bulk solar power are generally large power utilities. The main off-taker in Nigeria is NBET.

Profitability Analysis (Inputs, Outputs, Scenarios, Sensitivities)

A **profitability analysis for a large-scale PV project based on a PPA** is presented below.

Figure 5: Project Overview - Large Scale PV

PV Project			
PV System Size		kWp	50.000
Specific System Cost		USD/kWp	1.000
Investment Subsidy		USD	-
Total System Cost		USD	50.000.000
Fixed Operation Costs		USD p.a.	1.500.000
Variable Operation Costs		USD/kWh	-
PV Generation			
Yield		kWh/qm/a	2.000
Performance Factor		%	82%
Specific Yield		kWh/kWp/a	1.640
Degradation		% p.a.	0,70%
Investment			
Project Duration		Years	20
Equity		USD	12.194.463
Debt (Gearing)	80%	USD	40.000.000
Loan Tenor		Years	10
Interest Rate		%	9%
Discount Rate		%	12%
Inflation Rate (USD)		%	2%

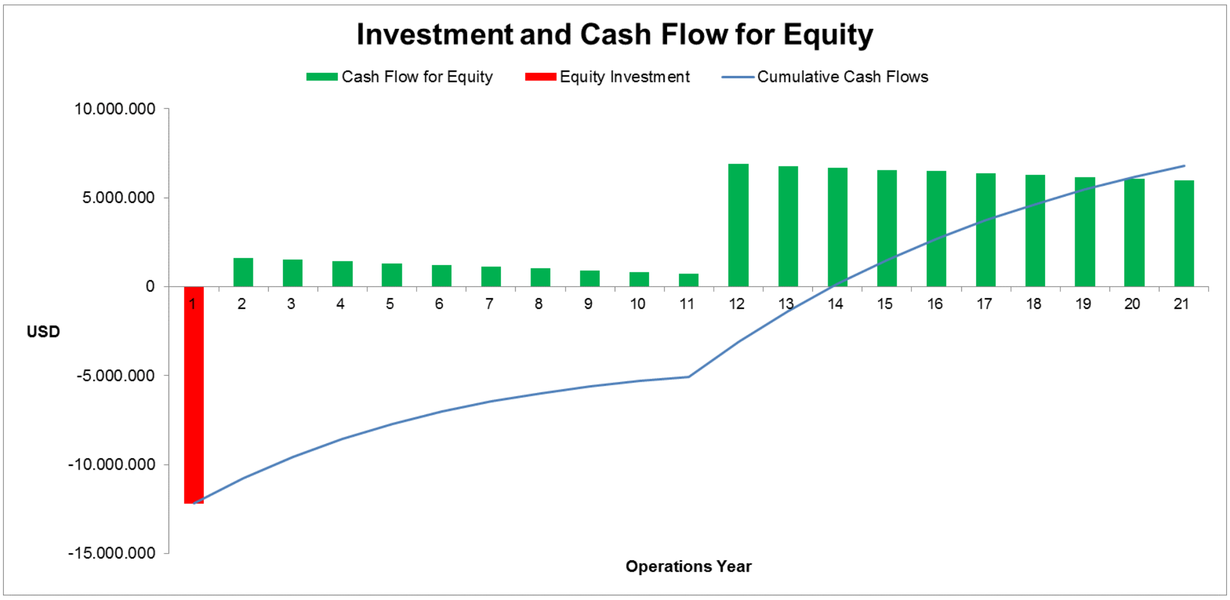
PV Business Model			
PPA Tariff	100%	USD/kWh	0,1150
Fees		USD/kWh	-
Overysupply Price		USD/kWh	-
Undersupply Penalty		USD/kWh	-
Inflation Adjustment		%	-
Results			
Net-Present Value		USD	5.342.131
Project IRR		%	11,75%
Equity IRR		%	15,99%
Payback Period		Years	12,89
LCOE (no subsidy)		USD/kWh	0,10
Min DSCR**		x	1,12 x
Min LLCR***		x	1,12 x

* LCOE: Levelized Cost of Electricity
** DSCR: Debt Service Coverage Ratio
*** LLCR: Loan Life Coverage Ratio

Source: eclareon; 2017 [64]

All cash flows including financing are assumed to be in USD because the PPA price as single source of revenue is paid in USD. Therefore, interest rates and inflation rate are also USD based.

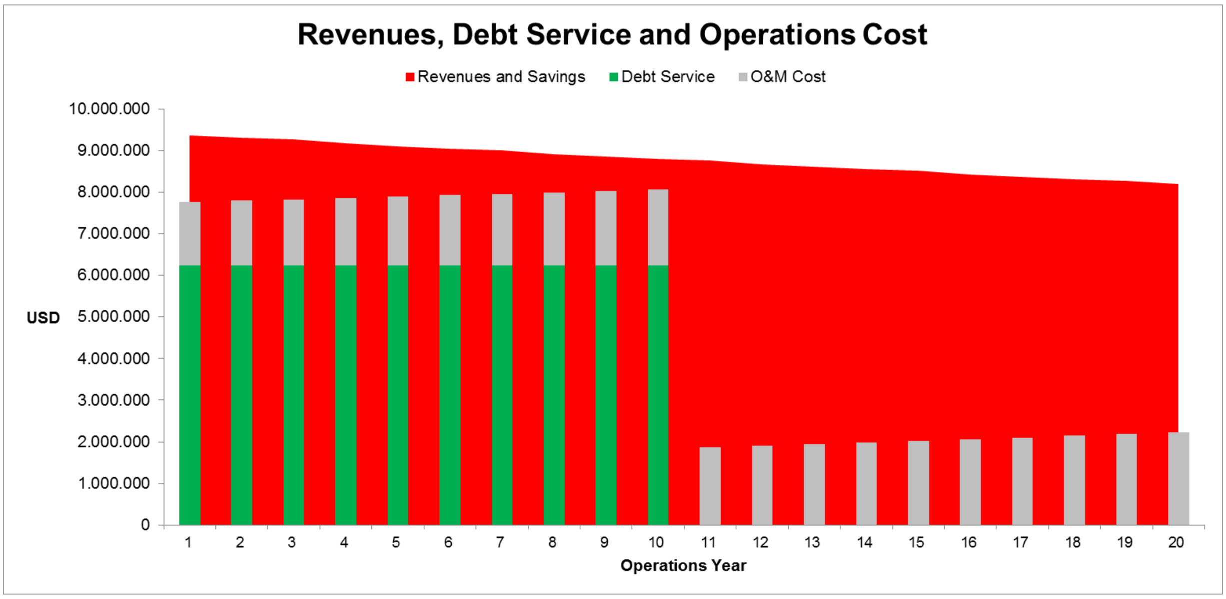
Figure 6: Equity Cash Flow - Large Scale PV



Source: eclareon; 2017 [64]

Due to module degradation and missing inflation adjustment for the PPA price, the yearly cash flows for equity are gradually reduced. The sudden increase after year 12 is caused by the end of the debt tenor and the full reimbursement of the loan.

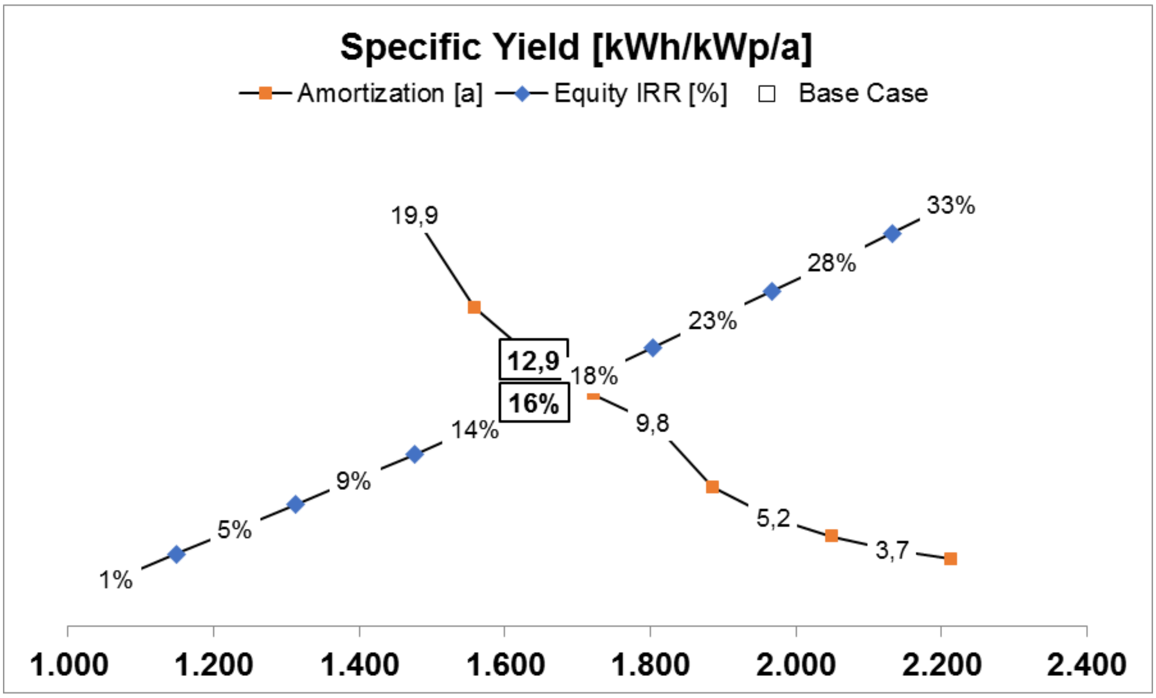
Figure 7: Project Cash Flows - Large Scale PV



Source: eclareon; 2017 [64]

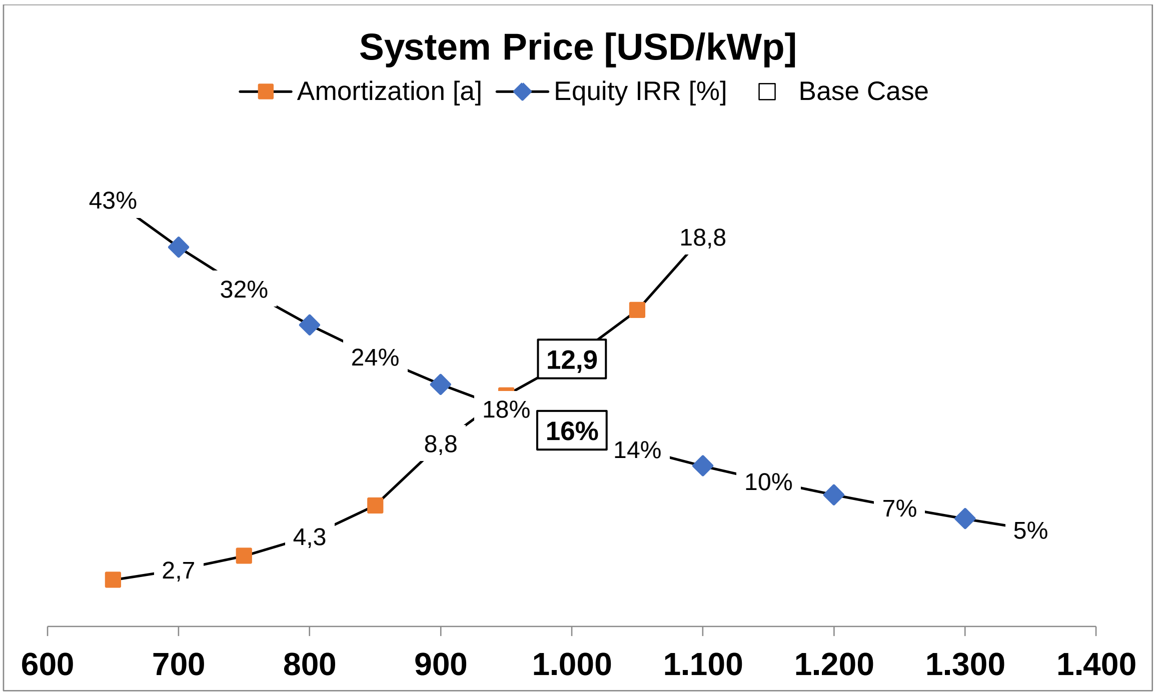
O&M costs are only escalated with the relatively low USD inflation, since the revenues are also in USD and it is assumed that O&M will be contracted and paid in USD as well.

Figure 8: Specific Yield Sensitivity - Large Scale PV



Source: eclareon; 2017 [64]

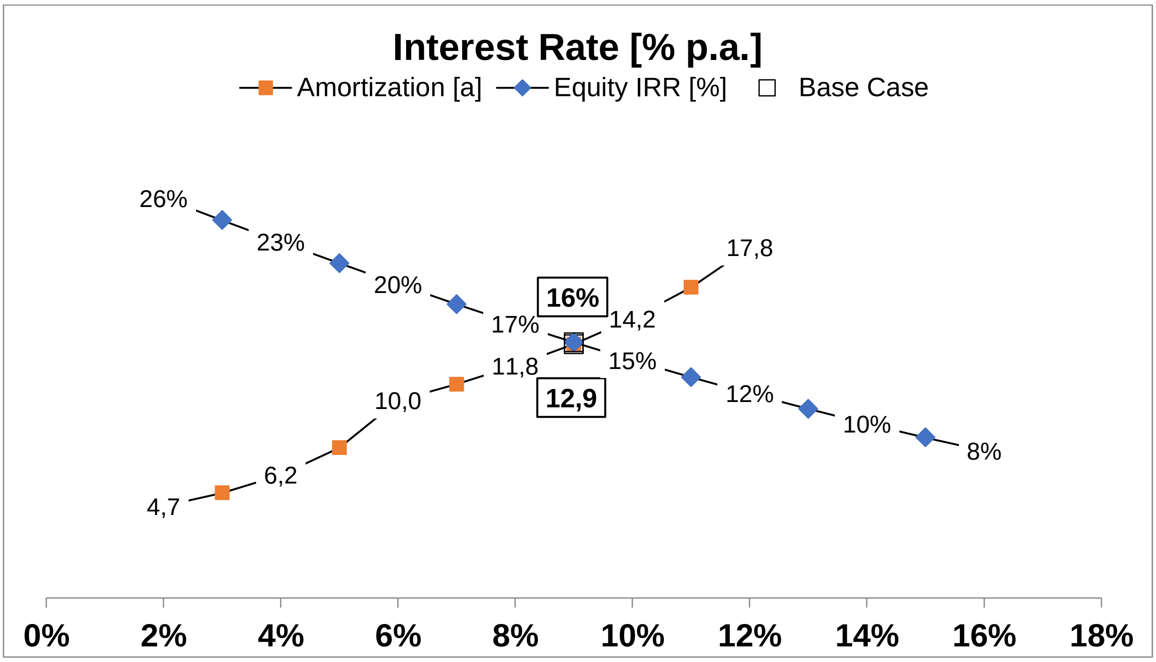
Figure 9: System Price Sensitivity - Large Scale PV



Source: eclareon; 2017 [64]

The profitability of PPA projects is strongly influenced by the yield and the system price because of their strong impact on revenues and overall costs.

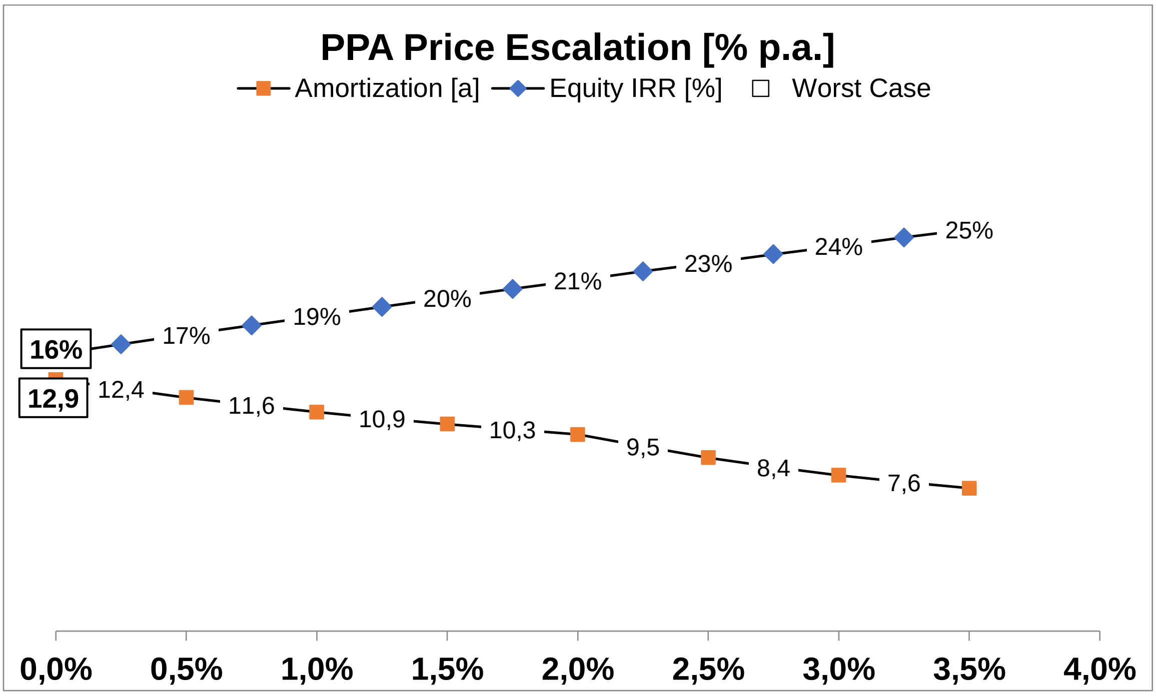
Figure 10: Interest Rate Sensitivity - Large Scale PV



Source: eclareon; 2017 [64]

Since compared to the other examples, the debt leverage with 80% is quite high and the debt tenor with 10 years quite long, we see a strong impact of the interest rate as well.

Figure 11: PPA Price Escalation Sensitivity - Large Scale PV



Source: eclareon; 2017 [64]

In the base case, no PPA price escalation has been assumed. However, via the sensitivity the impact of an inflation adjustment can be assessed.

3.2 Embedded PV systems (1 – 5 MWp)

Embedded generation is power that is obtained using a power generator, which is connected to a distribution network, that is operated by the Distribution Company (DisCo) and licensed by the Nigerian Electricity Regulatory Commission. The generators are directly connected to or are near the load centre of the distribution network. Embedded generation ensures that the power generated is utilized locally and supplied to eligible customers.

If embedded generation units are to be connected to the distribution network, this must be done according to the Distribution Code. Table 13 shows different licensing definitions according to NERC. **The regulation dictates that the licensee enters various network agreements such as PPAs, connection/interface agreements, use of network agreements, and ancillary services agreements with the relevant authorities, such as NERC and NBET**.

Table 13: Embedded Generation - Licensing Definitions

Rated Capacity	Connection Voltage Level
Small units with 1–6 MW	11 kV medium distribution voltage
Large units with 6–20 MW	33 kV medium distribution voltage
≥ 20 MW	33 kV medium distribution voltage for every 20 MW being evacuated

Source: NERC; 2012 [65]

Profitability Analysis (Inputs, Outputs, Scenarios, Sensitivities)

Figure 12: Project Overview - Embedded PV

PV Project			
PV System Size		kWp	2.000
Specific System Cost		NGN/kWp	430.000
Investment Subsidy		NGN	-
Total System Cost		NGN	860.000.000
Fixed Operation Costs		NGN p.a.	25.800.000
Variable Operation Costs		NGN/kWh	-

PV Generation			
Yield		kWh/qm/a	1800
Performance Factor		%	82%
Specific Yield		kWh/kWp/a	1.476
Degradation		% p.a.	0,70%

Investment			
Project Duration		Years	25
Equity		NGN	448.492.564
Debt (Gearing)	50%	NGN	430.000.000
Loan Tenor		Years	5
Interest Rate		%	9%
Discount Rate		%	15%
Inflation Rate		%	10%

PV Business Model		
Self-Consumption Rate	%	100%
Electricity Price	NGN/kWh	45
Fees	NGN/kWh	-
Elecitricity Price Escalation	%	10%

Results		
Net-Present Value	NGN	513.116.737
Project IRR	%	20%
Equity IRR	%	22%
Payback Period	Years	10,2
LCOE (no subsidy)	NGN/kWh	64
Min DSCR**	x	1,06 x
Min LLCR***	x	1,25 x

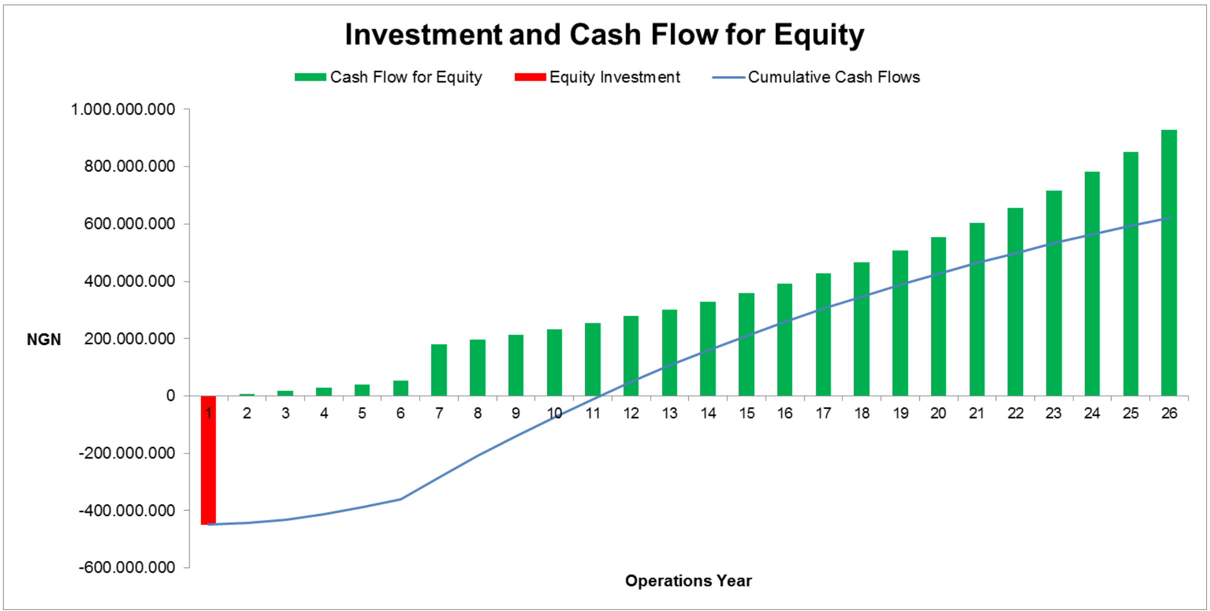
* LCOE: Levelized Cost of Electricity
** DSCR: Debt Service Coverage Ratio
*** LLCR: Loan Life Coverage Ratio

Source: eclareon; 2017 [64]

Above an exemplary **profitability analysis for an embedded PV project** based on grid electricity price savings is presented.

All cash flows are considered in NGN. Thus, an average inflation rate of 10% is assumed for the project period. The yield is assumed lower to account for usually lower irradiation in more densely populated areas compared to more remote, ground-mounted installations. Although it is planned to keep electricity prices stable in coming years, prices have still been increased recently. This is why a price escalation in the range of the inflation rate is assumed. The debt interest rate is assumed to be 9% which corresponds to the interest rate of the MSME facility. This interest rate will also be used in all subsequent examples to improve comparability.

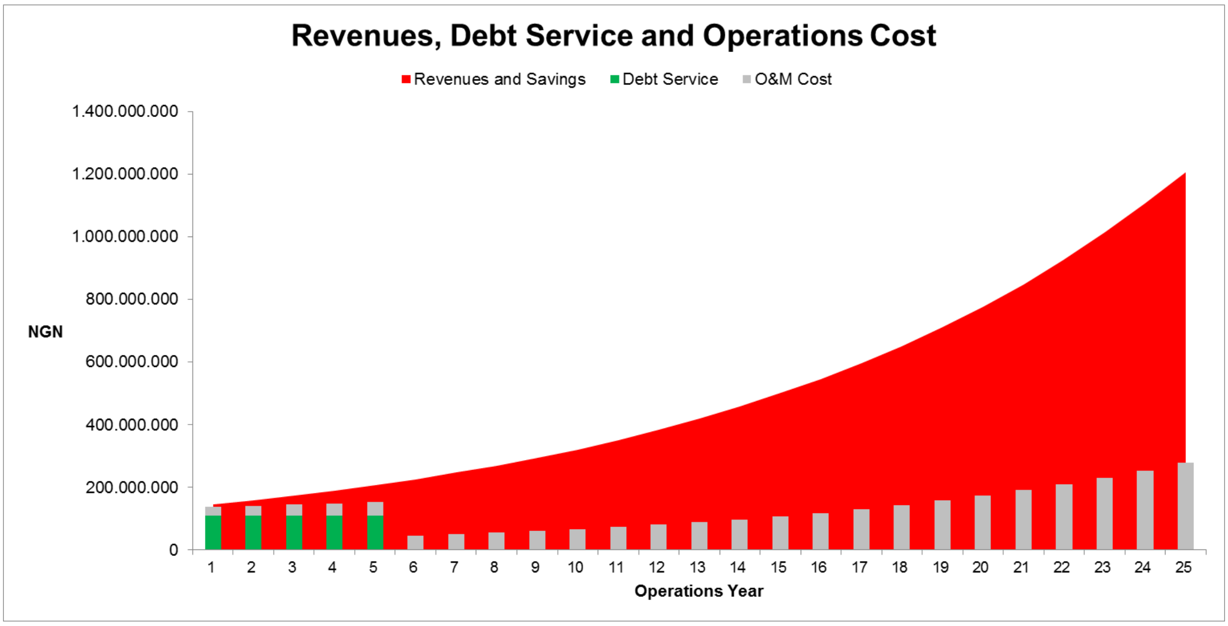
Figure 13: Equity Cash Flows - Embedded PV



Source: eclareon; 2017 [64]

Payback is achieved around year 10 for the investor due to the high electricity price and its escalation. Debt is repaid quickly within 5 years due to the low leverage of 50%. After 5 years, all cash flows after costs flow back to the investor.

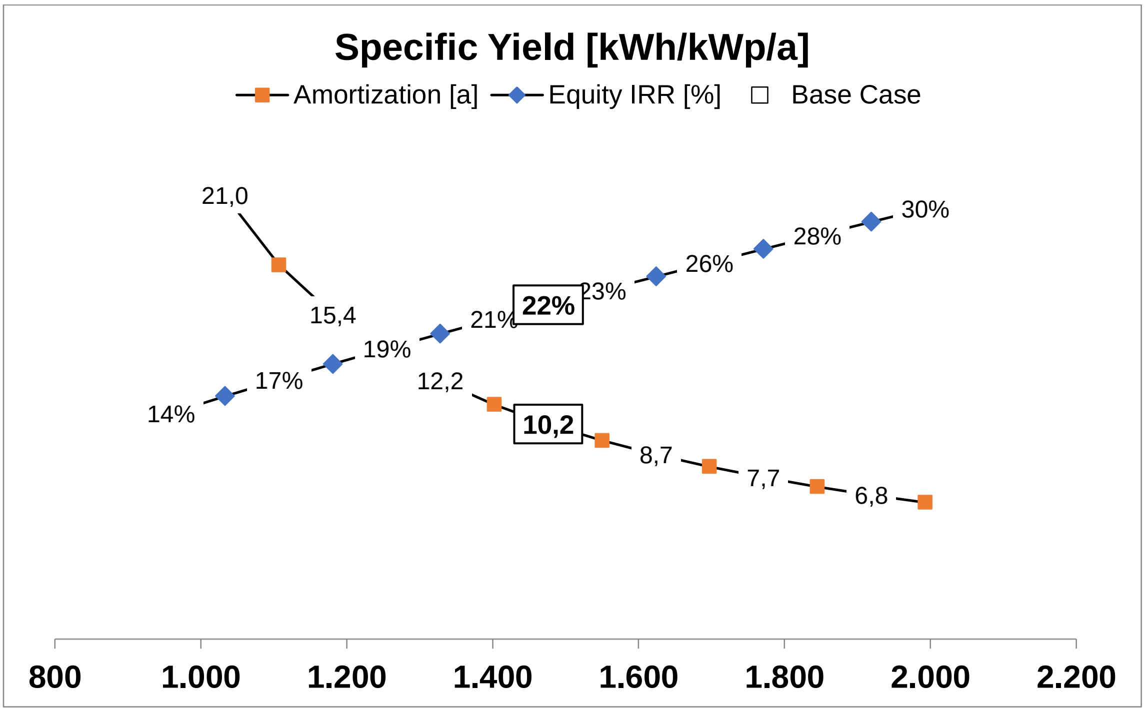
Figure 14: Project Cash Flows - Embedded PV



Source: eclareon; 2017 [64]

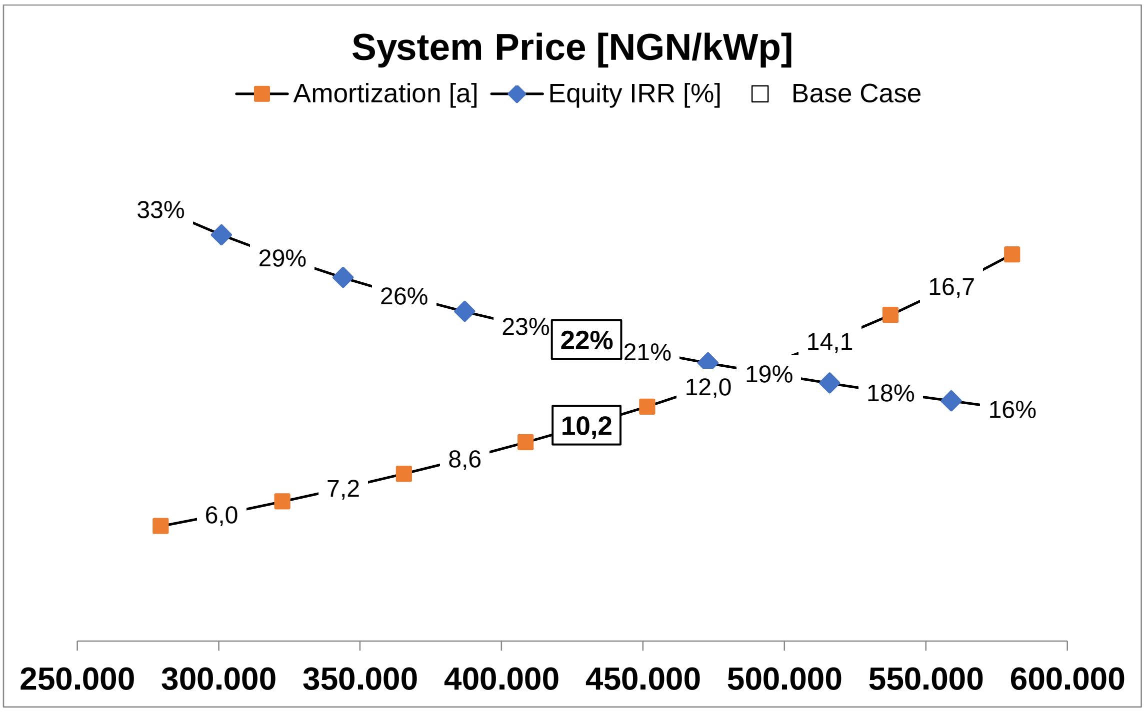
Since the electricity price escalation is set to be at the general inflation rate, revenues go up significantly in the later stages of the project.

Figure 15: Specific Yield Sensitivity - Embedded PV



Source: eclareon; 2017 [64]

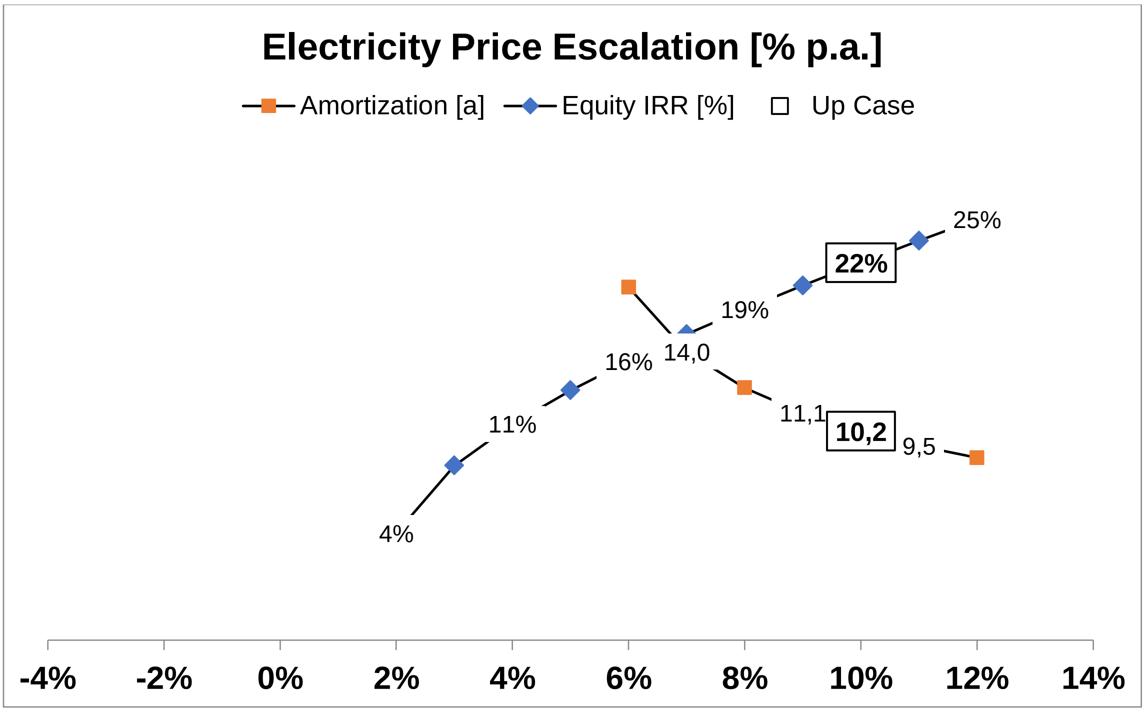
Figure 16: System Price Sensitivity - Embedded PV



Source: eclareon; 2017 [64]

As already shown by the previous example, the yield and the system price have a strong impact on the profitability of a project.

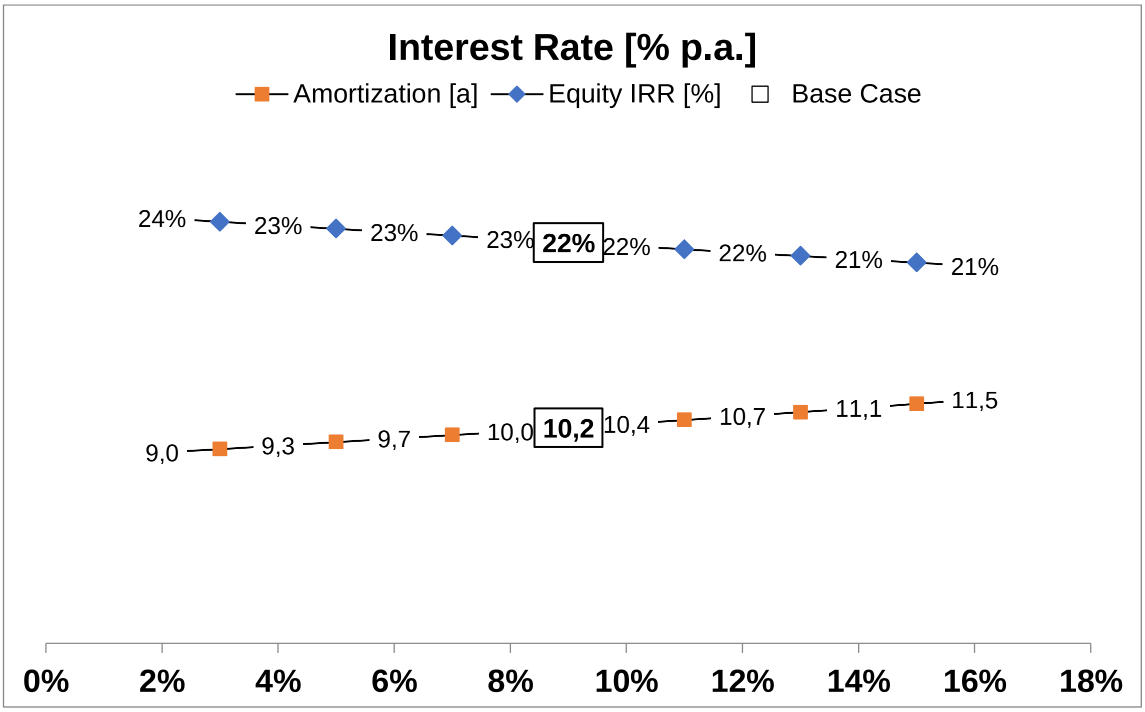
Figure 17: Electricity Price Escalation Sensitivity - Embedded PV



Source: eclareon; 2017 [64]

After recent steep price increases, the electricity price should remain stable for the coming years according to the electricity market authority. However, for the long-term, an average price increase of 10% has been assumed. As the sensitivity underlines, actual price increases have a strong impact on project economics.

Figure 18: Interest Rate Sensitivity - Embedded PV



Source: eclareon; 2017 [64]

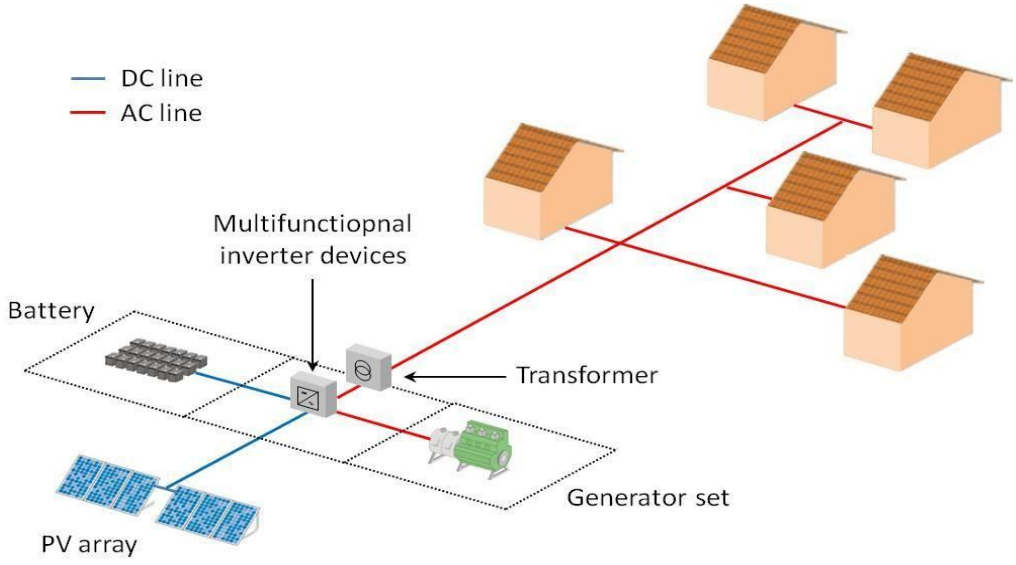
Since the debt leverage is only assumed to be at 50%, the interest rate has a reduced impact on profitability of a project compared to the previous example which had an 80% debt leverage.

3.3 Captive Diesel-PV hybrid (100 kWp – 1,5 MWp)

A solar PV diesel hybrid system combines the power output of PV arrays and diesel generators. The control system draws power in such a way that it maximizes the load contribution of PV and minimizes diesel generators. If there are multiple generators and there is sufficient power from PV, the control system will shut off some of the generators completely to minimize fuel consumption.

In Nigeria, captive power is a widespread form of off-grid power generation. In the EPSRA 2005, the NERC defines captive generation as power generating infrastructures of capacities above 1 MW, where the electricity is consumed by the generating entity itself and not sold to third parties.

Figure 19: Schematic view of a PV / diesel hybrid system for rural electrification



Source: IEA-PVPS T9; 2013 [66]

Figure 5 above indicates the setup of a PV diesel hybrid systems for rural off-grid electrification.

Profitability Analysis (Inputs, Outputs, Scenarios, Sensitivities)

Figure 20: Project Overview - Captive PV

PV Project			
PV System Size		kWp	100
Specific System Cost		NGN/kWp	500.000
PV Battery Size		kWh	100
Specific Battery Costs		NGN/kWh	100.000
Total System Cost		NGN	60.000.000
Fixed Operation Costs		NGN p.a.	2.100.000
Variable Operation Costs		NGN/kWh	-

PV Business Model		
Consumption via PV Battery	%	55%
Direct PV consumption	%	40%
Battery Losses	%	10%
Diesel Generation Costs	NGN/kWh	71
Fuel cost escalation	% p.a.	7%

PV Generation			
Yield		kWh/qm/a	2000
Performance Factor		%	82%
Specific Yield		kWh/kWp/a	1.640
Degradation		% p.a.	0,70%

Results		
Net-Present Value	NGN	4.782.401
Project IRR	%	15%
Equity IRR	%	16%
Payback Period	Years	16,73
LCOE (no subsidy)	NGN/kWh	91
Min DSCR**	x	1,05 x
Min LLCR***	x	1,15 x

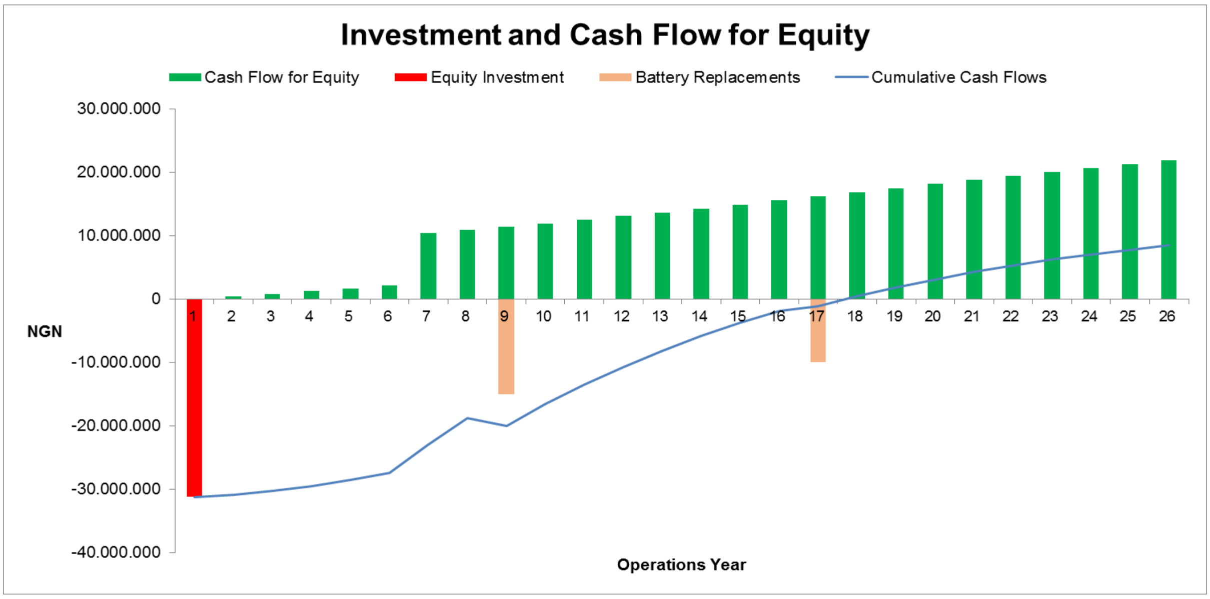
Investment			
Project Duration		Years	25
Equity		NGN	31.245.740
Debt (Gearing)	50%	NGN	30.000.000
Loan Tenor		Years	5
Interest Rate		%	9%
Discount Rate		%	15%
Inflation Rate		%	10%

* LCOE: Levelized Cost of Electricity
** DSCR: Debt Service Coverage Ratio
*** LLCR: Loan Life Coverage Ratio

Source: eclareon; 2017 [64]

Above an exemplary profitability analysis for a captive PV diesel hybrid project based on diesel savings is presented. The captive diesel project is also calculated in NGN since the revenues are generated from diesel savings which are assumed to be paid in NGN. The yield is higher due to the most likely higher irradiation in off-grid locations.

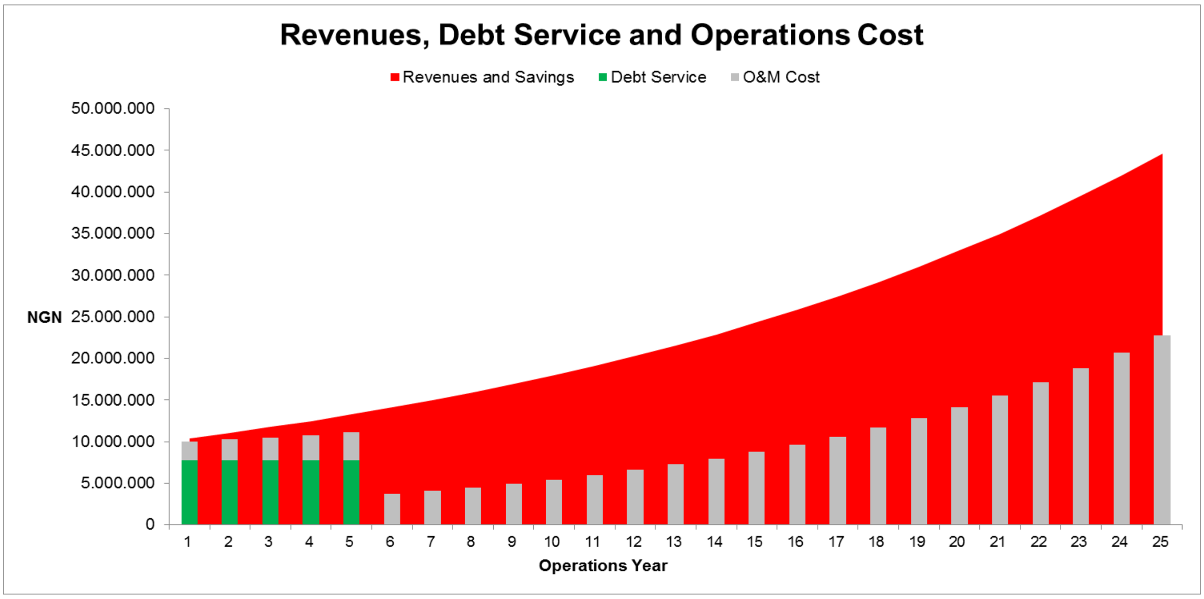
Figure 21: Equity Cash Flows - Captive PV



Source: eclareon; 2017 [64]

The captive diesel-PV case assumes two battery replacements, one in year 8 and one in year 16, with decreasing costs because the present value of those investments is considered and future cost reductions are very likely.

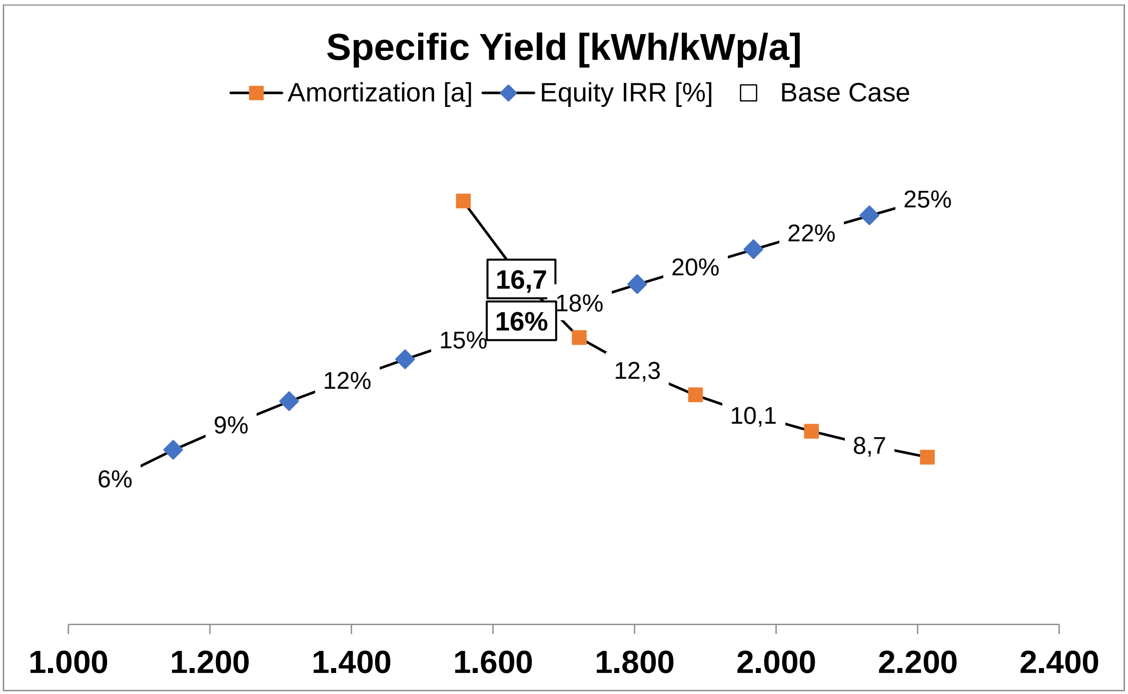
Figure 22: Project Cash Flows - Captive PV



Source: eclareon; 2017 [64]

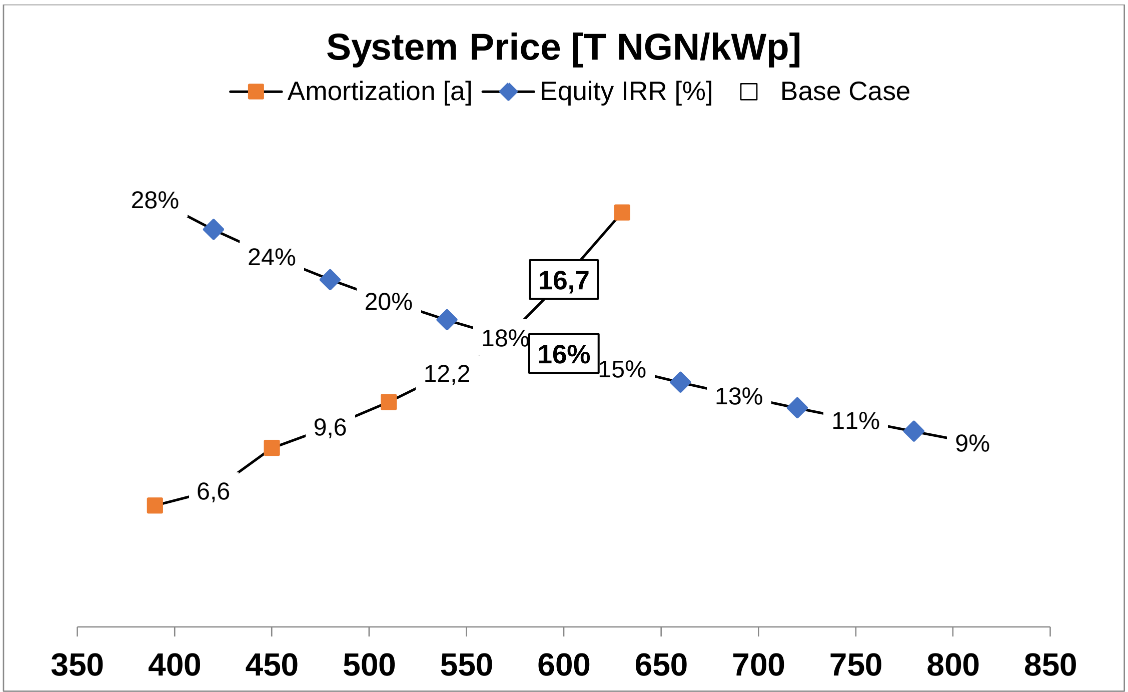
In this case the inflation rate (10%) applied to the O&M costs is higher than the fuel cost escalation (7%) that drives the increased savings over time. Thus, towards the end of the project the absolute O&M costs increase more than the revenues/savings.

Figure 23: Specific Yield Sensitivity - Captive PV



Source: eclareon; 2017 [64]

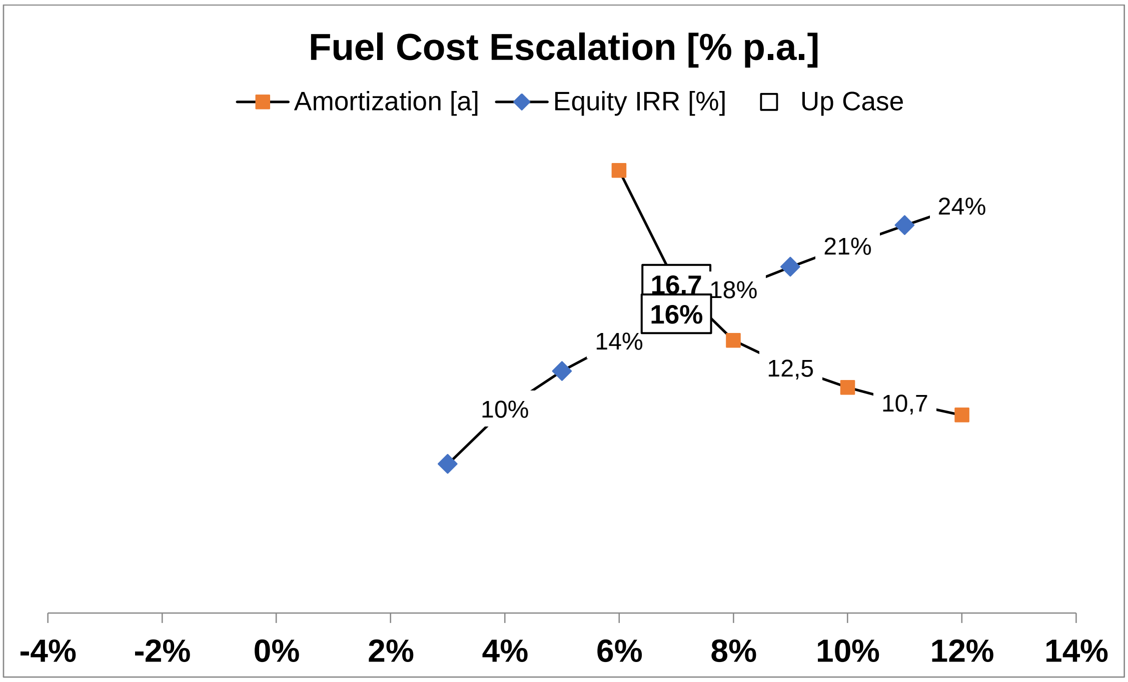
Figure 24: System Price Sensitivity - Captive PV



Source: eclareon; 2017 [64]

The yield and the system price have a strong impact on the profitability of a project.

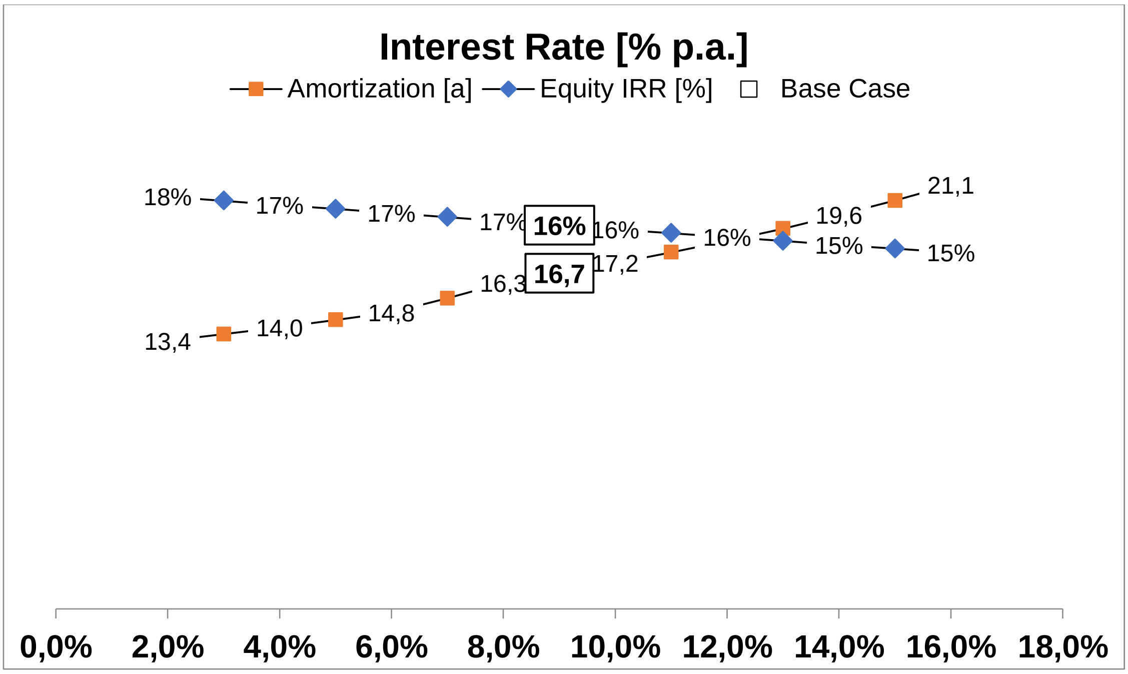
Figure 25: Fuel Cost Escalation Sensitivity - Captive PV



Source: eclareon; 2017 [64]

The rate at which the fuel costs are escalated over the project period has a strong impact on the profitability of the project.

Figure 26: Interest Rate Sensitivity - Captive PV



Source: eclareon; 2017 [64]

Since the debt leverage is only assumed to be at 50%, the interest rate has a reduced impact on profitability of a project compared to the PPA project which had 80% debt leverage.

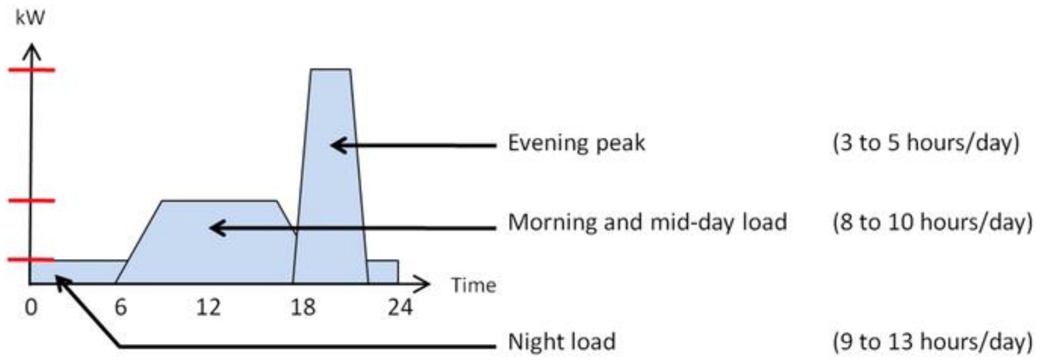
3.4 Off-Grid Generation

Off-grid generation is power generation with no connection to the local distribution network or the transmission grid. Power generation can be based on a Solar Home System (SHS) or on a larger scale to supply a PV mini grid.

Off-grid PV systems often are battery based solar power plants. During the day the system uses the solar power generated and stores the energy left over in a battery bank. The storage system provides a buffer and thus flexibility, allowing for optimal use of the generated solar power.

Figure 27 shows the typical load curve of a rural community. It is generally composed of a prominent peak in the evening corresponding to lighting use, a defined morning/midday load, and a base load during night time. In many cases, the peak load is two to five times higher than the base load.

Figure 27: Typical Load Profile in Rural Areas



Source: IEA-PVPS T9; 2013 [66]

3.4.1 Solar Home Systems (SHS)

Solar Home Systems (SHS) are stand-alone, standardized PV systems that offer a cost-effective mode of producing power for remote off-grid households and other off-grid consumers. SHS solutions are particularly important for rural off-grid areas where a grid connection cannot be established quickly and cost effectively, and many of these areas exist in Nigeria. A SHS typically includes one or more PV modules, a charge controller and a battery system to store energy for periods without sun. To supply AC appliances, they may also include an inverter.

SHS usually provides power for low power DC/AC appliances such as mobile phones, small batteries, lights, radios and TV sets during the day and, if coupled to a battery, for several hours during the night.

Besides providing private households in remote areas with electricity, SHS systems can also generate electricity for small non-profit facilities such as health stations where they power refrigerators for vaccines and medicines.

3.4.2 Off-Grid PV (10 – 250 kWp)

Off-grid PV in the form of a PV power plants with a local AC distribution network (mini grid) mostly scale between 10 – 250 kWp and usually include battery systems for energy storage. The systems are mostly used where extending the grid is not economically attractive but where communities live in established villages with houses in the proximity.

Profitability Analysis (Inputs, Outputs, Scenarios, Sensitivities)

The following shows the profitability analysis of an off-grid PV mini grid project based on electricity sales to consumers.

Figure 28: Project Overview - Off-grid PV Mini Grid

PV Project			
PV System Size		kWp	100
Specific System Cost		NGN/kWp	600.000
PV Battery Size		kWh	400
Specific Battery Cost		NGN/kWh	100.000
Total System Cost		NGN	100.000.000
Fixed Operation Costs		NGN p.a.	3.500.000
Variable Operation Costs		NGN/kWh	-

PV Generation		
Yield	kWh/qm/a	2000
Performance Factor	%	82%
Specific Yield	kWh/kWp/a	1.640
Degradation	% p.a.	0,70%

Investment			
Project Duration		Years	25
Equity		NGN	52.150.298
Debt (Gearing)	50%	NGN	50.000.000
Loan Tenor		Years	5
Interest Rate		%	9%
Discount Rate		%	15%
Inflation Rate		%	10%

PV Business Model			
Consumption via PV Battery		%	55%
Battery Losses		%	10%
Direct PV Consumption		%	40%
Price A (Anchor Client)	50%	NGN/kWh	140
Price B (Commercial)	30%	NGN/kWh	120
Price C (Households)	20%	NGN/kWh	120
Price Escalation		% p.a.	7%

Results		
Net-Present Value	NGN	20.218.975
Project IRR	%	17%
Equity IRR	%	18%
Payback Period	Years	12,91
LCOE (no subsidy)	NGN/kWh	154
Min DSCR**	x	1,17 x
Min LLCR***	x	1,29 x

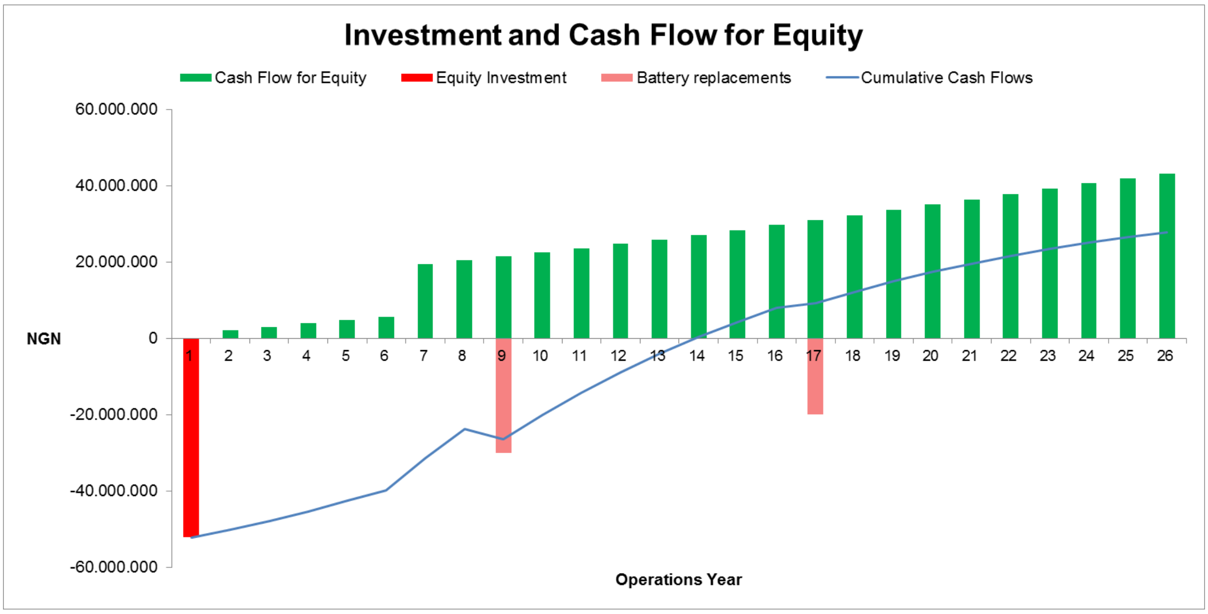
* LCOE: Levelized Cost of Electricity
** DSCR: Debt Service Coverage Ratio
*** LLCR: Loan Life Coverage Ratio

Source: eclareon; 2017 [64]

Different types of customers are connected to the mini grid. The anchor client has the highest priority and thus pays the highest price because of his high requirements for reliability of supply (e.g. telecom tower company). Small commercial and residential customers have lower requirements and thus benefit from lower prices. In order to offset increasing O&M costs due to the high inflation, the electricity price gets escalated by 7% per year.

The PV consumption that goes through the battery is reduced by 10% to account for losses during the battery storage process. 40% of the PV electricity is consumed directly. Additional 5% are lost due to lack of consumption and yet fully loaded batteries during periods of high irradiation.

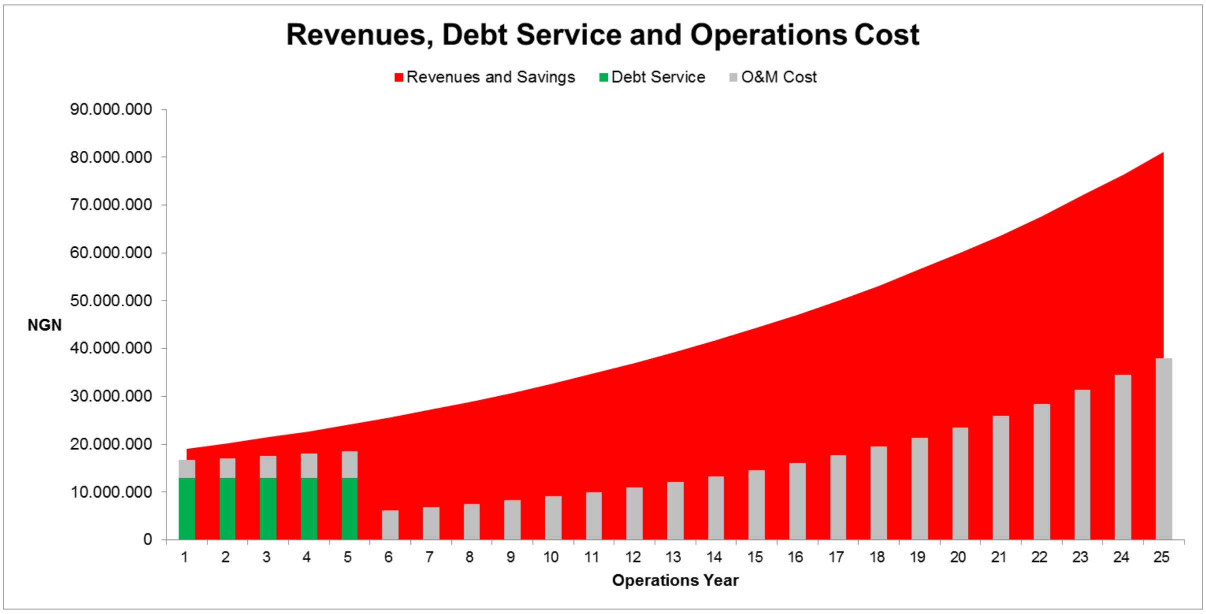
Figure 29: Equity Cash Flows - Off-grid PV Mini Grid



Source: eclareon; 2017 [64]

Investments to replace the battery are made in year 8 and year 16. Future battery investments are discounted to their present value. Also, reduced costs are assumed due to technological advancements.

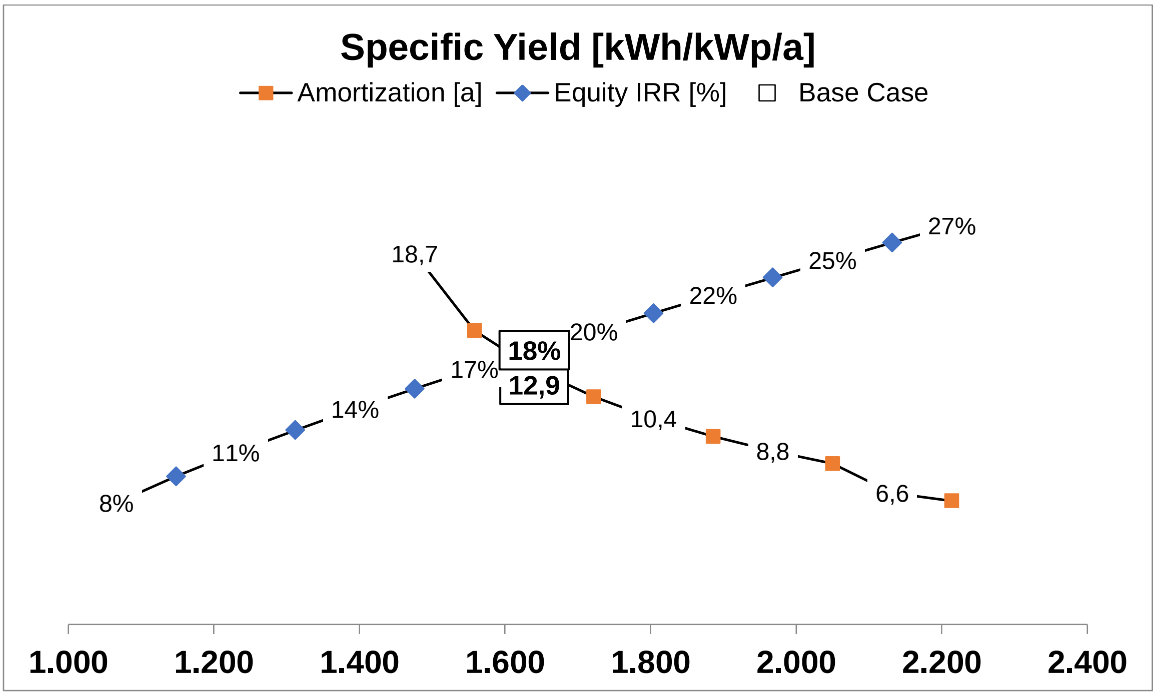
Figure 30: Project Cash Flows - Off-grid PV Mini Grid



Source: eclareon; 2017 [64]

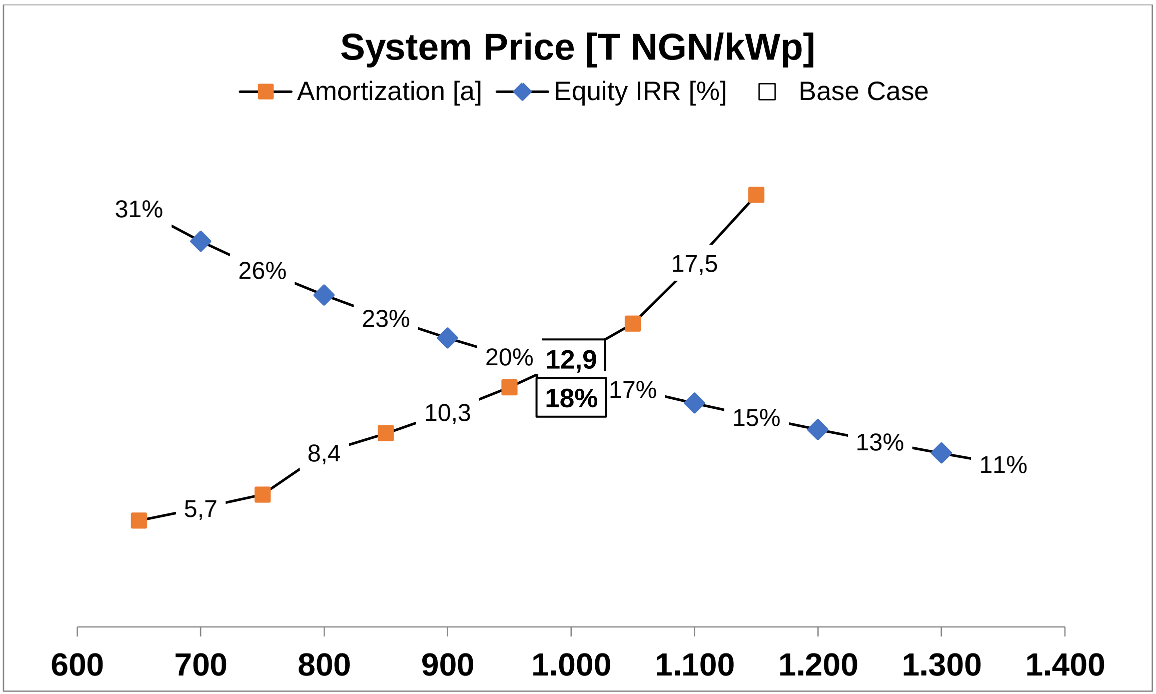
High O&M costs towards the end of the project duration are caused by the 10% inflation rate per year over 25 years.

Figure 31: Specific Yield Sensitivity - Off-grid PV Mini Grid



Source: eclareon; 2017 [64]

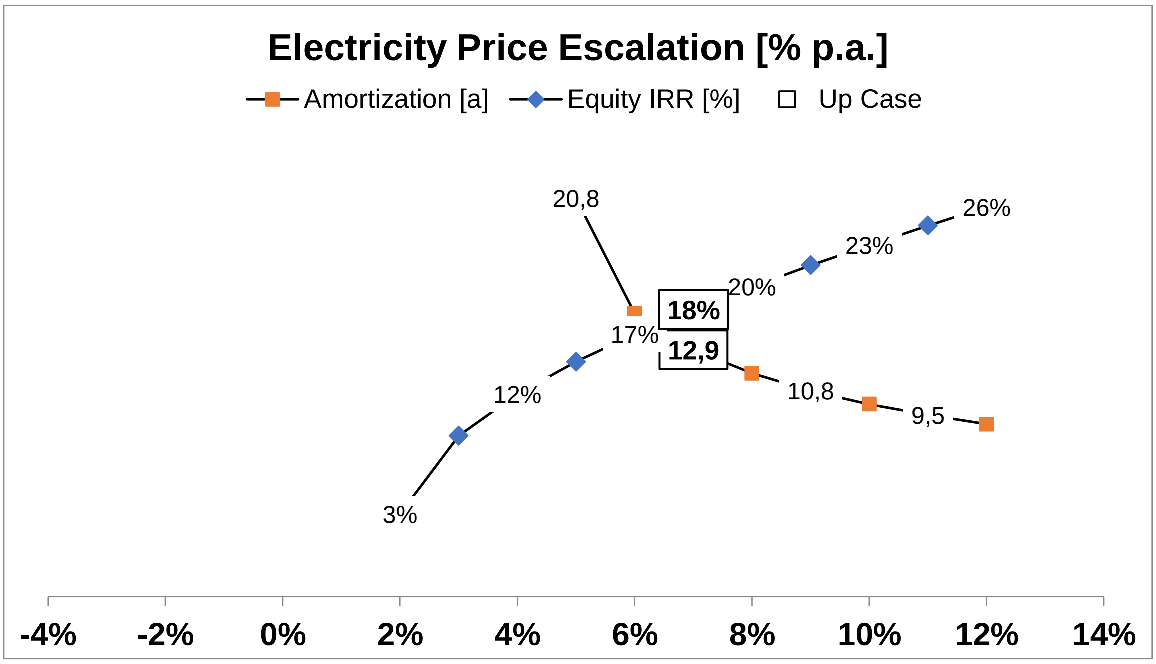
Figure 32: System Price Sensitivity - Off-grid PV Mini Grid



Source: eclareon; 2017 [64]

As in the previous examples above, the yield and the system price have a strong impact on the profitability of a project.

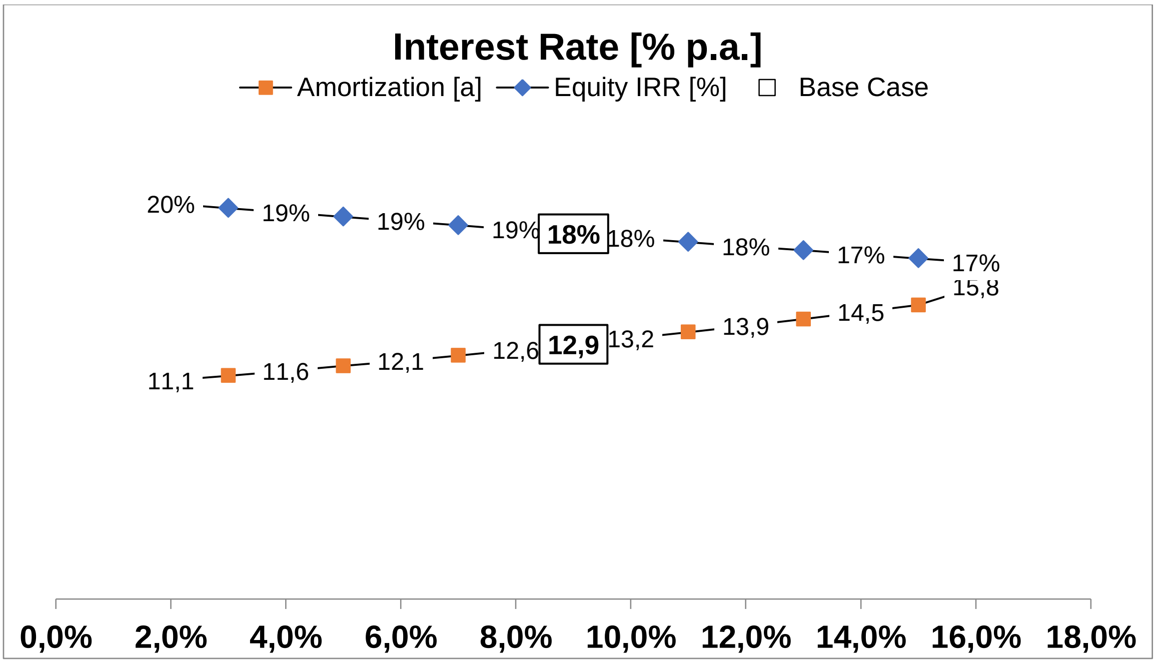
Figure 33: Electricity Price Escalation Sensitivity - Off-grid PV Mini Grid



Source: eclareon; 2017 [64]

Since the electricity sales to consumers connected to the mini grid are the main source of revenue, the price escalation applied to the electricity prices plays a key role.

Figure 34: Interest Rate Sensitivity - Off-grid PV Mini Grid



Source: eclareon; 2017 [64]

Since the debt financing only amounts to 50% of the total investment costs, the impact in changes to the interest rates has a reduced impact compared to the 80% debt used in the PPA project.

4. Success Factors for Developing PV Power Plants

The success factors for developing a PV power plant are divided into optimum power plant design, project implementation, commercial and financing aspects.

Depending on the chosen PV segment, it is important to understand the required design, implementation and financial requirements of each project. Costs for PV plants are decreasing, making solar power more competitive. However, it is necessary to understand the power purchase agreements offered in various environments to optimize the cash flow of a project.

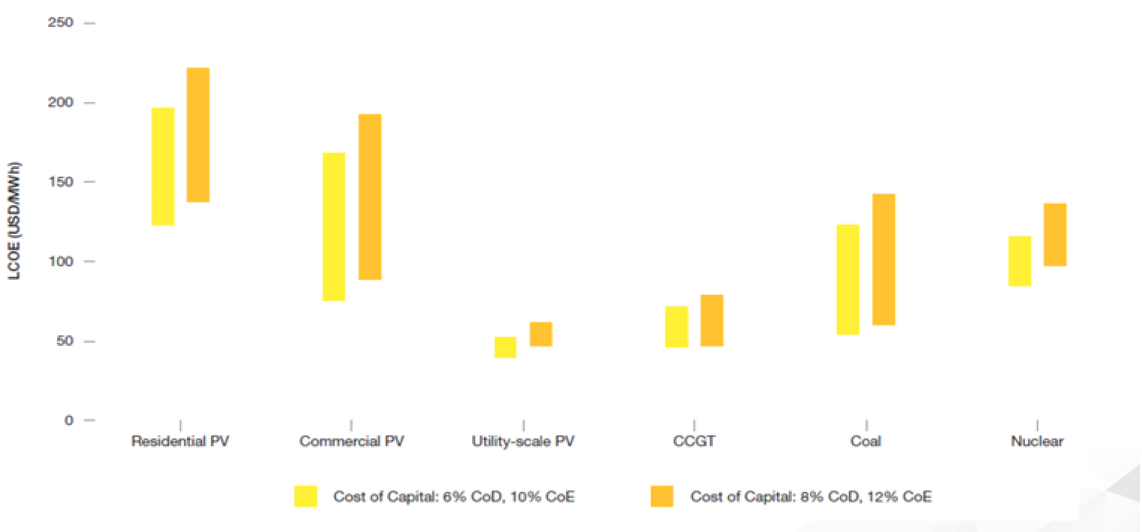
Lastly, there are several risks and mitigation measures that should be understood by the investor, developer and operator of each plant.

The following chapters provide a description of the success factors for developing PV power plants.

4.1 Status and outlook on most profitable PV segments

In general, it can be stated that due to the recent and ongoing cost reduction for PV systems there is a good (and increasing) chance for PV plants to be competitive. Nevertheless, it is hard to say which types of PV power plants are most profitable. Any decision on which type of PV plant is most suitable and profitable for any situation must be based on case by case analysis.

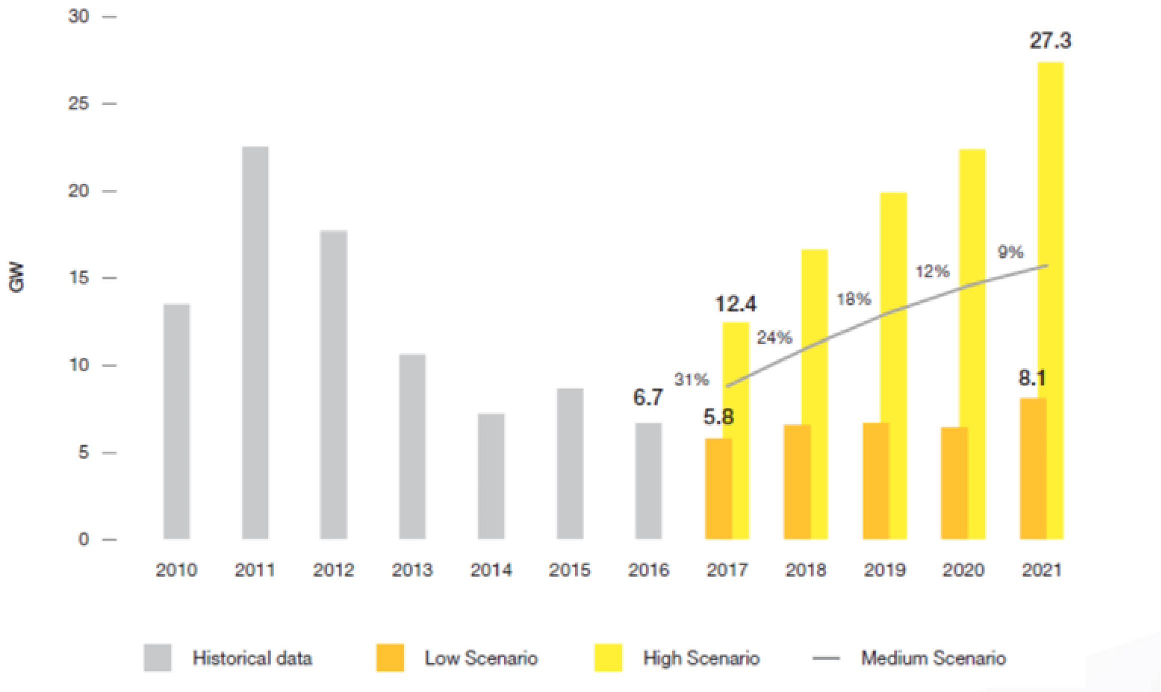
Figure 35: Electricity Generation Costs in Comparison



Source: Solar Power Europe; 2017 [67]

Figure 35 gives a good idea of the cost of PV in comparison with other means of power generation. The PV market is growing at a fast pace worldwide evidenced by Figure 36 below. With declining costs for PV and rising costs for thermal power generation, this development is likely to continue.

Figure 36: World Annual Solar PV Market Scenarios 2017 - 2021



Source: Solar Power Europe; 2017 [67]

The conclusion of the Global Market Outlook 2017 for solar power sums up a bright future for PV power plants:

“The global market outlook for solar power is bright. Before now, solar power was not as competitive as it is today. Utility-scale solar is cheaper than new fossil fuel plants and nuclear power generation plants in most regions of the world today. If retail electricity is not subsidised, it is usually more economic to produce solar on your rooftop and consume the clean power in-house. The costs for solar power continue to decrease, making this technology attractive for many users and investors around the world.”

4.2 Key requirements for successful implementation and operation of PV plants

For a PV project to be successful, three crucial areas can be identified:

1. **Optimum power plant design:**

   A key challenge is to design a PV power plant that is optimally balanced in terms of cost and performance for a specific site or circumstance.

2. **Project implementation:**

   Achieving project completion on time and within budget with a power plant that operates efficiently and reliably, and generates the expected energy and revenue, is another key requirement. Key aspects of project implementation include: permits and licensing, selection and contracting of the engineering, procurement and construction (EPC) company, power plant construction, and operations and maintenance (O&M).

3. **Commercial and financing aspects:**

PV regulatory frameworks and specific types of incentives/support mechanisms for the development of PV projects, such as preferential tariffs and other direct and indirect financial supports, have a paramount impact on the financial viability of PV projects, as they affect the revenue stream. Power Purchase Agreements (PPAs) specify the terms under which the off-taker purchases the power produced by the PV plant; this is the most important document to obtain financing.

4.2.1 Optimum Power Plant and Project Design

PV plant design is developed initially as part of a pre-feasibility study which is based on preliminary energy resource and yield estimates, as well as other site-specific requirements and constraints. The plant design is further improved during the feasibility study, which considers site measurements, site topography, and environmental and social considerations. Key design features include the type of PV module used, tilting angle, mounting and tracking systems, inverters, and module arrangement. Optimization of plant design involves considerations such as shading, performance degradation, and trade-offs between increased investment (e.g. for tracking) and energy yield. Usually, the feasibility study also develops design specifications on which the equipment to be procured is based.

Solar energy resource depends on solar irradiation of the geographic location as well as local issues like shading. Initially, solar resource assessment can be done based on satellite data or other sources, but as the project development moves progresses, ground-based measurements are desirable to provide an increased level of confidence.

Energy yield is a critical parameter that determines (along with the capital costs and the tariff) the financial viability of the project. Probability-based energy yield (for example P50, P75, P90) are modelled over the operating life of the project. A thorough analysis of the solar resource and projected energy yield are critical inputs for the financial analysis.

Site selection is based on many considerations, such as whether the PV plant is close to the grid, and whether the process for obtaining a grid connection agreement is transparent and predictable. Close cooperation with the grid company is essential in obtaining a grid connection agreement. The agreement, as well as applicable regulations, should clearly state the conditions of the PV developer’s access to the grid, and provide the guidelines for design, ownership, and operation of the grid connection. Access to land is also a basic requirement for project development. Project land must be purchased or leased for longer than the debt coverage period; a minimum of 15-20 years is desirable, although a 40-50-year lease is often signed and advantageous. In addition to the project site, the developer needs to secure access to the land over which the grid connection will be laid out.

4.2.2 Project Implementation

For a PV power plant that operates efficiently and reliably, generating the expected volumes of energy and revenue, the objective of the project implementation process must be to complete the project on schedule and within the allocated budget. To achieve this objective; several key activities need to be completed successfully. Permits and licensing are often a very bureaucratic process involving multiple agencies in the central and local governments which may not coordinate their procedures and requirements. The list of permits/agreements needed is usually very long and differs from one country to the other.

Typically, at least the following are needed:

1. Land lease Agreement;
2. Site access permit;
3. Building permits;
4. Environmental permit;
5. Grid connection agreement; and
6. Operator/generation license. Understanding the requirements and the local context is essential.

Consultations with the relevant authorities, the local community, and stakeholders are also important for a smooth approval process. Environmental and social assessments should be performed early in the project planning process and actions should be taken to mitigate potential adverse impacts. The grid connection agreement is critical to ensure that the PV plant can evacuate the power generated to the grid.

Engineering, procurement and construction can be broken into multiple contracts, but care must be taken to spell out the responsibilities, so that all parties are clear on who is managing various risks and the overall process. In some cases, overall coordination will be performed by the PV plant owner (if it has the in-house engineering expertise and experience in similar projects) or by an engineering company that is hired as a management contractor acting on behalf of the owner. However, the most common approach in building PV plants is turn-key responsibility through an EPC contract. An EPC contract involves one organization (the EPC Contractor) who has full responsibility to complete the project on schedule, under budget, and within the specified performance. The EPC contactor is paid a higher fee in return for managing and taking responsibility for all the risks of the project.

Operation and Maintenance (O&M) of PV plants can be performed by the owner or by contractors. Regular maintenance (including cleaning of the PV modules) is relatively easy and can be done by local staff trained by the equipment suppliers. Monitoring of plant performance can be achieved remotely by the original equipment manufacturer (OEM) or another asset manager. Spare parts, both for plant inventory and in response to equipment failures, need to be purchased from the OEM or an alternative supplier. There are companies offering lease agreements including leasing the PV plant or installing the PV plant and paying the owner of the building a rental. Under such agreements, electricity may be sold to the building owner at below-market prices.

4.2.3 Commercial and Financing Aspects

Activities related to project financing run in parallel with the project design and permitting. As the project developer initiates preparatory activities including securing land lease agreement and permits, preliminary financing schemes are also assessed. Adequate funds should be allocated to complete the initial stages of project development, most importantly for the energy resource assessment, site selection, land lease agreement, and preliminary permits/licenses.

Depending on the financing requirements of the project and how much of their own equity the developer can commit to the project, the developer may seek another sponsor. It is not unusual for the initial project developer to sell part or all rights of the project to sponsor - often with access to greater technical expertise and financial resources - who will complete the project.

As the project progresses, the developer/sponsor will reach out to potential debt financiers to get an idea of current lending rates, requirements and terms, and as the project develops, they will undergo due diligence. The experience and creditworthiness of the sponsor is critical for achieving financial closure and obtaining attractive financing.

Power projects are typically financed on a “back-to-back” basis, meaning that all contracts eventually rely on a bankable PPA**. In other words, a PPA with a creditworthy off-taker covering adequately all the key risks of the project provides a sound basis for the project developer to sign EPC and O&M contracts, lease or purchase land, etc., so the project can be implemented**. As the project takes shape, the developer begins negotiations with the off-taker (often but not always a state-owned utility in most emerging economies) on the price, duration, and terms of the PPA. In many markets, PV projects have benefitted from regulatory support providing above-market price for power. For example, under a Feed-in Tariff (FiT) program, the price of electricity from renewable energy is specified for a set period, usually 10–25 years. In another example, terms of the PPA may be pre-determined through a tender process in which the developer is submitting a competitive bid (e.g., reverse auction). In a third example, utilities may have an obligation to source a portion of their total energy from renewable sources, and then negotiate with developers according to their own priorities and parameters. In the (relatively rare) instance of a merchant solar power plant, power will be sold in the open market (i.e., “day-ahead,” “hour-ahead” markets) at fluctuating rates rather than at a pre-determined tariff. However, in the future (if PV prices continue to decline) regulatory support may not be needed and merchant PV plants may become more common. The type of grid connection and way of dispatching need to be clarified in the PPA. In most countries, the regulation requires the grid operator to take all the electricity produced by renewable facilities (“obligation to take”), but curtailment rules need to be included clearly in the PPA.

4.3 PV Potential

Nigeria’s close proximity to the equator exposes it to significant levels of solar radiation giving Nigerian solar businesses great potential to thrive.

The country’s current electrification rate is only 59% and energy demand is expected to grow steadily due to a rapidly growing population and economy. These trends will cause Nigeria to face challenges in keeping with demand in the power sector. Solar PV power plants can play a major role in solving the frequent transmission failures of the grid that Nigeria faces. The sinking costs for PV systems are helping to make the technology more accessible and viable.

The Nigerian government has taken significant steps to improve the standards of regulations for solar power projects. NERC has set a target of generating a minimum of 2,000 MW of electricity from solar PV by the year 2020 and seeks to ensure the following frameworks are fulfilled for solar power companies:

- 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 1000 MW
  (50 per cent of the total projected renewable sourced electricity)
- Nigerian Bulk Electricity Trading Company (NBET) to procure minimum of 1000 MW
  (50 per cent of the total projected renewable sourced electricity) [69]

If the Federal Government continues to improvement regulatory environment, there is a strong possibility of growth for solar PV businesses in Nigeria. Foreign companies and investors interested in the potential that the sun has to increase electrification rates in Nigeria, should explore the Nigerian market in partnership with a local company.

4.4 Risk factors

The main risk factors for solar PV in Nigeria can be divided into socio-political, geographical and financial risks.

4.4.1 Financial risk factors

A major financial risk that investors in PV systems face is initial funding. The reluctance of local commercial banks to grant investors loans has significantly impeded the growth of the solar PV sector because the high upfront cost of solar PV systems has traditionally been difficult for individual households to cover.

Capital costs for solar PV systems have fallen in recent years and yet they remain relatively high in Nigeria, because of poor infrastructure and a lack of trained personnel. Given the high commercial bank rates, solar project financing has largely been led by foreign investors because of the high interest rates and strict guarantee requirements [70]. Commercial bank rates range between 23% and 29% whereas rates from the Central Bank of Nigeria were 11% per annum in 2016. Nigeria's Bank of Industry announced its intention to offer loans at a rate of 7%.

The cost of solar PV systems in Nigeria is further impacted by Nigeria's vulnerability to currency devaluations as companies have to utilise foreign currencies to procure solar components and technical talent. The cost is further impacted by environmental and security hazards because capital items become more expensive as more repairs and replacements are necessary.

4.4.2 Socio-political/geographical risk factors

Technical barriers in Nigeria also have an impact on the feasibility of solar PV businesses. These include scarcity of skilled personnel and lack of training facilities. Nigeria also lacks a stable institutional and regulatory framework that can drive solar energy profitability. Given the lack of clarity and stability in the past, risks may also come in the form of sudden policy changes which may affect the profitability of projects.

Poor transmission infrastructure and an unreliable network system are also major risks to the success of solar PV in Nigeria. The existing power grid cannot accommodate the estimated 6,000 MW of power that is generated due to obsolete substation equipment, high technical and non- technical losses, and service providers' inability to effectively evacuate power generated by the generation companies (GenCos). These factors are constraining utility scale solar PV in Nigeria.

A pivotal risk in the solar PV business in Nigeria are natural disasters, such as heavy winds and heavy rainfall that may lead to corrosive damage of panels and appliances. Insecurity and vandalism are also major factors of risk in Nigeria. Theft of solar panels and batteries is a major concern for solar companies. Ongoing security concerns about terrorism in the north east of the country are also impeding growth, particularly because the north east has the highest solar radiation levels.

4.5 Recommendations for Investors and EPCs

The following is a list of risks that investors and EPCs should be aware of and address to help promote the further development and successful implementation of PV projects in Nigeria:

- Completion risks affected by permitting/licensing and construction delays.
- Energy yield: how much energy a facility produces depends on the energy resource and the design of the PV plant - changing weather patterns and performance degradation of the PV plant can significantly affect the revenue of projects in Nigeria.
- Regulatory environment: changes in regard to the amount of power the off-taker is obliged to purchase and the power price paid can impact projects, especially when they are applied retroactively. Developers are advised to consider the viability of their projects without subsidies or special treatment; particularly if these considerations show that the effective price of the generated solar power is well above the levelized cost of power in the existing power market.
- Off-taker creditworthiness: thorough due diligence of the off-taker is an essential step before finalizing financing. The appropriate financing arrangement depends on the specifics of each PV project, including investor risk appetite. The most common arrangement for these projects is to use a project finance type arrangement, typically with at least 30 percent equity and the remainder as debt. However, if local commercial debt is difficult to access or expensive, or the due diligence process for obtaining debt is expected to slow down a project and tariffs are sufficiently high, then equity investors may be incentivized to back the entire project. While debt is cheaper than equity, all equity financing can allow for speedier project development, a priority in markets where a specified amount of construction must be achieved by a certain deadline to be eligible for incentives. This dynamic is not unique to solar, but as most solar projects have historically been smaller, it has been more feasible for developers to finance them without debt financing, or at least to delay debt financing until the projects were operational and thus presented a significantly lower risk profile to lenders. For solar projects that are among the first in their market, local banks may be reluctant to lend until they have evidence of successful realisations; in such circumstances, seeking financing from development finance institutions like the IFC, which is willing to be a first-mover in new markets for renewables, may be a solution.

Investors who consider the abovementioned risks and adopt suitable mitigating measures as early as possible will be enabled to have high success rates with their PV projects.

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