Oando

PRE-FEASIBILITY ASSESSMENT

SOLAR POWER IN NIGERIA

Abridged version

Introduction

As the world actively pursues deliberate paths toward the creation of a more sustainable future, there is an increased emphasis on the role of state and non-state actors, corporate bodies and individuals in realizing the climate goals we have set ourselves. There is overwhelming evidence that the environmental damage caused by one country, industry, or a person affects all, to which effect we must all act together by taking responsibility for the creation of a greener planet. And there are rallying calls through the likes of the Sustainable Development Goals and the Paris Agreement, for all to step forward and act now.

Today, petroleum meets over 95% of global transportation demands; however, a sustainable world means the future of Energy companies will increasingly be based on a diversified portfolio that must include renewable energy in various forms, as oil and gas become less fashionable to investors and future workforce.

We are already witnessing a significant shift, across the world, in institutional investments, with some of the world's largest investment management firms and banks boldly reducing business dealings with or completely divesting from companies that do not have active plans to improve their Environmental, Social and Governance (ESG) metrics.

It is against this backdrop that Oando has made it's first foray into renewable energy, as the journey begins for the redefinition of the future of our business and our role in the achievement of a carbon neutral world.

This document presents a pre-feasibility study assessment of opportunities within the Solar Value Chain in Nigeria. It encompasses preliminary research to analyze, determine and select the most technically and economically viable business scenarios for further studies and adoption.

As a company that has always been invested in how Nigerians can through collaboration move the economy forward, we have taken the step of sharing this preliminary research of Nigeria's renewable energy space with the general public.

Our belief; if as a nation we are to pivot substantially into renewables then we must start to create platforms that will enable the growth and diversification of sector players. One of the ways we can do this is via knowledge sharing. Our objective in sharing this pre-feasibility assessment is to act as the first stage of research for interested individuals and businesses to determine and select the most technically and economically viable space they can play in.

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Executive Summary

Nigeria & Oando

Unstable global oil prices, an evolution of global and local polices in favor of "cleaner" energy sources, and a consequent shift in financiers' interest has accelerated the need for oil and gas companies, inclusive of Oando PLC to explore a portfolio diversification strategy towards renewable energy.

As the world transitions from fossil fuels into more renewable sources of energy (Solar, Wind, Geothermal, Tidal etc.), energy providers in the fossil fuel space must rapidly evolve to adapt to a new market reality or face disruption. A key part of that evolution is making deliberate efforts to gain an early understanding of the renewable energy value to determine opportunities and strategies for success.

Leveraging on the abundance of solar energy, growing financier interest in funding renewable energy projects in Africa as well as the FGN's interest in developing and executing solar power projects for rural and institutional electrification there are abundant opportunities for interested private actors to commit to an environmental sustainable Nigeria.

Introduction

The continued push for a world focused on Sustainable Development and the Energy Transition Act are increasingly tuning and shifting attention to transforming the global energy sector from fossil-based to zero-carbon by the second half of this century. The United Nations with its pledge to end poverty has provided an excellent roadmap aimed at protecting the planet and ensure prosperity for all by 2030.

The Oil and Gas industry is responding with operations models that seek to reduce carbon emissions, and with the Environmental, Social, and Corporate Governance-ESG framework, investors are putting increasing amounts of their funds in high sustainability and societal impact opportunities.

Renewables are essential in the drive towards universal access to affordable, sustainable, reliable and modern energy. Of the three end uses of renewable - electricity, heat, and transport - the use of renewable grew fastest with respect to electricity, driven by the rapid expansion of wind and solar technologies.

In Q1 2020, global use of renewable energy in all sectors increased by about 1.5% relative to Q1 2019, showing that renewable electricity has been largely unaffected while demand has fallen for other forms of energy.

The United Nations has set the pace with a plan that proposes an integrated approach to realize rapid results and progress, accelerating proven innovative solutions and partnerships. Over the next 10 years, the UN Climate Action targets:

Carbon Emissions; Absolute and per capita reductions of 25% by 2025 and 45% by 2030.

Electricity Consumption; Per capita reductions of 20% by 2025 and 35% by 2030.

Renewable Energy; 40% by 2025 and 80% by 2030 of consumed electricity.

Commercial Air Travel; Per capita emissions reductions of 10% by 2025 and 15% by 2030.

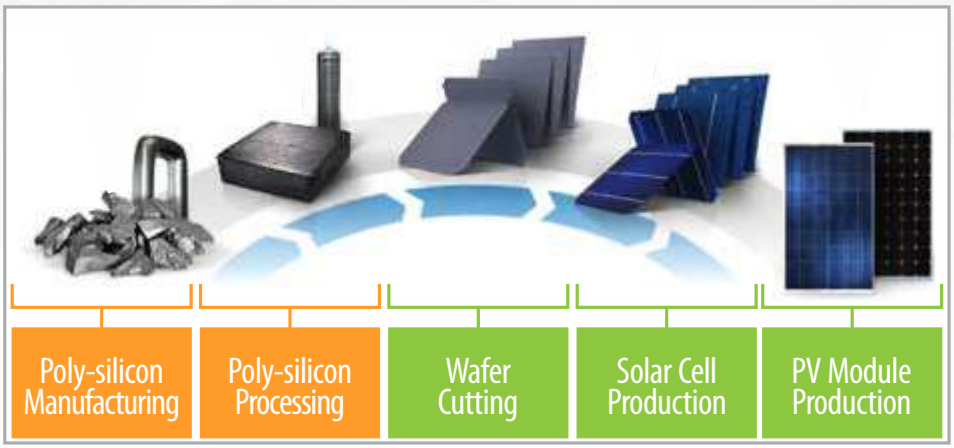
Climate Neutrality; 100% of unavoidable carbon emissions are offset yearly from 2019 via certified carbon credits.

Operational Efficiencies; demonstrated long term economic benefits from the Plan implementation.

Sustainable Development Co-Benefits; demonstrated increase in climate smart infrastructure and other sustainable development benefits to local communities from Plan implementation.

This report provides an assessment of the solar power value chain, its technologies, opportunities and potential obstacles.

The Photovoltaic (PV) Value Chain



Poly-silicon Manufacturing	Poly-silicon Processing	Wafer Cutting	Solar Cell Production	PV Module Production
Quartzite rock is mined and processed into high purity MG-Si and then into Poly-Si The processes involved are: **Carbon Reduction Acid Treatment** The Processes are power intensive and require an Arc-Furnace	Polysilicon rock is melted at ~1,400 °C until it forms a white-hot liquid. The processes involved are: **Charging Melting Growing Cooling** The Processes are power intensive and require a Quartz Crucible	The Crystal Ingot is first saw-cut into equal cylindrical lengths before being wire-cut into the squared wafer The processes are: **Cutting Squaring Slicing** The processes require precision cutters for proper shape configuration	The polysilicon wafer is converted into solar cells through the addition of phosphorus and bus bar circuitry The processes are: **Texturing Diffusing Coating Printing** The processes require specialized equipment set in a sterile environment	Solar cells are strung together in a panel modeling and assembly line The processes are: **Stringing Soldering Laminating Framing Inspecting Packing & Shipping** The process requires heavily automated robotics
Quartzite (Silica), Carbon (coke), Hydrochloric Acid, Hydrogen	Graphite, Silicon Crystal, Boron	Silicon Carbide	Silicon Film, Silicon nitride, Phosphorus	Titanium Dioxide, Ethylene Vinyl Acetate, Mylar or Tedlar sheets, Steel or Aluminum

END USE APPLICATION

Grid Power (Solar Farms)

Rooftop (Off-Grid Power)

Solar Products

High Level Market Entry Strategy

Poly-silicon Manufacturing | Poly-silicon Processing | Wafer Cutting | Solar Cell Production | PV Module Production

END USE APPLICATION

Distribution, Solution Architecture, System Aggregation, Installation and Energy Generation

UPSTREAM

- Oligopolistic
- Global incumbents increasing capacity
- High Entry barriers
- Tough Quality expectations
- High Electrical Power requirement
- **Complexity:** ○○○○○
- **Capital:** △△△△△

MIDSTREAM

- Dependent on supply of high-quality polysilicon
- Global incumbents increasing capacity
- Cutting edge technology and process requirements
- Tough Quality expectations
- PV Module Production Easiest Entry Point
- **Complexity (Wafer + Solar Cell):** ○○○○○ **(PV Module):** ○○○○○
- **Capital (Wafer + Solar Cell):** △△△△△ **(PV Module):** △△△△△

DOWNSTREAM

- Low Entry Barrier
- Partnership Support
- Funding Support
- Multiple Supply Chains
- Low Tech Requirement
- **Complexity:** ○○○○○
- **Capital:** △△△△△

Opportunity Description

Global PV Market

The Global PV market is currently valued at **$76 billion**

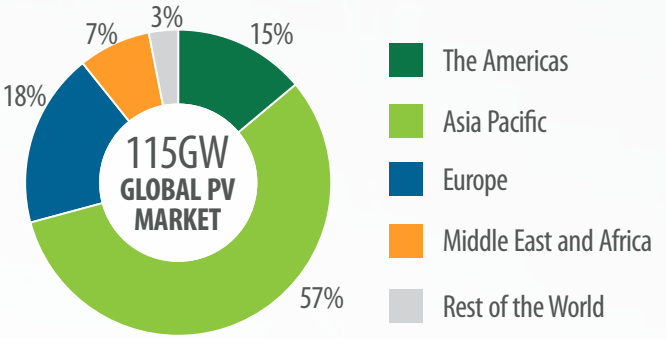
It is forecasted to grow to about **$120 billion** between 2023-2025.

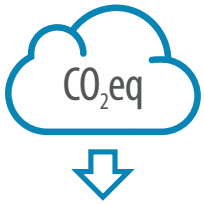
627GW installed Globally

~100GW Growth expected year on year

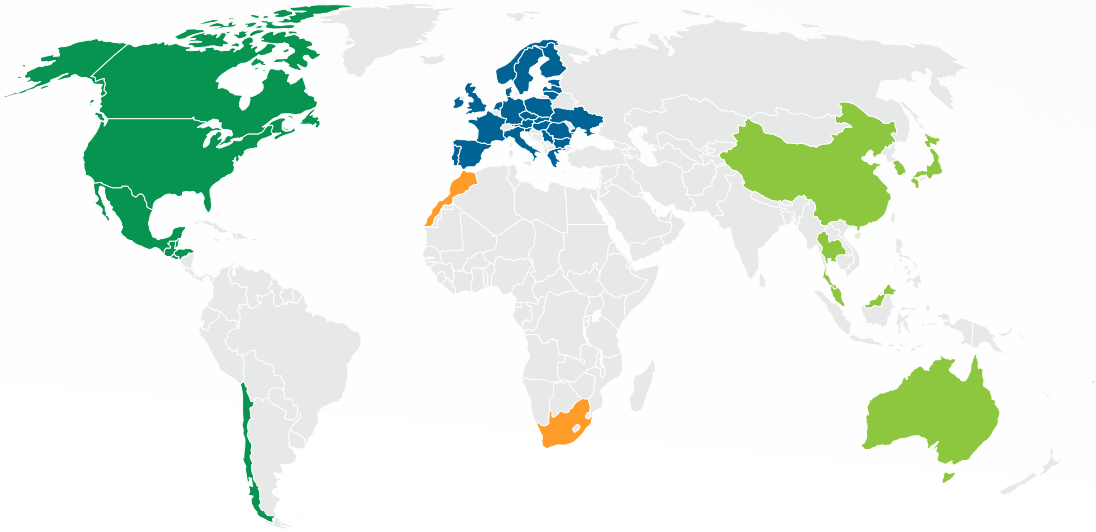
TOP PV MARKETS 2019

CHINA	30,0 GW
E U	16,0 GW
USA	13,3 GW





720 Mt Co_2 emissions avoided in 2019



627GW were installed all over the world by the end of 2019

CHINA is the world's **#1** PV market

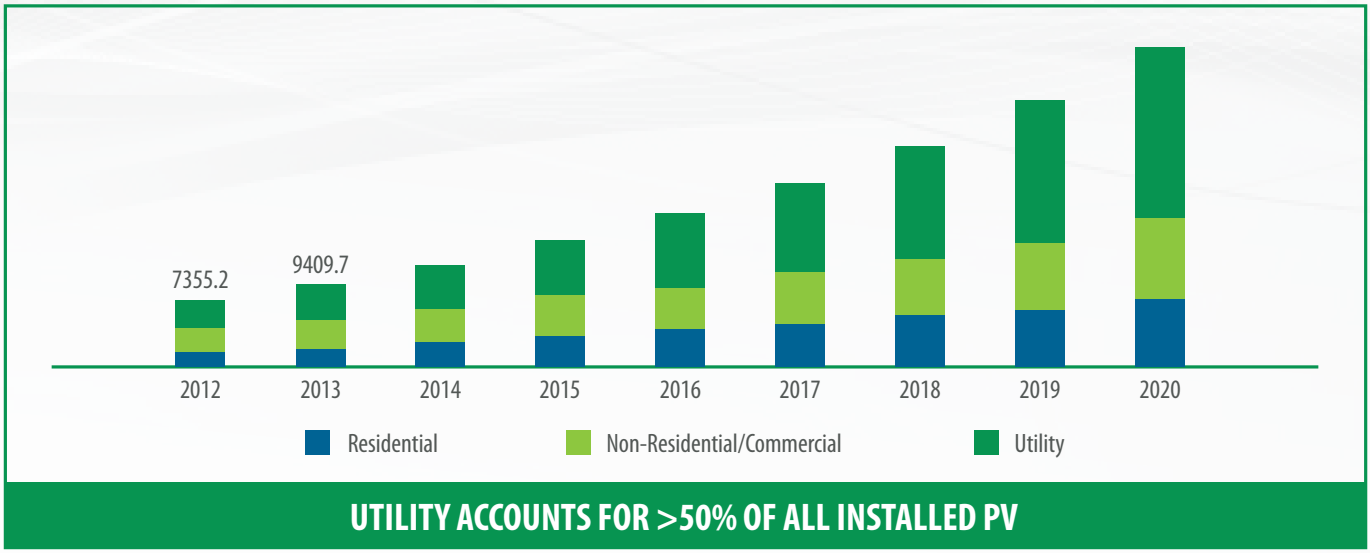
18 **countries** installed at least **1GW** of PV in 2019

09 **countries** have installed at least **10GW** of cumulative capacity at the end of 2019

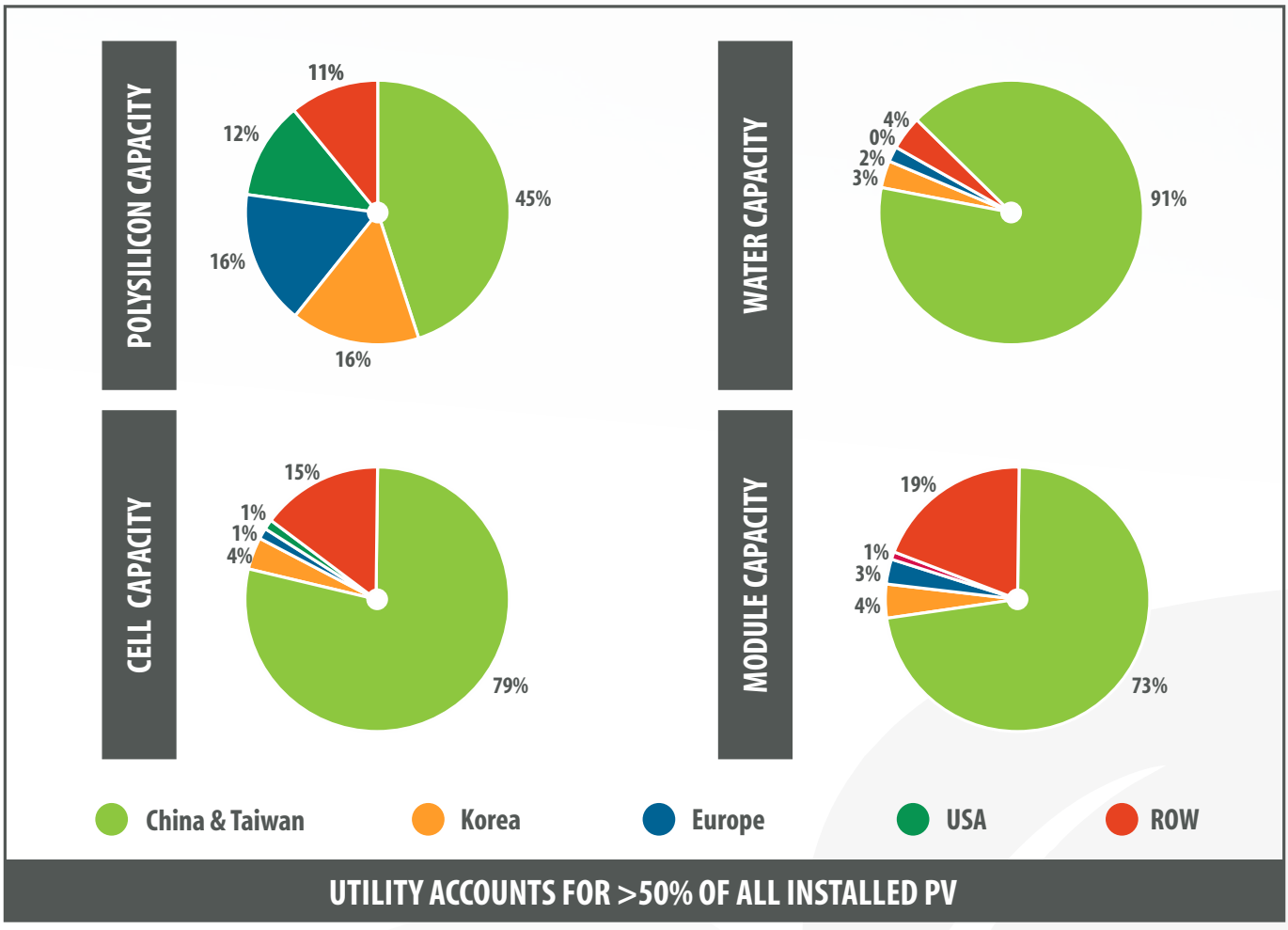
SOLAR PV PER CAPITA 2019 Watt/capita

1st GERMANY		595
2nd AUSTRALIA		585
3rd JAPAN		497

Global PV Market



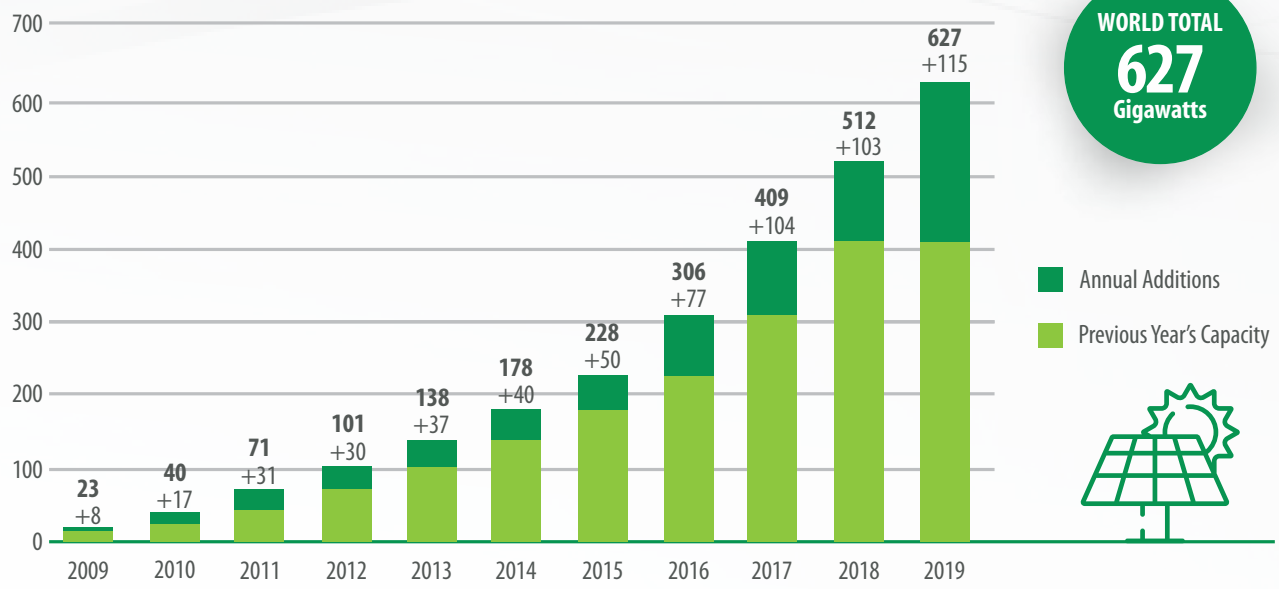
UTILITY ACCOUNTS FOR >50% OF ALL INSTALLED PV



UTILITY ACCOUNTS FOR >50% OF ALL INSTALLED PV

The Growth of Solar

SOLAR PV GLOBAL CAPACITY AND ANNUAL ADDITIONS (2009 - 2019)



Note: Data are provided in direct current (DC)
Totals may not add up due to rounding.

Source: Becquerel Institute and IEA PVPS
RENEWABLE 2020 GLOBAL STATUS REPORT

- The adoption of solar power continues to rise year on year.
- There is however a projected drop in additions due to the COVID-19 Pandemic which has stalled several projects

Solar Power and Energy Mix Developments in Nigeria

12,522MW Installed power Generating Capacity (Mainly Hydro and Gas)

28MW Installed Solar Power Generation

~6,000MW Actual Generation Performance

~24,000MW Estimated Actual Demand Required for consumption

~12,000 – 18,000 MW Opportunity for electricity generation

Some Information & Trends in the Nigerian Power Sector:

- Transmission Infrastructure Insufficient
- Planned Power Plants
- Market Status (Free) +
- The Mini-Grid Sector to Expand Rapidly 2020 + (WB)
- Several Grants, Loans and Funds Available
- Focus has been on Universities Power Independence, Rural Electrification and Grid Improvement
- Power Africa (USTDA) to Support Projects + Broker Partnerships
- Multi-Year Tariff Order by NERC to Enable New Developments

Opportunities Exist for:

- Distributed power generation (Micro & Mini Grid Projects)
- Residential homes, clusters and urban developments
- Rural Electrification
- Institutional Electrification

Solar Power Trends In the Nigerian Power and Electrification Market Space (Recent + Ongoing)

PROJECT	CAPACITY	LOCATION	SPONSOR
Construction of off-grid/on-grid renewable energy (solar) micro utility	TBD	Imo, Taraba, & Bayelsa State	MOP
Supply and Concession of Solar mini-grids	40, 60, 90 KW	Benue, Sokoto, & Kaduna State	MOP
Provision and Installation of Solar Hybrid Mini Grid	TBD	Benue State	MOP
Community Electrification (PowerGen – Kenya - 10 planned)	~70-100 KW each	Niger State	World Bank + REA
Rural Mini-grid Acceleration Scheme – 24 Planned	</= 1MW	Niger, Oyo, Anambra, Delta, & Edo State	REA + EU
Mini-Grid Projects (14 PPAs with NBET – Stalled since Final Extension in July 2018)	1125MW total	Multiple Locations	FGN + NBET
Energizing Education Program – 37 Universities + 7 Teaching Hospitals planned	89.6MW total	Universities & Teaching Hospitals	World Bank + REA
Energizing Education Program – Metka Project executed (4 Universities planned)	7.5MW	Bayero University, Kano State.	World Bank + REA

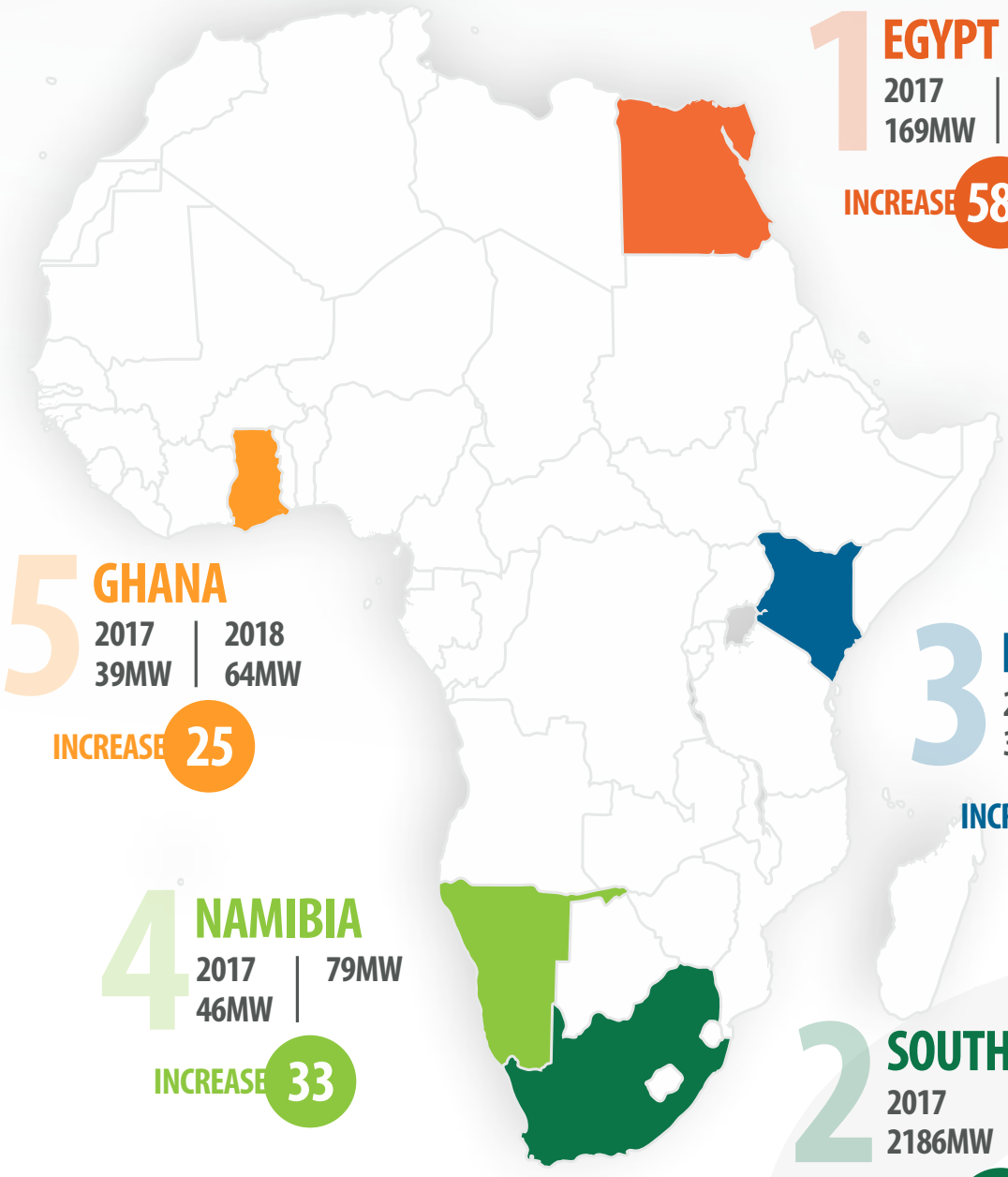
FUNDING

- **$200 Million** | The African Development Bank | REA | Expand Nigeria's Power Sector and Improve Access to Electricity | Investment Fund
- **$410 Million** | The African Development Bank | MOP | Transmission Infrastructure Development (Expansion of transmission lines and Construction of Substations) | Project Financing
- **$550 Million** | The World Bank | REA | Development of Mini-Grids and Solar Home Systems | Loan

Africa Opportunity: Solar Development in Africa

THE BIG 5 AFRICA'S FASTEST GROWING SOLAR ENERGY MARKETS

CUMULATIVE INSTALLED SOLAR PV CAPACITY IN AFRICA (MW)



1 EGYPT
2017 169MW | 2018 750MW
INCREASE 581

2 SOUTH AFRICA
2017 2186MW | 2018 2559MW
INCREASE 373

3 KENYA
2017 38MW | 2018 93MW
INCREASE 55

4 NAMIBIA
2017 46MW | 79MW
INCREASE 33

5 GHANA
2017 39MW | 2018 64MW
INCREASE 25

Africa Opportunity: Solar Development in Africa

WHY AFRICA – GAPS, OPPORTUNITIES AND BENEFITS

Africa has some of the world's fastest growing economies, with emerging markets for a wide array of products and services including renewable energy technologies.

The IEA estimates that a 28billion dollars per year capital spend is required to achieve universal energy access in sub-Saharan Africa by 2030

Africa is a key market for solar for the following reasons

- High density of under-served population with about 40% of the African population without access to electricity
- Low connection rates due to lack of adequate generation, transmission and distribution infrastructure to meet the needs of a rapidly growing urbanizing population
- Centralized power generating facilities are unable to adequately cater to the needs of a dispersed population creating a gap and opportunity for rapidly deployable decentralized power infrastructure like solar or wind
- Financiers and Investors want an African footprint due to its strong economic market potential, CSR component and ESG affinity. Financiers and Investors want to eliminate sole country/geopolitical risk
- A large amount of Funds (Investment and Loans) and grants are targeted at developing African countries with a commitment to the sustainable development of the region

INSTITUTIONAL INVESTMENTS & LOAN PROVIDERS

- The World Bank
- The African Development Bank
- US Trade and Development Agency
- USAID Power Africa Fund
- International Finance Corporation
- Africa Finance Corporation
- European Investment Bank
- China Development Bank

GRANTS AND FUNDS

- The EEP Africa Trust Fund
- Africa Renewable Energy Fund
- Sustainable Energy Fund for Africa
- IRENA/Abu Dhabi Fund for Development
- Global Climate Partnership Fund
- Other Climate Investment Funds

PROTECOSYST FOR AFRICA

Protecosyst believes that a business strategy that considers key African countries such as Egypt, Kenya, South Africa, Namibia, Ghana, Cape Verde and Mauritius presents a unique opportunity for an integrated network of technological expertise, manufacturing capacities, supply chain & logistical solutions, Raw materials and resources designed to commercialize renewables for Africa by Africans.

Africa Opportunity: Comparative Overview

Morocco: Home to Africa's largest solar power Project (500MW)

- **Total Energy Demand:**
- **Energy Mix:** Heavy Coal (43%), Heavy Oil (25%), Gas (23%) Biomass, Renewables (11%)
- **Energy Gap Description:** Morocco seeks to reduce its dependency on heavy oils which is imported
- **Policy and Plan Roadmap:** Morocco plans to have 52% of Energy supplied from renewables by 2030 (20% solar, s0% Wind and 12% Hydro)
- **Key Driver:** Financial incentives and aggressive climate policies and regulations
- **Key Resistor:** Regulatory hurdles, red-tape, transparency and high cost of labor
- **Opportunity Summary:** Located in one of the best locations for solar power, Morocco is a fine location for utility scale Solar power projects

Egypt: Most accelerated growth in additional power capacity ~30GW in 7 Years

- **Energy Demand and Supply:** Egypt currently has a surplus in energy supply
- **Energy Mix:** Gas, Hydroelectric, Coal, Crude Oil , RE(Wind & solar)
- **Energy Gap Description:** Egypt's main constraint lies in its transmission and distribution infrastructure Mini-grids and utility scale power are sound strategies for Egypt
- **Policy and Plan Roadmap:** Egypt plans to add an additional 500km of transmission lines to increase connectivity and reduce loses
- **Key Driver:** Well developed energizing strategies and policies in place
- **Key Resistor:** Primarily government owned power sector
- **Opportunity Summary:** Egypt provides an opportunity for manufacturing and supply partnerships

Ethiopia: Ethiopia wants to increase electricity access rate from 50% to 100% in 10 years

- **Energy Mix:** Heavily reliant on hydropower (85%) Others (Wind, coal and Solar)
- **Energy Gap Description:** Electricity access rate is at 45%
- **Policy and plan Roadmap:** Increase power generation capacity by 25GW - Hydro (22GW), geothermal (1GW), Wind and Solar (2GW)
- **Key Driver:** Government and International body commitment to achieve SDGs
- **Key Resistor:** Economic development
- **Opportunity Summary:** Ethiopia is part of the World Bank's scaling program, which has a goal of making privately funded grid-connected solar projects operational at competitive rates. The goal is to add 500MW of solar power to support its renewable energy growth plan

Cape Verde: Cluster of islands presenting a unique challenge for transmission and distribution

- **Total Energy Demand:** Cape Verde meets about 90% of its energy requirements
- **Energy Mix:** Heavy Oils (77%), Wind (15%), Solar (7%)
- **Energy Gap Description:** 77% of electricity is generated from heavy oils that is imported, in addition the distribution of the 10 Islands makes for a transmission and distribution nightmare
- **Policy and Plan Roadmap:** Cape Verde is looking to reduce its reliance on Heavy oils and make a shit towards wind and solar power with distributed generation and transmission
- **Key Driver:** Governments determination for economic growth with minimal increase in emission contributions has created policies and finance opportunities for solar energy development
- **Key Resistor:** Small insular market with limited spending power
- **Opportunity Summary:** Opportunity for micro grid applications and SHS

Ghana: Home to Africa's largest solar Total Energy Demand

- **Energy Mix:** Hydro (50%), Natural Gas (47%) Solar (3%)
- **Energy Gap Description:** major gap is in rural electrification and transmission network development
- **Policy and Plan Roadmap:** Ghana has a rural electrification master plan that seeks to install 55 mini-grids and other stand-alone solar systems for 33,000 households, 1350 schools, 500 health centers and 400 communities
- **Key Driver:** Strong support from government policies for Renewable development
- **Key Resistor:** Facilities are intended to be government run limiting private involvement to construction
- **Opportunity Summary:** Ghana provides an opportunity for EPC based solar projects where Protecosyst and its technical partners can obtain construction contracts

Africa Opportunity: Comparative Overview

Kenya: One of the few countries to develop and utilize Geothermal energy

- **Total Energy Demand:**
- **Energy Mix:** Hydro (30%), Geothermal (28%), Solar & Wind (14%), Fossil Fuels (28%)
- **Energy Gap Description:** Electricity access rate is at ~70%
- **Policy and Plan Roadmap:** Kenya aims for 100% electrification before 2030 and intends to do so by expanding its grid infrastructure and supporting the deployment of off-grid solutions
- **Key Driver:** Concerted government policy supporting stand-alone power stations and a strong availability of private investment
- **Key Resistor:** Simultaneous development of its oil and gas resources competing for investment
- **Opportunity Summary:** Kenya presents an opportunity for development of utility scale solar power stations. It also has strong potential as a manufacturing hub

South Africa: Home to 8 of Africa's biggest solar power plants

- **Current Generating Capacity:** ~60GW
- **Energy Mix:** Coal (80%) Gas (9%) Solar (6%) Wind (4%), Others (1%)
- **Energy Gap Description:** Less Dependency on Coal and Increased rural electrification
- **Policy and Plan Roadmap:** ~10GW additional solar by 2030
- **Key Driver:** Grid Support for Utility Grade Solar, extensive infrastructural development and policies and strong commercial structures
- **Key Resistor:** Strong indigenous players already in existence
- **Opportunity Summary:** There is an opportunity for leveraging on existing supply chain, manufacturing capacity and Technical expertise

Namibia: Currently imports a large amount of power from South Africa

- **Demand and Supply:** Namibia imports 61% of its electricity supply
- **Energy Mix:** Hydro, Coal, heavy oils and Solar
- **Energy Gap Description:** Only 36% of Namibians have access to electricity
- **Policy and Plan Roadmap:** Namibia is focused on Mini-grid (43%) and SHS (57%) solutions to meet its electrification targets by 2030
- **Key Driver:** Massive gap in supply and demand
- **Key Resistor:** Monopolistic commercial structure, Lack of commercial incentives
- **Opportunity Summary:** There is an opportunity for mini-grid development and SHS for rural electrification

Mauritius: Mauritius utilizes Bagasse (sugar cane waste) as a major resource for its WTE programs

- **Energy Mix:** Coal and Oil (80%) Biofuels and Hydro (15%), Solar and Wind (5%)
- **Energy Gap Description:** Mauritius needs to reduce its reliance on fossil fuels. It plans to do so by investing in more Solar, biomass, WTE and Wind power stations
- **Policy and Plan Roadmap:** Mauritius has a net metering policy in force to support independent power generation and has a plans to increase electricity generation from rentable energy sources from 22% to 40% by 2030.
- **Key Driver:** The Government is seeking international competitive bidding for its power projects and favors JVs between local private sector and international firms
- **Key Resistor:** small island with limited scale potential
- **Opportunity Summary:** Mauritius is a high prospect for the development of utility scale solar power plants (10MW recommended) qualified to participate in its medium-scale distributed generation scheme with potential sales agreements with the central electricity board

Market Entry Strategy

PV Business Landscape

VALUECHAIN FLOW

	Product	Process	Industry Characteristics	Technology	Generic Strategies
Upstream	Polysilicon	Quartz silica changed into silicon ingots	◦ Oligopolistic ◦ 5-10 companies ◦ High entry barriers** ◦ Ample supply of inputs	◦ Siemens trichlorosilane ◦ Fluidized bed reactor ◦ Upgraded metallurgical silicon ◦ Vapor-to-liquid deposition	◦ Build scale economies ◦ Establish quality control ◦ Set price ceilings
Midstream	Water	Silicon ingots cut into waters	◦ Limited competition ◦ About 50 Companies ◦ Medium entry barriers due to high investment ◦ High dependence on polysilicon suppliers	◦ Siemens trichlorosilane ◦ Fluidized bed reactor ◦ Upgraded metallurgical silicon ◦ Vapor-to-liquid deposition	◦ Build scale economies ◦ Establish quality control ◦ Set price ceilings
	Cell	Circuitry put on water	◦ Highly competitive ◦ About 100 companies ◦ Low entry barriers ◦ Essential component of silicon-based power ◦ Boom-bust exposure	◦ Crystalline ◦ Thin film (CIGS, CdTe, a-Si)	◦ Establish proprietary technology ◦ Integrate midstream operations
	Module	Cells placed on glass and made into panels	◦ Highly competitive ◦ About 400 companies ◦ Low entry barriers due to low investment ◦ Boom-bust exposure	◦ Low technology	◦ Differentiation
Downstream	Installation	Solar panels installed	◦ Fragmented ◦ Numerous companies ◦ Requires Financing and connections	◦ Low technology	◦ Price Non-market strategies

MID-LONG TERM GOAL

QUICK START

Source: Interviews/Research Barclay's, Deutsche bank (AG), GCL Poly, Evergreen Solar, Ignite solar, Natcore: Independent Research

Solar Power and Energy Development Insights

SCENARIOS (INSTALLED CAPACITY IN MW)	2019	2020	2025	2030	2035	2040	2045	2050
BP - Business As Usual Scenario	28	32	39	48	56	68	79	**91**
BP - Rapid Growth Scenario	28	32	44	57	77	104	127	142
BP - Net Zero Carbon Scenario	28	32	44	64	102	141	165	181
AAC & Energy Mix Ratio Constant	28	32	54	82	109	140		
AAC Progressive Pessimistic, Energy Mix Ratio Constant	28	33	56	90	128	178		
AAC Progressive Optimistic, Energy Mix Ratio Constant	28	37	62	104	156	**226**		
IEA Stated Policies & GHG Target Scenario	28	48	228	342	456	**570**		
IEA Africa Growth Case Scenario	28	342	799	1484	2168	**3196**		

Stated Policy Assumptions Considering Today's Policy Frameworks and Plans (Regulatory, Institutional, Infrastructural and Financial Circumstances)

- 85% of Population have access to electricity by 2040 (Grid Upgraded and expanded)
- 20% Unconditional reduction in GHG emissions by 2030

The Africa Growth Case Assumptions (based on Agenda 2063, the continents inclusive and sustainable vision for accelerated economic and industrial development)

- 100% of Population have access to electricity from 2030 (Grid Upgraded, Mini-grids and standalone systems deployed)
- Renewables will account for 1/3 o all new generation capacity.

Resistors to Solar Power Development:

- Government Policies and Incentives: Nigeria is still in the process of developing a robust set of policies to encourage and incentives solar power development. Tax breaks, and subsidies are good examples.
- Initial Investment: The Initial investment required for solar power plants of equivalent capacity to conventional power plants is higher
- Social Acceptance: Policy makers and end users have not fully embraced the concept of renewable energy
- Research and Development in Nigeria
- Renewables will account for 1/3 o all new generation capacity.

Source: Interviews/Research Barclay's, Deutsche bank (AG), GCL Poly, Evergreen Solar, Ignite solar, Natcore: Independent Research

Solar Power and Energy Development Insights

With the Information Available:

- Nigeria's Adoption of Solar might be slow
- Max Installed capacity in the next 20 years 220MW recommended pessimistic view and 570 recommended optimistic view
- Majority of this developments will be Micro-Grids for rural electrification and Institutional distributed power generation
- Majority of developments will initially be in the northern parts and in regions with available land space adapting as technology and efficiencies improve
- There are number of schemes, funds and partnership opportunities in place to spur on the solar development curve
  Exploitation of these opportunities requires preparedness and positioning in the following areas;
  - Technical and commercial partnerships
  - Technology and skill transference
  - Technical competency development
  - Project execution capability & history
  - Brand and clout development
  - External relations development
  - Opportunity conceptualization
  - Financial capacity or access
  - Feasibility studies

Recommendation:

- The solar boom is coming but it is not now (~2030)
- Entry into the renewable energy market requires long term direction and focus
- Down stream business set-up, capability development & positioning should be the short-term strategy, supported by influencing reform and project execution

PV Opportunities in Nigeria

RESIDENTIAL & PRIVATE APPLICATION

- Homes
- Small Businesses
- Lighting
- Solar Products

Small systems 1- 10KW systems are typical here.

RURAL ELECTRIFICATION APPLICATIONS

- Distributed Power Generation for Rural Locations with no Power infrastructure in place
- Rural Water projects
- Rural agricultural applications
- Solar Products

Solar systems vary from a few 100Kw to as much as 1MW.

MEDIUM SCALE UTILITY

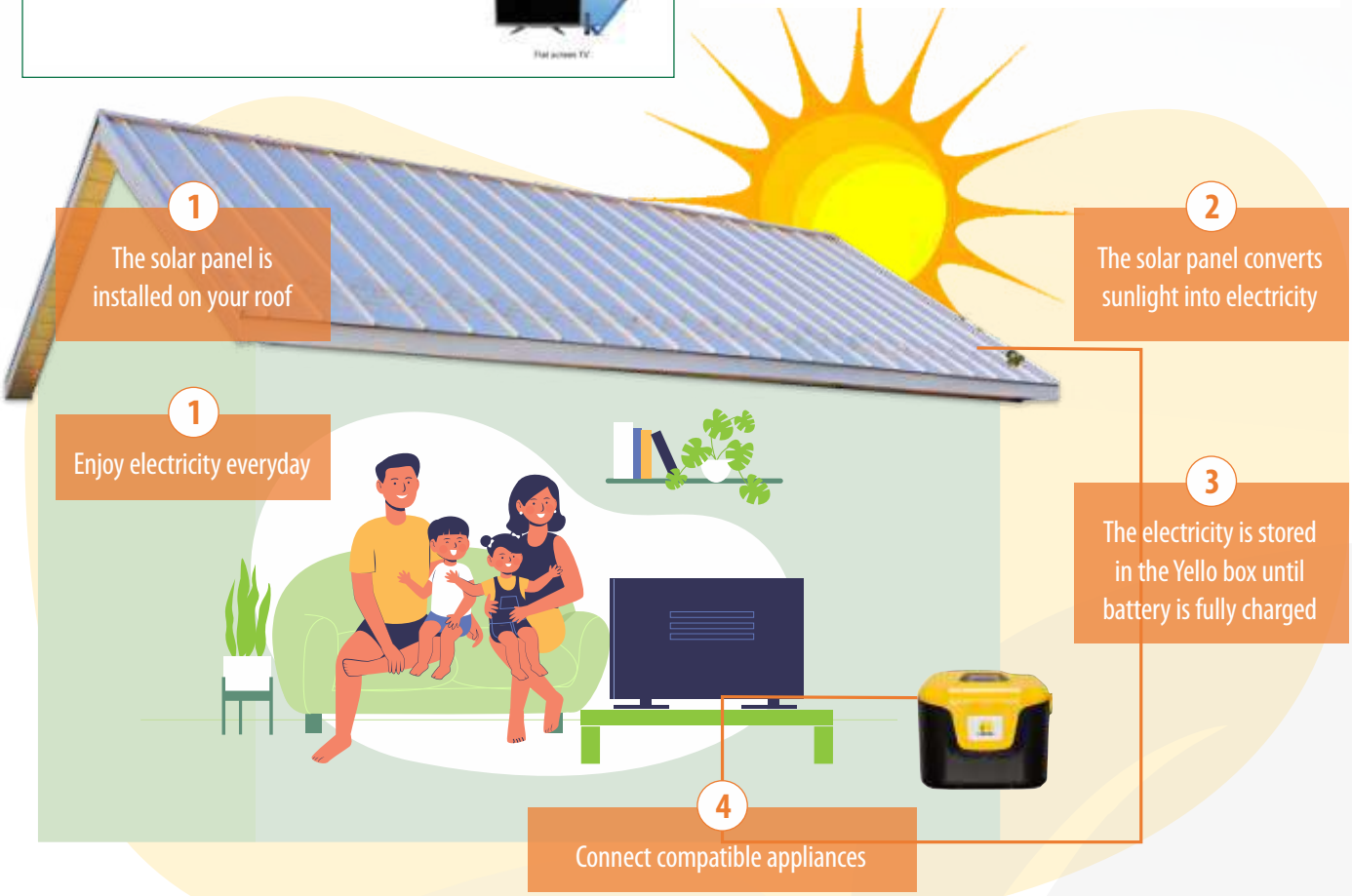
- PV solar Farms for Estates
- PV Solar Farms for New Urban Areas
- PV power systems for Health care Facilities
- PV solar systems for universities
- PV solar systems for housing projects

Solar systems can be as large as 3 -20MW.

Downstream: Solar Home Systems

Sample SHS by Fenix Power

Solar Home Systems are stand alone PV systems that offer a cost-effective mode of supplying amenity power for lighting and appliances to remote off-grid households. Typically run on a PAYG or Subscription based commercial model



Downstream: Solar Home Systems

OPPORTUNITY: SOLAR HOME SYSTEMS: FGN BACKED

25m Nigerians are targeted to own these systems:

- Target users are underserved, off-grid communities across the country
- This is backed by the FGN's Economic Sustainability plan
- Beneficiaries are expected to pay N4,000 Monthly over a period of 3 years (Total: N 144,000) for outright ownership
- Deployment will be facilitated by a low cost CBN loan and implemented by Rural Electrification Agency (REA)
- World Bank through the REA has indicated interest in providing 20% of the retail cost of the systems to participating solar companies

POWERDOME™ by Pulse Grids

Pulse Grids PowerDomes™ are pre-packaged systems that require little to no support infrastructure to set up. Pulse works with each customer on a project-by-project basis to provide subscription or project finance that get PowerDomes™ operating quickly.

About PowerDomes™

PowerDomes™ are not used like ground-mount or rooftop solar PV systems because they do more than simply produce power. PowerDomes™ are critical infrastructure hubs that can be expanded or moved as needed with minimal planning and cost. The Powerdome is not designed to sell power on a Kwh basis, but are designed to be critical infrastructure hubs that can be expanded or moved as needed with minimal planning and cost.

PowerDomes™ provide an end-to-end infrastructure solution to meet virtually any demand. The system's overall design and containerization pack renewable power into a radically small, but completely usable, footprint. All PowerDomes™ are built to provide underdome solutions powered solely by the sun, delivering sustainable experiences and results in real-time.

Some Technical Specifications

- PowerDomes are modular and easy to scape
- Installed footprint can be as little as 126sqm for a 20-22KWp system
- Includes battery storage
- Inverters include charge controllers
- Diesel tie-in possible for hybrid system

Timelines

- PowerDomes can be custom designed, built and ready to ship in **6 - 8 weeks**
- Installation timelines depend on scale.

POWERDOME™ by Pulse Grids

MICROGRIDS
Perfect for distributed energy. easy to site and install. The domes provide power and control with grid reliability.

BASE / MAN CAMPS
The Domes solve challenges with sustained off-grid operations. Underdone equipment packages can be designed to provide comfortable amenities.

MEDICAL CARE
For primary care, medical labs and humanitarian aid, the PowerDomes™ can be outfitted to supplement existing medical facilities or provide dedicated medical support in remote locations.

TELECOMMS AND CONNECTIVITY
PowerDomes™ can be designed to enable 5G and Internet rollout in remote locations.

EVENT SUPPORT
PowerDomes™ create sustainability experiences, while providing power and reducing event-related carbon emissions.

DISASTER RESPONSE
With equipment packages that provide, cold and dry storage, and water treatment systems, PowerDomes™ can be deployed for support during disaster responses.

HOSPITALITY AND RETAIL
PowerDomes™ can be used by hospitality brands to expand their offerings and product accessibility in a truly sustainable, off-grid package.

COLD STORAGE
Temperature and humidity-controlled systems that provide cost-effective and fully automated perishable good storage.

Market Entry Strategy (Downstream)

SOLAR PRODUCT DISTRIBUTION AND INSTALLATION

System Designer and Aggregator

Leveraging on the availability of funding for the deployment of solar power infrastructure. The is an opportunity to develop a solar power business focused on;

- Mini Grid (Term Loans and Working Capital Available)
- Home Installations (Up to 500 Million Naira Funding available)
- Solar Power Farms (> 750Million Dollars available)

System Size Limit: 1MW (Less Regulatory requirements and Entry Barriers.

KICK OFF - REQUIREMENTS

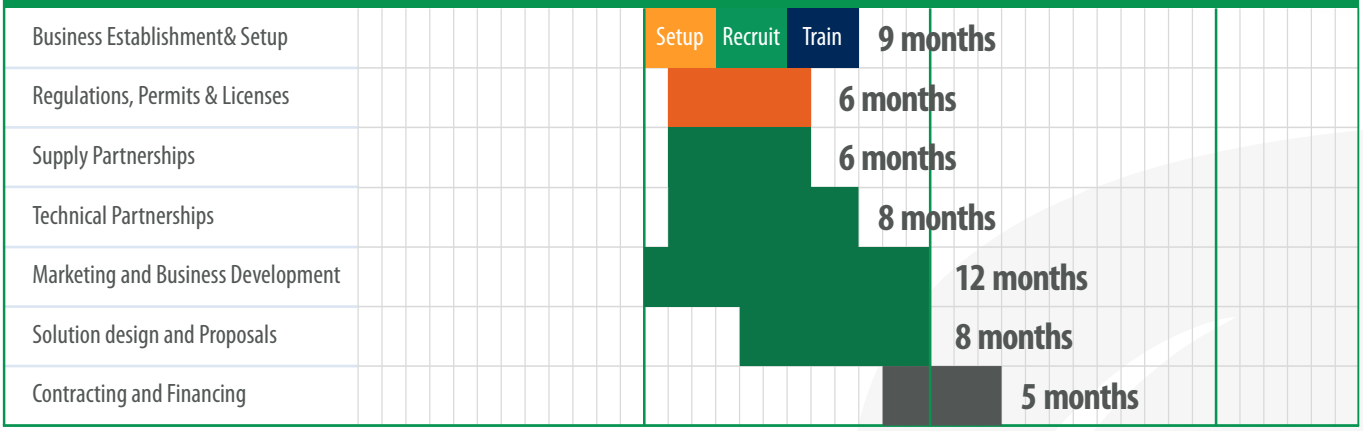
- Material Supply Partnerships
- Technical Support Partnerships
- Local Installation Capacity development (Partnership or Acquisition)
- Opportunity development

START-UP COST REQUIREMENT

Minimal cost required for:

- Business Organization Establishment
- Business development
- Travels
- Trainings

SOLAR PRODUCT DISTRIBUTION AND INSTALLATION – KEY ACTIVITY TIMELINE TO FIRST MAJOR CONTRACT (15 MONTHS)



Operations and Maintenance **20 – 25 Years**

PV Solar for Rural and Institution Electrification (EPC/GENCO)

RURAL ELECTRIFICATION APPLICATIONS

- Distributed Power Generation for Rural Locations with no Power infrastructure in place
- Rural Water projects
- Rural agricultural applications
- Solar Products

Solar systems vary from a few 100Kw to as much as 1MW

COMMERCIAL STRUCTURES

- EPC Lump Sum – Turnkey Solution
- Power Purchase Agreement

SAMPLE CASE: 1MW PV PLANT

- Space Requirement: 20,000 Square Meter
- Cost Per Watt: $0.8 - $1.4 per Watt
- Investment cost: $ 800,000 – $1.4 Million
- OPEX assumptions: $0.002/Kwh
- Selling Price of Power: $0.12Kw/h
- Revenue Assumptions:
  - 6-8hrs per day, 80% Delivery Efficiency
  - 90% Uptime

MATERIALS REQUIRED

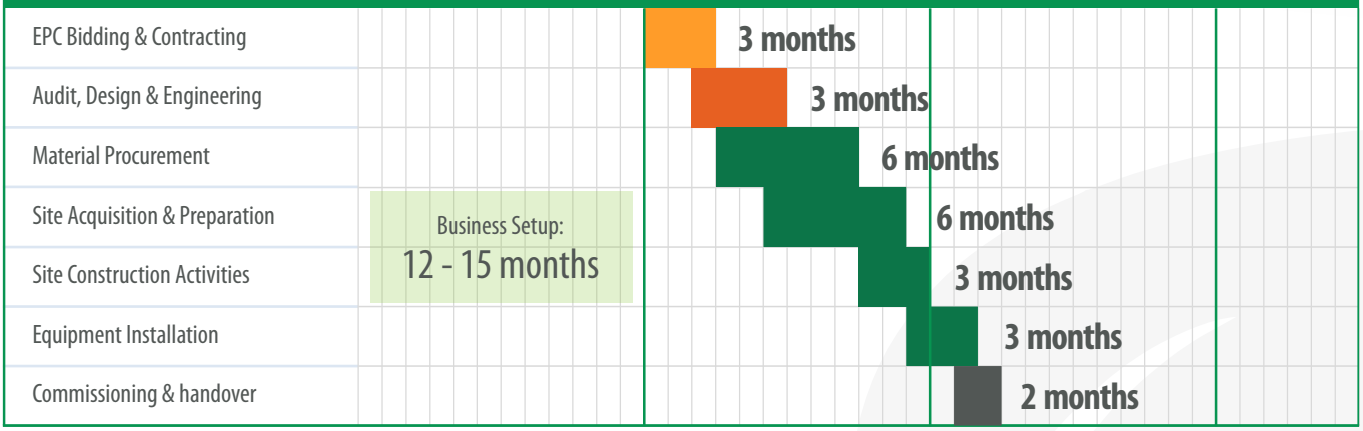
- 4326Nos of 250W Solar Panels
- 53Nos 20Kw Inverters
- Power Transformers
- Battery bank (Optional)

Other requirements include Cables, Protective devices, Connectors, Distribution panel etc.

KICK OFF - REQUIREMENTS

- Material Supply Partnerships
- Technical Support Partnerships
- Local Installation Capacity

SOLAR POWER DEPLOYMENT FOR RURAL ELECTRIFICATION – KEY ACTIVITY TIMELINE (15 MONths)



Operations and Maintenance **20 – 25 Years**

GENCO: Utility Applications (1-20MW)

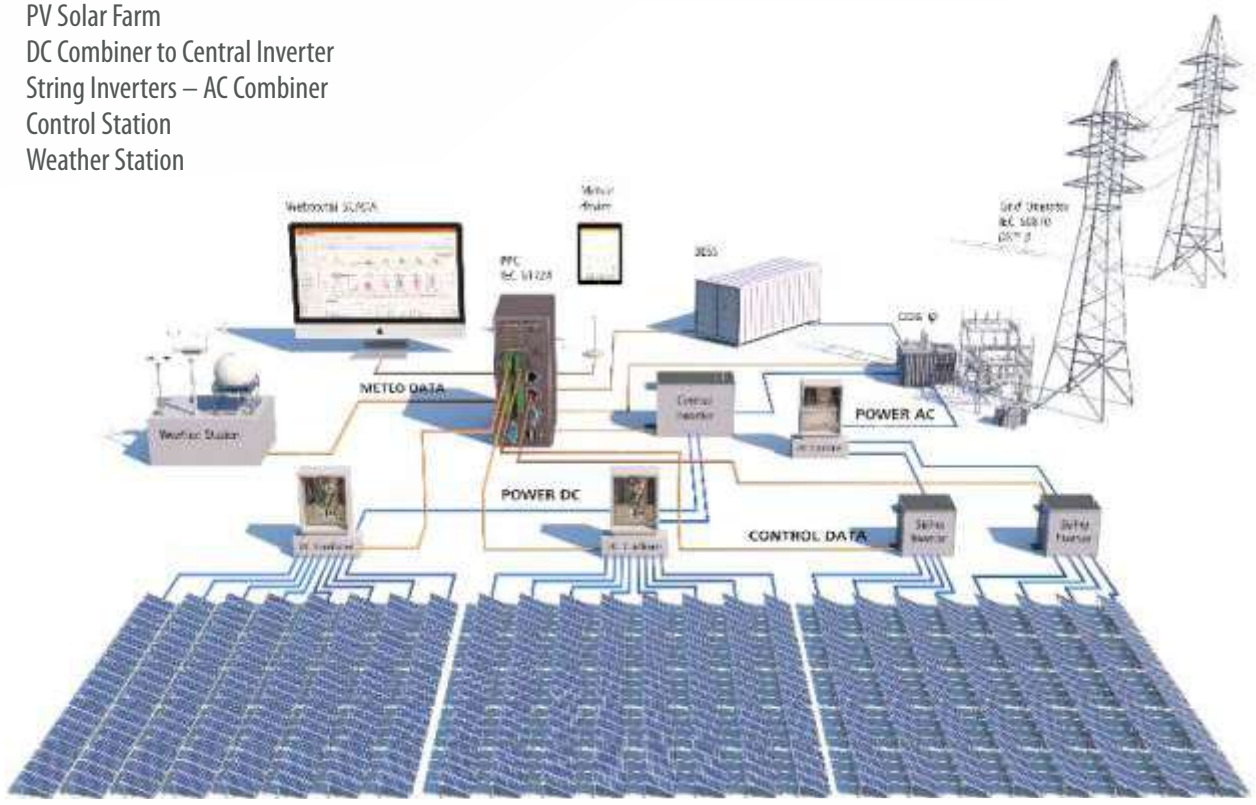
Utility scale applications are widely being considered and constructed for Rural electrification and Education Energizing Schemes. They are used for the following power provision scenarios:

- **Must-Take**
- **Peak-Load Support (Day time Only if without battery storage and All-day scenarios if inclusive of battery storage)**

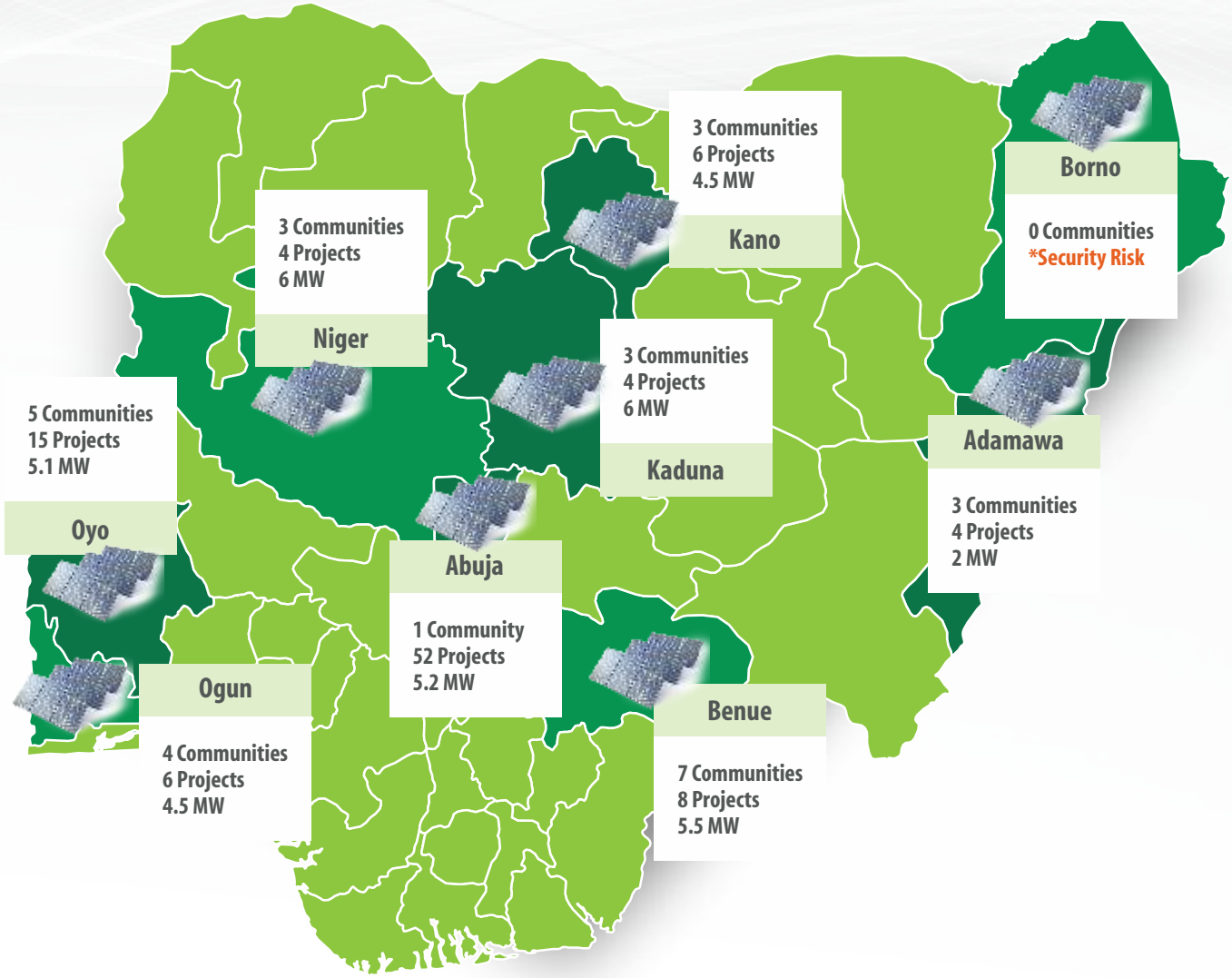
These Systems can be Configured as follows:

- **Stand alone off-grid (Micro-Grids) or Grid Connected with the following**
- **With or without battery storage / With or Without Diesel Power Support**

PV Solar Farm
DC Combiner to Central Inverter
String Inverters – AC Combiner
Control Station
Weather Station



Resource Map + Location Analysis



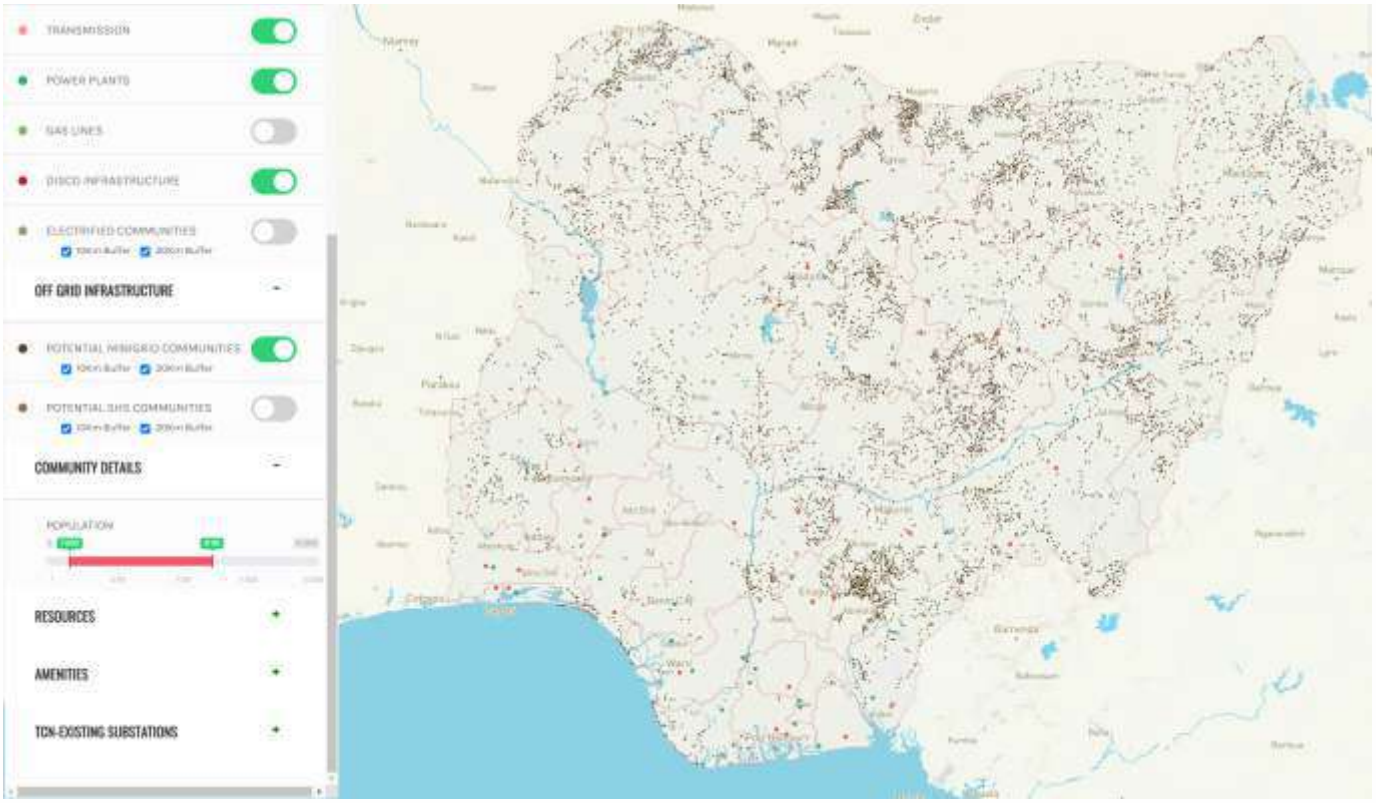
STATE SELECTION CRITERIA

1. Solar Irradiation
2. FGN Interest
3. Funding Scheme Preference
4. Request for Proposal specifications
5. Capacity to influence incumbent stakeholders
6. Nature of incumbent Stakeholders
7. Availability of land space
8. Market availability and potential
9. Potential for economic and sustainability impact
10. Energy Gap (Supply and infrastructure gaps)

Unelectrified Communities in Nigeria

Rural Electrification Agency Mapping for Communities without Access to Electricity:

Every Dot is a Community ~20km from the Nearest Grid Point



Community Project Strategy

Economic growth, urbanization and industrialization are all closely linked with electrification. Farmers reduce waste with proper storage (cold and dry) and processing, education is enhanced through improved telecommunications and internet availability, Institutions operate more efficiently, and micro industries thrive.

ENERGY USE CASE CONSIDERATION

Energization was considered for activities and scenarios that would improve economic activity and development in the regions. This includes rural electrification to eliminate burning of fossil fuels for lighting (use of Kerosene) and energizing markets, agricultural hubs and key development amenities.

GRID VS OFF-GRID STRATEGY

Grid Connections will not be considered as there are no Feed-in or Net Tariff policies in Nigeria

COMMERCIAL SUCCESS CONSIDERATIONS (DEMAND AND ECONOMIC FEASIBILITY)

Commercial success is possible with an energy cost swap. Swapping the cost of self-generation (kerosene for lanterns and Gasoline for generators) for the cost of solar power which is cleaner and consistent. Some Systems will also be beneficiaries of Grants

BESS CONSIDERATION

BESS will be considered for rural and institutional electrification. SMEs would not have BESS in place.

IMPLEMENTATION + O&M STRATEGY FOR MAXIMUM PROJECT SUCCESS AND SUSTAINABILITY

Project implementation will include local content participation which will involve engaging local expertise for project execution and also training and capacity development of indigenes towards building the required skill necessary for operations and maintenance.

Community Project Strategy

STATE	CONSIDERATIONS	RESULT
Ogun State	Main Economic Activities	Manufacturing Hub, Agriculture (including processing), Education
	Grid Infrastructure Status	Ibadan Disco, Grid Central to Abeokuta, Sagamu and Ijebu-Ode
	Populatin/Electrification Rate	31 unelectrified communities. Average of 30% of the population
	Government Plan/Interest	Strong interest & funding for SHS & mini-grid solutions for communities
Oyo State	Main Economic Activities	Agriculture (Crops + Animal Husbandry), Education
	Grid Infrastructure Status	Ibadan Disco, Grid Central to Ibadan Oyo, Ogbomoso and Iseyin
	Populatin/Electrification Rate	~85 unelectrified communities. Average of 30% of the population
	Government Plan/Interest	Strong interest & funding for mini-grid solutions for economy energizing
Niger State	Main Economic Activities	Hydro-Electric Power Generation, Agriculture
	Grid Infrastructure Status	Abuja Disco, Grid Central to Kainji, Shiroro, Jebba and Kontagora
	Populatin/Electrification Rate	>200 unelectrified communities. Average of 50% of the population
	Government Plan/Interest	Strong interest & funding for rural electrification and education energizing
Kaduna State	Main Economic Activities	Agriculture and Industry (Leather, Cotton, Food processing)
	Grid Infrastructure Status	Kaduna Disco, Grid Central to Gwagwada, Kaduna, Katabu and Zaria
	Populatin/Electrification Rate	>200 unelectrified communities. Average of 60% of the population
	Government Plan/Interest	Strong interest & funding for rural electrification
Benue State	Main Economic Activities	Agriculture
	Grid Infrastructure Status	Jos Dsico, Grid Central to Otukpo, Gboko, Makurdi and Zaki Biam
	Populatin/Electrification Rate	>200 unelectrified communities. Average of 60% of the population
	Government Plan/Interest	Strong interest & funding for rural, economy and education energizing
Kano State	Main Economic Activities	Agriculture (Grain), Industry (Textiles, Plastics, Pharmaceuticals), and Trade
	Grid Infrastructure Status	Kane Disco, Grid Central to Kano, Dabi, Bichi, Tsanyawa and Tadwea
	Populatin/Electrification Rate	>150 unelectrified communities. Average of 50% of the population
	Government Plan/Interest	Strong interest & funding for rural education and economy energizing
Borno State	Main Economic Activities	Agriculture
	Grid Infrastructure Status	Yola Disco, Grid Central to Maiduguri, Mainok, Borno, Kama, Biyu and Damboa
	Populatin/Electrification Rate	>400 unelectrified communities. Average of 60% of the population
	Government Plan/Interest	Strong interest & funding for rural electrification
Adamawa State	Main Economic Activities	Agriculture (including fishing and animal husbandry)
	Grid Infrastructure Status	Yola Dsico, Grid Central to Yola, Jimena, Nauman, Beti, and Mayo Belwa
	Populatin/Electrification Rate	>200 unelectrified communities. Average of 60% of the population
	Government Plan/Interest	Strong interest & funding for mini-grid solutions for economy energizing
Abuja	Main Economic Activities	Adminstrative and political capital. Host to major institutions
	Grid Infrastructure Status	Abuja Disco, Grid Central to Abuja, Gwagwalada, Juke, Madalla, and Bwari
	Populatin/Electrification Rate	>40 unelectrified communities. Average of 20% of the population
	Government Plan/Interest	Strong interest & funding for institution and rural electrification

Proposed Community Projects

State	Community	Opportunity Description	Project Type & Implementation Strategy	Scale	Justification
Ogun State	Obafemi	Rural Electrification	PV + BESS + Distribution	1MW (500KW x 2)	Rapid Urban Development
	Obafemi	Food Processing and Dry Storage	PV + BESS + Connections	2MW (1MW x 2)	Major Production of Food (Ofada Rice)
	Makoloki	Economy Energizing (Market)	PV + Connections	500KW	Major Market
	Lukogbe	Rural Electrification	PV + BESS + Distribution	1MW	Rapid Urban Development
Oyo State	Isemi-Ile	Rural Electrification	PV + BESS + Distribution	1MW	Rapid Urban Development
	Ado-Awaye	Economy Energizing (Tourism)	PV + Distribution	1MW	Tourist Destination and Urban Development
	Idi-Iya	Agriculture and Dry Storage	PV + Connections	1.5MW (300KW x 5)	Cocoa Production at Ido
	Aba Emo/Ilaju/Alako	Agriculture and Dry Storage	PV + Connections	600KW (200KW X 3)	Cocoa Production at Ido
	Saki	Agriculture and Dry Storage	PV + Connections	1.5MW (300KW x 5)	Developed Agricultural Communities
Niger State	Bida	Education Energizing	PV + BESS + Connections	3MW	Federal Polytechnic, Bida
	Zungeru	Education Energizing	PV + BESS + Connections	2MW	Niger State University, Zungeru
	Kampala	Rural Electrification	PV + BESS + Distribution	1MW (500KW x 2)	Rapid Urban Development (Proximity to Minna)
Kaduna State	Sabon Birnin Daji	Rural Electrification	PV + BESS + Distribution	2MW (500KW x 4)	Urban Development (Proximity to Tin Mine)
	Zaria	Health Centre Electrification	PV + BESS + Distribution	2.5MW (100KW x 25)	Government Sponsored Health Care Projects
Benue State	Ugbokolo	Education Energizing	PV + BESS + Distribution	3MW	Benue State Polytechnic, Ugbokolo
	Agate (5 Villages)	Agriculture processing	PV + Connections	500 KW (100KW x 5)	Farming Community
	Mbaanku	Rural Electrification	PV + Connections	2MW (500KW x 2)	Urban Development (proximity to Cement Mine)
Kano State	Dambatta	Education Energizing	PV + BESS + Distribution	1MW	Audu Bako School of Agricultture, Dambatta
	Dawanau	Economy Energizing (Market)	PV + Connections	1MW	Dawanau Grains Market (Incl. Dry Storage)
	Tsanyawa	Rural Electrification	PV + BESS + Distribution	1.5MW (500KW x 3)	Urbanization of Sabon Gari. Proximity to Market
Adamawa State	Yola	Health Centre Electrification	PV + BESS + Distribution	200KW	Adamawa State Polytechnic, Yola
	Ngugore	Food Processing and Dry Storage	PV + BESS + Connections	800KW (400 x 2)	Major Processing of Grains
	Girei	Economy Energizing (Market)	PV + Connections	1MW	Girei Grain Market (incl. Dry Storage)
Abuja	Gwagwalada	Health Centre Electrification	PV + BESS + Distribution	5.2MW (100KW x 52)	Government Sponsored Health Care Projects


Risk
Assessment

Risks and Mitigation Measures

TECHNICAL

Key Risk Indicators	Mitigation Measures
• Limited experience in the sector • Limited local technical expertise (in the midstream PV module, wafer and solar cell manufacturing) and research and development culture in Nigeria • Proprietary nature of technology in the midstream sector of the Solar Power value chain (Wafer and PV Cells manufacturing)	• Seek working partnerships and technical alliances with renowned international players in this sector. This is to augment local skill sets, gain new competitive skills and eventual technology and knowledge transfer that will have a lasting effect on a brand's product-market positioning

FEEDSTOCK RESOURCE

Key Risk Indicators	Mitigation Measures
• Supply chain risks – With the near-term entry strategy into the solar downstream sector of PV assembly, material logistics coupled with an optimal sourcing strategy is key into gaining immediate competitive advantage	• Leverage technical partners relationship with component manufacturers • Build strategic relationships and comprehensively assess solar components supply chain partnerships whilst expanding supply optionality and having alternative back up suppliers • Perform in-line and pre-shipment inspections on components for quality control assessments • Maintain module/component delivery timelines through a risk based logistics strategy

FEEDSTOCK RESOURCE/COMMUNITY

Key Risk Indicators	Mitigation Measures
• Location assessments for solar farms – security, route to market (proximity)	• Detailed feasibility, market studies and security risk assessments should be performed on all proposed locations and full route to market assessments performed to guarantee adoption and profitability

OUTPUT AND END USE

Key Risk Indicators	Mitigation Measures
• End user sensitization - End users have not fully embraced the concept of renewable energy • Evaluate optimal profitability of output within different streams within the value chain in order to make final investment decision	• Sensitization efforts to significantly drive adoption • Development of a detailed economic and financial model that evaluates the optimal profitability of the end-product within the different streams of the value chain from which a final investment decision can be made

Risks and Mitigation Measures

ECONOMICS AND FINANCING

Key Risk Indicators	Mitigation Measures
• Significant initial capital investment and access to finance (funding and grants) - Financial capabilities of project sponsor	• A number of solar intervention funds and grants (CBN intervention fund, World Bank Power sector loan) are available • Perform a thorough assessment of all identified funds/grants eligibility criteria and be strategically positioned to access same
• Eligibility to access identified funds and grants (CBN Intervention Fund, World Bank Power Loan)	• If there are any time or experience-based barriers for fund/grant prequalification, consider partnership/technical alliances with companies that meet the set criteria
• Alternative funding barriers	• The project economic model shows the viability of the project and should debt financing be required this would be ring-fenced to ensure banker's line of sight to re-payment • Development of a business model that seeks to optimize the commercialization of the energy/power output with a focus on cost optimization and profitability
• Perceived high cost of doing business in Nigeria and impact on the overall value creation potential of the project/ investment	• Perform a detailed project evaluation and commercial optimization / margin profit analysis which guarantees sustainability and profitability

GOVERNMENT AND REGULATORY

Key Risk Indicators	Mitigation Measures
• Limited policy support/traction from a regulatory perspective creating a near uncertain environment for major investors and entrepreneurs within this space. In addition there are currently no tax credits for renewable energy as the Nigeria government is still in the process of developing a robust set of policies to encourage and incentivize solar power or general renewable energy development locally.	• Investor confidence can be gained by a robust and stable policy framework and long-term national objectives and targets, backed-up by sound market forecasts. • Where and if applicable seekto drive policy changes/support within this sector. It is envisagedthat investor confidence would be gained by a robust and stable policy framework and long-term national objectives and targets backed up by sound market forecasts

Conclusive Information

Available Funding from the World Bank

The World Bank announced in June 2020, that it has approved the sum of $750 million as a loan to Nigeria's power sector after years of negotiations over long term reforms in the sector. The loan, which has been approved by Bretton Wood Institution, is for Power Sector Recovery Operation (PSRO) to improve the reliability of electricity supply, achieve financial and fiscal sustainability, and enhance accountability in the power sector in Nigeria.

The World Bank would likely disburse this loan through the Federal Government of Nigeria in line with specifications and requirements set by the World Bank.

Carbon Credits in Nigeria

Introduction

- Developed under the Kyoto Protocol;
- Establishes the Clean Development Mechanism ("CDM") applicable to developing countries
- The CDM allows Annex B Countries to execute/finance emissions reduction projects, including renewables (such as a solar power project, waste to power) in developing countries. Such projects can earn them saleable certified emission reduction ("CER") credits.

Eligibility

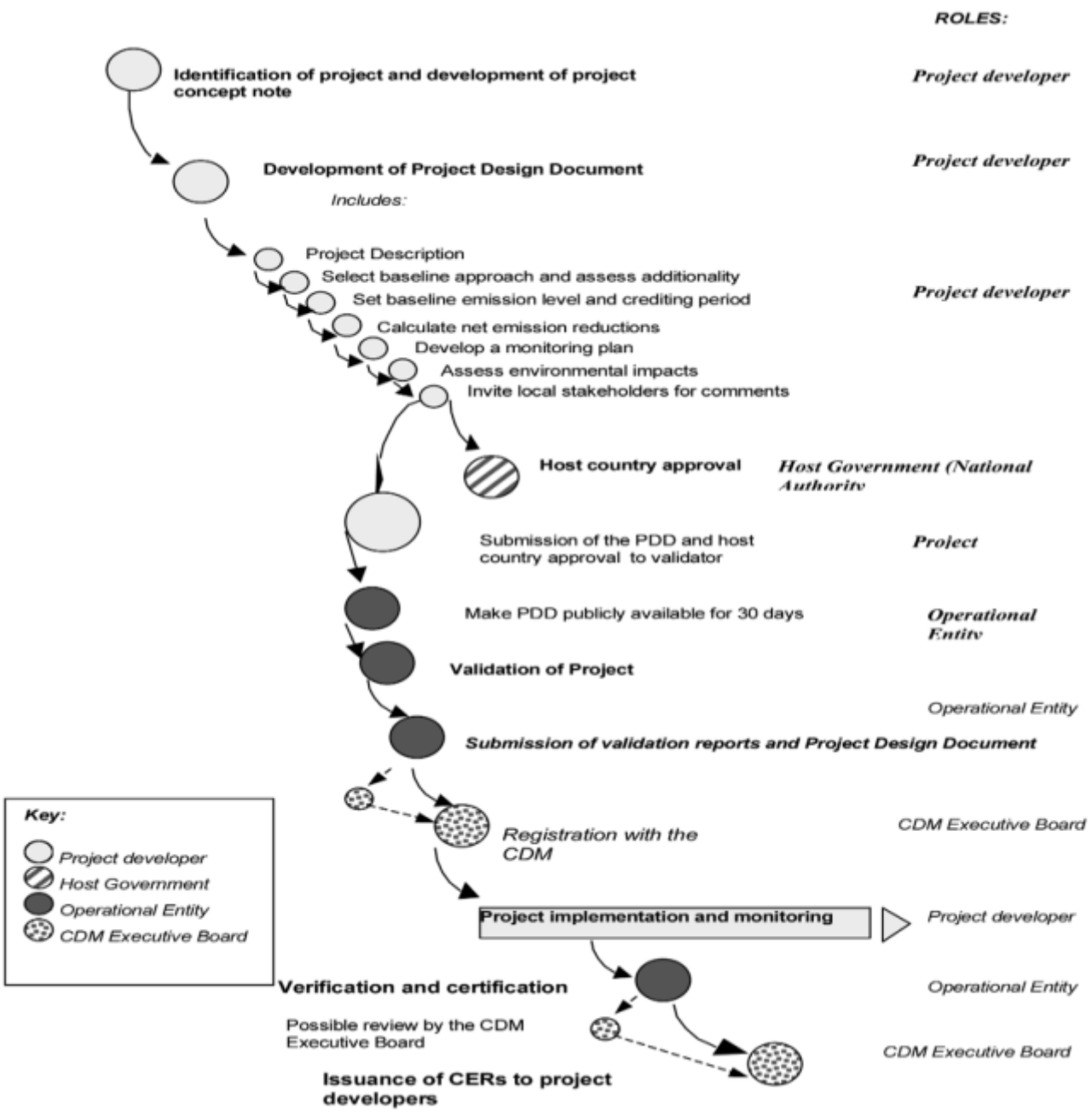
CDM project must:

- Have long term climate change benefits
- Achieve Reductions in emissions that are additional to any that would occur in the absence of the CDM project

Administration

- Presidential Implementation Committee for CDM, which was established under the auspices of the Federal Ministry of Environment;
- Companies creating projects, in developing countries, which actively reduce GHG emissions become eligible for carbon credits and then can raise funds, by selling them to a company exceeding its allowance on an exchange.
- Income from Carbon credit trading are tax exempt.
- Carbon credit prices are affected by forces of demand and supply, risks – project, sovereign, credit, etc

CDM Process flow



CBN Intervention Fund - Other Strategic Subsectors

Introduction

- Set up by the CBN in January 2016
- Funding for the agriculture, manufacturing, mining, solid minerals and other strategic subsectors
- For green and brown (expansion) projects - priority for local content, fx earnings and for job creation
- Trading activities shall not be accomodated

Other Key Points - Upstream

- Types – (i) Term Loan for acquisition of plants and machinery and (ii) Working Capital
- Tenor - Maximum of 10 years (1 year for Working Capital on a 1 year roll-over basis)
- Interest rate – 9%
- Moratorium – 1 year
- Eligibility – Borrower must be registered under CAMA

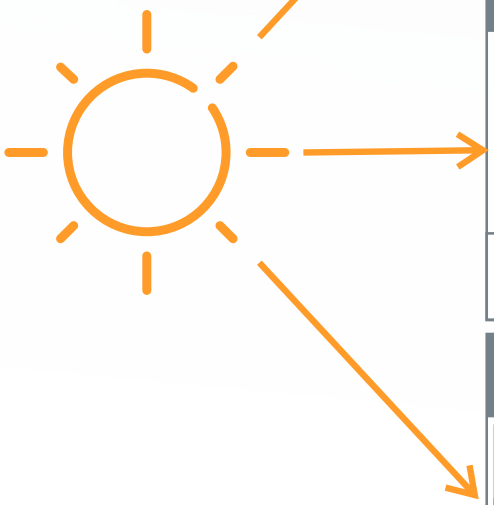
Real Sector Support Facility (initially for N300bn)

Appendix

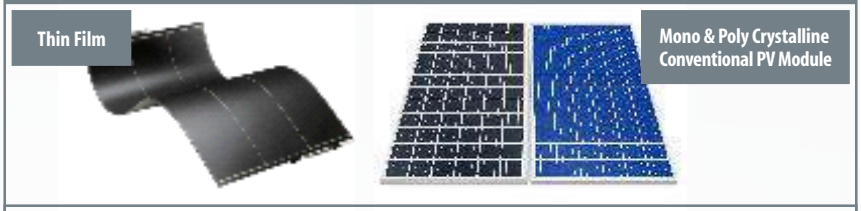
Technical

Solar Power

Solar Power is Energy from the sun: Solar power can be harnessed to produce electricity or heat using a variety of technologies:

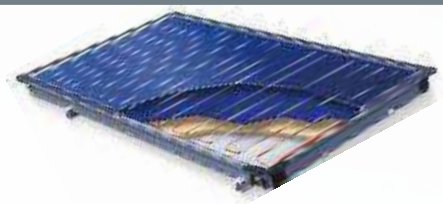


PHOTOVOLTAICS



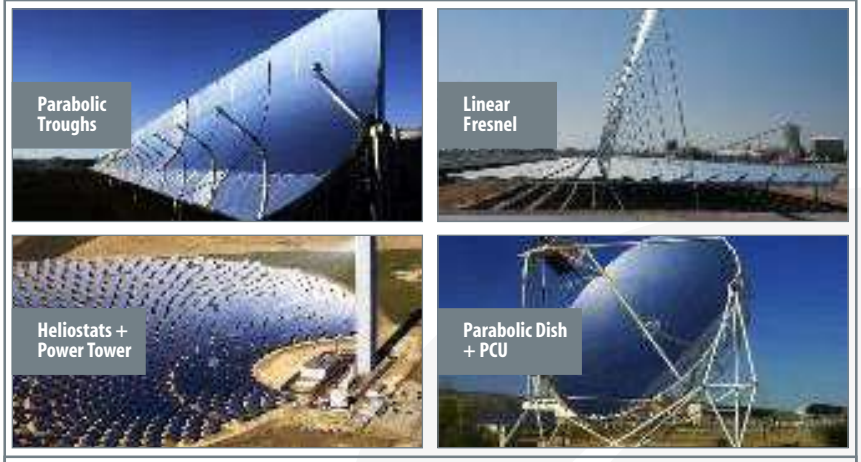
Solar cells Convert incident solar rays to Electricity – used for grid tied solar farms or distributed power generation

THERMAL COLLECTORS



Solar thermal collectors (flat plate or evacuated tube type) are used to heat up a working medium to convey heat to a use point

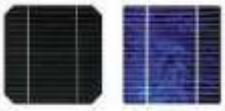
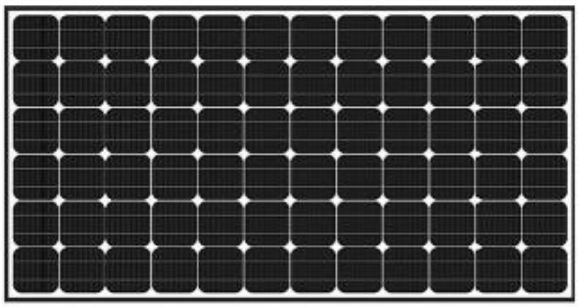
CONCENTRATED SOLAR POWER



Special mirrors are used to concentrate the suns rays in order to generate heat which is used to heat up a working medium or heat engine for electricity generation

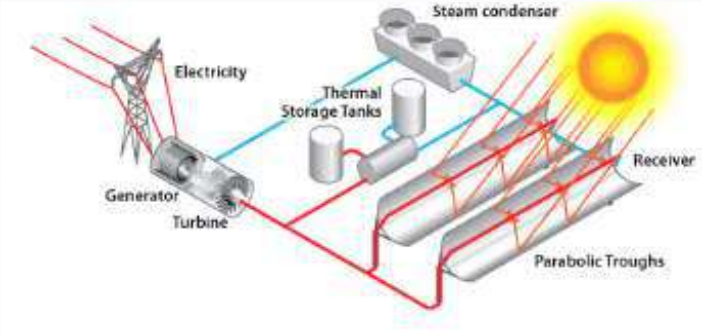
Monocrystalline vs Polycrystalline Solar Panels

There are two main categories of PV Panels. Monocrystalline (Mono) Solar Panels and Polycrystalline (Poly) Solar Panels. Below are some key differences between the two

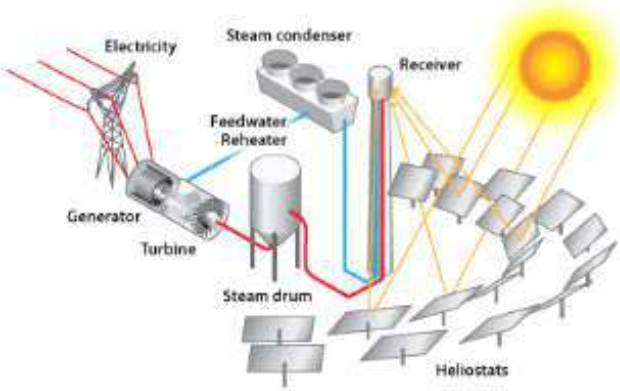
Mono-Crystalline		Poly-Crystalline
To make cells for mono panels, silicon is formed into bars and cut into wafers. Solar Cells are thus made from a single crystal of silicon	 Sample Cells	To make cells for poly panels, fragments of silicon are melted together to form the wafers. Solar cells are this made from many crystals of silicon
		
More Expensive (10 - 15% more)	**Cost**	Less Expensive (10 - 15% less)
Higher Efficiencies (23%)	**Efficiency**	Lower Efficiencies (17%)
Sleeker: Solar cells have a black hue	**Aesthetics**	Solar cells have a blueish hue
25+ years	**Longetivity**	25+ years
Best with space constraints	**Size (Space)**	Could be more economic with available space
Canadian Solar SunPower Hyundai SolarWorld	**Major Manufacturers**	Hanwha Trina Hyundai Solar World

Concentrated Solar Power (CSP)

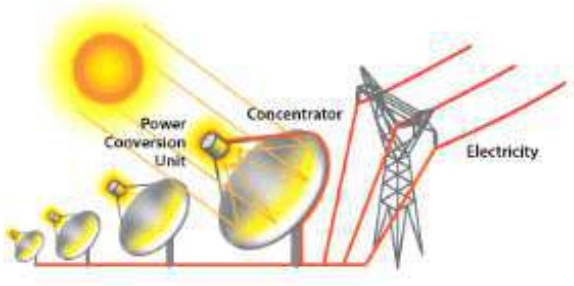
Concentrated Solar Power (CSP) – Is a thermal Energy Solution Strategy. CSP systems concentrate the radiation of the sun to heat up a working fluid (Oil, Water, Molten Salts, Games) which is then used to drive a heat engine (E.g. Steam turbines converting thermal energy to mechanical work) which drives an electric generator.



PARABOLIC TROUGH



POWER TOWER + HELIOSTATS



SOLAR DISH CONCENTRATORS

CSP vs Solar Farms

CSP is Very Different from PV. While PVs convert solar radiation directly to electricity by exciting electrons in the silicon cells using photons of light from the sun, CSP concentrates the thermal energy from the sun to heat up a working fluid which runs a heat engine for electricity generation.

Photovoltaic Panel Solar Farm		Concentrated Solar Power
Generates direct electric current (DC) which requires conversion to AC before transmission **Recommended for Grid-Tie in**	**Type of Electricity**	Generates alternating current (AC) which requires no conversion before transmission **Recommended for Off-grid solutions**
PV directly generates electricity which is more difficult to store especially at large energy levels and demand requirements. Battery electricity storage is considered more expensive and less efficient compared to thermal energy storage. **Recommended for small scale power generation: 1-100MW**	**Energy Storage, Power avilability & Efficiency**	Thermal Energy storage is used. Allows continuous generation even during times of low or no sunlight. This eliminates intermittence and allows CSP to be used as a primary power generation strategy for supplying base load requirements **Recommended for Large Scale power generation: > 100MW**
Cost of PV is lower for the same scale of power in the small to medium range of power generation capacity	**Cost**	Cost of CSP is competitive for the same scale of power in the large-scale range of power generation capacity
Although cost of energy, Ancillary services and power dispatch-ability on demand are top factors for determining investment in power, cost of energy has taken the lead in an uncertain economic climate thus supporting more investment in PV technologies	**Investors Perspective**	Cost of energy for CSP plants is much higher than PV plants from a CAPEX and OPEX perspective. However CSP provides greater power availability and potential energy storage which when included to a PV system by way of battery storage makes CSP almost competitive
Simpler to design, construct, operate and maintain	**Complexity**	More complex to design, construct, operate and maintain

The choice between CSP or PV is dependent on use case and Scale. Recommendation: Run economics for systems greater than 100MW capacity

Battery Storage & Hybrid Systems

Solar farms can only provide useable power when the sun light is available at good – high intensities or irradiation: 6 - 8 hours a day in most cases from 8:30am – 4:30Pm (Nigeria's Best Case). The presence of cloud cover also reduces the ability of PV to generate electricity. At night power generation is zero. To improve on power availability, intermittency and output quality the following strategies are employed:

- Battery Storage
- Back up power generation (Usually Diesel Generators)

1MW BATTERY STORAGE: $300,000 – $500,000 (4-8YEARS)

500KW Diesel Generator	$50,000	20 years	Will Include Maintenance and Operations Cost

Why Solar Is the Next Big RET?

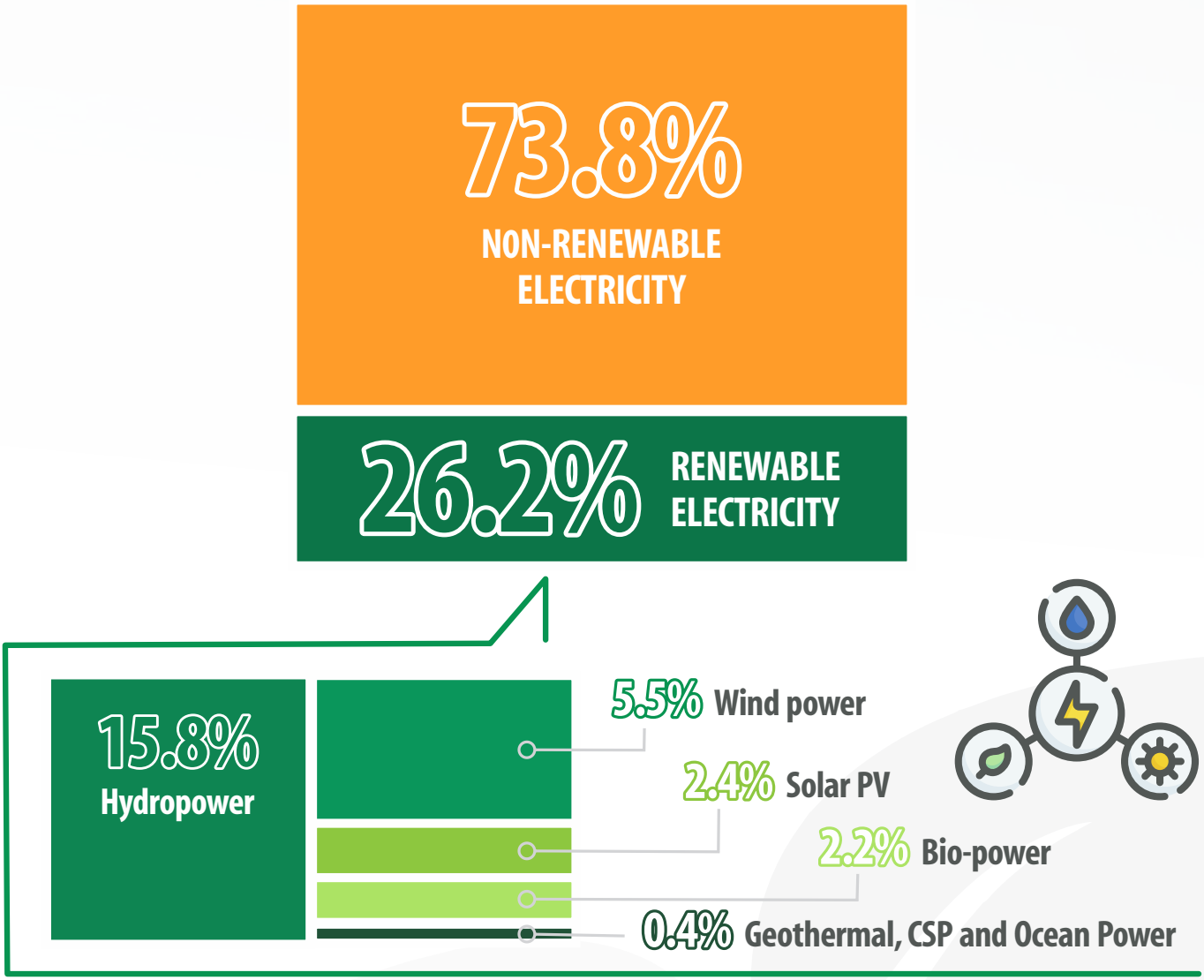
Solar Power is the considered to be the **3rd highest renewable energy source** contributor to the global energy mix, overtaking bio-power in 2017.

Solar is considered one of the fastest growing sources.

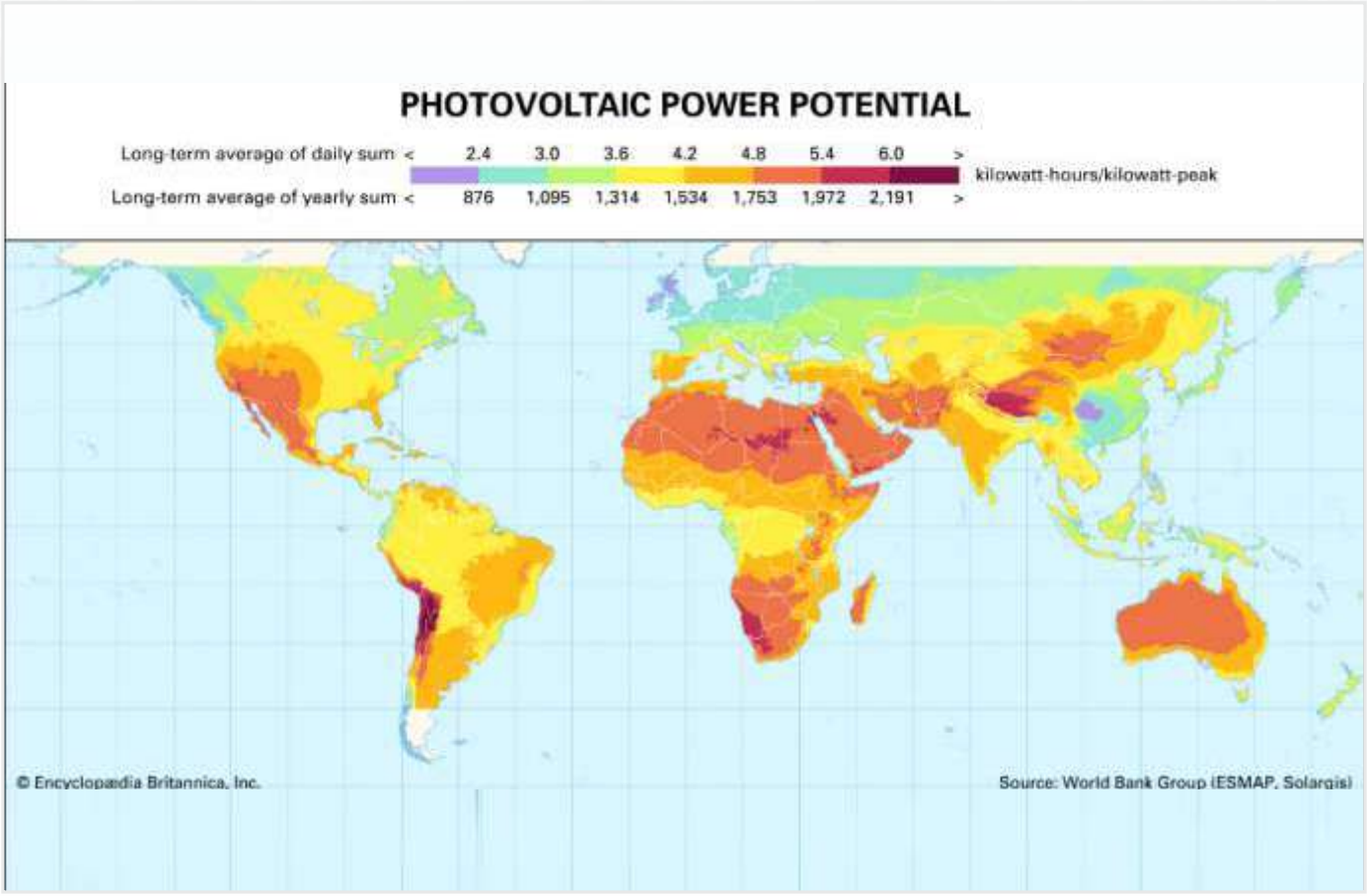
2015 1.2%
2016 1.5%
2017 1.9%

The increase in adoption has been due to improved efficiencies, lower cost, Government incentives / Policies and its suitability and scalability for distributed power generation

ESTIMATED RENEWABLE ENERGY SHARE OF GLOBAL ELECTRICITY PRODUCTION, END - 2018



Solar Resource Distribution

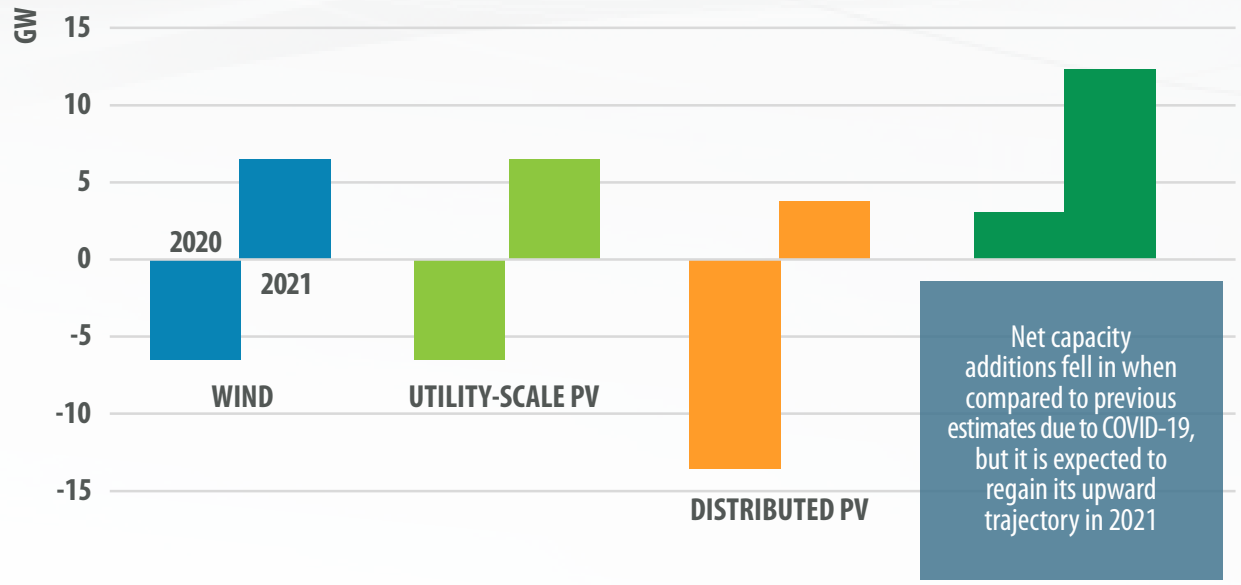


With an average daily Photovoltaic power potential of between **3.6 – 4.8 KWh/KW-P**

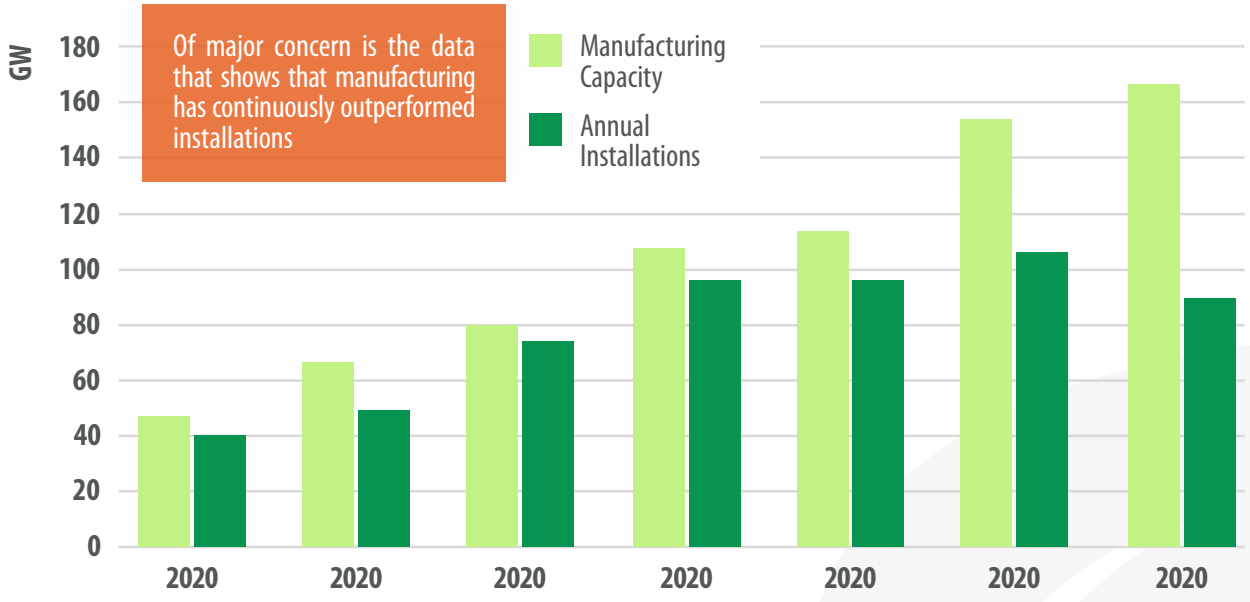
Nigeria has good solar irradiance for the adoption of solar technologies, with the best potential located in the northern states

PV Capacity Addition: Global Outlook

RENEWABLE ELECTRICITY NET CAPACITY ADDITIONS GROWTH BY TECHNOLOGY IN 2020 AND 2021

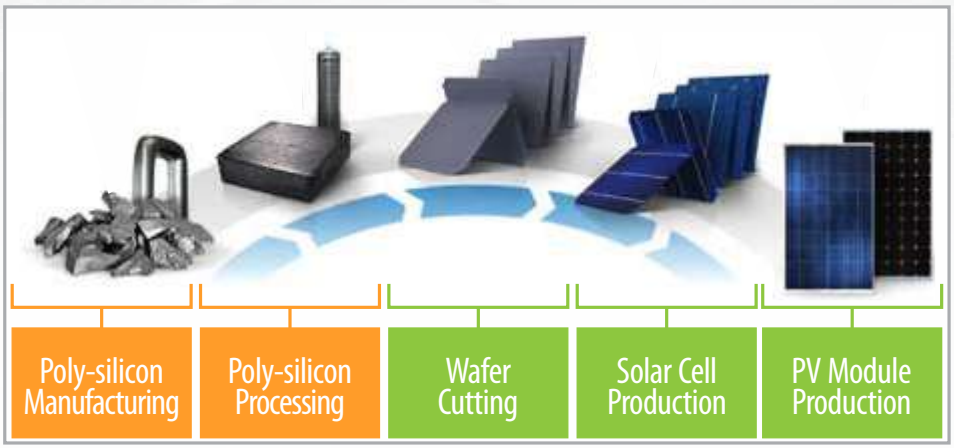


SOLAR PV MODULE MANUFACTURING AND DEMAN, 2014 -19 ACTUAL AND 2020 ESTIMATE



IEA Analysis based on Pauls Mints (2020), The Solar Flare, SVP Market Research, San Francisco, CA.

PV Value Chain



Poly-silicon Manufacturing	Poly-silicon Processing	Wafer Cutting	Solar Cell Production	PV Module Production
Quartzite rock is mined and processed into high purity MG-Si and then into Poly-Si The processes involved are: **Carbon Reduction Acid Treatment** The Processes are power intensive and require an Arc-Furnace	Polysilicon rock is melted at ~1,400 °C until it forms a white-hot liquid. The processes involved are: **Charging Melting Growing Cooling** The Processes are power intensive and require a Quartz Crucible	The Crystal Ingot is first saw-cut into equal cylindrical lengths before being wire-cut into the squared wafer The processes are: **Cutting Squaring Slicing** The processes require precision cutters for proper shape configuration	The polysilicon wafer is converted into solar cells through the addition of phosphorus and bus bar circuitry The processes are: **Texturing Diffusing Coating Printing** The processes require specialized equipment set in a sterile environment	Solar cells are strung together in a panel modeling and assembly line The processes are: **Stringing Soldering Laminating Framing Inspecting Packing & Shipping** The process requires heavily automated robotics
Quartzite (Silica), Carbon (coke), Hydrochloric Acid, Hydrogen	Graphite, Silicon Crystal, Boron	Silicon Carbide	Silicon Film, Silicon nitride, Phosphorus	Titanium Dioxide, Ethylene Vinyl Acetate, Mylar or Tedlar sheets, Steel or Aluminum

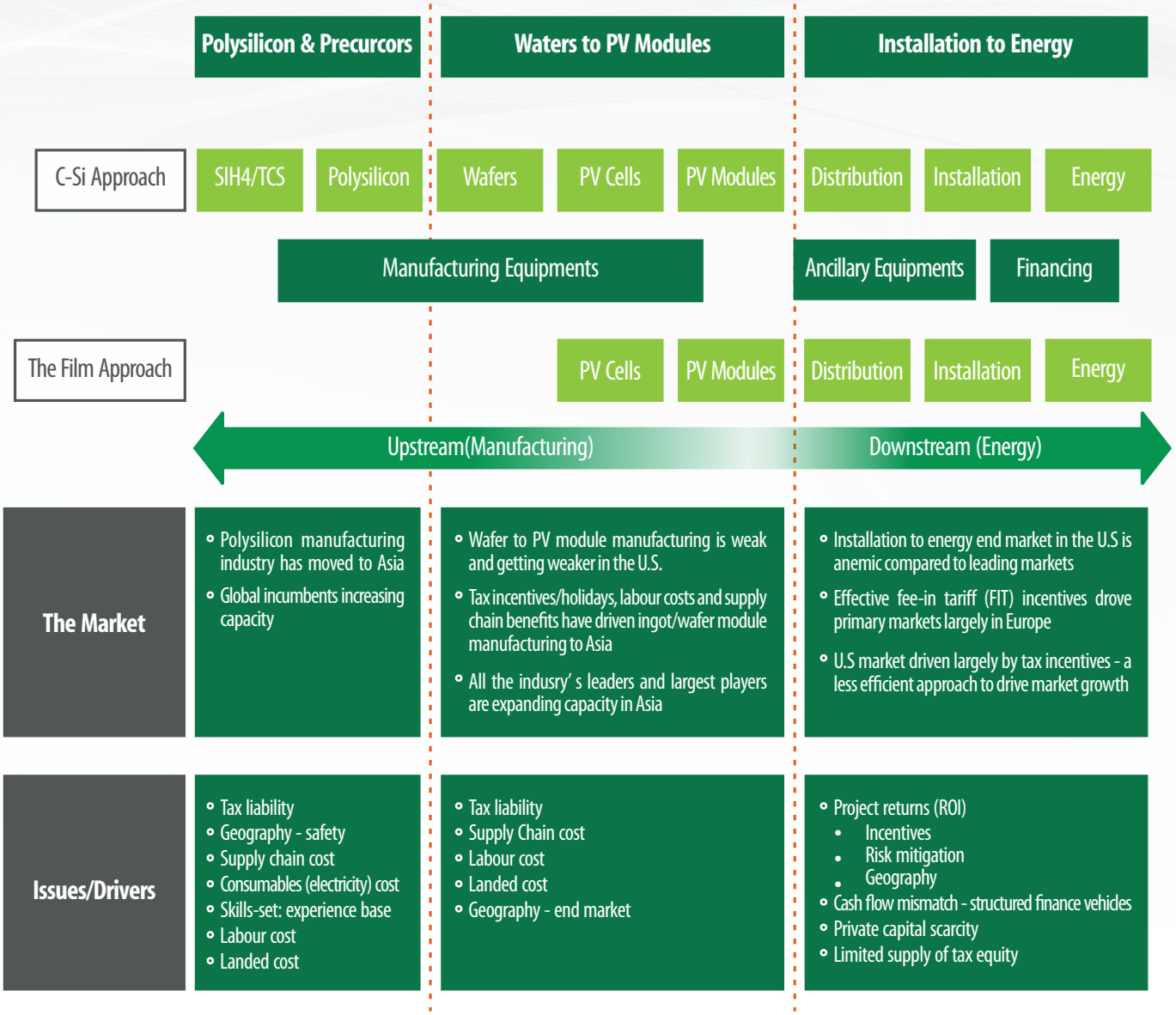
END USE APPLICATION

Grid Power (Solar Farms)

Rooftop (Off-Grid Power)

Solar Products

PV Value Chain



Source: Deutsche Bank - Alternative Energy Solar Photovoltaics

PV Global Drivers and Resistors

- **Technology:** Available and deployed solar power technologies must be efficient in solar power conversion to reduce the cost and space requirement for conventional power need
- **Economics:** Economies of scale and the cost of raw materials play a vital role in the overall feasibility of solar power utilization – this is of course affected by location, nearness to raw materials, nearness to market, power cost and more
- **Regulatory/Policy:** Without the support of regulations, policies, subsidies and incentives put into law to support the adoption and development of solar power infrastructure, the PV market will fail to compete with other sources of energy

Incremental growth is expected in the following categories of the PV Market Segments

By Circuit Structure Type: Crystal Silicon
By End Use: Commercial
By Region: Asia Pacific

This is due to increased investments in PV, Declining cost of solar technology and the need for distributed energy generation

SOLAR MARKET INCENTIVES THAT HAVE BEEN DEPLOYED IN OTHER COUNTRIES

Incentives vary among nations, states and even cities, but they typically fall into these categories:

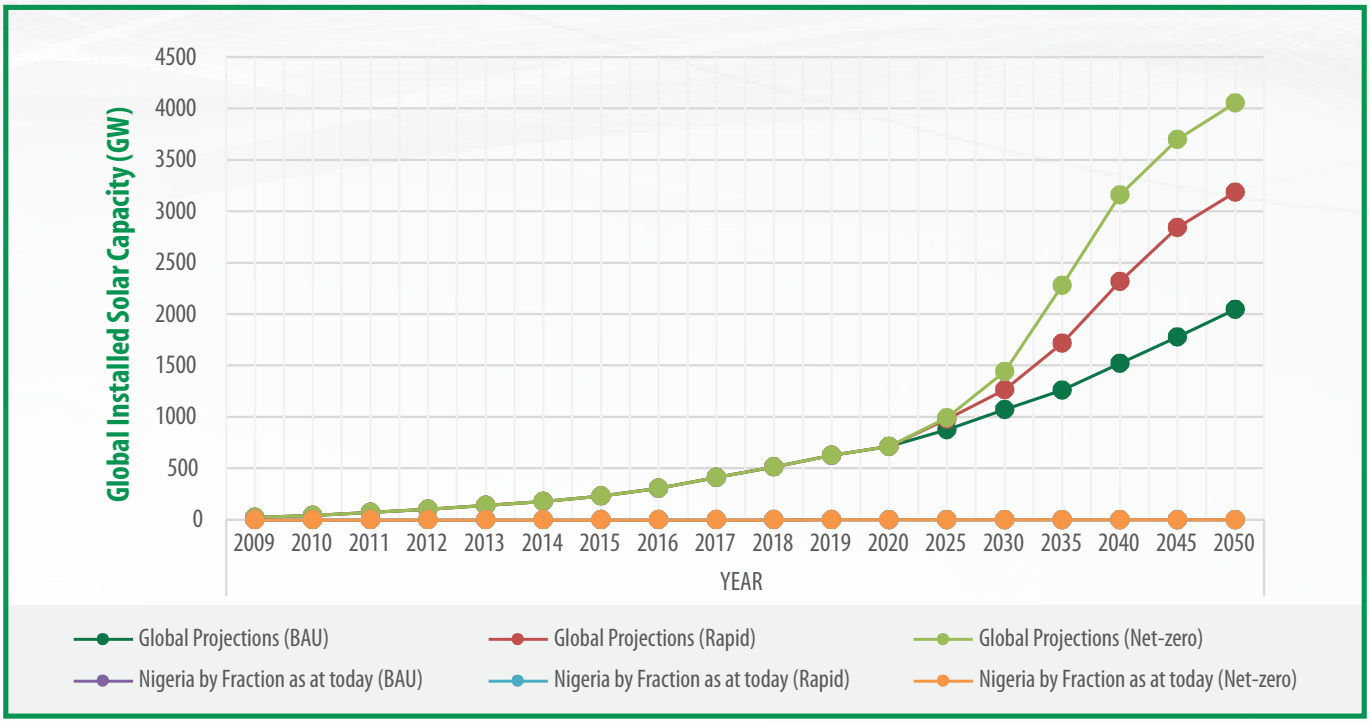
Rebates: Some organizations distribute outright reimbursements for a portion of system costs.

Tax incentives: The U.S. government and several states may offer investment tax credits or accounting provisions allowing extraordinary terms for asset depreciation. On Jan. 1, 2009, for instance, the federal government removed a $2,000 cap on a 30 percent credit for residential systems.

Net metering: This alternative to feed-in tariffs allows solar power producers to generate and use power with the same pricing and according to a single meter. When a home system, for instance, makes more power than it uses, its meter rolls backward.

Feed-in tariffs: Dozens of countries have implemented feed-in tariff systems – set premium rates that utilities are required to pay for power from solar systems. The rates remain fixed for a set number of years, perhaps 20. A power producer, such as a homeowner or business, separately pays normal market rates for power from the grid.

Solar Power and Energy Development Insights



ASSUMPTIONS

Assumed BP's Energy Outlook estimate for projected increase in solar installed capacity from 2020 to 2050 across three possible scenarios:

- Net Zero
- Rapid
- Business as Usual

Assumed that Nigeria will track global growth

Assumed that Nigeria's current fraction of global capacity, will remain the same

INSTALLED CAPACITY TODAY

Current Installed Global Capacity: **627GW**

Current Installed Nigeria Capacity: **28GW**

Current Fraction of Global Capacity: **0.0045%**

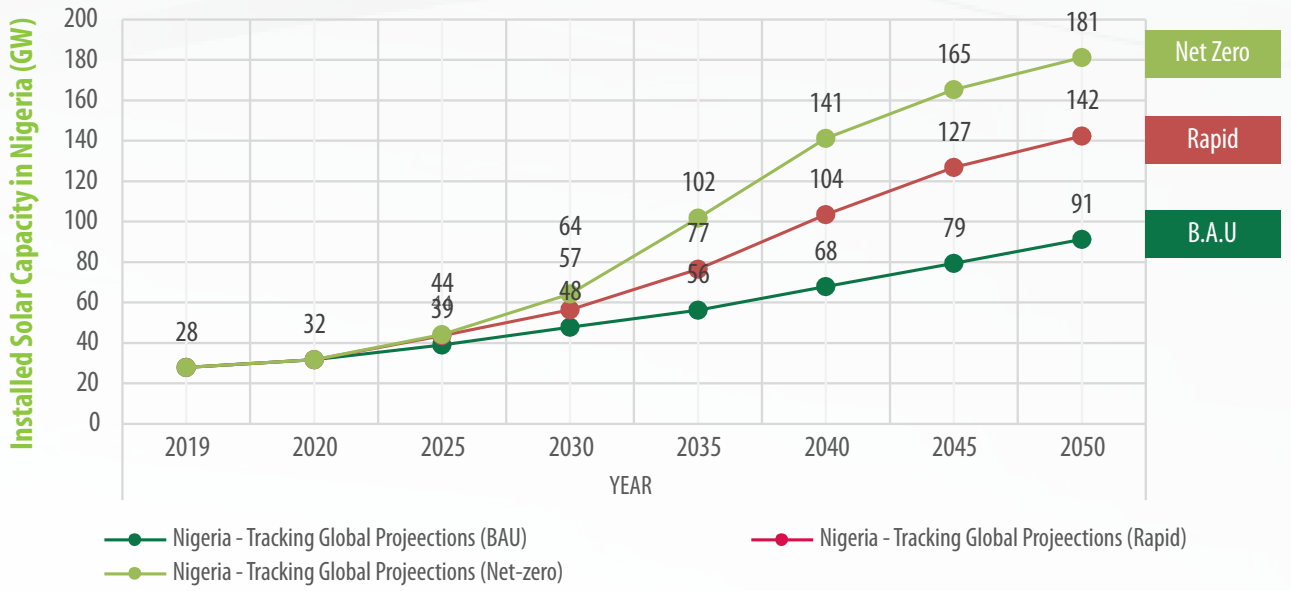
Nigeria's Installed capacity by 2050 is Pessimistically estimated to range between

91MW Business as Usual

181MW Net Zero

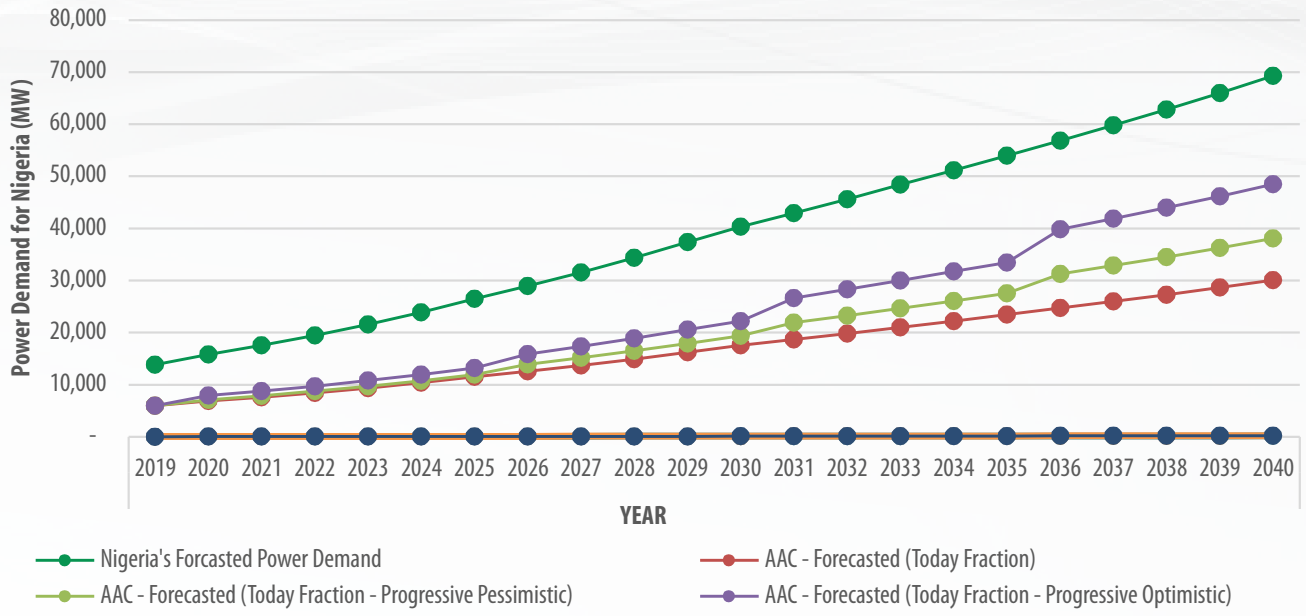
Solar Power and Energy Development Insights

SOLAR POWER INSTALLATION GROWTH TRACKING BP ENERGY OUTLOOK SCENARIOS



None of these projects have...

Solar Power and Energy Development Insights



Using Third – Party Research (Master Plan study on National Power System Development in Nigeria – 2019), Nigeria's Power Demand is expected to grow at an average growth rate of **7.8%** from 2015 – 2040. **Estimated to be 70,000MW by 2040**

ASSUMPTIONS

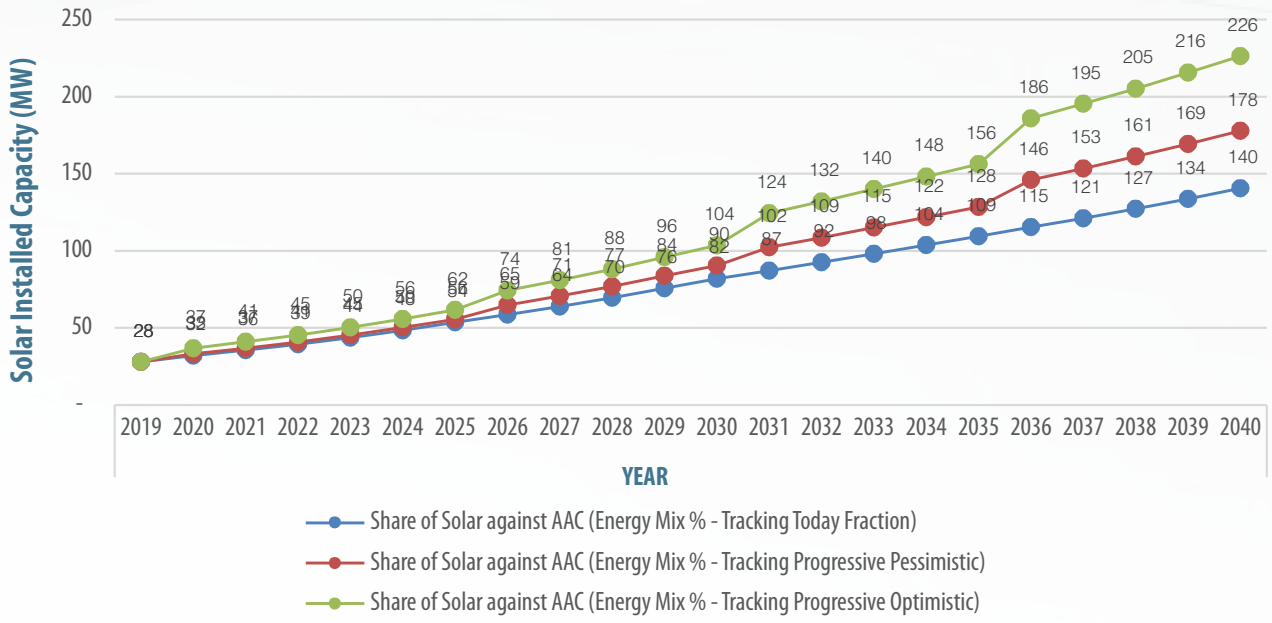
- Assuming Nigeria's Actual Available capacity (AAC) or Capacity Factor against actual Demand ranges from its current 43% up to 70%
- Assuming Nigeria's Solar contribution to the energy mix remains constant

Thus, assuming some growth in AAC but keeping solar fraction of the energy mix constant (0.47%)

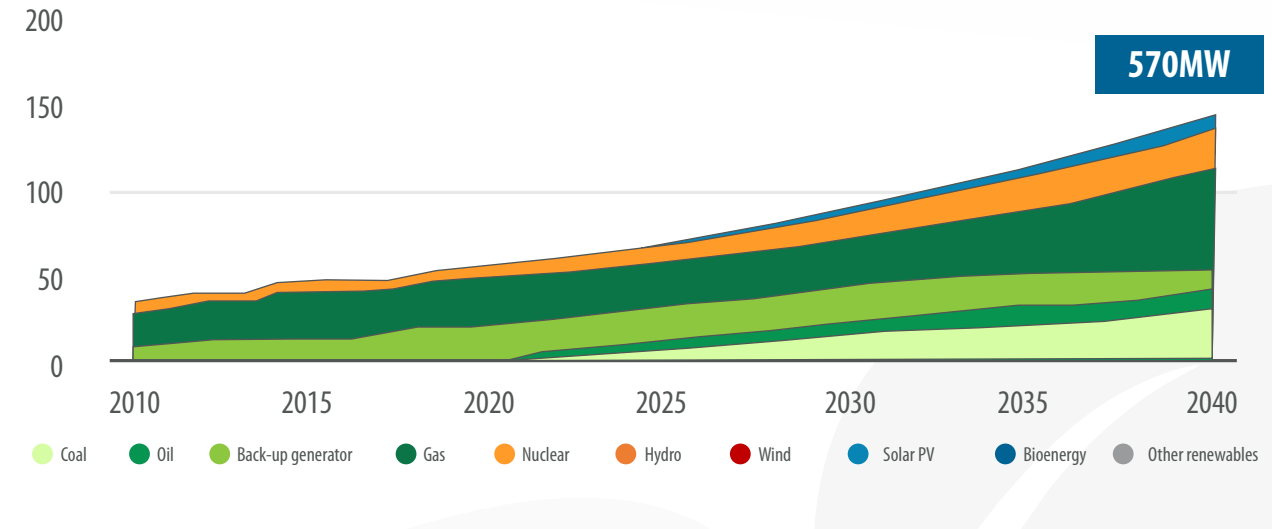
Solar Installed capacity is expected to be between **140 – 226 MW by 2040**

Solar Power and Energy Development Insights

INSTALLED SOLAR CAPACITY TRACKING FORECASTED POWER DEMAND GROWTH, ASSUMING 3 CAPACITY FACTOR SCENARIOS (MINISTRY OF POWER STUDY)



But..... IEA Estimates from Nigeria's stated policy scenarios and GHG emission Targets – PV Installed capacity will be >500MW by 2040



Quartzite Mining & Poly-Si Production

1. POLY-SILICON PRODUCTION

Stage 1

$$Sio_2 + 2C \rightarrow Si + 2CO$$

Silicon dioxide — Carbon — Silicon — Carbon monoxide

Stage 2

$$Si + 3HCl \rightarrow HSiCl + 2H_2 \rightarrow 2Si + 6HCl$$

Silicon — Hydrochloric Add — Trichlorosilane — Hydrogen — High Purity Silicon — Hydrochloric Acid

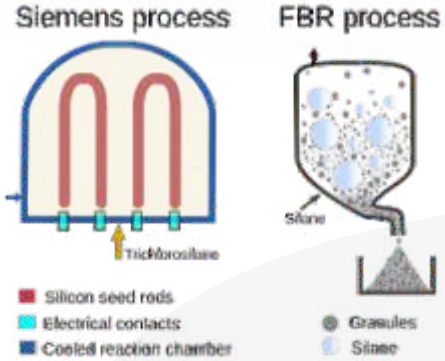
Silicon is the starting point of our solar production cycle.

It is extracted from sand (Quartzite Rock), which is made up primarily of silicon dioxide. As the second most common element of the earth's crust, there is an almost endless supply.

Silicon is treated and processed into poly-silicon

Mining Quartzite for Silicon

Silica Sand is then processed to obtain Poly-silicon



Of the 92 elements, silicon (Si) is Earth's most prevalent semiconductor – & second most common element of any kind, after oxygen. Appearing in silicon oxides such as sand (silica), quartz, rock crystal, amethyst, agate, flint, jasper and opal, silicon makes up about a quarter, by weight, of the Earth's crust. Photovoltaic manufacturing starts with polysilicon, a refinement of silicon materials.

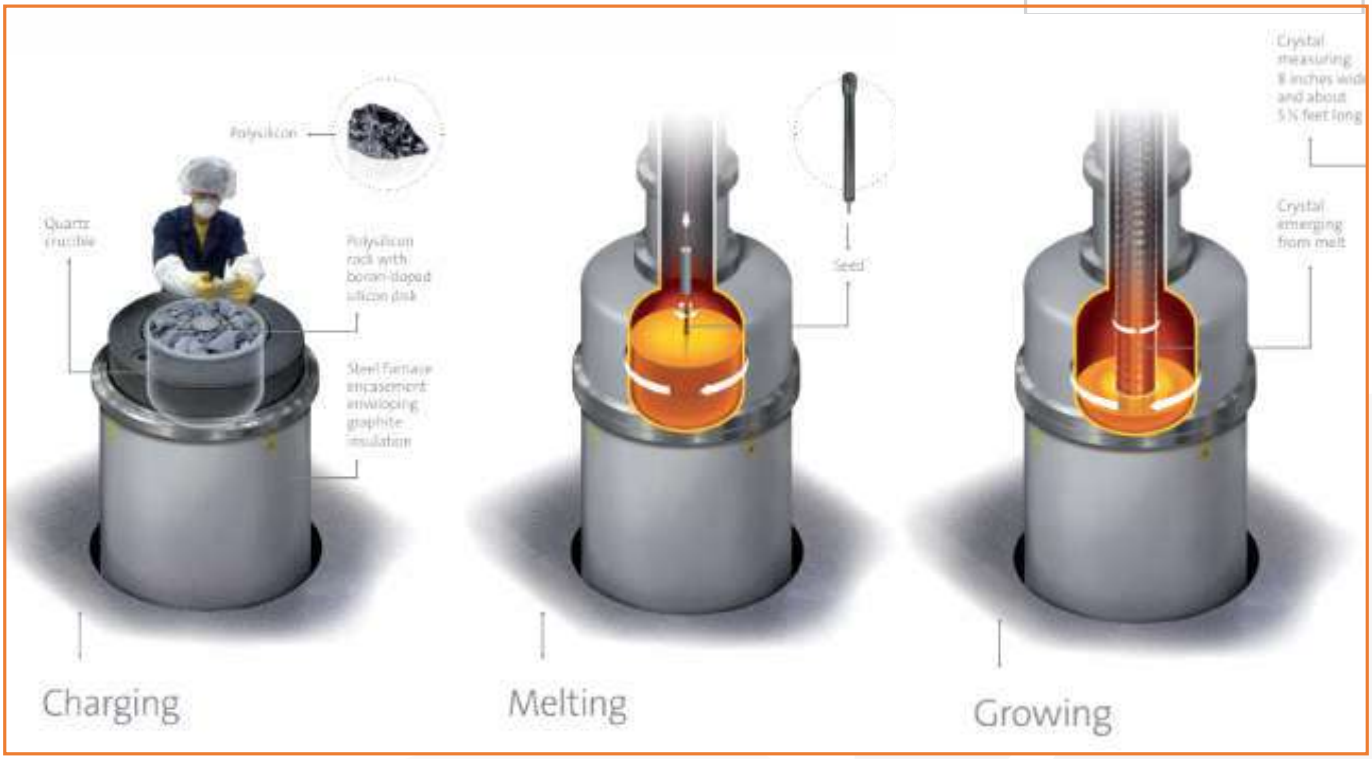
Poly-silicon Processing

2. POLY-SILICON PROCESSING

Poly-Silicon processed from quartzite rocks is melted and resolidified into cylindrical Ingots

This process involves the use of a Quartzite Crucible which melts and re-crystallizes the poly-silicon chunks into a cylindrical ingot in preparation for the next phase of PV Manufacturing – Solar Wafer Manufacturing

The Czochralski process is commonly used



Quartzite Mining & Poly-Si Production

COST ESTIMATES

CAPEX ($ Million)
500 - 980

Production (Metric Tonnes per Annum)
6,000 - 20,000

Polysilicon Spot prices ($/Metric Tonnes)
10,000 - 14,000

Projected Revenue ($ Million)
60 - 280

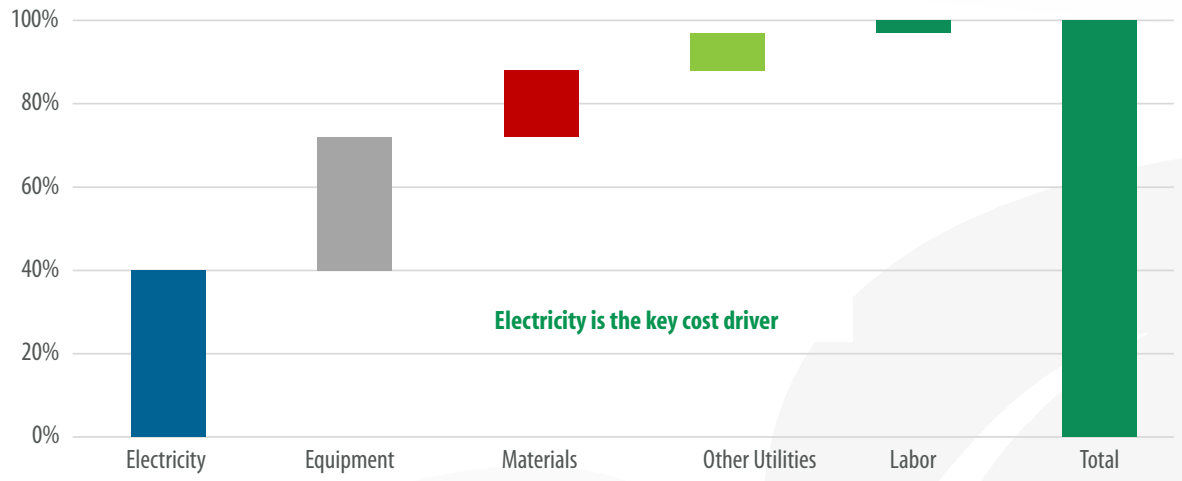
COST DRIVERS

1. Technology of Processing (Siemens / Fluidized Bed / CZ)
2. Scale of Operations
3. Materials for construction and raw materials for plant
4. Plant design and equipment selection
5. Construction Methodologies

Quartzite Mining & Poly-Si Production

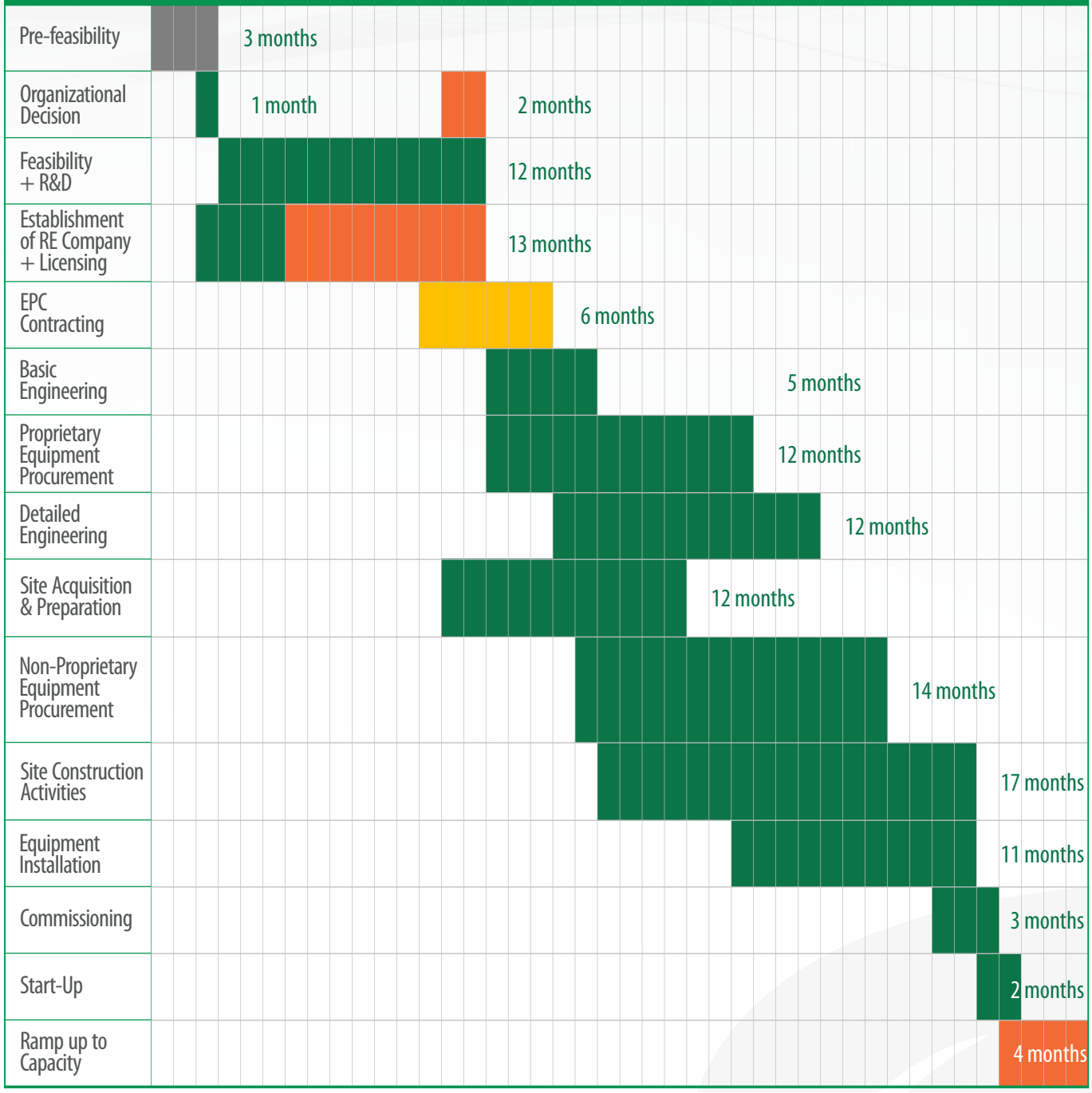
- Declining prices are due to oversupply of Polysilicon as more manufacturing capacity is added
- Increased demand in Sola panels may see the price average at $14/kg

OPEX COST STRUCTURE



Quartzite Mining & Poly-Si Production

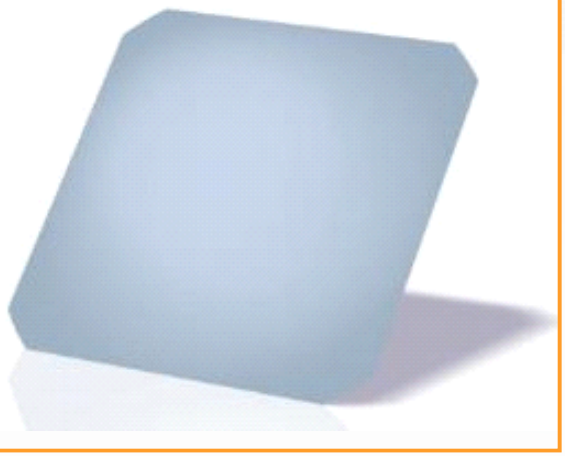
POLYSILICON MINING AND PRODUCTION FACILITY DEVELOPMENT – KEY ACTIVITY TIMELINE (42 MONTHS)



Operations and Maintenance **20 - 25 years**

Solar Wafer Production

3. WAFER CUTTING

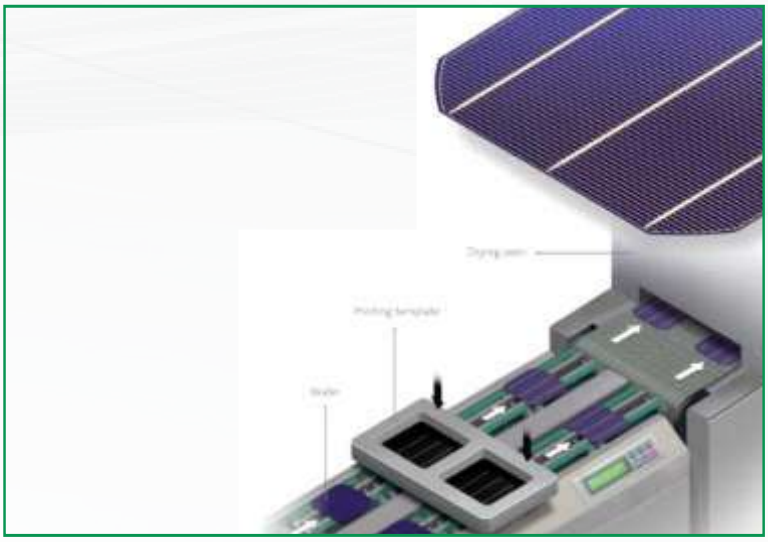


Crystallized Silicon Ingot columns are cut into extremely thin slices, or wafers, using state-of-the-art Saw-cutting and wire-cutting technology.

After cutting, squaring, slicing cleaning and thorough final testing, the monocrystalline and polycrystalline wafers form the base for the production of solar cells.

Solar Cell Production

4. SOLAR CELL PRODUCTION



The wafers are further processed into **solar cells** in the third production step. They form the basic element of the resulting solar panels.

The cells already possess all the technical attributes necessary to generate electricity from sunlight. Positive and negative charge carriers are released in the cells through light radiation, causing electrical current (direct current) to flow.

Quartzite Mining & Poly-Si Production

COST ESTIMATES

CAPEX ($ Million)
500 - 980

Production (Metric Tonnes per Annum)
6,000 - 20,000

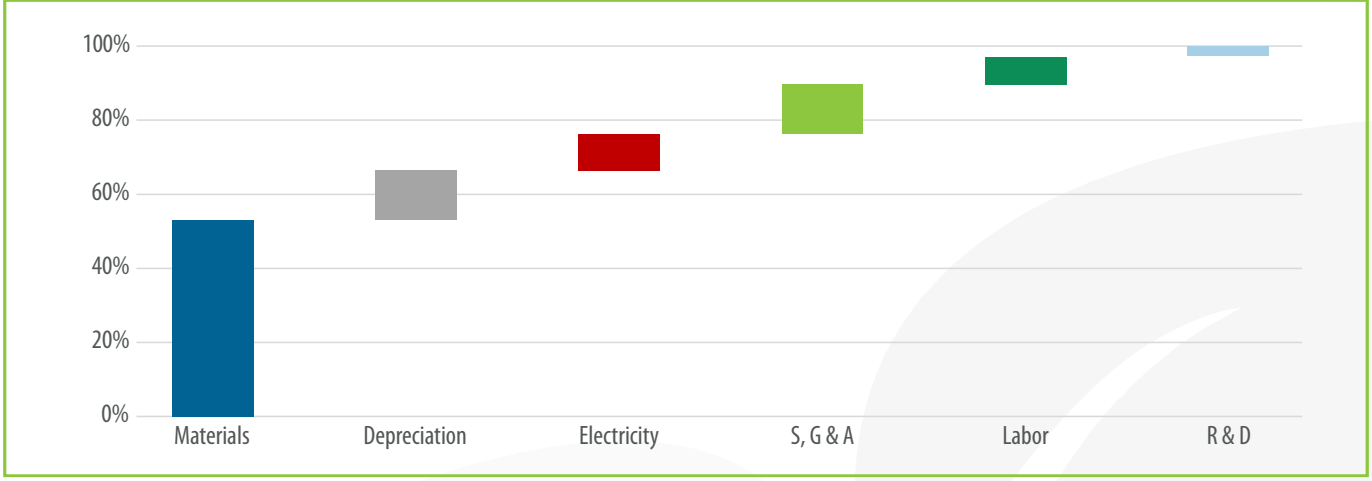
Polysilicon Spot prices ($/Metric Tonnes)
10,000 - 14,000

Projected Revenue ($ Million)
60 - 280

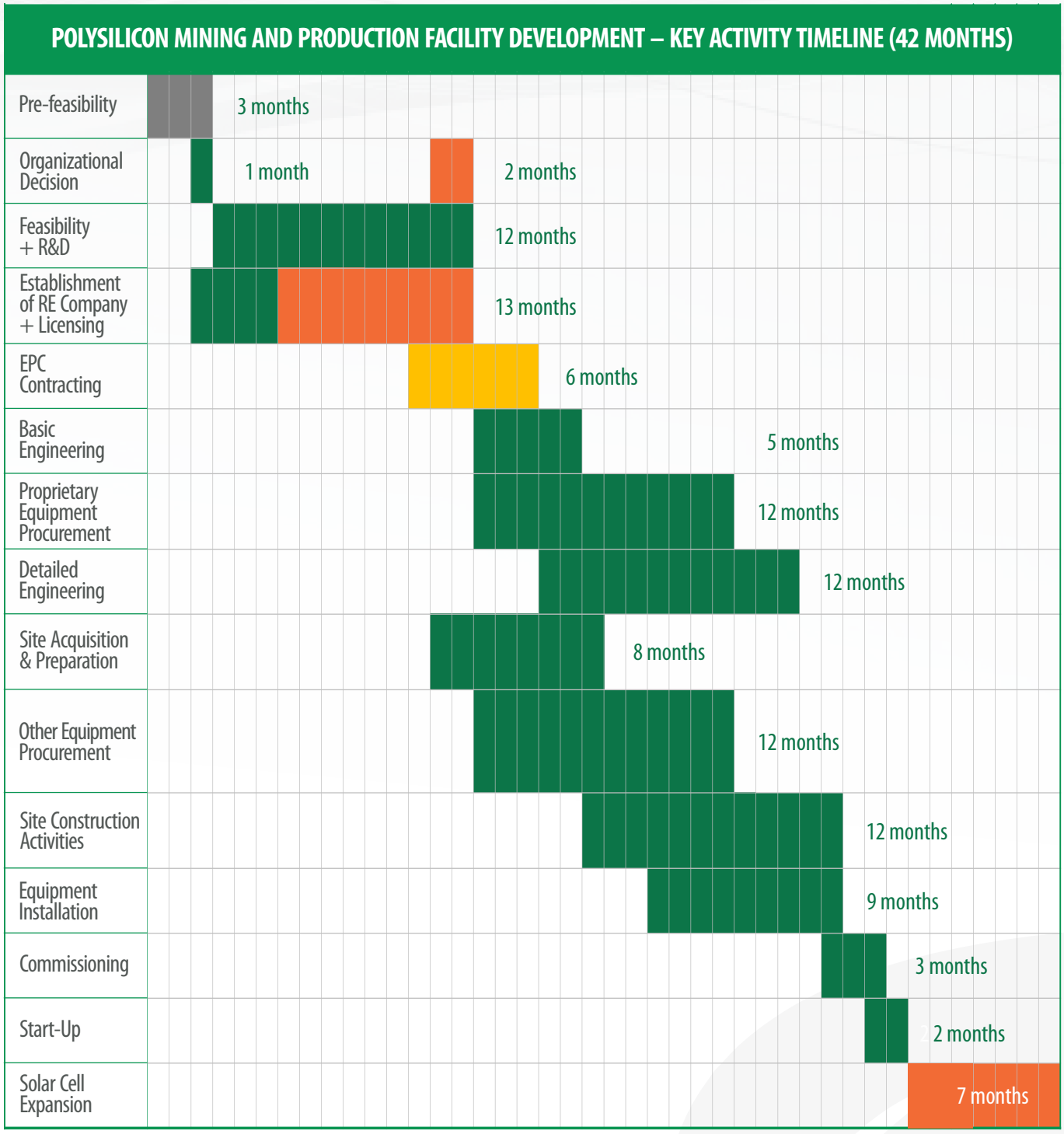
WAFER AND SOLAR CELL COST DRIVERS

1. Technology of Processing
2. Scale of Operations
3. Materials for construction and raw materials for plant
4. Plant design and equipment selection
5. Construction Methodologies
6. Electricity Cost

OPEX COST STRUCTURE



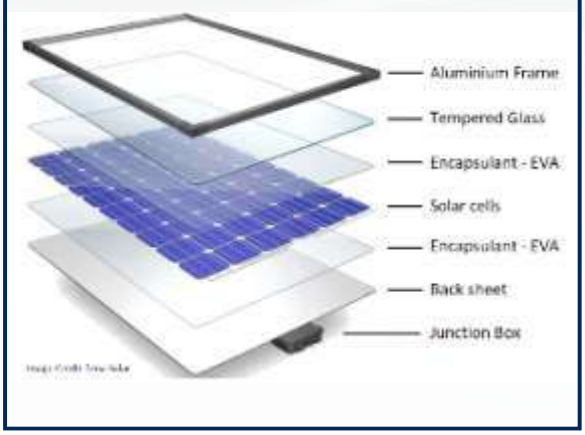
Quartzite Mining & Poly-Si Production



Operations and Maintenance **20 - 25 years**

PV Panel Assembly

5. PV PANEL ASSEMBLY



Solar cells are merged into larger units – the panels – in panel production. They are framed and weather-proofed.

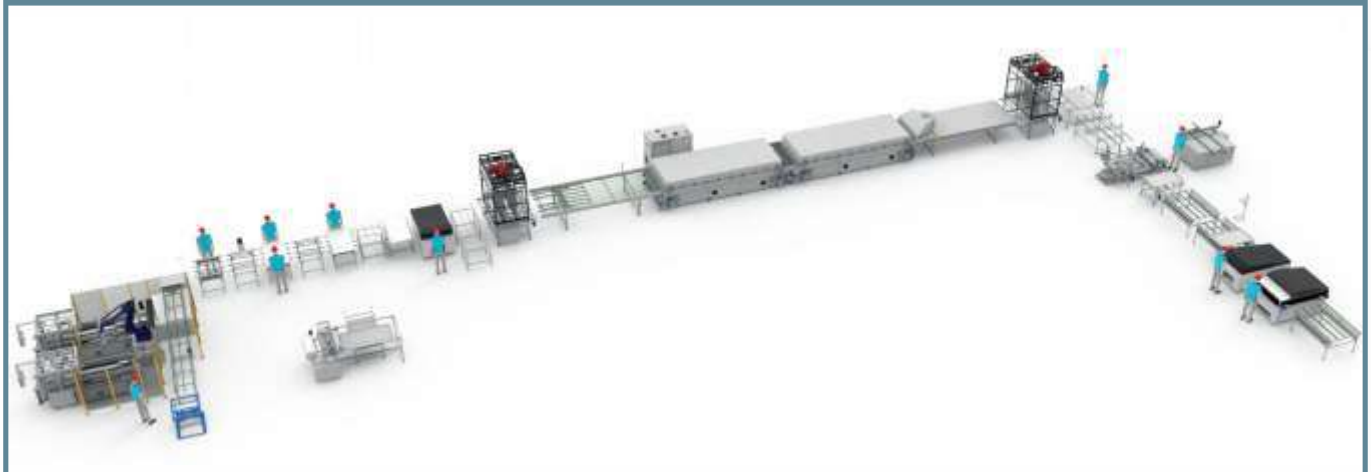
The solar energy panels are final products, ready to generate power. Sunlight is converted into electrical energy in the panels.

The direct current produced this way is converted to alternating current by a device called an inverter so that it can be fed into the utility grid or, if applicable, straight into the house.

PV Panel Assembly

100MW MODULE PRODUCTION SMART LINE

COMPLETE SOLUTION FOR PV MODULE MANUFACTURING

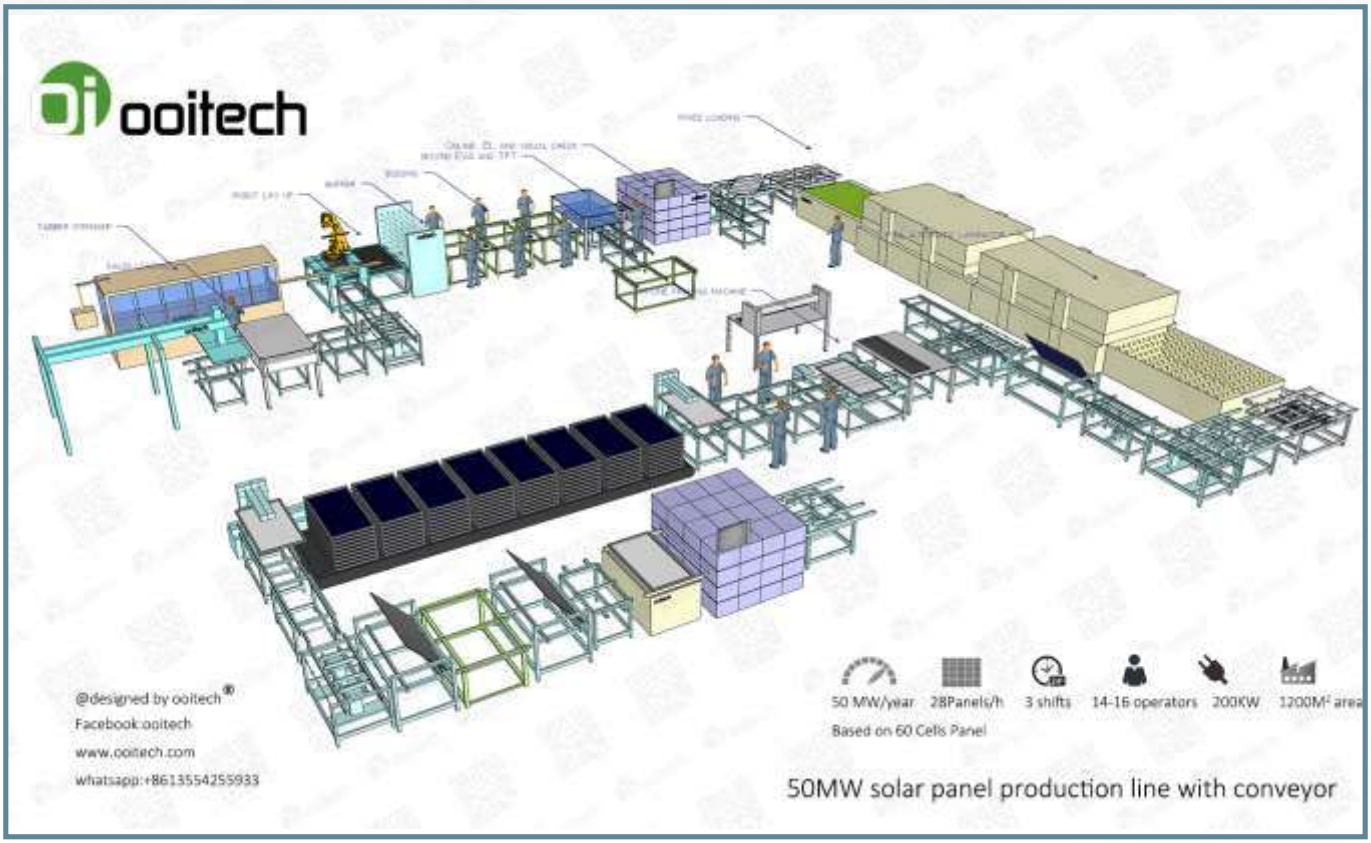


100 MW/year	58 modules/h	10 operators per shift	850m² production area required
4.7 W/cell	72 cells per module	160 kW/h	6bar 200nL/1
3shift of 8 hours	330 days/year		

Ecoprogetti "turnkey solutions". In this instance we will use the 100 MW Line, consisting of the following equipment and accessories:

- Stringer machine
- Layup station
- Automatic station with conveyor belts for manual bussing
- Electroluminescence Test
- Laminator with Buffers
- Automatic Framing Machine
- Automatic silicon dispenser
- Solar Simmulator

PV Panel Assembly



50 MW/year	28 panels/h	3shift
200 KW	14-16 operators per shift	1200m² area

PV Module Assembly

COST ESTIMATES

Production (Megawatts per Annum)
100 - 200

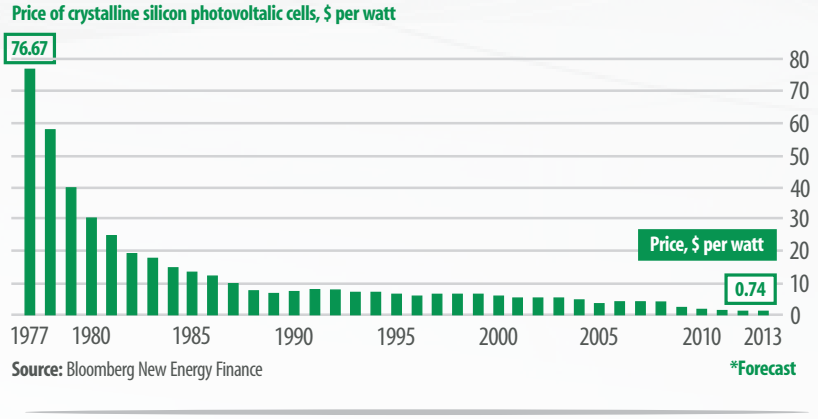
CAPEX ($ Million)
6 -12

OPEX per Annum ($ Million)
21 -54

Averge PV Panel Prices ($/Watt)
0.7 - 1.5

Projected Revenue ($ Million)
70 - 150

THE SWANSON EFFECT

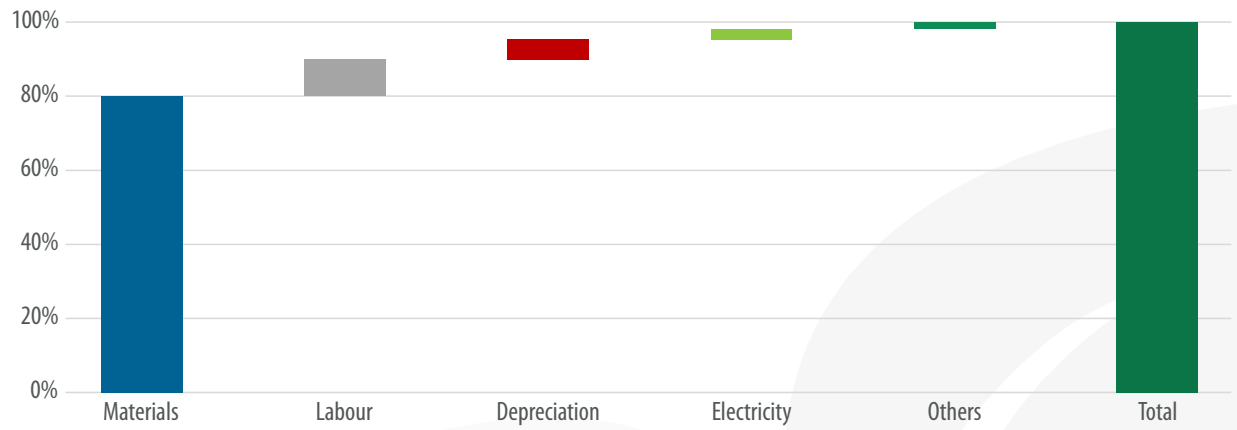


- Declining prices are due to increased efficiency PV Panels
- Prices have also declined due to more efficient methods of manufacturing

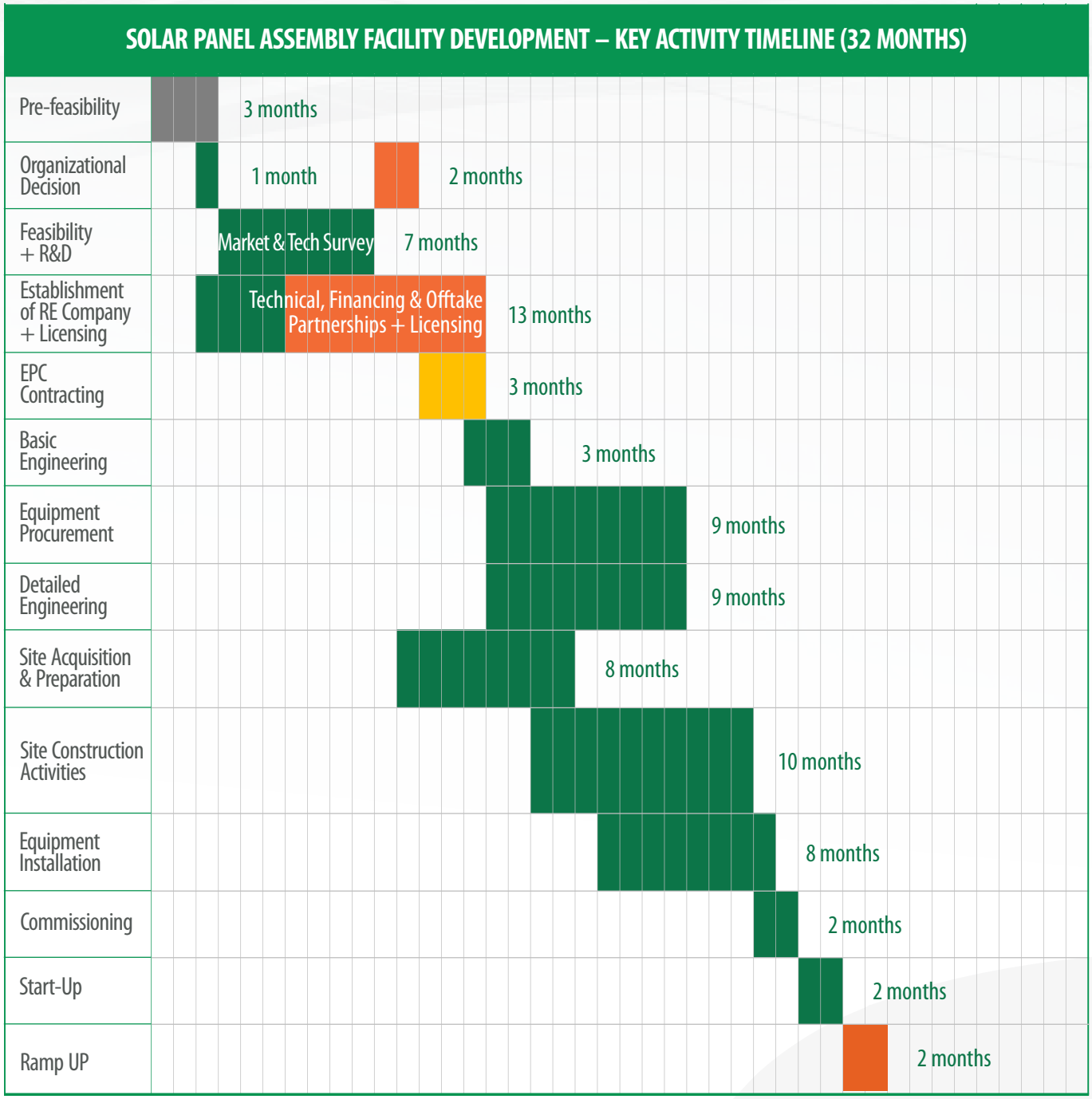
SOLAR PV MODULE ASSEMBLY PLANT COST DRIVERS

1. Number of Assembly Lines
2. Scale of Operations (Capacity)
3. Materials for construction and raw materials for plant
4. Plant design and equipment selection
5. Construction Methodologies
6. Electricity and Labour Cost

OPEX COST STRUCTURE



Quartzite Mining & Poly-Si Production



Operations and Maintenance **20 - 25 years**

Integrated Manufacturing Plant

SOLAR PV MODULE PRODUCTION (POLY-SI TO PANEL) COST ESTIMATES

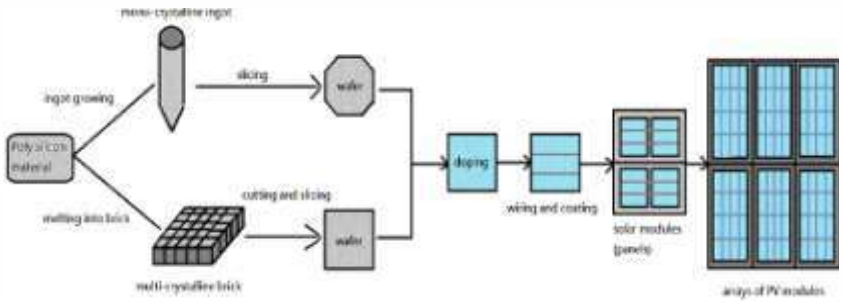
Production (Megawatts per Annum)
500 - 1000

CAPEX ($ Million)
200 - 400

OPEX per Annum ($ Million)
160 - 300

Averge PV Panel Prices ($/Watt)
0.7 - 1.5

Projected Revenue ($ Million)
350 - 1,000

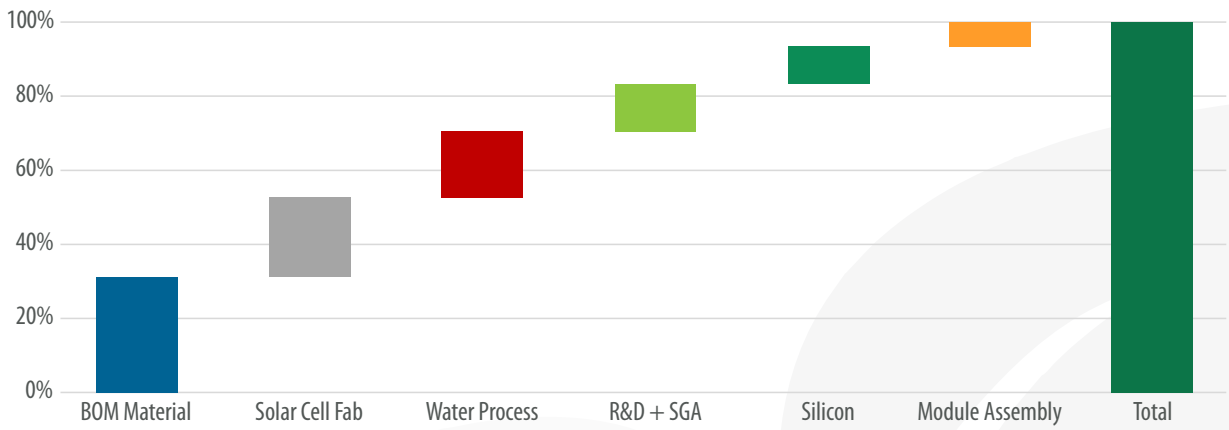


- A Large percentage of Solar Companies have integrated other value chain systems into their production portfolio to increase revenue margins
- The Most Common structure is from wafer – PV Module Production
- Integration is easier with scale

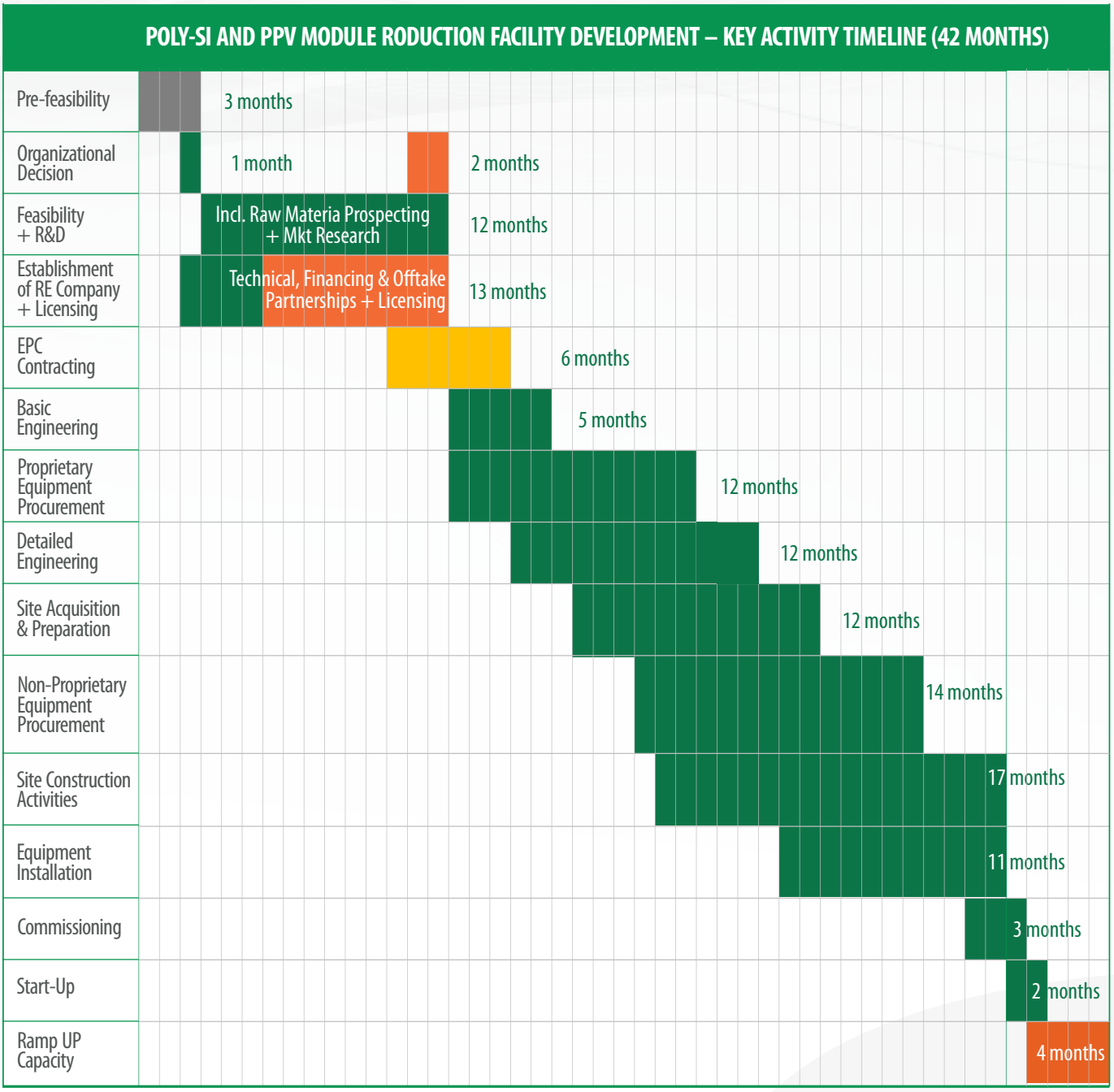
SOLAR PV MODULE PRODUCTION COST DRIVERS

1. Number of Assembly Lines
2. Scale of Operations (Capacity)
3. Materials for construction and raw materials for plant
4. Plant design and technology
5. Construction Methodologies
6. Electricity and Labour Cost
7. Location (Access to Raw Materials and Off-takers)

OPEX COST STRUCTURE

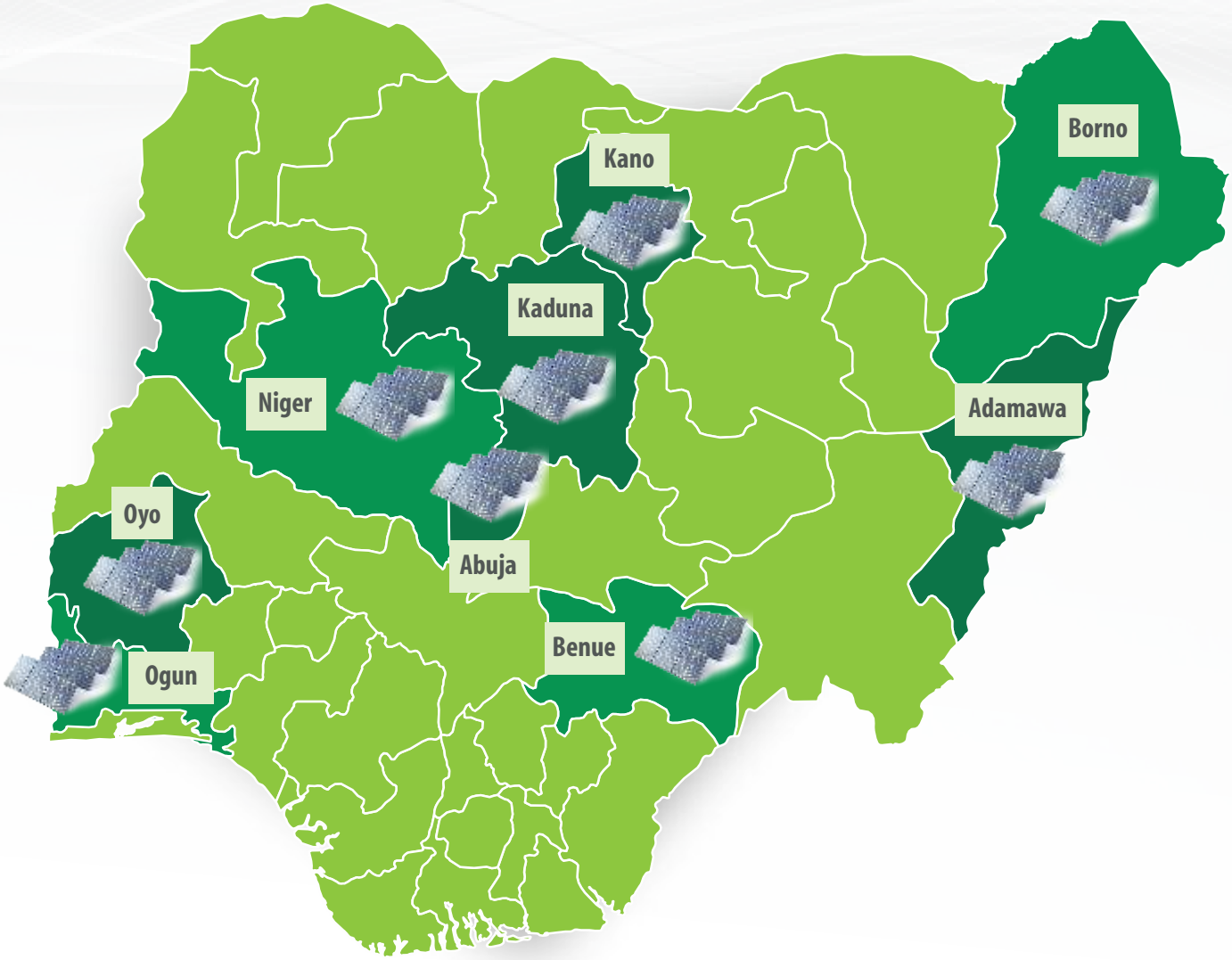


Poly-Si to PV Module Manufacturing



Operations and Maintenance **20 - 25 years**

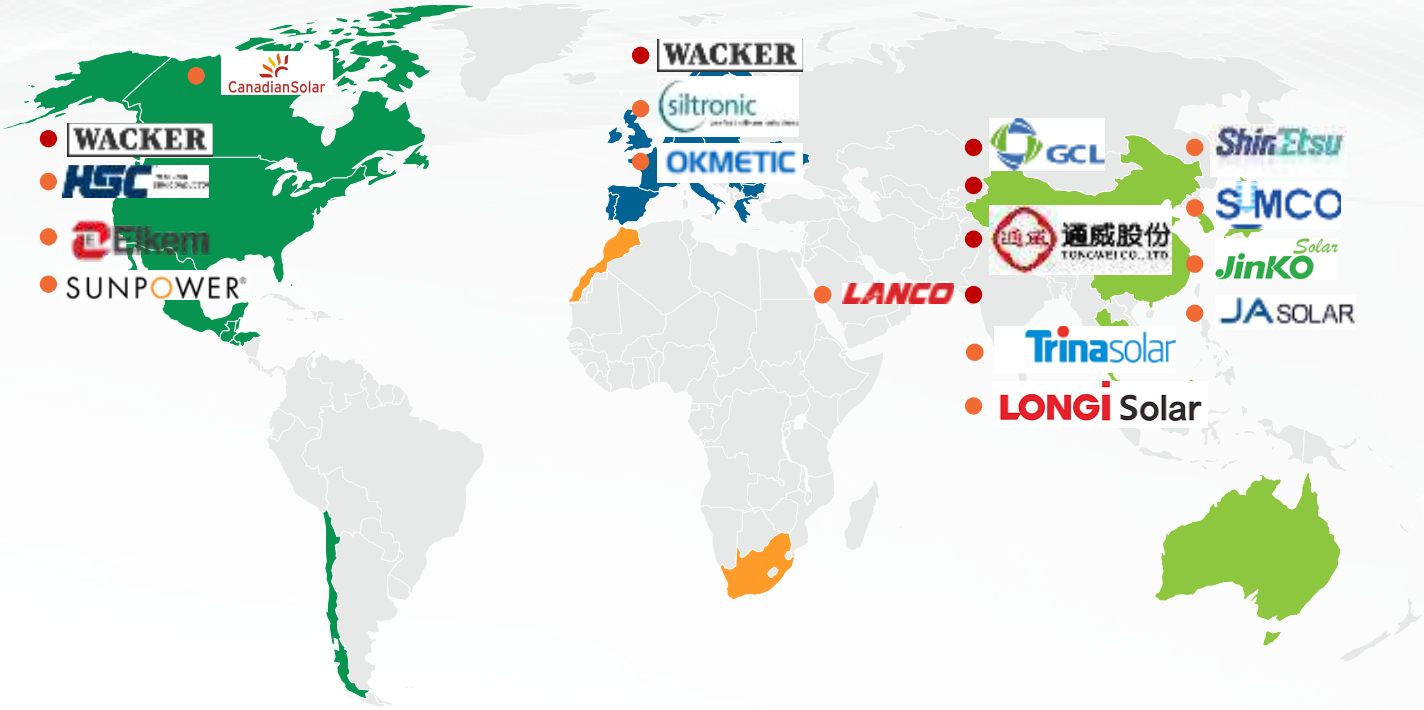
Investment Appraisal: Resource Map + Location Analysis



SELECTION CRITERIA

1. Solar Irradiation
2. FGN Interest
3. Funding Scheme Preference
4. Request for Proposal Specifications
5. Capacity to Influence Incumbent Stakeholders
6. Nature of incumbent Stakeholders
7. Availability of Land Space
8. Market Availability and Potential

Investment Appraisal: Key Players and Recommendations



RECOMMENDED PARTNERSHIPS

UPSTREAM

Quartzite Mining, Polysilicon Production

- Wacker Chemie AG (Germany)
- GCL Poly Energy Holdings (China)

Manufacturing expertise and Technology transfer

MIDSTREAM

PV Panel Manufacturing (Water, Solar Cell, PV Assembly)

- SunPower (USA)
- Trina Solar

Manufacturing expertise and Technology transfer

DOWNSTREAM

PV Panel Installation (Residential & Commercial)

- SolarWox
- Auxano Solar

Local Expertise can be utilized for these partnerships.

PV Solar Farm Installation (Grid/Off Grid) - Incl. EPC + O&M

- Q-Cells
- First Solar (USA)

EPC Expertise for Large Scale Solar Farms

OTHER PARTNERSHIPS

Research and Development

- GCL (PV Silicon & Wafer)
- NREL
- SEIA
- Tesla

Feasibility Reports

- Research Gate
- NREL

Balance of Plant (Batteries, Inverters, Cables, Installation Accessories)

- Tesla, Powerplus, LG Chem
- Fronius, Sungrow, ABB, SMA
- Siemens, Victor, Morningstar

Financing

- **CBN**-Solar Connection Facility
- **World Bank**
- **Trina Solar (PPA/ Others)**
- **Bank Of Industry**

Legal and Regulatory Framework

Applicable Laws & Regulatory Institutions

Electric Power Sector Reform Act, No. 6 of 2005 ("EPSRA")

Nigerian Electricity Management Services Agency Act

Nigerian Electricity Regulatory Commission (NERC)	The regulator of the electricity industry and generally responsible for enforcement of the EPSRA and such other related or incidental matters.
Nigerian Electricity Management Services Agency (NEMSA)	Carries out electrical inspectorate services in Nigeria's electricity supply industry and ensures that all major electrical materials and equipment used in Nigeria are of the right quality and standards, among other powers
Standard Organisation of Nigeria (SON)	Issues the Mandatory Conformity Assessment Programme ("MANCAP") Certificate for all locally manufactured products in Nigeria to ensure they conform to the relevant Nigerian Industrial Standards (NIS) before being presented for sale in Nigeria or exported. Also issues the Standards Organisation of Nigeria Conformity Assessment Programme ("SONCAP") Certificate for all products imported into Nigeria. The SONCAP Certificate will be required for components or equipment imported for use in installing power systems in Nigeria.
National Office for Technology Acquisition and Promotion (NOTAP)	Registers contracts for the transfer of foreign technology to Nigerian parties as well as every agreement in connection with the use of trademarks, use of patented inventions, supply of technical expertise, the supply of basic or detailed engineering, and the supply of machinery and plant, among others

Technical & Commercial Options Assessment

Tech.	Available Tech. Opitons	Recommendations	Industrial Processes	End-Products	Potential Off-takers	Possible Licences
Solar	Sun Irridiation	Sun Irridiation	Changing quartz silica into silicon ingots	Polysilicon	• China High Sun • Dmsolar • Hareon Solar Tech	• NEMSA, • Factories Licence • MANCAP • EIA
			Cutting Silicon ingots into wafers	Wafer	• Tsinghua Unigroup, China	• NEMSA, • Factories Licence • MANCAP • EIA
			Putting circuitry on wafer	Solar Cell	• Ashanti Gold Group • LITE-UP NAIJA	• NEMSA, • Factories Licence • MANCAP • EIA
			Placing cells on glass & processing into panels	PV Module	• Tsinghua Unigroup, China	• NEMSA, • Factories Licence • MANCAP • EIA
			Changing quartz silica into silicon ingots	Polysilicon	• Ecozar technologies • Leks Environmental Ltd. • Solar Force Nig.	• NEMSA, • Factories Licence • MANCAP • EIA
			Installation	Solar Panels	• Bezalili House Solutions Ltd	• NEMSA, • Factories Licence • MANCAP • EIA

Licence Regime

S/N	Type of Licence	Description
1	Generation Licence	Required for electricity generation capacity (excluding captive power generation) exceeding 1 Megawatt (MW). Issued in respect of a specific site
2	Distribution Licence	Entitles the licensee to construct, own, operate and maintain a distribution system and facilities.
3	Mini-Grid Licence	Issued for integrated off-grid local generation and distribution systems with installed capacity below 1 MW. For projects below 100 Kilowatts (Kw), only a simple registration with NERC is mandatory.
4	Captive Generation Permit	Issued for generation of electricity exceeding 1 MW for the purpose of consumption by the generator, and which is not sold to a third-party. NERC's consent is required before supplying surplus power not exceeding 1MW to a third party.
5	Embeded Generation Licence	Enables the generation of electricity that is directly connected to and evacuated through a distribution system which is connected to a transmission network operated by the Transmission Company of Nigeria.
6	Independent Electricity Distribution Network Licence	Enables distribution of electricity through a network not directly connected to a transmission system and is issued where: (i) there is no existing distribution system within the geographical area to be served by the proposed IEDN; and (ii) where the infrastructure of an existing DISCO is unable to meet the demand of customers in the area.

Other Authorization or Institutions that May be Applicable

Authorization	Purpose	Issuing Authotiry
Environmental Impact Assessment (EIA) certificate	Confirms that an EIA of the mining activity have been adequately done and provisioned for. **Threshold for conduct of EIA for power projects is 10MW.**	Federal Ministry of Environment
NEMSA Certificate	Persons undertaking electrical installation work and contractors looking to engage in the business of electrical installations. The NEMSA certificate has therefore become one of the compulsory tender documents for contractors looking to bid for power projects in Nigeria.	Nigerian Electricity Management Services Agency
Building & Construction Permits	Required where construction would be carried out in relation to the Project.	Various land and physical planning agencies of various states.
Factories licence	Where any premises is occupied as a factory.	Director of Factories, Ministry of Labour
NESREA	Required for importing new electrical/electronic equipment and waste generation.	National Environmental Standards Regulation Enforcement Agency
NOTAP Registration	Required for agreements with foreign partners for technology transfer, such as, use of trademarks, patented inventions, technical/management, technological expertise, etc.	National Office for Technology Acquisition and Promotion
Import Related Permits	Where the company would import goods for use in the business.	Central Bank of Nigeria; Standards Organisation of Nigeria
Import Clearance Certificate	The importation (and clearing from the ports) of fully assembled generators, knocked-down parts imported for domestic assembling or spare parts	Nigerian Customs Service (NCS)

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