Federal Ministry of Power, Works and Housing (FMPWH)
Transmission Company of Nigeria (TCN)
The Federal Republic of Nigeria

THE PROJECT FOR MASTER PLAN STUDY ON NATIONAL POWER SYSTEM DEVELOPMENT IN THE FEDERAL REPUBLIC OF NIGERIA

FINAL REPORT

February 2019

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

YACHIYO ENGINEERING CO., LTD.

IL
JR
19-010

Federal Ministry of Power, Works and Housing (FMPWH)
Transmission Company of Nigeria (TCN)
The Federal Republic of Nigeria

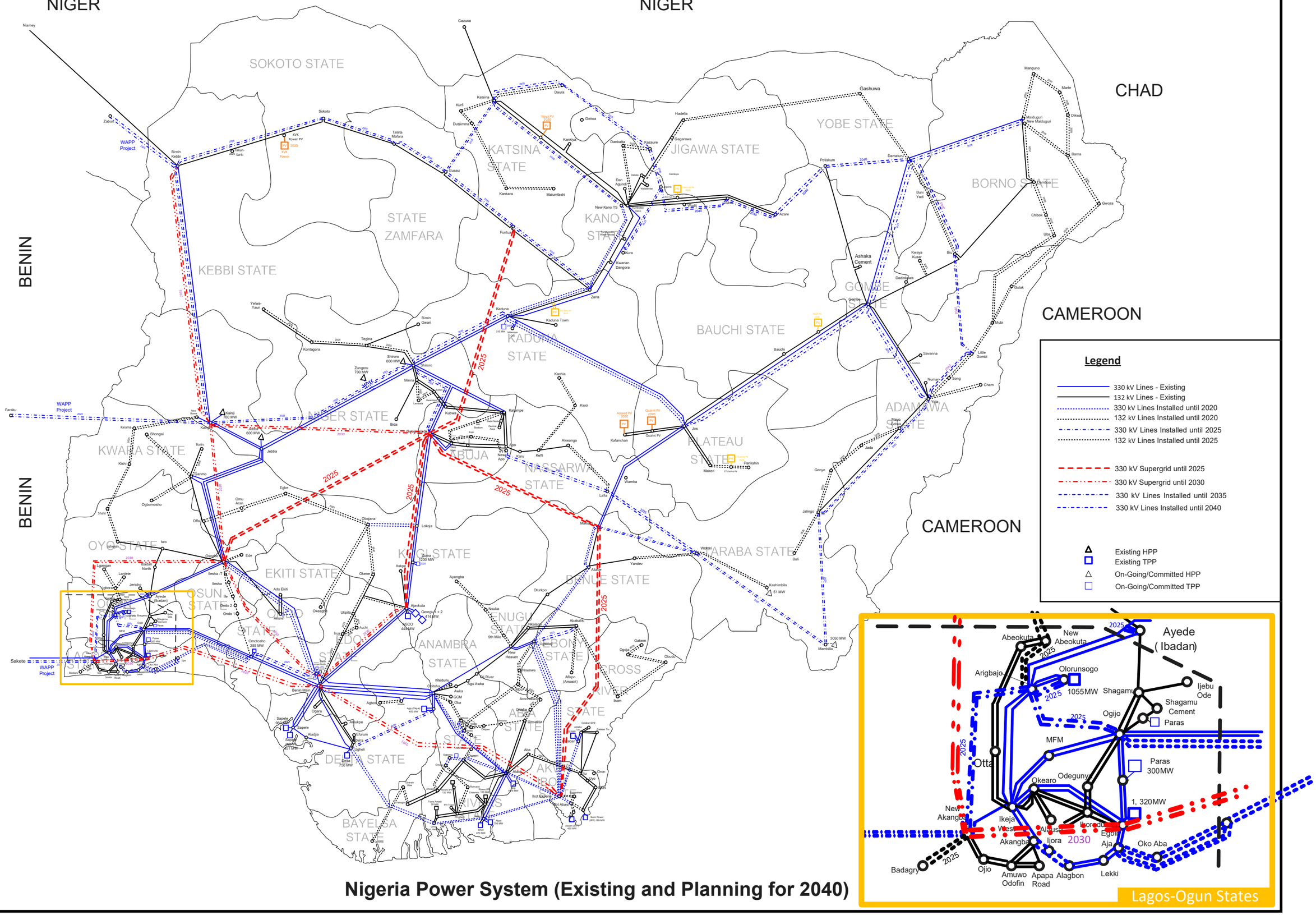
THE PROJECT FOR MASTER PLAN STUDY ON NATIONAL POWER SYSTEM DEVELOPMENT IN THE FEDERAL REPUBLIC OF NIGERIA

FINAL REPORT

February 2019

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

YACHIYO ENGINEERING CO., LTD.



Nigeria Power System (Existing and Planning for 2040)

Summary

Chapter 1 Introduction

1-1 Background of the Study

Nigeria, having the largest population in Africa of 191 million, is a country rich in natural resources and its crude oil and natural gas reserves are one of the world's most abundant. However, for various reasons, such as the power transmission capacity being restricted to only about 5,300MW (as of December, 2015) compared to a potential electrical demand estimated to be around 12,800MW and the shortage of gas supply, which is the principal fuel used in power generation, the capacity of available power generation is limited to about 6,600MW (as of December, 2015). Consequently, planned outages are frequent not only in local areas but also in urban areas. This leads to the general view that the economic growth of Nigeria is hindered by the power sector.

The Nigerian government, by utilizing the excess crude account, has implemented the NIPP (National Integrated Power Project) which allows for the building of thermal power plants and transmission lines; furthermore, it is promoting the privatization of the power sector with an aim to improve efficiency in this sector and to reduce investment charges to the government.

For the purpose of improving the above situation, FMPWH (Federal Ministry of Power, Works and Housing) of Nigeria, the organization responsible for global development in the power sector, has formed a long-term electric power development plan and grid extension plan on the basis of a future electrical load demand forecast. In addition, they asked the Japanese side to develop a power master plan which makes it possible to advance development in the power sector in a strategic and efficient way, and also requested a technology transfer which would be necessary in the course of development and renewal of such a plan. In response to this, JICA has conducted a survey for the preparation of a detailed plan for the master plan study in July 2014 and signed R/D (Record of Discussions) with the Nigerian side in October 2014, which made the project ready for implementation.

1-2 Objectives of the Study

The purpose of the study is to develop a 25 year power development master plan which shall include a power demand forecast, developing a plan with the lowest possible cost and an optimal power generation master plan which takes into account constraints on primary energy supply and the best energy mix, and also to develop a power transmission development plan based on the above mentioned power generation development plan. Improvement of performance of the personnel of FMPWH, TCN (Transmission Company of Nigeria), and TWG (Technical Working Group), which are the relevant organizations in the power sector, on the development and renewal of master plan preparations through development of this master plan shall also be included in the purpose of the study.

1-3 Outline of the Study

Table 1-1 shows the basic concept.

Table 1-1 Basic Concept of the Study

Item	Description
Objectives	Formulation of Master Plan on National Power System Development for 25 years Technical Transfer to the Nigerian counterparts
Target Facilities	Electric power generation facilities and power system facilities of not less than 66/33kV Substation facilities and transmission system owned by TCN
Implementation Agency	FMPWH
Scope of Work	Formulation of Master Plan on National Power System Development including power demand forecast, power generation development, power system development, and investment plan

Source: JICA Study Team

Chapter 2 Socioeconomic Conditions and Development Plans

2-1 Economic Recovery and Growth Plan 2017-2020：ERGP

The ERGP was formulated in 2014 and aims to improve the resilience of the economy and make it less vulnerable to external shocks through a reduction in dependence on the oil sector, and better implementation of government policies. To achieve the objectives of the ERGP, the key execution priorities, as illustrated in Figure 2-1, are:

- Stabilizing the macroeconomic environment
- Achieving agriculture and food security
- Ensuring energy sufficiency (power and petroleum products)
- Improving transportation infrastructure
- Driving industrialization focusing on small and medium scale enterprises

Source: Ministry of Budget and National Planning, "Economic Recovery and Growth Plan 2017-2020", February 2017

Figure 2-1 ERGP'S TOP Execution Priorities

The objectives aimed for in the ERGP is to "optimize the delivery of at least 10 GW of operational power capacity by 2020 to boost economic activity across all sectors and improve the quality of life of the citizenry." The Nigerian government has placed the power sector (electric power and transportation) as one of the first priorities in ERGP.

The strategies are as follows:

- With regard to the power value chain, efforts will be concentrated on overcoming the current challenges which relate to governance, funding, legal, regulatory, and pricing issues across the three main power segments of generation, transmission, and distribution, and ensuring stricter contract and regulatory compliance.
- The ERGP aims to optimize the delivery of at least 10 GW of operational capacity by 2020 and to improve the energy mix including greater use of renewable energy.
- The plan also aims to increase power generation by optimizing operational capacity, encouraging small-

scale projects, and building more capacity over the long term.

- The Government will also invest in transmission infrastructure.

ERGP reported that "Nigeria has 12.5 GW of installed capacity, but less than one-third is operational (average 3.9 GW in 2015; 3.2 GW in November 2016)." It is hoped that effective utilization of the capacity of existing power supply facilities, improvement of reliability, and higher quality of electric power supply will be achieved.

2-2 Development Plan in the Power Sector

In Nigeria, the National Energy Policy that was decided on in 2003 and revised in 2014 shows the enforcement method and framework.

Moreover, the National Energy Master Plan is scheduled to look forward as far as to 2030, and indicates a tendency for industrialization to progress further as shown in Table 2-1 regarding energy demand.

Table 2-1 Total Energy Demand Projection

Unit: Mtoe Unit: %

Sector	Growth rate(%)	Demand						Share					
	2009-2030	2009	2010	2015	2020	2025	2030	2009	2010	2015	2020	2025	2030
Industry	24.01	1.15	0.47	23.34	46.72	73.80	105.52	3.20	1.30	38.0	49.6	53.2	55.3
Transport	6.46	7.65	9.26	11.63	15.53	21.12	28.51	21.20	24.90	18.9	16.5	15.2	14.9
Household	3.16	24.09	24.68	23.40	27.28	36.46	46.29	66.90	66.50	38.1	28.9	26.3	24.2
Services	6.01	3.13	2.71	3.06	4.76	7.46	10.67	8.70	7.30	5.0	5.0	5.3	5.6
Total		36.02	37.12	61.425	94.29	138.84	190.99	100.00	100.00	100.0	100.0	100.0	100.0

Source: National Energy Master Plan (Draft Revised Edition) 2014

Moreover, a power demand estimate assuming a GDP growth rate of 7% (reference), 10% (high case), and 13% (optimistic) has been formulated in the National Energy Master Plan. The power generation equipment capacity plan based on fuel type is as shown in Table 2-2.

Table 2-2 Electricity Supply Projections by Fuel Type

Unit: MW

Item	2009	2010	2015	2020	2025	2030
Electricity Demand Projection						
Reference Growth (GDP growth rate: 7%)	4,054	7,440	24,380	45,490	79,748	115,674
High Growth (GDP growth rate: 10%)	4,052	8,420	30,236	63,363	103,859	196,875
Electricity Supply Project by Fuel						
Coal	0	609	1,850	6,527	7,545	10,984
Electricity Import	0	0	0	0	0	31,948
Gas	3,803	4,572	18,679	33,711	61,891	80,560
Hydro (Large and Small)	1,930	1,930	3,043	6,533	6,533	6,533
Nuclear	0	0	1,000	1,500	2,500	3,500
Small Hydro	20	60	172	409	894	1,886
Solar	0	260	1,369	3,455	7,000	25,917
Wind	0	10	19	22	25	29
Biomass	0	0	3	16	35	54
Supply	5,753	7,440	26,092	52,174	86,422	161,411

Source: National Energy Master Plan 2014 (Draft Revised Edition) 2014

Chapter 3 Organizations, Policies and Regulations of Energy and Power Sector

3-1 Issues of Power Sector

Important issues of the Nigerian power sector are described in 3-1-1 to 3-1-4 below:

3-1-1 Lack of Coordination among Ministries Related to Policy-making

In the power sector, many institutions are involved in policy formulation and their implementation. However, there are signs of lacking coordination among the ministries during policy formulation. Information sharing is not carried out sufficiently enough for demand forecasting and determining of the target values, and there are often cases in which some policies are not consistent with others.

3-1-2 Uncertainty of Securing Power Generation Energy Sources

Supply of natural gas, which holds a share of 82% among the power generation energy sources used in Nigeria, is far from stable. The supply is frequently stopped due to strikes and destructive actions, such as staving holes in gas pipelines for theft or political reasons. Such destructive actions cause serious accidents with over 100 casualties once or twice every few years. Under these circumstances, there is a need to take measures such as encouraging Gas Sale Aggregated Agreement with 'take or pay' contracts and countermeasures against vandalism.

3-1-3 Unpaid Generation and Transmission Charge by DisCoS

During October 2016 to October 2018, the amount paid by distribution companies (DisCos) to Nigerian Bulk Trading Company (NBET) and by the NBET to generation companies (GenCos) was around one fourth of the respective billed amounts. DisCos' payment rates are relatively high in DisCos where large cities are located, and lower in other DisCos. The payment rate from DisCos to the TCN decreased from 61% to 34% during 2013 to 2016, which is has been a cause of TCN's financial pressure.

3-1-4 Unpaid Electricity Charge by Users

The direct cause of the DisCos' payment problems is the low rate of electricity charge collection from consumers, which was 62% on average in the first quarter of 2018.

In addition to private consumers, government organizations such as ministries and agencies, which are large consumers, also neglect to pay electricity charges. This is caused by the fact that the budget to the ministries and agencies is not being disbursed as planned. To improve this situation, in March 2017 the Government pledged to pay a total of NGN 26 billion (USD 85 million) of the unpaid amount of the charges of government organizations owed to electric power companies. Details such as the timing of enforcement are unknown at present.

3-1-5 High Loss Rate in the Distribution Sector

According to the Advisory Power Team's Power Baseline Report (2005), the distribution sector had a technical loss of 12.5%, a commercial loss of 6.9%, and an uncollected rate of 36.5%. According to the

NERC's report for the first quarter of 2018, the average aggregated technical, commercial and collection loss rate of 11 DisCos was 55%. The national average metering rate in the same quarter was 42%.

3-1-6 Low Electrification Rate

The electrification rate of Nigeria is as low as only 61% of the population. This is lower than other African countries such as Ghana (82%) and South Africa (86%). Even in the electrified area, many businesses and families rely on private power generation due to instability of the power supply. The low electrification rate and unstable power supply are major obstacles to national economic growth.

3-2 Power Sector Recovery Programme (2017-2021)

The Power Sector Recovery Programme 2017-2021 (PSRP) describes detailed action plans regarding 1) financial interventions, 2) operational/technical interventions, 3) governance interventions and 4) policy interventions. These action plans are formulated carefully with a clear and deep understanding and analysis of the issues and challenges faced by the Nigerian power sector.

1) **Financial Interventions:** i) Establishment of Sustainable and Appropriate Electricity Tariffs, ii) Commitment to Fully Fund Future Sector Deficits (2017-2021, USD 3,770 million), iii) Clearing Historical Sector Deficits due to Tariff Shortfall (2015-2016, USD 1,378 million), iv) Securing Financing Sources, v) Clearing Historical MDA (Ministries, Departments and Agencies) Debts (USD 85 million) and Automatic Future Payments, World Bank Financial Support

2) **Operational/Technical Interventions:** i) Baseline Power Generation, Transmission and Distribution (on grid, 4,500W) by 2021, ii) Improving DisCo Performance iii) Adequate Gas Supply for Power Generation

3) **Governance Interventions:** i) Restoring Proper Sector Governance, ii) Improving Sector Transparency, iii) Ensuring Contracts are Fully Effective, iv) Clear Communications of PSRP, v) Establishment of PSRP Implementation Monitoring Team

4) **Policy Interventions:** i) Fiscal and Monetary Policies to Encourage Private Sector Investments, ii) Increase in Electricity Access, iii) Economic Procurement of Power

It appears that only limited action has been implemented to date, when around a year has passed since the issuance of PSRP. In the interviews conducted by the JICA Study Team, one respondent said, "PSRP is well planned and no one can deny it. At the same time, no one know how to start the implementation" while another said, "It is beautifully planned but its effectiveness is doubtful." It was found that the NERC has started to formulate the detailed implementation plan.

Chapter 4 Power Demand Forecasts

4-1 Current Power Demand Situation

(1) Trends of power energy consumption

Nigeria has long suffered from chronic power shortages and according to the Statistical Yearbooks of the FMPWH, reasons include the low operation load of hydro power plants and poor maintenance at all kinds of power stations. When calculating the growth rates of domestic power demands at the transmission point (power energy base) by using TCN data, the average growth rate from 2005 to 2016 was 3.2% per year, whereas as a general rule, the power demand elasticity relative to GDP in developing and emerging countries is within the range 1.2 – 2.0. As the Nigerian average GDP growth rate was 6.9% from 2005 to 2014 (despite the drop in GDP growth rates from 2015 and 2016 due to the decline in world crude oil price), Nigerian power demand is expected to grow from 8 to 14% annually under the above economic conditions.

In some countries, the actual power supply data sometimes lacks details of the power demand size, which means the real power demand is shown by "Actual power supply + α". In this project, power demand forecasts are implemented with "Computed data", which refers to unhindered power demand. The "National Load Demand Supply in 2009" is established without constraint data, so the forecast values from 2009 to 2014 in the report are used as "Without constrain data" and the actual values from TCN are used as "With constrain data". The latter are referred to as "Recorded data" in this Chapter.

(2) Current peak demand

According to the "Analysis of Nigeria's National Electricity Demand Forecast in 2009" published in March 2014 (and studied by staff and professors of Nigerian universities.), the peak time and season are analyzed as per the following table:

Table 4-1 Daily load demand

Time	Demand	Reasons
00-05	Low	Relatively low demand from Residential and Commercial sectors.
05-08	High	Considerable power demand from residences.
08-18	Low	Low power demand due to many people working outside their houses.
18-24	High	Considerable power demand from residences.

Source: Analysis of Nigeria National Electricity Demand Forecast in 2009

Table 4-2 Annual load demand

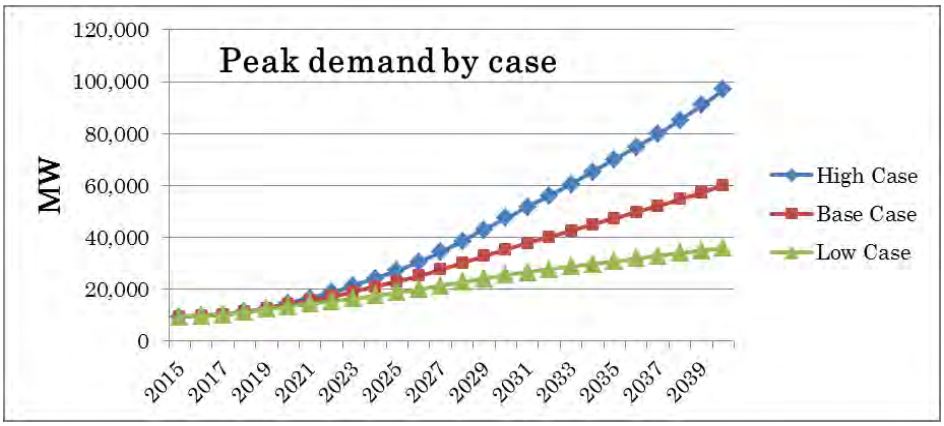
Months	Load	Reasons
Jan. – Apr.	High load	High temperature and low humidity during these months
Jun. – Sep.	Low load	Power demand lower during these months

Source: Analysis of the Nigeria National Electricity Demand Forecast

The peak demand (MW) of computed data is 9,571 MW and the actual peak demand for recorded data was 5,074 MW. In 2016, the power supply covered around half the computed demand. In the recorded demand, Off-grid power demand in regional areas is excluded.

4-2 Power demand under the GDP scenario

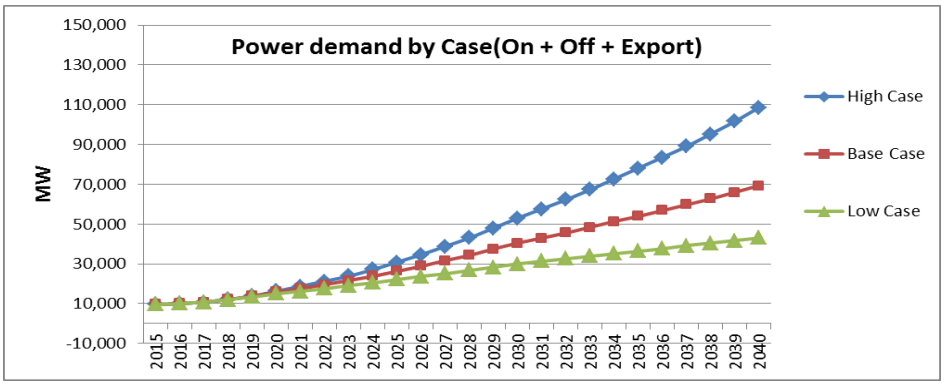
The power demands under the GDP scenario are as shown in the following figure: The average growth rates of GDP in the High case are 7.3% / year from 2015 to 2040 (8.0% per year after 2020), with a base case of 6.1% from 2015 to 2040 (6.5% per year after 2020) and a Low case of 4.8% (5.0% per year after 2020). Moreover, the average peak demand growth rates of cases are 9.9% / year for the High case from 2015 to 2040, 7.8% / year in base case during the same period and 5.6% / year in the Low case during the same period.



Source: JICA Study Team

Figure 4-1 Peak demand by case (TCN + Auto producers)

The nationwide power demand including TCN, Auto producers, Off-grid and Export is shown in the following figure:

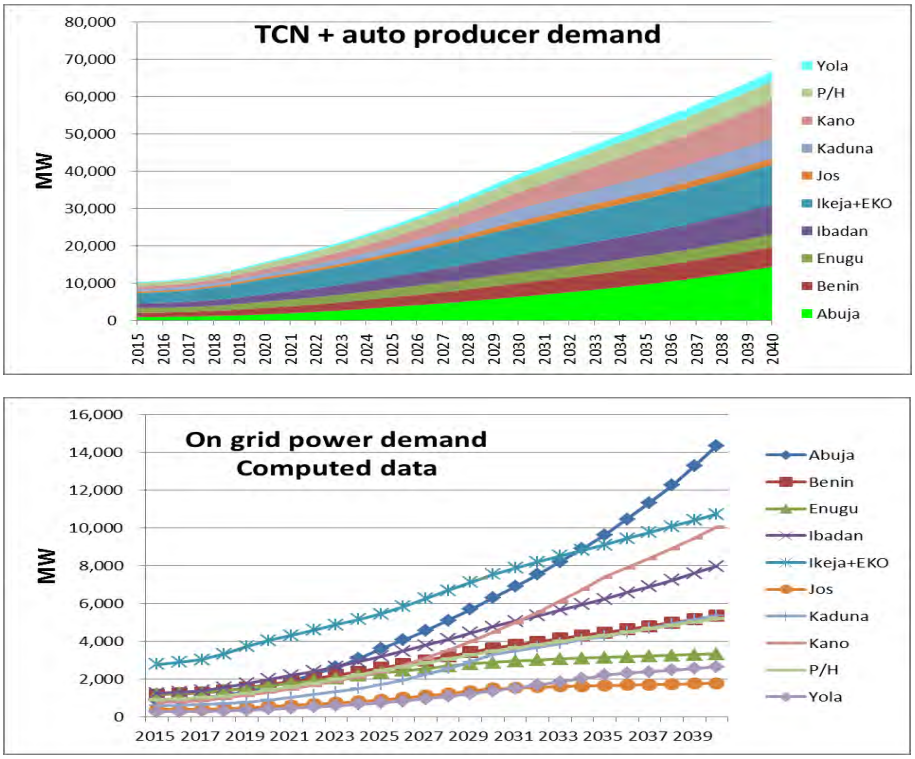


Source: JICA Study Team

Figure 4-2 Power demand by case (On + Auto producers + Off+ Export)

4-3 Power demand forecasts by DisCo

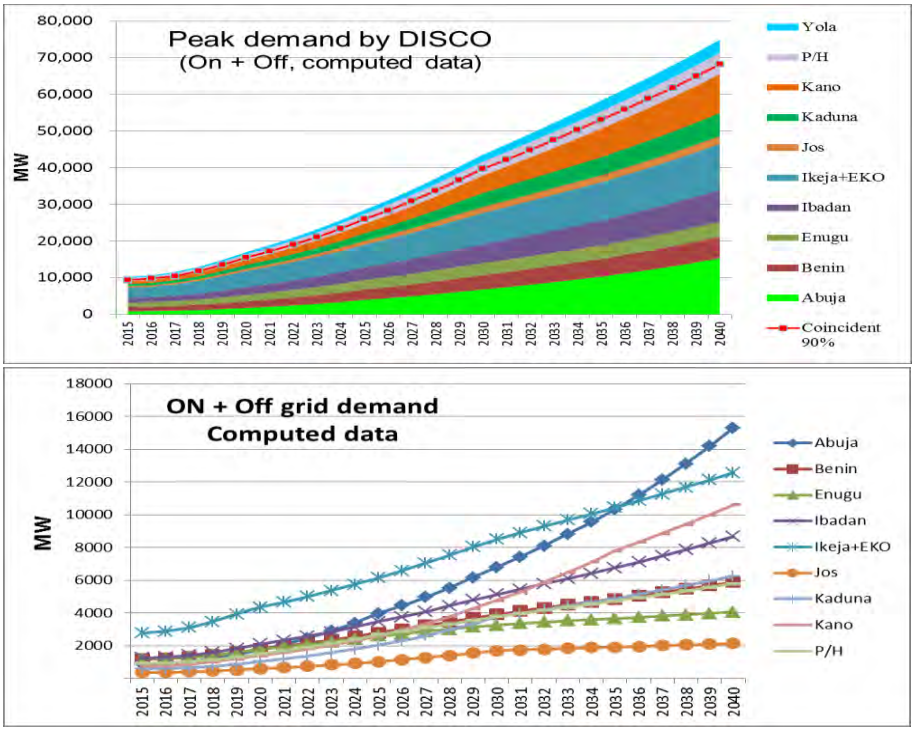
Sectoral and DisCo-wise power demand in the base case are calculated by dividing the sectoral country power demand by the DisCo-wise sector power demand using their number of customers as the denominator. The results are as follows:



Source: JICA Study Team

Figure 4-3 DisCo-wise power demand (TCN + Auto producers)

The DisCo power demands including the above demand (TCN + Auto producers) and Off-grid are follows:



Source: JICA Study Team

Figure 4-4 DisCo-wise power demand (TCN + Auto producers + Off-grid)

Chapter 5 Primary Energy

5-1 Current State of Primary Energy in Nigeria

The current state of primary energy in Nigeria has been studied. The energy resources studied include fossil energy sources such as coal, crude oil, oil products, and natural gas as well as renewable energy including hydropower, solar, wind, biofuel, and waste. The data and information used as a base in the study are statistical data available from the International Energy Agency (IEA), Nigerian NNPC's Annual Statistical Bulletin (ASB), OPEC Annual Statistical Bulletin (ASB), and various publications related to energy from Nigerian governmental organizations. In addition, data available in publications from international study and research organizations are referred to as needed to supplement the study.

Table 5-1 and Table 5-2 show Nigeria's total energy balances and structure of sector-wise energy supply and consumption in 2015, respectively, based on the 2017 IEA Database. The resource columns for nuclear, heat and geothermal, solar, etc. included in the original balance table are omitted as they are either negligibly small or not applicable as of 2015.

Table 5-1 Energy Balance in Nigeria 2015

[Unit in Mtoe]

	Coal	Crude Oil	Oil Products[1]	Natural Gas	Hydro	Biofuel Waste	Electricity	Total
Production	0.03	106.49	0	35.68	0.49	111.57	0	254.26
Imports			10.43					10.43
Exports		-106.25	-0.12	-20.78				-127.15
International marine bunker			-0.37					-0.37
International aviation bunker			-0.36					-0.36
Stock changes		1.61	0.95					2.56
Total Primary Energy Supply (TPES)	0.03	1.86	10.53	14.90	0.49	111.57	0	139.38
Transfers		0.40	-0.35					0.05
Statistical difference				-0.87				-0.87
Transformation (incl. Energy industry own use)	0	2.25	-1.41	10.20	0.49	8.76	-2.16	18.13
Electric power plants		0	0	-5.63	-0.49		2.70	-3.33
CHP plants		0	0					0.00
Oil refineries		-1.76	1.62					-0.14
Other transformation		0	0.00			-8.76		-8.76
Energy industry own use		0	-0.17	-4.57			-0.09	-4.83
Losses		-0.49	-0.04				-0.45	-0.98
Total Final Consumption	0.03	0	11.59	3.94	0	102.80	2.16	120.52
Industry	0.03		0.43	2.56		4.15	0.36	7.50
Transport			8.43			0	0	8.43
Residential			0.54			95.88	1.24	97.66
Commercial & public services			0			2.77	0.56	3.33
Agriculture & forestry			0					0
Fishery			0					0
Other non-specified			2.16					2.16
Non-energy use			0.03	1.38				1.41
(Chemicals/petrochemicals)				(1.38)				(1.38)
Electricity generated - TWh				25.71	5.72			31.43

Source: IEA Database 2017

[1] Total gross oil products input: Import + Stock Change + Products from Oil Refineries = 13.00Mtoe

Notes: 1. Hydropower output is directly converted to tons of oil equivalent (1.0 GWh=86.0 toe)
2. Natural gas input is expressed in "Net", i.e. gross gas production less gas reinjected and flared.

Table 5-2 Constitution of Energy Supply and Consumption in 2015

	Coal %	Crude Oil %	Oil Products %	Natural Gas %	Hydro %	Biofuel Waste %	Electricity %	Total %
Production	0.0	41.9	0.0	14.0	0.2	43.9	0.0	100.0
Imports	0.0	0.0	100.0[2]	0.0	0.0	0.0	0.0	100.0
Exports	0.0	88.6	0.1	16.3	0.0	0.0	0.0	100.0
International marine bunker	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0
International aviation bunker	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0
Stock changes	0.0	62.9	37.1	0.0	0.0	0.0	0.0	100.0
Total Primary Energy Supply (TPES)	0.0	1.3	7.6	10.7	0.4	80.0	0.0	100.0
	Constitutions at Total Primary Energy Supply = 100 [Notes 2&3] [Note 4]							
	%	%	%	%	%	%	%	%
Transformation (incl. Energy industry own use)	0.0	121.0[3]	-10.8	68.5	100.0	7.9	0.0	13.0
Electric power plants	0.0	0.0	0.0	-37.8	-100.0	0.0	100.0	-2.5
CHP plants	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oil refineries	0.0	-94.6	12.5	0.0	0.0	0.0	0.0	-0.1
Other transformation	0.0	0.0	0.0	0.0	0.0	-7.9	0.0	-6.3
Energy industry own use	0.0	0.0	-1.3	-30.7	0.0	0.0	-3.3	-3.5
Losses	0.0	-26.3	-0.3	0.0	0.0	0.0	-16.7	-0.7
Total Final Consumption	100.0	0.0	89.2	26.4	0.0	92.1	80.0	86.5
Industry	100.0	0.0	3.3	17.2	0.0	3.7	13.3	5.4
Transport	0.0	0.0	64.8	0.0	0.0	0.0	0.0	6.0
Residential	0.0	0.0	4.2	0.0	0.0	85.9	45.9	70.1
Commercial & public services	0.0	0.0	0.0	0.0	0.0	2.5	20.7	2.4
Agriculture & forestry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fishery	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-specified	0.0	0.0	16.6	0.0	0.0	0.0	0.0	1.5
Non-energy use	0.0	0.0	0.2	9.3	0.0	0.0	0.0	1.0

Source: IEA Database 2017

The IEA Energy Balance Table presents the energy production, energy supply, energy transformation and total final consumption situations in the respective year on a consistent basis for a whole country. The supply section indicates production, import and export balances to arriving at Total Primary Energy Supply (TPES).

The transformation section indicates energy balances of electricity plants, cogeneration plants, oil refineries and the others (including for coal and fuel wood transformation) as well as those of energy industries own use.

The final consumption section indicates energy consumption for industry, transport, residential, commercial & public services, agriculture & forestry and fishery sectors as well as for non-specified sector and non-energy use.

[2] For oil products, total gross input of oil products = 100 (See Note of Table 5-1.1 above)
[3] Transformation of crude oil is higher than 100%, as other feedstock is processed additionally

5-2 Primary Energy Demand Forecasts

The sum of final energy demand and the fuel consumption in power and other transformation sectors is primary energy.

Table 5-3 Primary Energy Demands (Physical unit)

Year	GDP from Model	LPG	Gasoline(PMS)	Kerosene (ATK)	Kerosene (HHK)	Diesel (AGO)	Fuel oil	Natural gas	Coal	Hydro	Nuclear	RE	Wood & Charcoal
	%	1000 ton	Million liter	Million liter	Million liter	Million liter	Million liter	Million cma	1000ton	ktoe	ktoe	ktoe	1000tons
2015	3.0	141	9,345	113	588	1,197	242	16,565	0	527	0	0	58,660
2016	4.0	152	10,072	121	634	1,273	261	18,419	0	583	0	0	57,850
2017	4.5	168	11,079	132	701	1,381	288	19,544	0	610	0	0	57,051
2018	5.0	188	12,389	147	784	1,526	322	20,979	0	610	0	0	56,263
2019	5.5	213	14,024	165	888	1,703	365	22,779	0	610	0	15	55,486
2020	6.0	241	15,884	186	1,005	1,910	414	23,893	0	868	0	315	54,720
2021	6.0	265	16,938	198	1,106	2,059	455	25,972	0	1,323	0	551	53,660
2022	6.0	291	18,063	211	1,216	2,220	500	27,677	0	1,476	0	768	52,620
2023	6.0	320	19,262	225	1,337	2,394	550	29,610	0	1,489	0	932	51,600
2024	6.0	352	20,541	240	1,470	2,582	605	31,733	0	1,489	0	1,096	50,600
2025	6.0	387	21,905	256	1,615	2,784	664	31,663	2,130	1,614	1,831	1,260	49,620
2026	6.5	415	23,385	273	1,735	2,975	713	33,853	2,130	1,974	1,831	1,424	48,145
2027	6.5	446	24,966	292	1,864	3,181	765	35,790	2,130	2,357	1,831	1,588	46,714
2028	6.5	478	26,653	312	2,002	3,400	821	38,002	2,840	2,403	2,746	1,752	45,325
2029	6.5	513	28,454	333	2,151	3,634	881	40,828	2,840	2,448	3,662	1,916	43,977
2030	6.5	551	30,377	355	2,311	3,884	946	44,614	2,840	2,494	3,662	2,081	42,670
2031	6.5	586	32,338	378	2,460	4,135	1,007	46,908	3,550	2,539	4,577	2,143	41,401
2032	6.5	623	34,336	401	2,612	4,391	1,069	49,563	3,550	2,585	5,493	2,242	40,171
2033	6.5	660	36,414	426	2,770	4,657	1,133	53,044	3,550	2,630	5,493	2,329	38,976
2034	6.5	698	38,522	450	2,931	4,926	1,199	55,576	4,260	2,630	6,408	2,454	37,818
2035	6.5	737	40,636	475	3,092	5,196	1,265	58,494	4,260	2,630	7,323	2,566	36,693
2036	6.5	776	42,812	500	3,257	5,475	1,333	61,858	4,970	2,630	7,323	2,715	35,603
2037	6.5	816	44,993	526	3,423	5,753	1,400	65,620	4,970	2,630	7,323	2,840	34,544
2038	6.5	857	47,257	552	3,595	6,043	1,471	69,447	4,970	2,630	7,323	2,964	33,517
2039	6.5	900	49,660	580	3,778	6,350	1,546	73,214	5,680	2,630	7,323	3,114	32,521
2040	6.5	946	52,149	610	3,967	6,669	1,623	77,464	5,680	2,630	7,323	3,263	31,554
2040/15	6.1	7.9	7.1	7.0	7.9	7.1	7.9	6.4	6.8	6.6	9.7	6.5	−2.4

Note: Natural gas for LNG is not included
Source: PSD

Table 5-4 Primary Energy Demand Forecasts (Oil equivalence unit: ktoe)

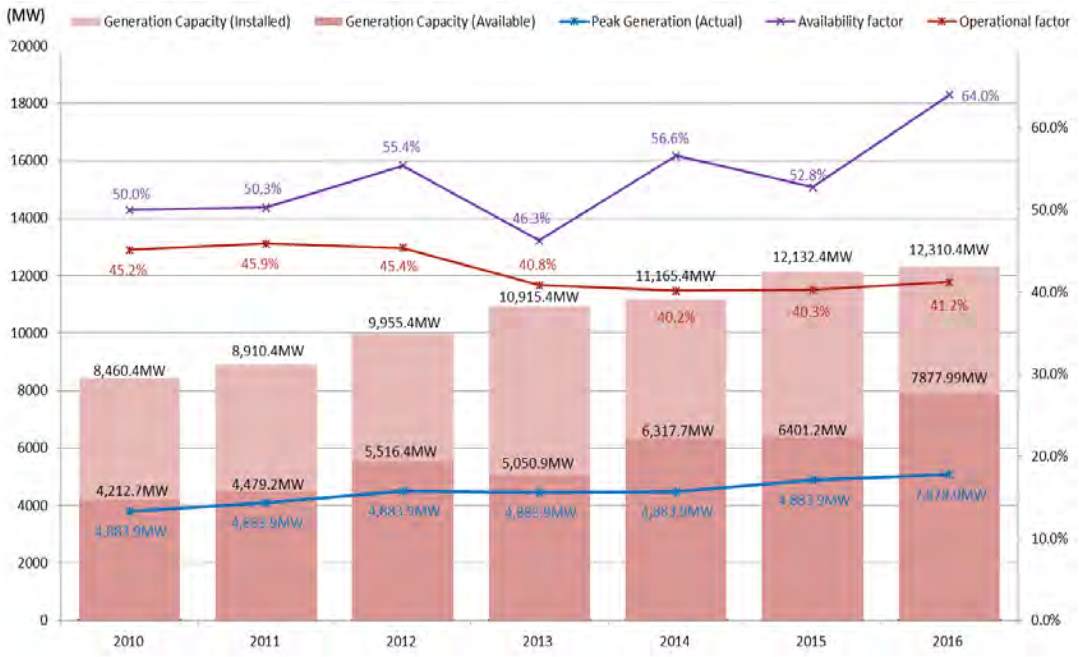
Year	GDP from Model	LPG	Gasoline(PMS)	Kerosene (ATK)	Kerosene (HHK)	Diesel (AGO)	Fuel oil	Natural gas	Coal	Hydro	Nuclear	RE	Wood & Charcoal	Total
	%	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2015	3.0	153	7,402	94	487	1,043	210	14,296	0	527	0	0	24,900	49,111
2016	4.0	165	7,977	100	525	1,109	226	15,896	0	583	0	0	24,600	51,182
2017	4.5	183	8,775	109	580	1,203	250	16,867	0	610	0	0	24,200	52,777
2018	5.0	204	9,812	122	649	1,329	280	18,105	0	610	0	0	23,900	55,011
2019	5.5	231	11,107	136	735	1,484	317	19,659	0	610	0	15	23,600	57,894
2020	6.0	262	12,580	154	832	1,664	359	20,621	0	868	0	315	23,300	60,954
2021	6.0	288	13,415	164	915	1,794	395	22,415	0	1,323	0	551	22,800	64,061
2022	6.0	317	14,306	175	1,007	1,934	434	23,886	0	1,476	0	768	22,400	66,702
2023	6.0	348	15,256	186	1,107	2,086	478	25,554	0	1,489	0	932	21,900	69,335
2024	6.0	383	16,269	199	1,216	2,249	525	27,386	0	1,489	0	1,096	21,500	72,311
2025	6.0	421	17,349	212	1,336	2,425	577	27,326	1,193	1,614	1,831	1,260	21,100	76,643
2026	6.5	451	18,521	226	1,436	2,592	619	29,216	1,193	1,974	1,831	1,424	20,500	79,984
2027	6.5	484	19,773	241	1,542	2,770	664	30,888	1,193	2,357	1,831	1,588	19,900	83,234
2028	6.5	520	21,109	258	1,657	2,961	713	32,798	1,590	2,403	2,746	1,752	19,300	87,807
2029	6.5	558	22,536	275	1,780	3,166	765	35,237	1,590	2,448	3,662	1,916	18,700	92,633
2030	6.5	599	24,059	294	1,912	3,384	821	38,504	1,590	2,494	3,662	2,081	18,100	97,498
2031	6.5	637	25,612	313	2,036	3,602	874	40,483	1,988	2,539	4,577	2,143	17,600	102,404
2032	6.5	677	27,194	332	2,162	3,825	928	42,775	1,988	2,585	5,493	2,242	17,100	107,300
2033	6.5	718	28,840	352	2,293	4,056	984	45,779	1,988	2,630	5,493	2,329	16,600	112,062
2034	6.5	759	30,509	373	2,425	4,291	1,041	47,965	2,386	2,630	6,408	2,454	16,100	117,341
2035	6.5	801	32,184	393	2,558	4,526	1,098	50,482	2,386	2,630	7,323	2,566	15,600	122,548
2036	6.5	844	33,907	414	2,695	4,769	1,157	53,386	2,783	2,630	7,323	2,715	15,100	127,724
2037	6.5	887	35,634	435	2,833	5,012	1,216	56,632	2,783	2,630	7,323	2,840	14,700	132,925
2038	6.5	932	37,428	457	2,975	5,264	1,277	59,935	2,783	2,630	7,323	2,964	14,200	138,169
2039	6.5	979	39,331	480	3,126	5,532	1,342	63,186	3,181	2,630	7,323	3,114	13,800	144,024
2040	6.5	1,028	41,302	504	3,283	5,809	1,409	66,855	3,181	2,630	7,323	3,263	13,400	149,988
2040/15		7.9	7.1	7.0	7.9	7.1	7.9	6.4	6.8	6.6	9.7	6.5	−2.4	4.6

Note: Natural gas for LNG and export is not included
Source: PSD

Chapter 6 Power Generation Development Plan

6-1 Power Generation Situation in Nigeria

The actual power supply from 2010 to 2016 in Nigeria shows the installed generation capacity increasing every year, reaching 12,310 MW in 2016 as shown in Figure 6-1. Moreover, although the ratio of available generation capacity relative to installed generation capacity is improving, it declined to around 50% at its lowest point, underlining the wide gap between the available capacity and national peak demand forecast. The national peak demand benchmarks Nigeria's potential power demand assuming an unhindered power supply. Actually, due to power supply restrictions such as planned outages, the actual power supply doesn't satisfy national peak demand in Nigeria. While the available capacity was 7,743MW, the peak demand forecast was 14,630 MW[4] in 2017. This underlines the urgency of examining generation constraints as well as planning new forms of power generation.



Source: TCN Annual Technical Report 2010-2016

Figure 6-1 Power Supply Record in Nigeria (2010-2016)

6-2 Condition of Power Development Planning

6-2-1 Thermal power

Thermal power development in future will be covered by private investment due to the privatization of thermal power in the power sector.

Projects under construction and NERC-licensed IPPs in thermal power development are defined as already decided. NERC-licensed projects are judged as highly likely and with high-grade maturity.

[4] TCN, "Transmission Expansion Plan, Development of a Power System Master Plan for the Transmission Company of Nigeria", December 2017

Future possible power development, excluding the development decided upon, will be input to the power development formulation software (WASP: Wien Automatic System Planning Package).

Table 6-1 shows the parameters of combined cycle, simple-cycle gas turbine and planned coal-fired power plant to be targeted as candidate model plants for power development planning in this study; notwithstanding the possibility of domestic fuel and already launched in Nigeria.

Table 6-1 Parameters of candidates on thermal power development

Type	Model [degree Celsius]	Capacity	Heat efficiency[5]	Unit Price[6]	Construction Period	Lifetime
Simple-cycle gas turbine	1,100-degree centigrade class	100MW class	30.8%	US $980/kW	Two years	30 years
	1,100-degree centigrade class	200MW class	34.7%	US $680/kW	Two years	30 years
Combined-Cycle Gas Turbine	1,100-degree centigrade class, Single Shaft	300MW class	51.4%	US $980/kW	Three years	30 years
	1,300-degree centigrade class, Single Shaft	500MW class	54.0%	US $941/kW	Three years	30 years
	1,300-degree centigrade class, Multiple spindle	1,000MW class	55.1%	US $842/kW	Three years	30 years
Coal-fired	Subcritical pressure	300MW class	40.7%	US $2,500/kW	Four years	40 years
	Ultra-supercritical	700MW class	42.1%	US $2,000/kW	Four years	40 years
	Ultra-supercritical	1,000MW class	43.0%	US $2,000/kW	Four years	40 years

6-2-2 Hydropower

(1) New hydropower development sites

1) Method of candidate site selection

Tractebel Engineering (France) has surveyed potential hydropower sites in Nigeria, which comprise those already identified sites by FMPWH and additional potential sites newly identified. The latter category is based on the "National Water Resources Master Plan 2013, Supporting Report 04" executed by JICA (January 2014), which presents the coordinates of potential sites and most of the main dam characteristics.

Additional potential sites newly identified are found by Tractebel Engineering using an ISHY tool in conjunction with ArcGIS software and Google Earth research. The ISHY tool is used to automatically identify potential hydropower sites where the river slope could create a significant hydraulic head between a dam upstream and a powerhouse downstream with a reasonable height. The research is based on identifying the steepest river slopes and identifies sites with a significant hydraulic head, including possible redirection of river bends. All the project sites identified are categorized into three types as

[5] HHV (Higher Heating Value) basis
[6] "Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants" (US-EIA), Gas Turbine World Handbook

small (5～20 MW), medium (20～100 MW) and large (>100 MW) installed capacity respectively.

Those potential sites are tabled in river basin, project location, project cost, economic feasibility and project environmental status adoption comments for large-, medium- and small-scale, respectively.

6-2-3 Nuclear

In March 2016, the minister of FMPWH declared that all procurement activities for the first nuclear power plant with a generation capacity of 1,200MW to the national grid by 2025 would be performed as scheduled. The two sites selected by the Nigeria Atomic Energy commission are located in Geregu in the Ajaokuta Local Government Area of Kogi-State and the Itu Local Government Area of Akwa Ibom State. These projects are to be financed through Public-Private Participation policy for infrastructural development nationwide, aiming to increase it to 4,800MW by 2035.[7]

Also, the IAEA (International Atomic Energy Agency) periodically dispatches its mission to Nigeria to monitor preparation for nuclear power development, which it deems smooth. Furthermore, according to the NAEC (Nigeria Atomic Energy Commission) there is no problem with LGA (Local Government Area) and communities in and around the nuclear power development sites and the reactor type is WWER-1200 to be constructed under BOT (Build Operate and Transfer) scheme by a Russian company.

Based on the above, it is judged that nuclear power development is proceeding in line with Nigeria's energy policy and nuclear power is considered as a generation expansion candidate.

6-2-4 Renewable energy

Renewable energy power projects such as solar and wind are to be developed as IPP by the private sector. Therefore, ongoing and planned renewable power projects shown in Table 6-2 are considered candidates for the generation expansion plan.

Table 6-2 Renewable power candidates

Name of projects	Type	Rated capacity (MW)
PAN AFRICA SOLAR	Solar	75
NIGERIA SOLAR CAPITAL PARTNERS	Solar	100
NOVA SOLAR	Solar	100
MOTIR DUSABLE	Solar	100
LR AARON SOLAR POWER PLANT	Solar	100
MIDDLE BAND SOLAR	Solar	100
AFRINERGIA SOLAR	Solar	50
NOVA SCOTIA POWER	Solar	80
KVK POWER NIGERIA LTD	Solar	55
QUAINT ENERGY SOLUTIONS	Solar	50
ANJEED KAFACHAN SOLAR IPP	Solar	100
CT COSMOS	Solar	70
ORIENTAL	Solar	50
EN Consulting & Projects - Kaduna	Solar	100

[7] Federal Ministry of Power, Works and Housing, Press and Public Relations (Power) (16 March, 2016) "FG Committed to diversifying Electricity Generation with Nuclear Energy- Fashola"

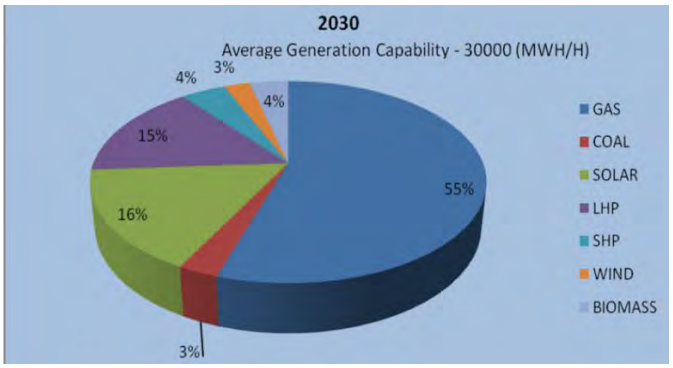
KAZURE (KANO DisCo)	Solar	1000
JBS Wind Power Plant	Wind	100

Source: TCN

6-3 Analysis on Generation Expansion Scenarios

6-3-1 Scenario Setting for Generation Expansion Plans

In Nigeria, the energy mix target in power generation toward 2030 is set as shown in Figure 6-2. Since the power generation sector in Nigeria is already privatized, all power generation other than hydro and nuclear power which will be developed as a national project shall be developed by private investors. Accordingly, three generation expansion Scenarios as shown in Table 6-3 are set based on ongoing and planned IPP projects as well as hydro and nuclear power projects to be implemented by the Federal Government.



Source: Federal Ministry of Power Works and Housing (June 2016)
"The Nigerian Power Sector Investment Opportunities and Guidelines"

Figure 6-2 Energy mix target in power generation

Table 6-3 Generation Expansion Scenarios

Type	Energy Mix Target of Nigeria	Scenario 1 In line with ongoing and planned IPPs	Scenario 2 More renewable than Scenario 1	Scenario 3 In line with the Energy Mix Target
Gas	55%	70%	65%	55%
Coal	3%	3%	3%	3%
Hydro	Total: 19% Large: 15% Small: 4%	16%	16%	16%
Renewable Energy	Total: 23% Solar: 16% Wind: 3% Biomass: 4%	5%	10%	20%
Nuclear	-	6%	6%	6%
Non-carbon origin*	42%	27%	32%	42%

Remarks: *: The total of hydro, renewable and nuclear
The% shares indicated in the above table are calculated based on the rated generation capacity

Source: JICA Study Team

6-3-2 Comparison of Generation Expansion Scenarios

The summarized total generation costs and the CO_2 emissions in each Scenario are shown in Table 6-4.

Table 6-4 Comparison of generation expansion Scenarios

	1	2	3
Total generation capacity as of 2040	54,927MW (Base)	58,727MW (+7%)	66,127MW (+20%)
Accumulated total generation cost by 2040 (Investment +fuel +O&M)	US$ 204,556 million (Base)	US$ 210,315 million (+3%)	US$ 214,646 million (+5%)
Accumulated CO_2 emissions by 2040	1,008 million tons (Base)	1,002 million tons (-1%)	957 million tons (-5%)
Need for power system stabilization measures due to increased renewable energy	Not necessary	Necessary	Necessary

Remarks: Figures in parentheses indicate the rate of increase or decrease compared to Scenario 1.

6-4 Evaluation of Generation Expansion Scenarios

As for Scenario 1, 70% of gas-fired power plants included in the expansion candidates are simple-cycle gas turbines while the remaining 30% are combined-cycle. The thermal efficiency of the combined cycle outperforms the simple-cycle gas turbine, while when both are compared in terms of energy generated, the combined cycle consumes 33% less fuel compared to the simple-cycle gas turbine. By converting simple cycle to be developed as IPP to combined cycle, CO_2 emissions can be reduced. For example, by converting 50% of the simple-cycle gas turbine included in Scenario 1 to combined cycle, CO_2 emissions from Scenario 1 can be reduced by 10%. The unit construction cost of the 100MW class gas turbine is almost equivalent to that of the 300MW class combined cycle, meaning no huge burden on private investors from this conversion.

As for Scenario 3, further cost reduction depends on renewable energy power plants becoming cheaper and grid stability systems. Although these costs will be reduced in future, but it is difficult to forecast when and how much. Furthermore, such cost reduction cannot be controlled by the regulations and incentives of the government.

Generation expansion Scenarios are evaluated from the perspectives of overall generation cost, CO_2 emissions and the impact on power system stability. As shown in Table 6-5, Scenario 1 is top-ranked of the three Scenarios. Under the circumstances described above, it would be better and more realistic to take Scenario 1 as the basis of the generation expansion plan and improve it by converting simple-cycle gas turbines to combined-cycle with government regulations and incentives. Efficient gas-fired power generation is recommended by INDC as a measure to reduce greenhouse gases. Accordingly, this Scenario conforms to the government' policy on climate change.

Table 6-5 Evaluation of generation expansion Scenarios

	Scenario-1	Scenario-2	Scenario-3
Total generation cost	3	2	1
CO_2 emissions	1	2	3
Impact on power system stability	3	2	1
Overall rating (Total)	7	6	5

Remarks: As for ratings, three is the highest and one the lowest.

Chapter 7 Transmission network development plan

7-1 Outline of Transmission Network in Nigeria

7-1-1 Difficulties and Challenges Faced by TCN

The electric power system of Nigeria has long suffered from a lack of generation capacity which requires permanent load shedding. Furthermore, frequent transmission and distribution system disturbances exacerbate the unreliability of the power system.

The main reasons for power shortages are outages of generation units and a lack of gas to generate power. The gas supply is frequently interrupted due to the pipeline network being sabotaged.

The main concern for the future expansion of generation, however, is the availability of gas for additional generation capacity and the expansion of the gas pipeline network. Currently, most power plants are installed in southern Nigeria close to oil and gas fields. To ensure a reliable and optimally expanded transmission system, there will be a need to install new power plants also elsewhere in Nigeria.

There are some plans for new hydro power plants, while photovoltaic and wind power plants are also under consideration.

However, to provide sufficient base load power in future, large coal-fired power plants may have to be included in the generation expansion program.

In terms of generation and load balance in the eight TCN planning regions, four or five have a significant generation deficit. With the exception of Benin and Port Harcourt regions, demand exceeds available generation power in all others. In the Shiroro region however, the situation will be reversed once new HPP plants (e.g. Zugeru) come into operation.

The reason for this imbalance is due to the generation being mainly concentrated in South (thermal stations in Port Harcourt, Enugu, Benin and Lagos) and Central West (hydro stations of Jebba, Kainji and Shiroro in Shiroro region). The Central, North and North-East in particular are characterized by the total absence of generating stations, while load demand is mainly in the South and South-West.

To supply power in areas with little or no generation such as the North-East, long 330 kV transmission lines are built (radial system), which means voltage regulation problems may occur and the reactive power flowing through them necessitates large reactive power compensation equipment (reactors) at the corresponding substations (Kano, Gombe, Maiduguri).

Additional 330 kV lines running in parallel are expected to exacerbate overvoltage issues, necessitating additional compensation equipment at Yola, Jalingo and other substations.

7-1-2 Power Pool With Neighboring Countries

The sphere of operations of the Transmission Company of Nigeria transcends the geographical landscape of the country; the Republics of Niger and Benin are interconnected with the Nigerian transmission network.

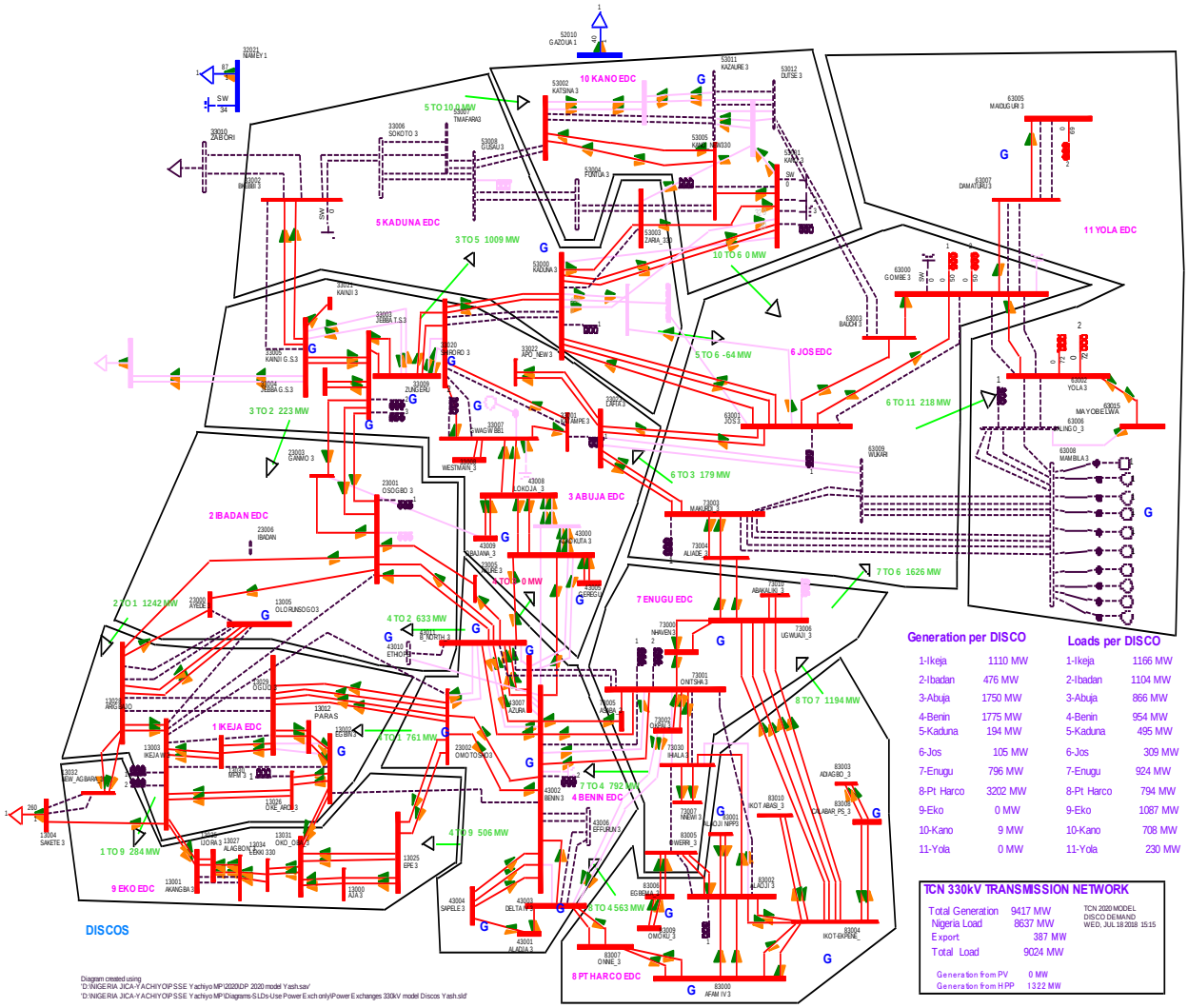
The energy supplied to Benin Republic in 2016 was 1,275 GWH, signifying a decrease of 16.95% when compared with the 2015 figure of 1,535 GWH. The Republic of Niger was furnished with energy of 666 GWH in 2016, which is lower than the 2015 supply of 692 by 3.77%. These values represent only energy delivered through the 132kV transmission lines only. A fraction of the total supply to that country was through some 33kV distribution feeders.

7-2 Expansion plan for 2020

Figure 7-1 below shows the 330-kV transmission system in 2020 (red lines), assuming all the ongoing and committed TCN, NIPP and certain JICA new projects will be completed by 2020.

The diagram shows the running generation and load in each DisCo area and the power flows between DisCos.

Dotted lines and lines in magenta denote future projects beyond 2020, which were analyzed in the study of the corresponding year and reported accordingly in this report.



Source: JICA Study Team

Figure 7-1 330 KV Transmission System 2020

7-3 Examination of the need for a Supergrid

7-3-1 Requirement for Supergrid (330, 500 or 750 kV)

The load-flow simulations with generation and load, as detailed in the previous Section, showed that without a major upgrade of the transmission system, widespread undervoltages and overloads will proliferate throughout the system and at all voltage levels, leading to high system losses. It is therefore considered necessary and appropriate at this stage to roll out the new "supergrid" in full, i.e. a backbone for bulk transmission at 330, 500 or 750 kV.

With regards to the conductor necessary for each supergrid option, the following arrangements are recommended:

- At 330 kV a Double-Circuit is proposed with 4-bundle (Quad) Bison conductors for each circuit.
- At 500 kV a Single-Circuit is proposed with 4-bundle (Quad) Bison conductors.

At 750 kV a Single-Circuit is proposed with 5-bundle Bison conductors, which is typical at this voltage level due to corona phenomenon.

7-3-2 Conclusion on Supergrid/EHV Options

The load-flow simulations have shown that without a major upgrade of the transmission system, widespread undervoltages and overloads will proliferate system-wide and at all voltage levels, meaning high system losses.

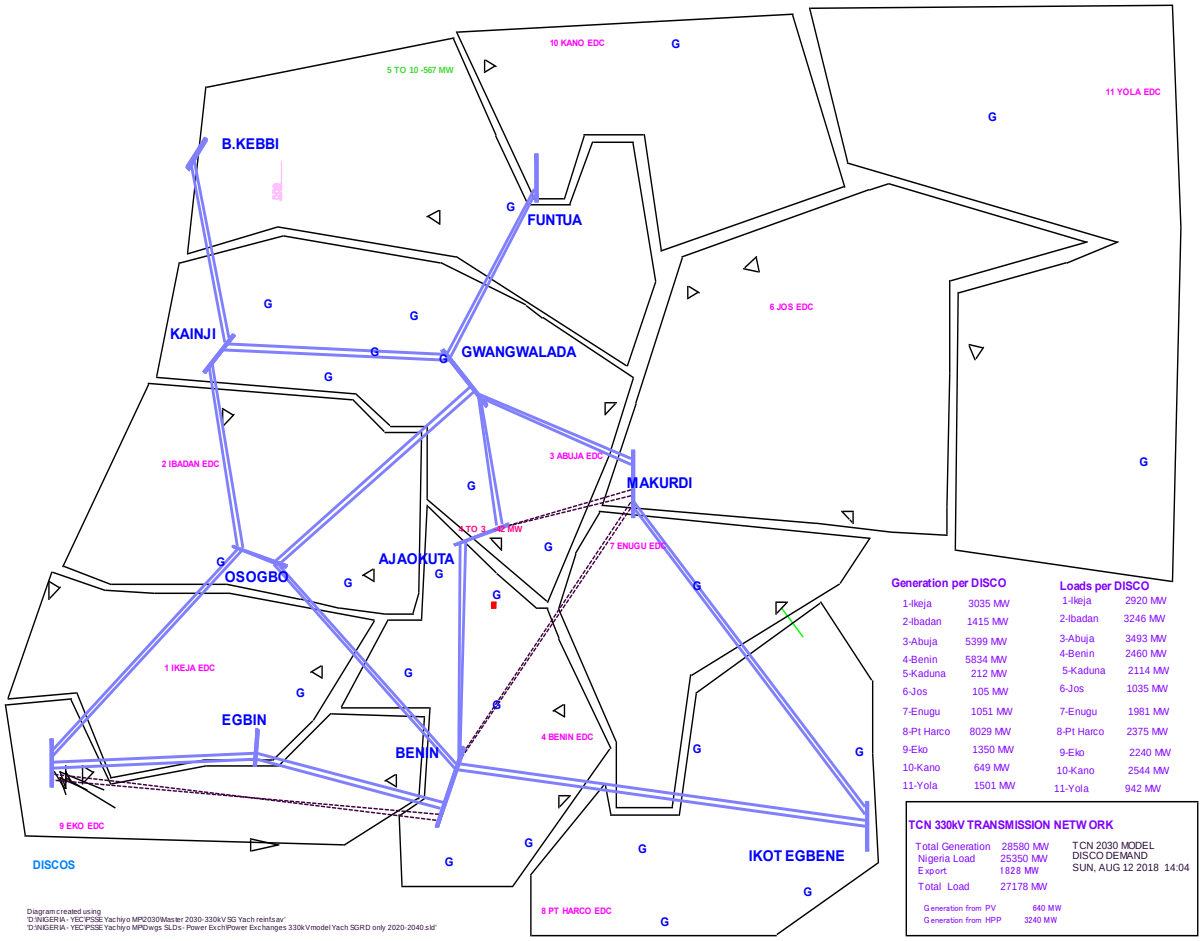
It is therefore considered necessary and appropriate at this stage to introduce the full new "supergrid", i.e. a backbone for bulk transmission at either 330, 500 or 750 kV. It was found necessary to introduce part of this supergrid.

A number of configurations have been examined and compared in terms of efficacy in voltage support, system losses and easing the line loadings of the existing and planned 330 kV systems.

The optimum configuration of a 330, 500 or 750 kV EHV grid is shown in Figure 7-2.

Table 7-1 Evaluation of 330, 500 or 750 kV supergrid

Voltage level	Voltage support	System loss	Stability	Cost	Comprehensive evaluation
330 kV	A	A	A	B	1
500 kV	B	A	B	A	2
750 kV	B	A	B	C	3



Source: JICA Study Team

Figure 7-2 Supergrid Configuration

The supergrid will encompass the following substations: Ikot-Ekpene, Benin, Egbin, Ajegunle (New Agbara), Osogbo, Gwangwalada, Makurdi, Ajeokuta, Funtua, Kainji, Bernin Kebbi.

From technical perspectives, both the 330 and 500 kV options are adequate. Furthermore, taking into consideration that:

- Capacity of 330 kV supergrid lines: 3,100 MVA
- Capacity of 500 kV supergrid lines: 2,350 MVA
- Difference in losses between 330 and 500 kV supergrids: Marginal
- Impact on O/U voltages and overloads: 330 kV advantageous
- Higher static N-1 security of the 330 kV supergrid due to the Double-Circuit lines involved

It appears that the 330 kV supergrid system is technically the preferred option.

There is no justification to adopt and/or consider further any higher (750 kV) option for the EHV grid, particularly when the implications in cost differences are taken into account.

The higher transmission capacity (4,400 MVA) is not required at this stage and the marginal differences in losses cannot offset the high investment cost required in the planning horizon of this Master Plan.

The following table summarizes the Double-Circuit 330kV transmission lines required to complete the supergrid for the 2030 system requirements. Part of this supergrid transmission system is required by 2025, as mentioned in the previous sections:

Table 7-2 Supergrid lines for 2030

From	To	Thermal rating (MVA)	Length (km)	Remarks
Ikot-Ekpene	Benin	2 x 1,550	300	
Ikot-Ekpene	Makurdi	2 x 1,550	320	Required in 2025
Benin	Egbin	2 x 1,550	230	
Egbin	Ajegunle (New Agbara)	2 x 1,550	50	
Benin	Osogbo	2 x 1,550	200	
Ajegunle (New Agbara)	Osogbo	2 x 1,550	150	
Osogbo	Kainji	2 x 1,550	200	
Benin	Ajeokuta	2 x 1,550	150	
Ajeokuta	Gwangwalada	2 x 1,550	150	Required in 2025
Gwangwalada	Makurdi	2 x 1,550	180	Required in 2025
Gwangwalada	Kainji	2 x 1,550	250	
Gwangwalada	Funtua	2 x 1,550	260	Required in 2025
Gwangwalada	Osogbo	2 x 1,550	250	Required in 2025
Kainji	Bernin Kebbi	2 x 1,550	300	

Source: JICA Study Team

(*) Note on the introduction of the "supergrid" in 2025:

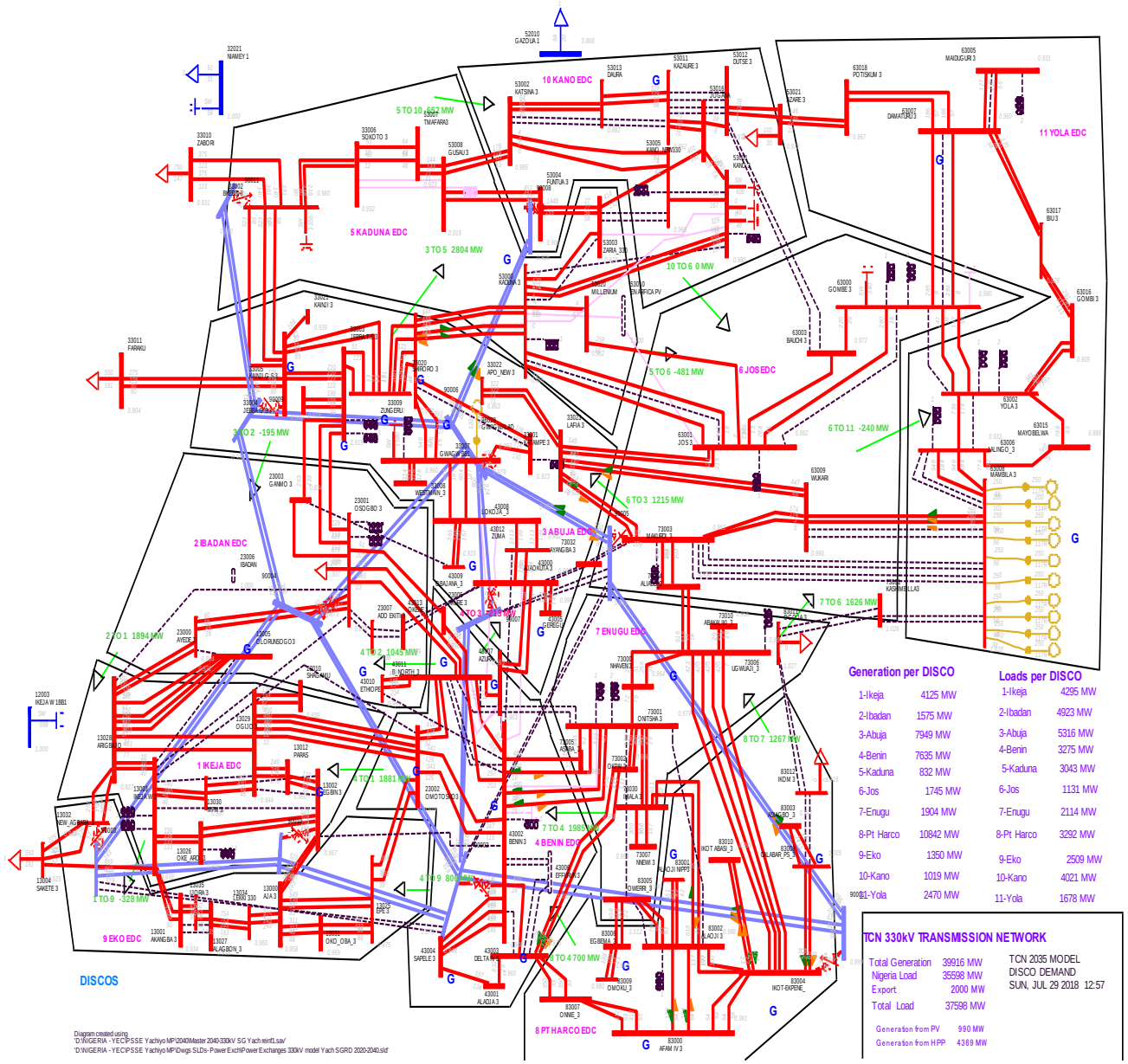
The supergrid is to be fully rolled out in 2030 and its necessity is demonstrated in Section 7-6. However, due to the forecast high increase in load demand in the Abuja region and elsewhere by 2025 plus resulting overloads and undervoltages, the most cost-effective approach will involve introducing part of the supergrid in 2025, to avoid other temporary and potentially costly measures which will not be needed after the full roll-out of the supergrid in 2030.

A full analysis of the supergrid and justifications for the selection of the appropriate voltage level and conductor type option is given in Section 7-6.

7-4 Expansion Plan for 2040

7-4-1 2035 base cases load-flow analysis

Figure 7-3 below shows the 330kV transmission system in 2040.



Source: JICA Study Team

Figure 7-3 Configuration of 330 kV grid in 2040

No voltage violation encountered in the 330 and 132 kV systems.

A few minor voltage violations at 132 kV will be corrected when the 132-kV network is reinforced to meet the N-1 criterion, as proposed earlier.

With regards to thermal overloads of the 330-kV system, the following lines are overloaded and need to be reinforced:

- Aladja - Delta IV
- Osogbo – Ganmo

Chapter 8 Environmental and Social Considerations

8-1 SEA Approach of the Master Plan development

(1) Alternative scenario development

In the Master Plan, based on the power configuration target (Energy Mix Target) of 2030, three alternative scenarios of power development, as described below, are set up in consideration of ongoing and planned IPP projects and national projects such as hydropower and nuclear power. The scenarios comprise various fuels and power sources in terms of the optimum configuration (refer to Chapter 6-3).

Scenario 1: Scenario based on ongoing and planned IPP projects

Scenario 2: Scenario with a higher percentage of renewable energy than Scenario 1

Scenario 3: Scenario with the highest percentage of renewable energy
(corresponding to the Energy Mix Target)

Gas-fired power generation remains the mainstream. However, more than half the gas-fired power currently included in the development candidate constitutes simple-cycle gas turbines, which are less efficient compared to combined cycles. Considering the fact that INDC mentions CO_2 reduction by introducing high-efficiency gas thermal power, half the simple cycle power in the development candidate is converted to a combined cycle in each scenario, whereupon six cases are analyzed for the alternative comparison.

Table 8-1 Power development scenarios in 2030

Configuration		Scenario					
		1		2		3	
		S1-1	S1-2	S2-1	S2-2	S3-1	S3-2
Gas-fired		70%	70%	65%	65%	55%	55%
	SC	49%	24%	46%	23%	38%	19%
	CC	21%	46%	19%	42%	17%	36%
Renewable		5%	5%	10%	10%	20%	20%
Coal-fired		3%					
Hydro		16%					
Nuclear		6%					

SC: Simple-cycle CC: Combined cycle

* Scenario 1-2 is the case that 50% of the simple cycle (which occupies 70% of total gas-fired) is converted to the combined cycle. Scenarios 2-2 and 3-2 are set likewise.

* Coal-fired, hydro and nuclear power configurations are based on ongoing and planned projects, so there is no difference among the scenarios.

Source: JICA Study Team

8-2 SEA implementation

8-2-1 Impact analysis of alternative scenarios

Each scenario is scored in terms of total cost, the need for system stabilization measures, CO_2 emissions and environmental and social impacts, with a maximum of three points in each category and the total scores of the scenarios are compared.

Table 8-2 Scenario alternatives comparison (with environmental and social considerations)

Category		Scenario					
		S1-1	S1-2	S2-1	S2-2	S3-1	S3-2
1	Total cost by 2040 (Million USD)	204,556	204,556	210,315	210,315	214,646	214,646
	Point	3.0	3.0	2.0	2.0	1.0	1.0
2	Need for system stabilization measures due to renewable energy connection	No	No	Yes	Yes	Yes	Yes
	Point	3.0	3.0	1.5	1.5	1.5	1.5
3	CO_2 emission by 2040 (Million t)	1,008	907.2	1,002	901.8	957	861.3
	Point	0.5	2.0	1.0	2.5	1.5	3.0
4	Environmental and social impact (except climate change)	0.48	0.48	0.47	0.47	0.45	0.45
	Point	1.0	1.0	2.0	2.0	3.0	3.0
Point total		7.5	**9.0**	6.5	8	7	8.5

Based on the abovementioned six scenario comparisons, S1-2 receives the highest points score. Although S1-2 has the lowest environmental and social impact due to the low percentage of renewable power, installing a combined-cycle gas-fired system paves the way for a scenario of fewer CO_2 emissions at the lowest cost. Scenario 1 includes power generation projects involving gas-fired, coal-fired, hydro, nuclear and renewable energy (solar and wind). The preferred scenario involves converting half the simple-cycle gas-fired plants to the combined cycle in Scenario 1.

In Nigeria, INDC targets 13GW of off-grid solar power by 2030 and NPCC has introduced at least 20% renewable energy by 2030. When 13GW off-grid solar power is installed by 2030, the total generating capacity would become 67,927MW (on- and off-grid) in case of S1-2. Considering that 5% of S1-2 (2,746MW) is renewable energy, approximately 23% of electricity (15,746MW) in Nigeria would be generated by renewable energy. Accordingly, even in the case of Scenario 1, the lowest renewable energy case, the target stated in NPCC would be achievable.

8-2-2 Mitigation measures

The preferred scenario targets CO_2 reduction with an efficient gas-fired system, so priority power generation projects are apparently gas-fired. However, specific projects cannot be chosen at this stage due to Nigeria's decision that thermal power will be further fully developed by the private sector. In addition, the transmission development plan includes various rehabilitation and new installation of transmission lines based on technical analysis with the power generation scenario, but individual routes of the lines have not been discussed at this stage. In this Master Plan, the framework of the survey contents, mitigation measures and monitoring from environmental and social considerations is developed for a gas-fired power plant and a transmission line in general, in accordance with key environmental items. It is essential for an individual project to fully perform EIA considering the project's unique characteristics and referencing this framework.

Chapter 9 Economic and Financial Analysis

9-1 Economic Analysis

9-1-1 Objective and Methods

(1) Objective

In this economic analysis, the economic viability of the Master Plan is assessed from the perspective of the national economy of Nigeria. A cost-benefit analysis is conducted to examine the magnitude of the economic benefits brought by implementing the Master Plan in comparison with the costs, i.e. the value of resources used for the Master Plan implementation as shown in economic costs.

9-1-2 Results of Economic Analysis

(1) Estimated Indicators to Show Economic Viability

The estimated economic internal rate of return (EIRR), benefit-cost ratio (B/C) and net present value (NPV, at a discount rate of 10%) are shown in Table 9-1. The Master Plan is economically viable and to be implemented to develop the national economy efficiently, as the EIRR exceeds the cut-off rate of 10%, the B/C surpasses 1.0 and the NPV is positive.

Table 9-1 Estimated Indicators on Economic Viability of the Master Plan

Economic Internal Rate of Return (EIRR)	15.1%
Benefit-cost Ratio (B/C)	1.22
Net present Value (NPV, at discount rate of 10%, USD million)	18,448

Source: JICA Study Team

(2) Results of the Sensitivity Analysis

The EIRRs, B/Cs and NPVs, given a 22% increase in the investment and O&M costs and an 18% decrease in benefits, are shown in Table 9-2. In these cases, the EIRRs are close to the cut-off rate of 10% and the B/Cs are almost 1.00. If the cost increases or the benefit decreases further, the Master Plan would no longer be economically viable.

Table 9-2 Results of the Sensitivity Analysis

Case	EIRR	B/C	NPV
22% increase in costs	10.1%	1.00	USD 240 million
18% decrease in benefits	10.1%	1.00	USD 230 million

Source: JICA Study Team

9-2 Financial Analysis

9-2-1 Objective and Methods

(1) Objective

In this financial analysis, the financial soundness of the Master Plan is assessed by comparing the investment and O&M costs and revenues for power generating and transmitting entities. Suggestions on

policies to finance the investment costs of the projects included in the Master Plan are explored according to the project characteristics and the financial internal rate of return (FIRR).

9-2-2 Results of the Financial Analysis

(1) Estimated Indicators to Show the Financial Feasibility

As shown in Table 9-3, the Master Plan is financially feasible and implementable since the FIRRs in the overall Master Plan and the generation and transmission sub-sectors exceed the cut-off rate of 9%, the B/Cs surpass 1.0 and the NPVs are positive. Provided the tariff is collected properly, the investment and O&M costs could be recouped through accrued revenue.

Table 9-3 Estimated Indicators on the Financial Feasibility of the Master Plan

Overall Master Plan	
Financial Internal Rate of Return (FIRR)	11.7%
Benefit-cost Ratio (B/C)	1.14
Net present Value (NPV, at discount rate of 9%, USD million)	13,320
Generation Sub-sector	
Financial Internal Rate of Return (FIRR)	11.6%
Benefit-cost Ratio (B/C)	1.13
Net present Value (NPV, at discount rate of 9%, USD million)	10,747
Transmission Sub-sector	
Financial Internal Rate of Return (FIRR)	12.2%
Benefit-cost Ratio (B/C)	1.17
Net present Value (NPV, at discount rate of 9%, USD million)	2,257

Source: JICA Study Team

(2) Results of the Sensitivity Analysis

The results of the sensitivity analysis are shown in Table 9-4. For the overall Master Plan, it is estimated that the Master Plan remains financially feasible even in the event that costs increase by up to 13%, or revenue declines by 11%. The Master Plan, however, may lose its financial viability in case of further cost increase or revenue decrease.

For the generation sub-sector, the sub-sector remains financially feasible even if costs increase by up to 12.5% or revenue decreases by 11%. For the transmission sub-sector, financial soundness can be maintained with an increase of up to 17% in investment and O&M costs, and a decrease of up to 14% in revenue collection.

The results of this sensitivity analysis reveal that reducing aggregated technical, commercial and collection (ATC&C) losses in the distribution sub-sector, which currently remains 55% is a critically important challenge; not only for the distribution sub-sector itself but also in the generation and transmissions sub-sectors, in other words for the overall power sector, since end-user tariff collection is the source from which the revenue collection of the generation and transmissions sub-sectors comes.

Table 9-4 Results of the Sensitivity Analysis

	Case	FIRR	B/C	NPV
Overall Master Plan	13% increase in costs	9.1%	1.00	USD 541 million
	11% decrease in benefits	9.2%	1.01	USD 1,002 million
Generation Sub-sector	12.5% increase in costs	9.1%	1.00	USD 276 million
	11% decrease in benefits	9.1%	1.00	USD 351 million
Transmission Sub-sector	17% increase in costs	9.0%	1.00	USD 40 million
	14% decrease in benefits	9.2%	1.01	USD 127 million

Source: JICA Study Team

Chapter 10 Recommendations for Realizing the Master Plan

10-1 Measures to be Taken to Realize the Master Plan

10-1-1 Financing for investment

Implementing the Master Plan requires investment costs of USD 79.3 billion in the power generation sub-sector (USD 84.6 billion including facility and equipment for renovation) and USD 19.8 billion in the power transmission sub-sector. According to the results of a financial analysis, both the power generation and transmission sub-sectors are financially viable, and adequate payments to the power generation and transmission sub-sectors will allow for the recovery of not only operating and maintenance costs, but also capital investment and financing costs.

The construction and rehabilitation of hydroelectric power plants proposed in the Master Plan requires the investment of approximately USD 10 billion. Nearly USD 6 billion of this will be prepared with assistance from China. The remaining should be funded by government loans, primarily donor loans.

The investment funds for the transmission sub-sector are preferably borrowed from donors. However, there is also a need to consider borrowing from public and private financial institutes directly by TCN, mainly for investments in subordinate systems. Private financial initiatives with concession agreements have to be introduced as public funds will not be enough to finance all requirements in the transmission sub-sector.

(1) Private Sector Financing for Capital Investment

Excluding hydroelectric power generation, the private sector invests in and manages the power generation sub-sector. The private sector is likely to hesitate to enter into the sub-sector because of the high technical and commercial losses and the low rate of charge collection by distribution companies (DisCos) at present. Measures to promote IPPs have to be taken as proposed in Section 10-1-3 below. It is also necessary to facilitate the application of loans from development financial institutes.

10-1-2 Reduction of Loss and Improvement of the User Charge Collection by DisCos

As proposed in the Power Sector Recovery Programme 2017-2021 (PSRP), assistance to DisCos for i) development of the customer databases, ii) meter dissemination programs, iii) implementation of performance improvement plans (PIPs), as well as iv) settlement of past accounts payable by government agencies and enforcing non-delayed payment should be properly implemented.

Measures such as i) meter dissemination, including pre-paid meters and automatic reading, and ii) awareness raising and educational activities for the users and campaign activities with the users, have been proven effective for reducing losses in the distribution sub-sectors in Sub-Saharan African countries. Consequently, it is suggested that FMPWH and other related agencies should assist DisCos in implementing the two measures by a) developing and disseminating cheap, high-quality, durable meters and b) developing tools and manuals by incorporating the good practices of successful countries after observations tours and the exchange of views with stakeholders in these countries.

10-1-3 Promotion of IPP

To promote IPP, the Government has to prepared conditions for tendering with sets of four contract forms, namely i) Power Purchase Agreement (PPA)/ii) Gas Sale Aggregated Agreement (GSAA), iii) Put and Call Option Agreement (PCOA) and iv) Partial Risk Guarantee (PRG). Under the conditions prepared by the Government, tenderers will propose the generation charge or wholesale prices and the tenderer with the cheapest proposal will be awarded the contract. It is recommended to further expand and develop this procedure/mechanism to promote IPPs.

The establishment of a taskforce with a leader from FMPWH, an advisor from the Federal Ministry of Finance and members from NERC, NBET, TCN, etc. is proposed. Members must devote themselves full time to the task, instead of having concurrent jobs. Members should also have sufficient education and training opportunities, especially those of NBET, who will be core persons for drafting standard and individual contracts/agreements.

10-1-4 Promoting the Combined Cycle

It is proposed that subsidies for introducing/disseminating the combined cycle using a surcharge for gas turbine power generation as a source.

10-1-5 Stable Supply of Natural Gas

Fundamental solutions are recommended in PSRP such as i) determining of priority development issues and the implementation of development projects in natural gas production areas, ii) sharing the stakes with local communities in natural gas-producing areas and providing incentives to preserve resources, iii) paying all outstanding amounts to gas suppliers via the Nigeria Electric Power Market Stabilization Fund, and iv) managing the gas pipeline infrastructure development project.

10-1-6 Steady Implementation of Power Sector Recovery Programme 2017-2021 (PSRP)

It is necessary to promptly formulate detailed implementation plans for PSRP. Each organization responsible for each action has to formulate i) methods, ii) deadline, iii) target indicators and iv) budget for the implementation of each action and submit these to the PSRP Secretariat or Advisory Power Team, FMPWH and NERC for approval.

Even for PSRP, there is a possibility that it will not be implemented given the risk of conflicts in implementing power sector reform and the fact that external pressure may be needed for the implementation. A number of donors are involved in the Nigerian power sector. It is expected that these donors will cooperate and coordinate in monitoring PSRP progress, encouraging implementation, and making financial assistance conditional on taking PSRP implementation steps.

10-2 Policy Recommendations to Improve the Power Sector

10-2-1 Development of Reliable Basic Statistical Data

It is necessary to consolidate the collection and storage of basic statistical data to make justifiable demand

forecasts and to formulate realistic and achievable policies and plans.

10-2-2 Clarification of the Roles of the Ministries and Agencies in the Power and Energy Sector and Enhancement of Coordination

It is expected that the communications policies outlined in the PSRP will be properly implemented for efficient and consistent policy formulation as many ministries and agencies are involved in policy formulation in the power and energy sectors.

It is necessary to improve coordination and cooperation among relevant organizations for effective energy demand forecasting and consistent energy policy formulation as the responsible agencies are spread out among various ministries and agencies which makes consistent policy formulation difficult.

Chapter 11 Cooperation with the Transmission Expansion Plan (TEP)

11-1 Comparison between JICA and the Transmission Expansion Plan (Power Demand Forecast)

The Master Plan and TEP can only be compared in terms of TCN demand (i.e. Domestic Demand + Exports), so it is implemented with only TCN demand.

Incidentally, TEP power demands are forecast every 5 years, with forecast years of 2020, 2025, 2030, 3035 and 2037. The results of the comparison are as shown in the following table. Moreover, "3) JICA (Low Case)" in the following table is applied for Master Plan and "5) TEP (Planning)" is applied for TEP.

Table 11-1 Power demands of Master Plan and TEP Power Demands

Unit GW

	2016	2020	2025	2030	2035	20/16	25/20	30/25	35/30
1) JICA (High Case)	3.7	7.4	23.8	45.3	67.1	18.7%	26.2%	13.7%	8.2%
2) JICA (Base Case)	3.7	7.1	19.7	33.0	44.0	17.5%	22.5%	10.9%	5.9%
3) JICA (Low Case)	3.7	6.6	15.6	23.0	27.4	15.3%	18.8%	8.0%	3.5%
4) TEP (Demand)	5.3	10.3	15.3	24.0	40.0	17.8%	8.2%	9.5%	10.8%
5) TEP (Planning)	5.3	10.0	15.0	23.0	28.0	17.0%	8.4%	8.9%	4.0%

Source: Made by the JICA Study Team

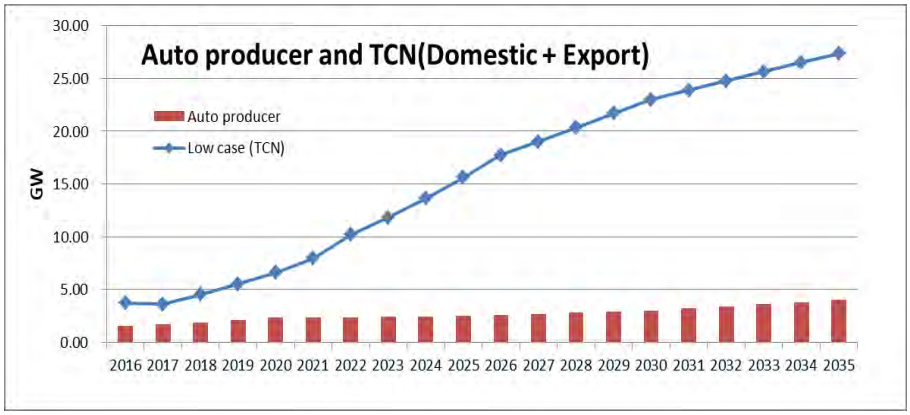
Note: TCN power demand is Domestic Demand + Exports

Note: TCN power demand in the above table excludes Auto Producers, so the values in the above table do not correlate with the power demands in other tables in the previous session. For example, Auto Producers with 4GW are estimated in 2035, power demand including Auto Producers in 2035 is 31.4GW (=27.4GW+4GW) in the Low Case of the previous session.

The power demand of TEP only equates to TCN demand, including domestic demand and exports, so the power demand of the JICA study for making a comparable power demand to TEP has been changed via the following expression. The values here equate to the power demand for the Low Case in 2035:

Domestic (30,718MW) + Export (673MW) — Auto Producers (4,000MW) = TCN demand (27,391MW)

In the above expression, TCN demand without Auto Producers' demand is as shown in the following figure:



Source: JICA Study Team

Figure 11-1 Auto Producer Demand and TCN Demand (Low Case)

11-2 Comparison between JICA and the Transmission Expansion Plan (Generation Expansion Plan)

The difference between the TEP and JICA's Master Plan in terms of generation expansion plans is described as follows:

① TEP does not consider nuclear power an expansion candidate but JICA's generation expansion plan includes nuclear power plants in line with Nigeria's policy.
② TEP does consider hydro candidates identified under "Screening of potential hydropower options with associated water resources developments in the Niger basin" assisted by the World Bank but JICA's generation expansion plan includes those hydro candidates.
③ Due to the difference in the power demand forecast used to underpin planning, TEP's total generation capacity in 2037 is 48,823MW but the JICA figure is 54,927MW (+6,104MW).

11-3 Comparison between JICA and the Transmission Expansion Plan (Transmission Expansion Plan)

The difference between the TEP and the transmission network development plan of this Master Plan is as follows:

This Master Plan is based on PSS/E analysis results, which reflect the current power system in Lagos and Ogun states provided from TCN and the project component planned by the JICA preparatory survey.

Since the estimated load demand in this Master Plan exceeds the estimated load in TEP, the estimated load demand for the target year differs, which is why some plans included in the post-2025 system expansion plan in this Master Plan are set earlier than the period in TEP.

Table 11-2 Comparison of Maximum Load Assumptions in TEP and this Master Plan

Master Plan	Load	2020	2025	2030	2035	2040
Transmission Expansion Plan	DisCo estimated Load (MW)	9,883	13,628	20,812	25,286	-
	Export (MW)	387	1,540	1,831	2,000	-
	Load Demand Assumption (MW)	10,270	15,168	22,643	27,286	-
This Master Plan	DisCo estimated Load (MW)	8,636	17,703	25,447	30,719	35,890
	Export (MW)	387	1,540	1,831	2,000	2,000
	Load Demand Assumption (MW)	9,023	19,243	27,278	32,719	37,890

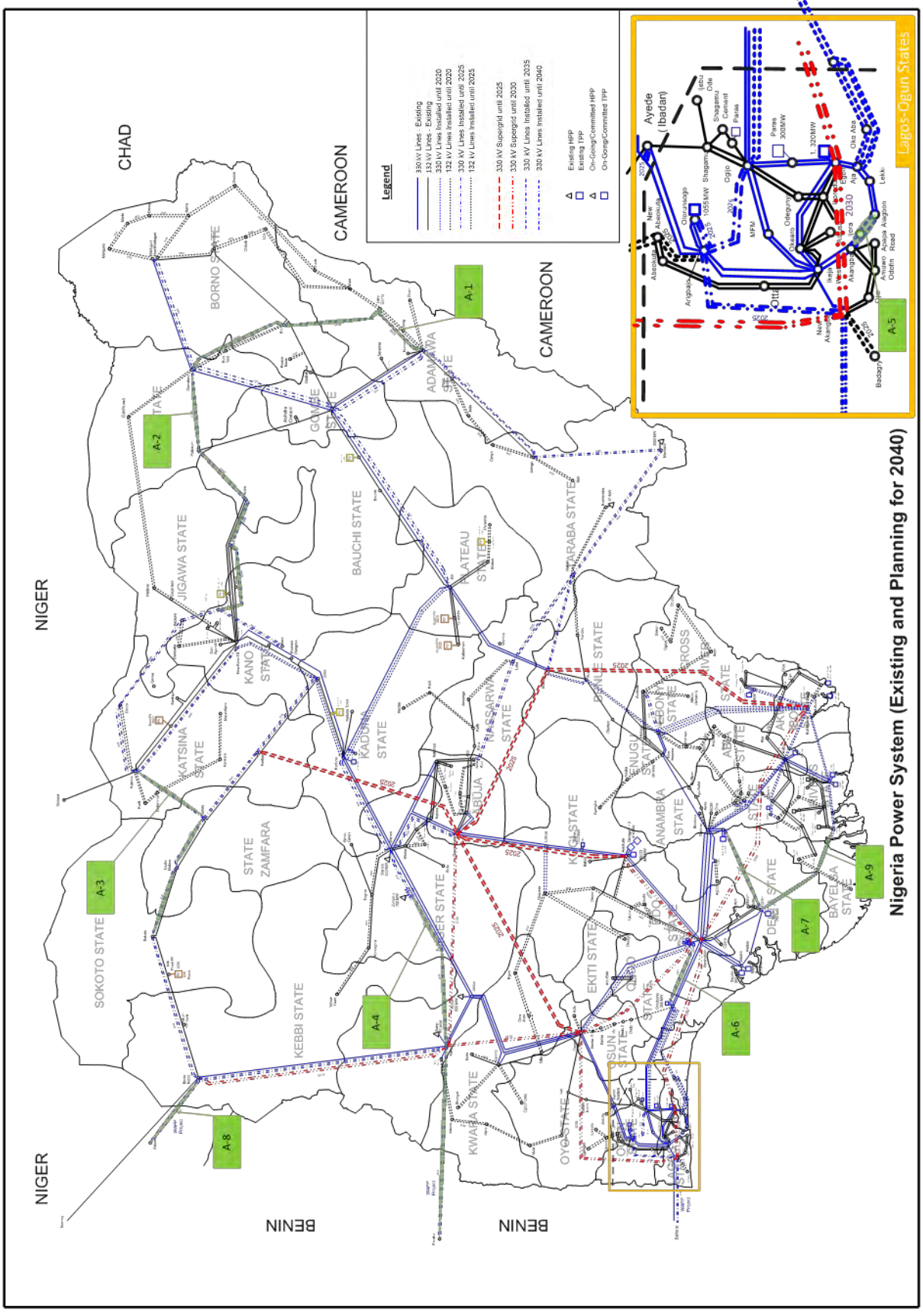
Source: JICA Study Team

Table 11-3 shows the list of 330-kV Transmission Lines requested by TCN after TEP. Every line was considered and most are recommended transmission lines (Apply: Yes) to the transmission network development plan of this Master Plan. Accordingly, transmission lines which were not considered in TEP are included in this Master Plan.

Table 11-3 Additional 330 kV Transmission Lines requested by TCN after TEP

330kV Transmission Lines	Apply	Transmission Line
330kV line Mambila-Kashimbila- Ogoja- Calabar	No	-
330kV line Yola-Little Gombi-Biu-Damaturu	Yes	A-1
330kV line Damaturu-Potiscum-Azare-Dutse-Jogana	Yes	A-2
330kV line Katsina-Sokoto (already considered in the TEP study by Fichtner)	Yes	A-3
330kV line Makurdi (Apir)-Ayangba-Ajaokuta	No	-
Zungeru to Kainji to Kaiama to Parakuay of Benin Republic (Mid-Core Project)	Yes	A-4
Akangba to Ijora to Alagbon (Closing of Lagos Loop)	Yes	A-5
Oshogbo to Ado Ekiti to Okene to Ajaokuta	No	-
Proposed Benin North (Ihovbor) to Omotosho through PPP business plan	Yes	A-6
Okpai to Ughelli	Yes	A-7
Birnin Kebbi to Niamey (North Core Project)	Yes	A-8
Ughelli (Delta) to Onne (Port-Harcourt)	Yes	A-9

Source: JICA Study Team



Source: JICA Study Team
Note: The applicable transmission lines are indicated with Green.

Figure 11-2 Additional 330 kV Transmission Lines requested by TCN after TEP

THE PROJECT FOR MASTER PLAN STUDY ON NATIONAL POWER SYSTEM DEVELOPMENT IN THE FEDERAL REPUBLIC OF NIGERIA

FINAL REPORT

Contents

[Annex]

Annex 3a - List of IPP

Annex 3b - Invoices to Distribution Companies (DisCos) and Payment from DisCos

Annex 3c - Invoices from Generation Companies (GenCos) and Payment to GenCos

Annex 6.1 - Generation expansion plan (Low case demand)

Annex 7.1 - Nigerian map showing existing, on-going & proposed TCN grid projects (NETAP/NIPP/TCN) as at January 2018

Annex 7.1b - Nigeria grid map depicting the existing, on-going and planned power transmission projects 10 year plan (2018-2028)

Annex 7.1c - Single line diagram of the existing Nigeria grid network

Annex 7.1d - Transmission lines - Technical data

Annex 7.1e - Transformer -Technical data

Annex 7.2a - Classification of on-going TCN capital projects by zones TCN Projects - updated July 2018

Annex 7.2b - Classification of on-going TCN capital projects by zones NIPP Projects - updated July 2018

Annex 7.2c - 330 kV network in Lagos region

Annex 7.2d - 330 kV network in Lagos region

Annex 7.2e1 - Proposed Abuja transmission ring project to be financed by AFD

Annex 7.2e2 - Lagos/Ogun Transmission Project to be financed by JICA

Annex 7.2e3 - Proposed Transmission Infrastructure Project to be financed by AfDB

Annex 7.2e4 - Proposed NETAP package to be financed by World Bank

Annex 7.2e5 - Northern Corridor Transmission Project to be financed by AFD

Annex 7.4.1 - 330 kV transmission 2020

Annex 7.4.2 - SLD in PSSE for TCN transmission system-2020

Annex 7.4.3 - Nigeria 330+132 kV network existing + expansions

Annex 7.4.4 - Nigeria electricity and gas improvement project transmission expansion plan

Annex 7.4.5 - DisCos served loads in 2020

Annex 7.4.6 - Dry season peak 2020

Annex 7.4.7 - Dry season Off-peak 2020

Annex 7.4.8 - Wet season Peak 2020

Annex 7.4.9 - Wet season Off-peak 2020

Annex 7.4.10 - Results of fault level analysis

Annex 7.5.1 - 330 kV transmission - 2025

Annex 7.5.2 - SLD in PSSE for TCN transmission system-2025

Annex 7.5.3 - Dry season Peak 2025

Annex 7.5.4 - Dry season Off-peak 2025

Annex 7.6.1 - 330 kV transmission - 2030

Annex 7.6.2 - SLD in PSSE for TCN transmission system-2030

Annex 7.7.1 - 330 kV transmission - 2035

Annex 7.7.2 - SLD in PSSE for TCN transmission system-2035

Annex 7.8.1 - 330 kV transmission - 2040

Annex 7.8.2 - SLD in PSSE for TCN transmission system-2040

Annex 9a - Electricity Tariff in Nigeria

Annex 9b - Current Status of the Power Sector Companies

Abbreviation

ACCC	AC Contingency Calculation
ACHPR	African Commission on Human and Peoples' Rights
ACSR	Aluminium Conductor, Steel Reinforced
ADB	Asian Development Bank
AEDC	Abuja Electricity Distribution Company
AFD	Agence Française de Developpement
AfDB	African Development Bank
a.n.	abstract number same to u.n.= unitless number
ASB	Annual Statistical Bulletin
AU	African Union
AVR	Automatic Voltage Regulator
BAU	Business As Usual
B/C Ratio	Benefit by Cost Ratio
BPE	Bureau of Public Enterprise
BTU	British Thermal Unit
C/P	Counter Part
CBN	Central bank of Nigeria
CCGHRU	Climate Change, Gender, and Human Rights Unit
CEB	Ceylon Electricity Board
CGCC	China Gezhouba Group Corporation
CHP	Combined Heat and Power
COP	Conference of the Parties
CR	Critically Endangered
DAC	Development Assistance Committee
DC	Double Circuit
DCC	Department of Climate Change
DISCO	Distribution Company
D-loss	Distribution loss
DSM	Demand Side Management
EAD	Environmental Assessment Division
ECN	Energy Commission of Nigeria
ECOWAS	Economic Community of West African States
EHS	Environment, Health and Safety Policy
EHV	Extra High Voltage
EIA	Environmental Impact Assessment
EIA	U.S. Energy Information Administration
EIAD	Environmental Impact Assessment Decree
ELP	Escravos-Lagos Pipeline
EMP	Energy Management Program

EN	Endangered
EPC	Engineering, procurement, Construction
EPCL	Eleme Petrochemicals Company Limited
EPIC	Electric Power Sector Reform Implementation Committee
EPSRA	Electric Power Sector Reform Act
ERGP	Economic Recovery and Growth Plan 2017-2020
FAO	Forestry Resources Assessment
FCDA	Federal Capital Development Authority
FCT	Federal Capital Territory
FGN	Federal Government of Nigeria
FMEnv	Federal Ministry of Environment
FMP	Federal Ministry of Power
FMPR	Federal Ministry of Petroleum Resources
FMPWH	Federal Ministry of Power, Works and Housing
FMST	Federal Ministry of Science and Technology
FMWR	Federal Ministry of Water Resources
F/S	Feasibility Study
GACN	Gas Aggregation Company Nigeria Ltd.
GAVI	Global Alliance for Vaccine and Immunization
GDP	Gross Domestic Product
GENCO	Generation Company
GFATM	Global Fund to Fight AIDS, Tuberculosis and Malaria
GHG	Greenhouse Gas
GMR	Geometric Mean Radius
giz	Gesellschaft für Internationale Zusammenarbeit
GSAA	Gas Sales and Aggregation Agreement
GSPA	Gas Sales and Purchase Agreement
GT	Gas Turbine
GTA	Gas Transportation Agreement
HA	Hydrological Area
HPP	Hydroelectric power plant
HSEU	Health Safety & Environment Unit
HV	High Voltage
IDA	International Development Association
IAEA	International Atomic Energy Agency
ICREEE	Inter-Ministerial Committee on Renewable Energy and Energy Efficiency
IEA	International Energy Agency
IEE	Initial Environmental Evaluation
IFC	International Finance Corporation
IFS	International Financial Statistics
IGU	International Gas Union

ILO	International Labour Organization
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contributions
IOC	International Oil Company
IPP	Independent Power Producer
IUCN	International Union for Conservation of Nature
JCC	Joint Coordination Committee
JICA	Japan International Cooperation Agency
LGA	Local Government Area
LNG	Liquefied Natural Gas
LOLP	Loss Of Load Probability
LPG	Liquefied Petroleum Gas
MBNP	Ministry of Budget and National Planning
MEAs	Multilateral Environmental Agreements
MIGA	Multilateral Investment Guarantee Agency
MO	Market Operator
MOF	Ministry of Finance
MOU	Memorandum of Understanding
MYTO	Multi-Year Tariff Order
NACOP	National Council On Power
NAPTIN	National Power Training Institute of Nigeria
NBET	Nigeria Bulk Electricity Trading Plc
NBS	National Bureau of Statistics
NCC	National Control Center
NDPHC	Niger Delta Power Holding Company
NEGIP	Nigeria Electricity and Gas Improvement Project
NELMCO	Nigeria Electricity Liability Management Ltd.
NEMSA	Nigeria Electricity Management Services Authority
NEMP	National Energy Master Plan
NEPA	National Electric Power Authority
NERC	Nigerian Electricity Regulatory Commission
NESREA	National Environmental Standards and Regulation Enforcement Agency
NESI	Nigerian Electricity Supply Industry
NG	Natural gas
NGC	Nigerian Gas Company Ltd.
NGL	Natural Gas Liquids
NGN	Nigerian Naira
NGO	Non-governmental Organization
NGSA	Nigerian Geological Survey Agency
NIHSA	Nigeria Hydrological Services Agency
NIIMP	National Integrated Infrastructure Master Plan

NIPP	National Integrated Power Project
NNPC	Nigeria National Petroleum Corporation
NPC	National Planning Commission
NPCC	National Policy on Climate Change
NPopC	National Population Commission
NPV	Net Present Value
NREEEP	National Renewable Energy and Energy Efficiency Policy
Nt	Nigeria NGN per US dollar
O&M	Operation and Maintenance
ODA	Official Development Assistance
OPEC	Organization of the Petroleum Exporting Countries
PHCN	Power Holding Company of Nigeria
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PRG	Partial Risk Guarantee
PSD	Master Plan Study on National Power System Development
PSRP	Power Sector Recovery Programme 2017-2021
PTFP	Presidential Task Force on Power
PV	Photovoltaic
RAP	Resettlement Action Plan
RCC	Roller Compacted Concrete
RE	Reconductoring
REA	Rural Electrification Agency
REF	Rural Electrification Fund
REMP	Renewal Energy Master Plan
RES	Renewal Energy Sources
RESIP	Rural Electrification Strategy and Implementation
REUAs	Rural Electricity Users Associations
SCADA	Supervisory Control and Data Acquisition
SCF	Standard Conversion Factor
SEA	Strategic Environmental Assessment
SHAs	Sub-hydrological Areas
SHP	Small Hydro Power
SHS	Small Hydropower Systems
SIL	Surge Impedance Loading
SO	System Operator
SC	Single Circuit
SPM	Suspended Particular Matter
ST	Steam Turbine（蒸気タービン）
SVC	Static Var Compensator
TCN	Transmission Company of Nigeria

T/D loss	Transmission / Distribution loss
T-loss	Transmission loss
TFC	Total Final Energy Consumption
TEM	Transitional Electricity Market
TOR	Terms Of Reference
TPES	Total Primary Energy Supply
TSP	Transmission Services Provider
TWG	Technical Working Group
UBRBDA	Upper Benue River Basin Development Authority
UFLS	Under Frequency Load Shedding
UN	United Nations
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund
US	United States
VU	Vulnerable
WAGP	West Africa Gas Pipeline
WAPP	West African Power Pool
WASP	Wien Automatic System Planning Package
WB	World Bank
WHO	World Health Organization
WSC	Water Steam Condenser
WTI	West Texas Intermediate

List of Figures & Tables

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

Chapter 7

Chapter 8

Chapter 9

Chapter 10

Chapter 11

CHAPTER 1 Introduction

Chapter 1 Introduction

1-1 Background of the Study

Nigeria, having the largest population in Africa of 191 million, is a country rich in natural resources and its crude oil and natural gas reserves are one of the world's most abundant. However, for various reasons, such as the power transmission capacity being restricted to only about 5,300MW (as of December, 2015) compared to a potential electrical demand estimated to be around 12,800MW and the shortage of gas supply, which is the principal fuel used in power generation, the capacity of available power generation is limited to about 6,600MW (as of December, 2015). Consequently, planned outages are frequent not only in local areas but also in urban areas. This leads to the general view that the economic growth of Nigeria is hindered by the power sector.

The Nigerian government, by utilizing the excess crude account, has implemented the NIPP (National Integrated Power Project) which allows for the building of thermal power plants and transmission lines; furthermore, it is promoting the privatization of the power sector with an aim to improve efficiency in this sector and to reduce investment charges to the government.

For the purpose of improving the above situation, FMPWH (Federal Ministry of Power, Works and Housing) of Nigeria, the organization responsible for global development in the power sector, has formed a long-term electric power development plan and grid extension plan on the basis of a future electrical load demand forecast. In addition, they asked the Japanese side to develop a power master plan which makes it possible to advance development in the power sector in a strategic and efficient way, and also requested a technology transfer which would be necessary in the course of development and renewal of such a plan. In response to this, JICA has conducted a survey for the preparation of a detailed plan for the master plan study in July 2014 and signed R/D (Record of Discussions) with the Nigerian side in October 2014, which made the project ready for implementation.

1-2 Objectives of the Study

The purpose of the study is to develop a 25 year power development master plan which shall include a power demand forecast, developing a plan with the lowest possible cost and an optimal power generation master plan which takes into account constraints on primary energy supply and the best energy mix, and also to develop a power transmission development plan based on the above mentioned power generation development plan. Improvement of performance of the personnel of FMPWH, TCN (Transmission Company of Nigeria), and TWG (Technical Working Group), which are the relevant organizations in the power sector, on the development and renewal of master plan preparations through development of this master plan shall also be included in the purpose of the study.

1-3 Outline of the Study

Table 1-3.1 shows the basic concept and Table 1-3.2 shows the contents and outline of the study.

Table 1-3.1 Basic Concept of the Study

Item	Description
Objectives	Formulation of Master Plan on National Power System Development for 25 years Technical Transfer to the Nigerian counterparts
Target Facilities	Electric power generation facilities and power system facilities of not less than 66/33kV Substation facilities and transmission system owned by TCN
Implementation Agency	FMPWH
Scope of Work	Formulation of Master Plan on National Power System Development including power demand forecast, power generation development, power system development, and investment plan

Source: JICA Study Team

Table 1-3.2 Contents of the Study

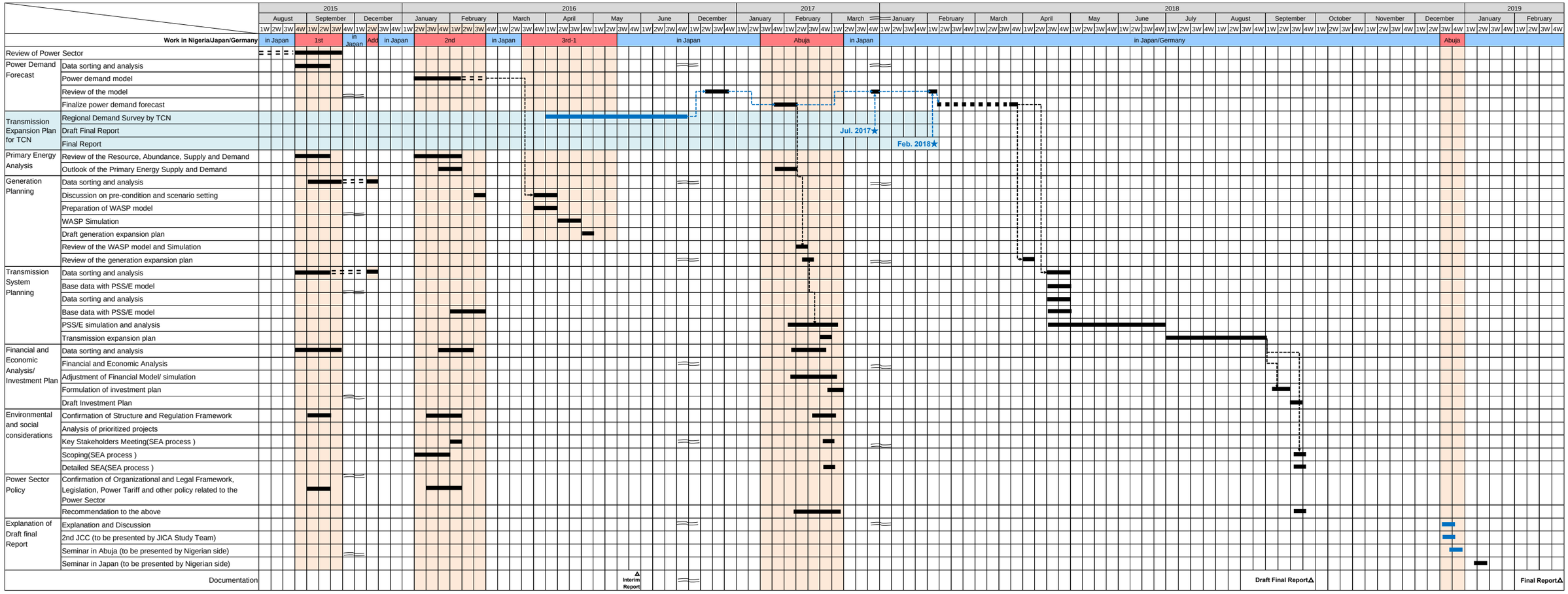
Contents	Outline
1. Review of the Power Sector	■ Review of organizational and legal framework, legislation, power tariffs, and other policies related to the power sector ■ Review and analysis of the current power supply situation ■ Review of the existing power supply facilities
2. Primary Energy Analysis	■ Review of energy policy, energy supply and demand, and organizational structure ■ Review of primary energy as a domestic production ■ Outlook of the primary energy supply and demand
3. Power Demand Forecast	■ Review of method for power demand forecast ■ Formulation of power demand forecast ■ Power demand forecasting up to 2040
4. Study of optimization of power development plan	■ Data collection on existing power plants ■ Data collection and analysis of planned new / planned expansions of power plants ■ Study of optimization of power development plan
5. Formulation of Power System Development Plan	■ Data collection of the existing power system ■ Data collection and analysis of planned new / planned expansions of transmission and substation facilities ■ Coordination with “Development of Power System Master Plan” ■ Study of power system development plan
6. Environmental social considerations	■ Data collection on organizational structure and regulation framework for environmental social considerations ■ Data collection and analysis of prioritized projects ■ Implementation of SEA
7. Formulation of Master Plan on National Power System Development	■ Formulation of optimization of power development plan ■ Formulation of Power System Development Plan ■ Long-term investment plan and economic evaluation ■ Marshaling of the formulation of Master Plan on National Power System Development
8. Policy Recommendation	■ Recommendations on organizational and legal framework, legislation, power tariffs, and other policies related to the power sector shall be made in order to achieve the master plan.

Contents	Outline
9. Technical Transfer	■ The formulation of the master plan shall be a collaborative effort between the study team and the Nigerian counterparts. ■ Classroom training, actual data and software to formulate the master plan shall be utilized in the workshop.
10. Counterpart program in Japan	■ In order to make the master plan public and exchange information and opinions, seminar shall be held in Japan. ■ Introduction of power sector policy or institutional framework in Japan and facility tours

Source: JICA Study Team

1-4 Process of the Study

The study is mainly divided into data collection and analysis, base data compilation, scenario settings and formulation of master plan, and review of master plan and recommendations stages. The process of the study for these stages is shown in the Figure 1-4.1.



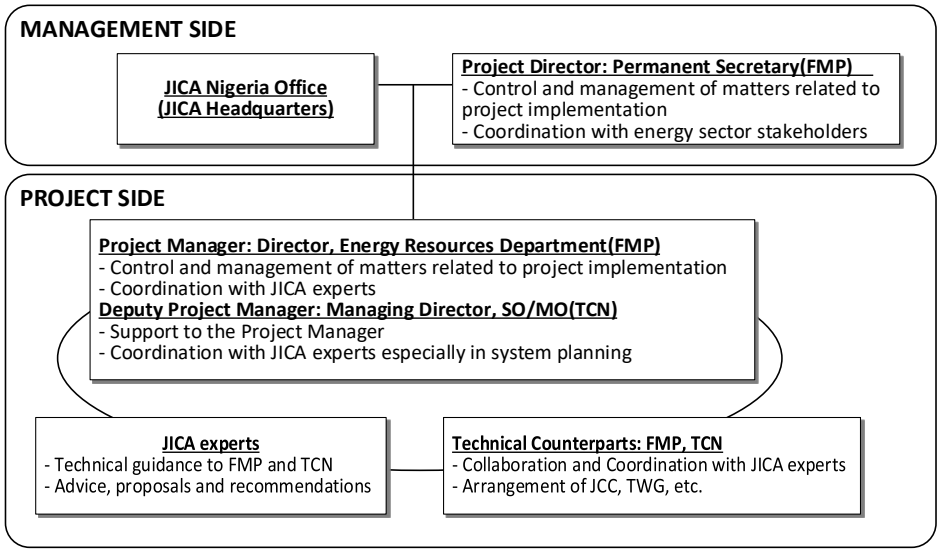
Source: JICA Study Team

Figure 1-4.1 Process of the Study

1-5 Organizations of the Study

(1) Organization and Roles of the Study Implementation

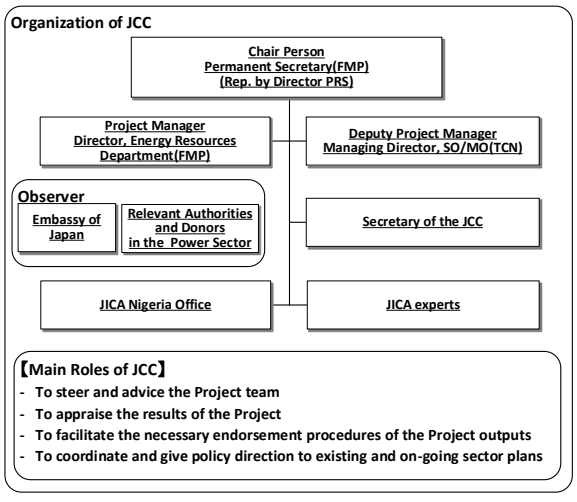
Organization and roles in implementation of the project are shown in Figure 1-5.1. Furthermore, organization and roles for the JCC (Joint Coordination Committee) and TWG are shown in Figure 1-5.2 and Figure 1-5.3.



FMP: Federal Ministry of Power (Current FMPWH), TCN: Transmission Company of Nigeria
SO: System Operation, MO: Market Operation
JCC: Joint Coordination Committee, TWG: Technical Working Group

Source: JICA Study Team

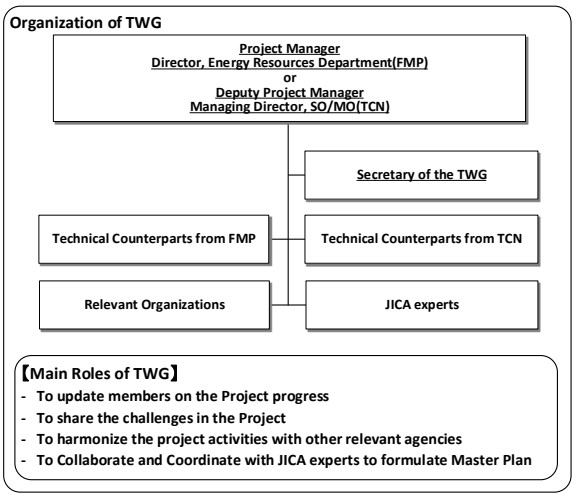
Figure 1-5.1 Organization and Roles for Project Implementation



FMP: Federal Ministry of Power (Current FMPWH), TCN: Transmission Company of Nigeria
PRS: Planning, Research and Statistics, JCC: Joint Coordination Committee
SO: System Operation, MO: Market Operation

Source: JICA Study Team

Figure 1-5.2
Organization and Roles for JCC



FMP: Federal Ministry of Power (Current FMPWH), TCN: Transmission Company of Nigeria
PRS: Planning, Research and Statistics, TWG: Technical Working Group
SO: System Operation, MO: Market Operation

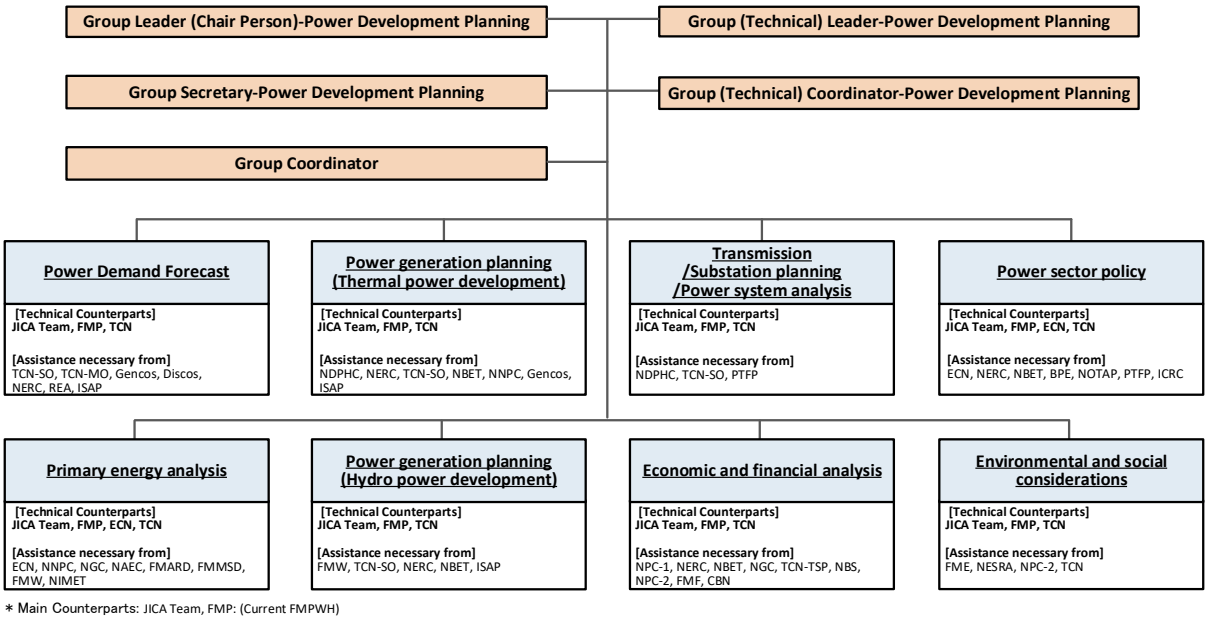
Source: JICA Study Team

Figure 1-5.3
Organization and Roles for TWG

(2) Technical Counterpart Team

The study team and FMPWH have established an organization of TWG for the study and the review of the master plan throughout series of discussions commenced in August 2015 and shared it with concerned parties in the first JCC held on the 4th September, 2015.

Figure 1-5.4 shows the organization of the TWG.

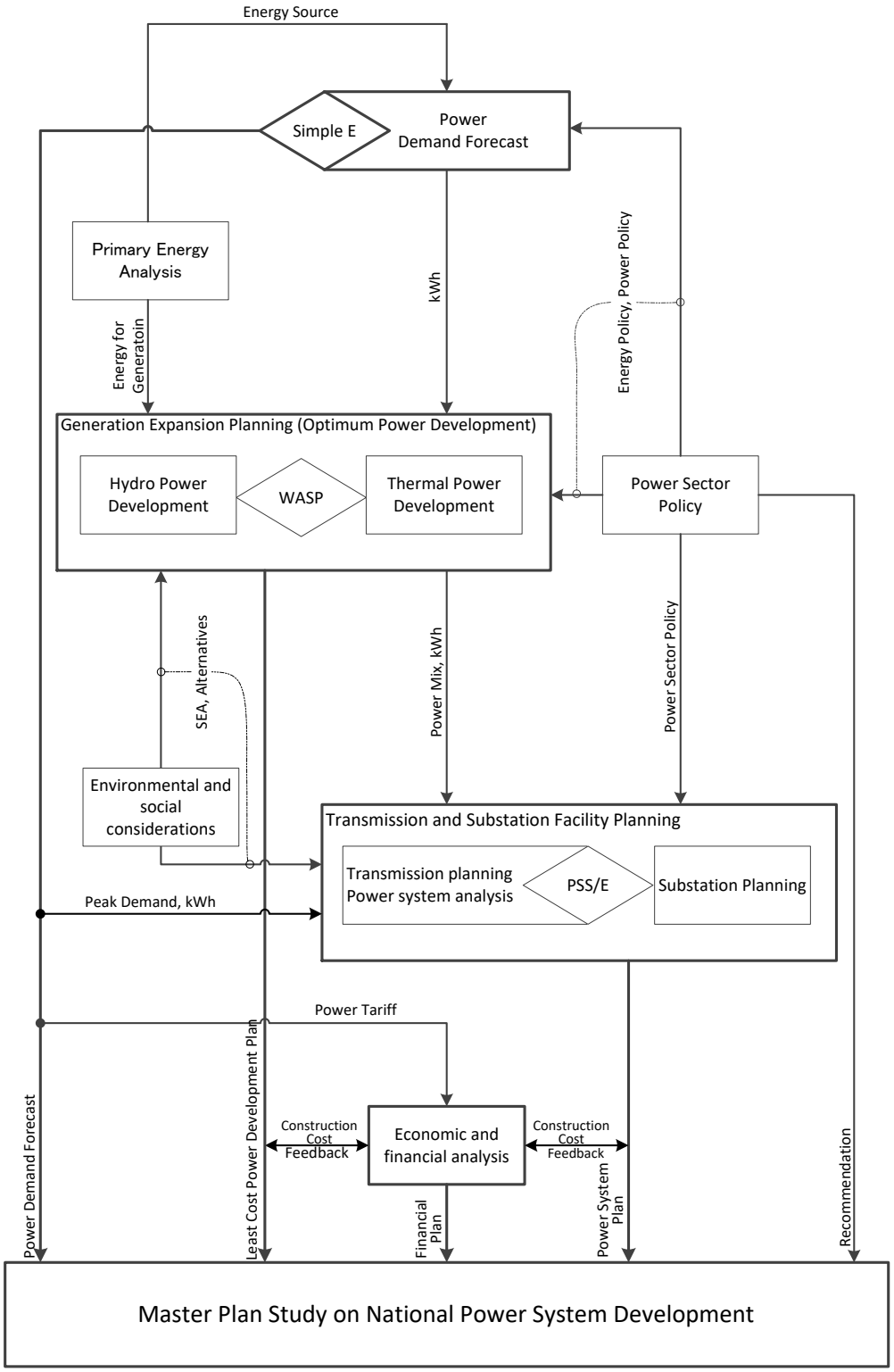


Source: JICA Study Team

Figure 1-5.4 Organization of Technical Working Group

1-6 Flow of Formulation of the Master Plan

Figure 1-6.1 shows the flow for the formulation of the master plan for the project.



WASP: Wien Automatic System Planning Package, PSS/E: Power System Simulator for Engineering
SEA: Strategic Environmental Assessment
Source: JICA Study Team

Figure 1-6.1 Overall Composition of Formulation of Master Plan for the Project

CHAPTER 2 Socioeconomic Conditions and Development Plan

Chapter 2 Socioeconomic Conditions and Development Plan

2-1 Social Conditions

2-1-1 Basic Information of Nigeria

Nigeria is located on longitude N3° - N14°and latitude E 3° - E15°, with a country area of 923,769km^2. The territory faces Guinea bay in the south and borders Benin in the west, Niger in the north, Cameroon in the east, and Chad in the north-east.

Nigeria, is the country with the highest population in Africa with a population of 191 million, or about 20 to 25% of the total population of Africa. In addition, Nigeria is a multiracial nation with more than 250 ethnic groups and more than 500 languages. The largest ethnic groups are the Hausa and Fula in the northern area with 29% of the total population, followed by Yoruba in the southwest area with 21% of the population, Ibo in the southeast area with 18% of the population, and many other ethnic minorities. English is used as an official language in assembly and government offices, but the languages of Hausa, Yoruba, and Ibo can also be used as major languages in assembly. Elementary grade classes are carried out in the mother tongue of each ethnic group, while only English is used in higher education. Many ethnic conflicts have been repeated since the country's independence in 1960. After gaining indepencede Nigeria initially only had three states, but this has now increased to 36 states and a Federal Capital Territory (FCT), reflecting the division over time.

Nigeria fulfills a leading duty in Africa. Through the frameworks of the African Union (AU) or the Economic Community of West African States (ECOWAS), Nigeria actively leads political stability and economic integration efforts. Nigeria is also actively involved with the activities of the United Nations and other international organizations.

Basic information on Nigeria is shown in Table 2-1.1.

Table 2-1.1 Key Indicators of Nigeria

Official Name	Federal Republic of Nigeria
Area	923,769 km^2 [1]
Population	190.9 Million [2]
Capital	Abuja (transfered from Lagos in December 1991)
Ethnic Groups	Hausa, Yoruba, Ibo, etc. (more than 250 ethnic groups)
Language	English (official language), various ethnic languages
Religion	Christian: Southeast, Islam: North, Animism: entire area
Political System	Federal Republic (President)
Sovereign	President (Muhammadu Buhari) 4-year terms, Start from May 2015

Source: Ministry of Foreign Affairs of Japan, Japan External Trade Organization, etc.

[1] Annual Abstract of Statistics 2010. National Bureau of Statistics, Federal Republic of Nigeria
[2] Assumption referred to Census 2006, World Population Prospects 2012, UN

2-1-2 Administrative Units of Nigeria

(1) State Administration

The governance system of the FRN is based on the separation of legislative, executive, and judicial powers.

- Legislative Branch
  The National Assembly is a legislative branch which consists of two chambers: the House of Representatives that has 360 members elected for a 4-year term, and the Senate that has 109 members also elected for a 4-year term with 108 seats shared among the 36 states and 1 seat for Abuja, FCT.

- Executive Branch
  The executive branch consists of the President and the Federal Ministries. The President is elected for a 4-year term directly by the people. There are currently 25 ministries as shown in Table 2-1.2, which are headed by ministers nominated by the President.

- Judicial Branch
  The judicial branch consists of the Supreme Court, the Court of Appeal, the High Courts, and other trial courts.

Table 2-1.2 Executive Branches of the Federal Government of Nigeria

No.	Federal Ministry	No.	Federal Ministry
1	Agriculture and Rural Development	13	Industry, Trade & Investment
2	Budget and National Planning	14	Justice
3	Communication	15	Labour and Employment
4	Defence	16	Niger Delta Affairs
5	Education	17	Petroleum Resources
6	Environment	18	Power, Works and Housing
7	Federal Capital Territory Administration	19	Science and Technology
8	Finance	20	Mines and Steel Development
9	Foreign Affairs	21	Transportation
10	Health	22	Water Resources
11	Information and Culture	23	Women Affairs
12	Interior	24	Youth and Sports

Source: Web-site of FGN and Budget Office of the Federation

(2) State and Local Government

The Local Government consists of two administrative layers, namely the states and the local government areas (LGAs).

- The FRN is divided into 36 states and Abuja, FCT, as presented in Table 2-1.3. The number of states (including the FCT) increased from 31 to 37 in 1996 follwoing jurisdiction boundary splits. Each state is administered by a state government headed by a governor, elected for a 4-year term.

- Each state is further divided into LGAs. There are 775 LGAs in the FRN at present. Each LGA is

administered by a local government council headed by a chairman and other councilors. The chairman is the chief executive of the LGA.

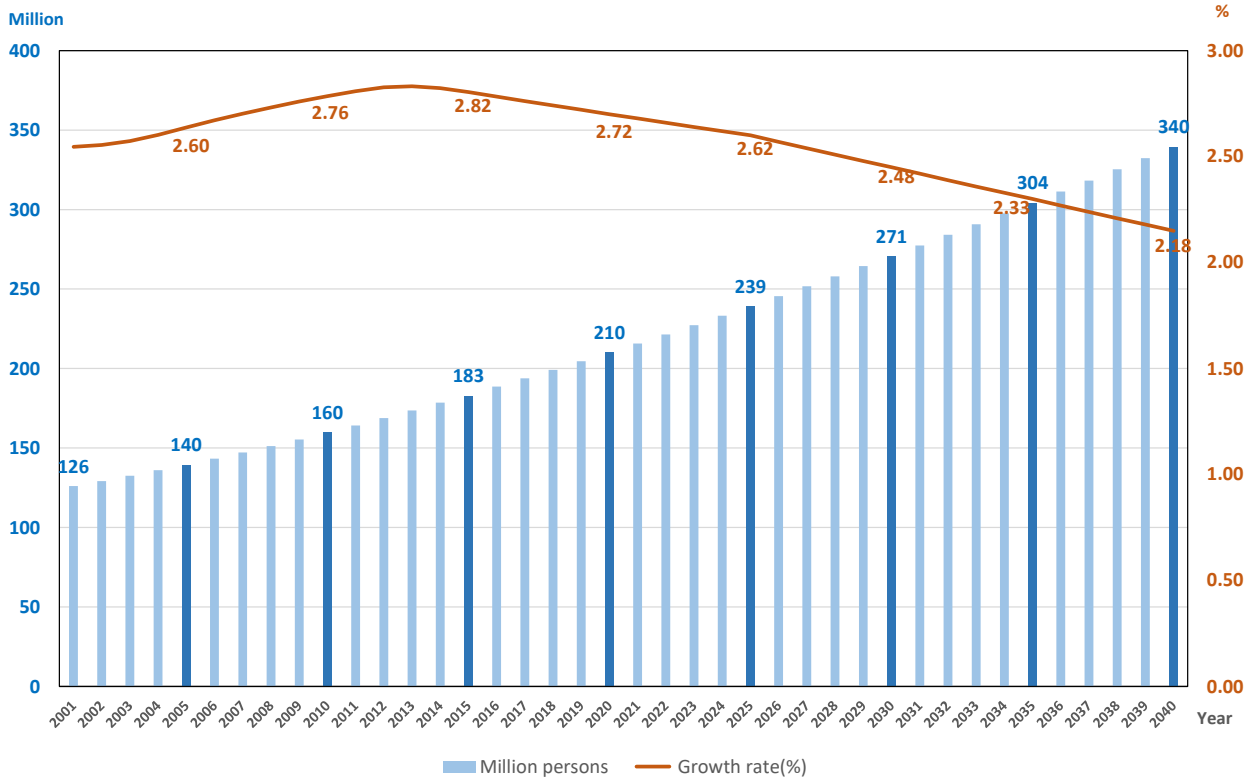
2-1-3 Population

(1) Census Population of Year 1991 and 2006

The comprehensive population census was carried out in 1991 and 2006. The result of the census revealed that the total population of Nigeria in 1991 and 2006 was respectively 88.9 million and 140 million as shown in Table 2-1.3. The population growth between the above two census was 3.18% annually.

(2) Estimated Population

The study team has estimated the future population up to the year 2040 based on Nigeria's census for 2006 and the "World Population Prospects 2012" population study by the UN and by setting the base case for the year 2015. Figure 2-1.1 shows the trends and forecast for the population from 2001 to 2040.



Note: Population growth from 2016 to 2040 is forecasted by the JICA Study Team
Source: Nigeria Census 1991 and 2006, NPC and "World Population Prospects 2012, UN"

Figure 2-1.1 Assumption and Transition of Population

Nigerian nation-wide and state-wise population estimates are shown in Table 2-1.3. Population distribution for target years of the master plan is shown in Figure 2-1.2 to Figure 2-1.5, while population density is shown in Figure 2-1.6 to Figure 2-1.9.

Table 2-1.3 State-wise area and population in Nigeria

Country	Target	Unit	Census		Estimate (UN)	Assumption		
			1991	2006	2015	2020	2030	2040
Population (Country)	Country	1000psn	88,992	140,432	183,523	210,096	270,901	339,543
	Urban	1000psn	32,287	66,518	95,564	115,584	164,650	224,971
	Rural	1000psn	56,705	76,797	87,959	94,512	106,251	114,573
Share	Urban	%	36.0	46.4	52.1	55.0	60.8	66.3
	Rural	%	64.0	53.6	47.9	45.0	39.2	33.7
Growth rate	Country	%	-	3.18	2.8	2.7	2.5	2.2
	Urban	%	-	4.15	4.1	3.8	3.4	3.0
	Rural	%	-	1.43	1.5	1.3	1.0	0.5

Unit: person/km^2

	State and FCT	Land (km^2)	No. of LGA	Census		Estimate (UN)	Assumption			Population Density			
				1991	2006	2015	2020	2030	2040	2015	2020	2030	2040
1	Abia	4,734	17	1,914	2,845	3,553	3,993	5,019	6,124	751	844	1,060	1,294
2	Adamawa	37,943	21	2,102	3,179	3,932	4,363	5,290	6,270	104	115	139	165
3	Akwa Ibom	6,964	31	2,410	3,902	4,997	5,640	7,025	8,542	718	810	1,009	1,227
4	Anambra	4,722	21	2,796	4,178	5,253	5,876	7,233	8,668	1,112	1,244	1,532	1,835
5	Bauchi	48,095	20	2,862	4,653	6,369	7,441	9,987	12,939	132	155	208	269
6	Bayelsa	13,018	8	1,122	1,704	2,304	2,676	3,564	4,575	177	206	274	351
7	Benue	30,732	23	2,753	4,254	5,550	6,381	8,293	10,458	181	208	270	340
8	Borno	74,463	27	2,536	4,171	5,437	6,216	7,971	9,924	73	83	107	133
9	Cross River	22,212	18	1,911	2,893	3,973	4,652	6,235	8,071	179	209	281	363
10	Delta	17,169	25	2,590	4,112	5,642	6,628	8,937	11,641	329	386	521	678
11	Ebonyi	6,320	13	1,454	2,177	2,683	2,954	3,502	4,145	424	467	554	656
12	Edo	19,603	18	2,172	3,233	4,106	4,641	5,840	7,139	209	237	298	364
13	Ekiti	5,281	16	1,536	2,399	3,205	3,725	4,936	6,323	607	705	935	1,197
14	Enugu	7,666	17	2,125	3,268	4,065	4,508	5,487	6,469	530	588	716	844
15	Gombe	17,261	11	1,489	2,365	3,195	3,725	4,967	6,406	185	216	288	371
16	Imo	5,434	27	2,486	3,927	4,925	5,465	6,661	7,893	906	1,006	1,226	1,453
17	Jigawa	23,529	27	2,876	4,361	5,663	6,473	8,324	10,395	241	275	354	442
18	Kaduna	44,236	23	3,936	6,114	7,404	8,161	9,696	11,337	167	184	219	256
19	Kano	20,615	44	5,810	9,401	12,391	14,274	18,633	23,585	601	692	904	1,144
20	Katsina	23,516	34	3,753	5,802	7,793	9,036	11,920	15,210	331	384	507	647
21	Kebbi	35,186	21	2,068	3,257	4,321	4,991	6,537	8,312	123	142	186	236
22	Kogi	29,045	21	2,148	3,314	4,137	4,621	5,705	6,878	142	159	196	237
23	Kwara	36,066	16	1,548	2,365	2,939	3,262	3,918	4,648	81	90	109	129
24	Lagos	3,836	20	5,725	9,114	11,971	13,811	18,061	22,894	3,120	3,600	4,708	5,967
25	Nassarawa	26,385	13	1,208	1,869	2,273	2,490	2,931	3,371	86	94	111	128
26	Niger	72,201	25	2,422	3,955	5,386	6,288	8,418	10,897	75	87	117	151
27	Ogun	16,688	20	2,334	3,751	4,977	5,743	7,534	9,568	298	344	451	573
28	Ondo	14,689	18	2,250	3,461	4,629	5,362	7,056	8,992	315	365	480	612
29	Osun	9,481	30	2,158	3,417	4,700	5,516	7,420	9,652	496	582	783	1,018
30	Oyo	27,854	33	3,453	5,581	7,578	8,840	11,774	15,168	272	317	423	545
31	Plateau	27,948	17	2,105	3,207	3,871	4,250	5,040	5,914	138	152	180	212
32	Rivers	9,309	23	3,188	5,199	7,045	8,223	10,984	14,174	757	883	1,180	1,523
33	Sokoto	32,253	23	2,397	3,703	4,987	5,773	7,597	9,673	155	179	236	300
34	Taraba	59,313	17	1,512	2,295	2,796	3,067	3,710	4,365	47	52	63	74
35	Yobe	43,998	17	1,400	2,321	3,154	3,684	4,936	6,386	72	84	112	145
36	Zamfara	35,614	14	2,073	3,279	4,393	5,104	6,765	8,689	123	143	190	244
37	FCT(Abuja)	7,330	6	372	1,406	1,925	2,243	2,993	3,852	263	306	408	526
	Country	920,710	775	88,994	140,432	183,523	210,096	270,901	339,543	199	228	294	369

Source: Nigeria Census 1991 and 2006, NPC and "World Population Prospects 2012, UN"

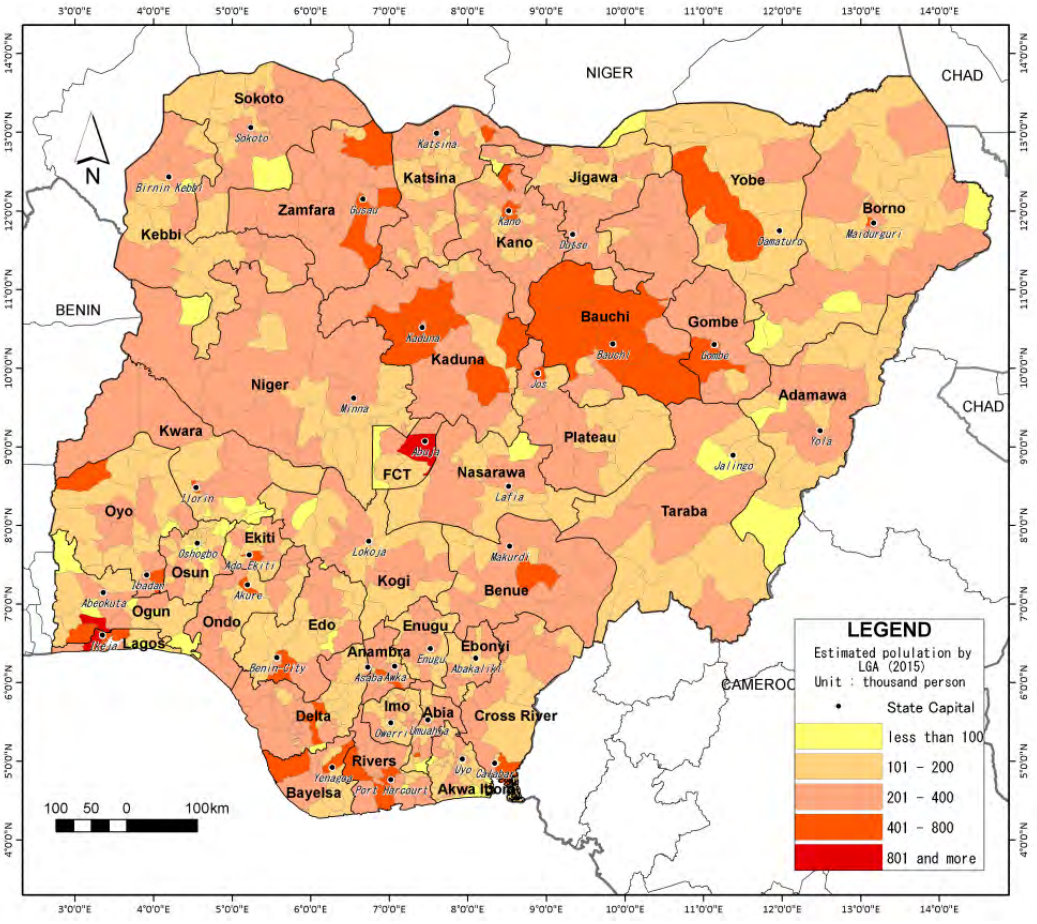


Figure 2-1.2 Estimated Population by LGA in 2015

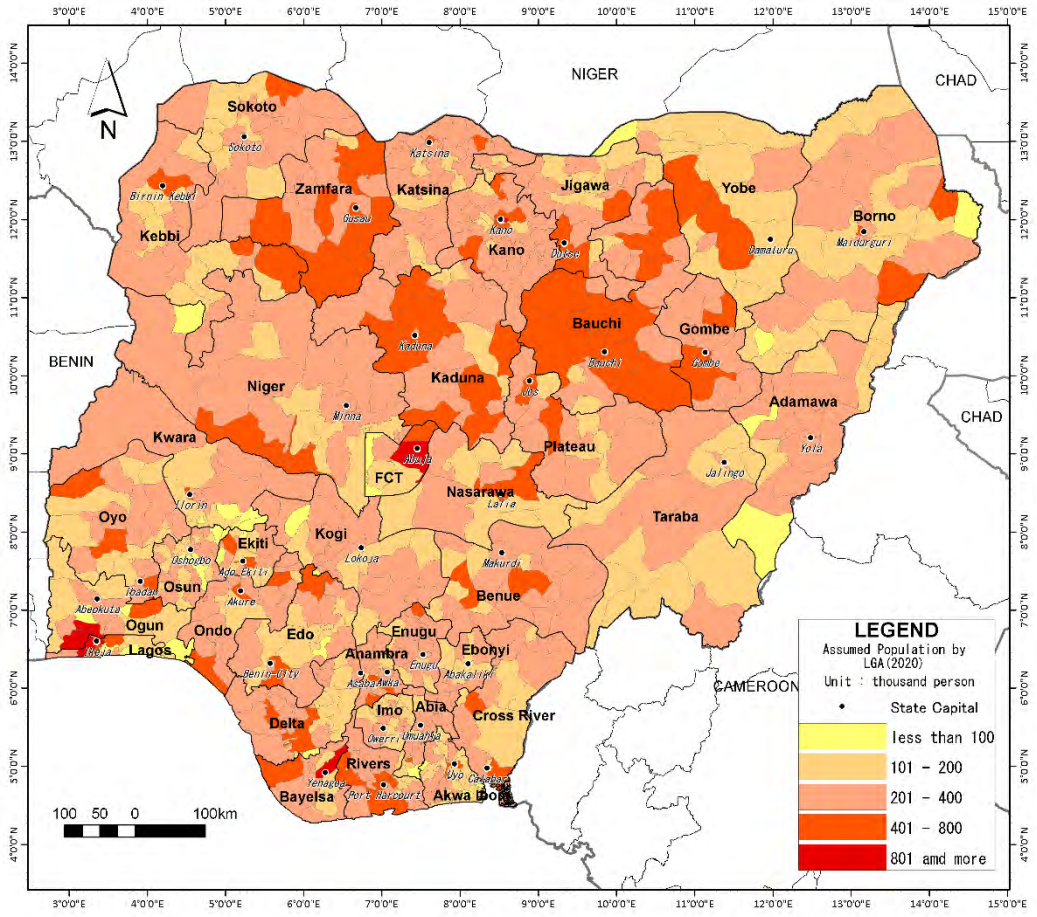


Figure 2-1.3 Assumed Population by LGA in 2020

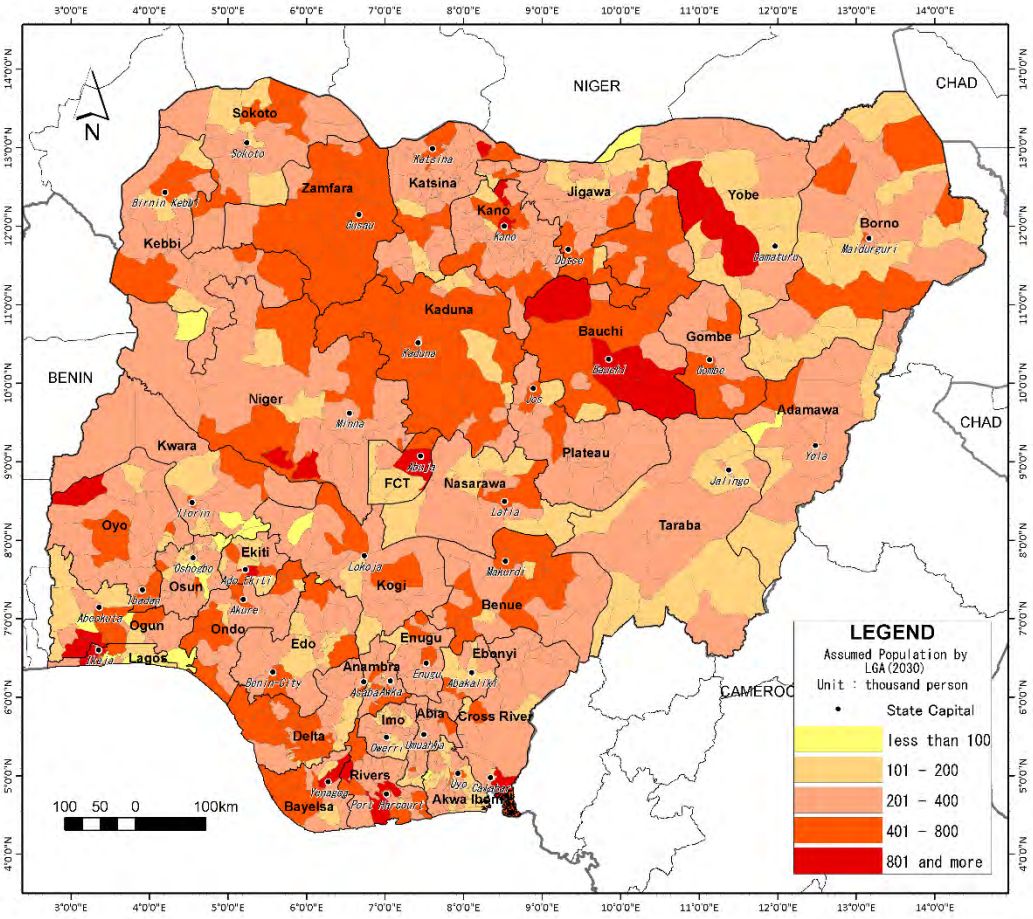


Figure 2-1.4 Assumed Population by LGA in 2030

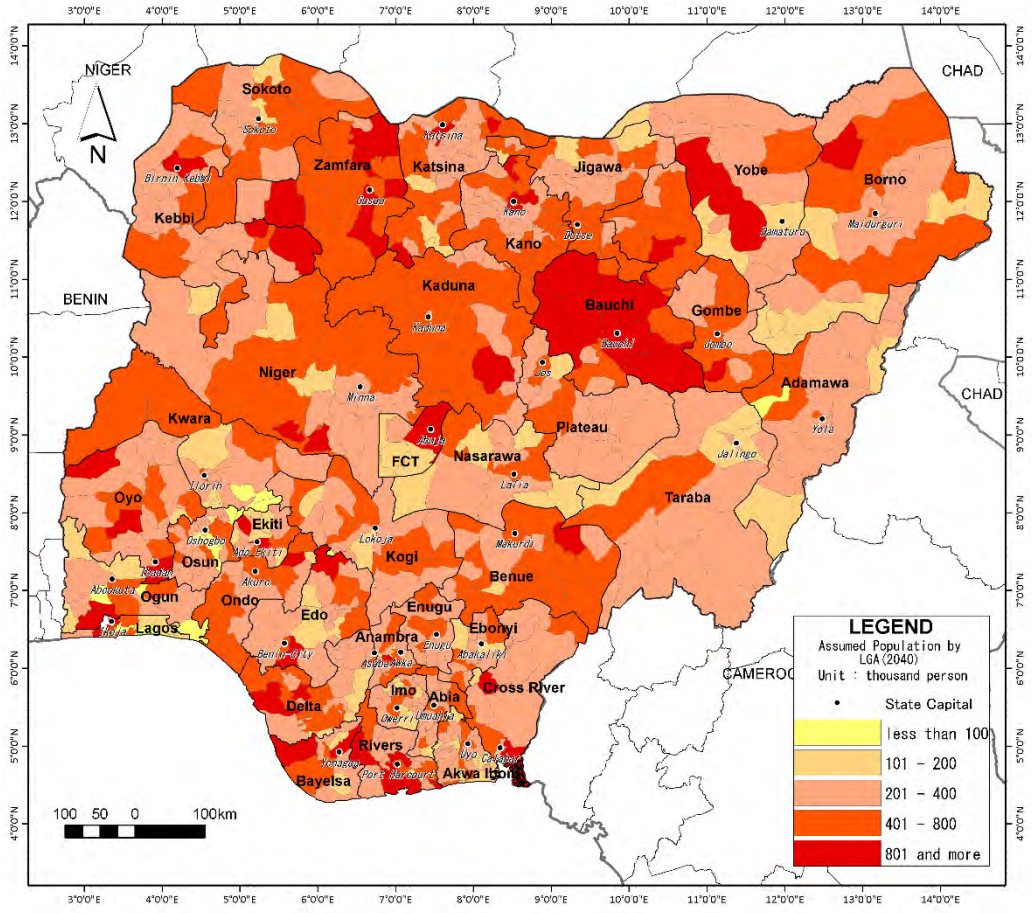


Figure 2-1.5 Assumed Population by LGA in 2040

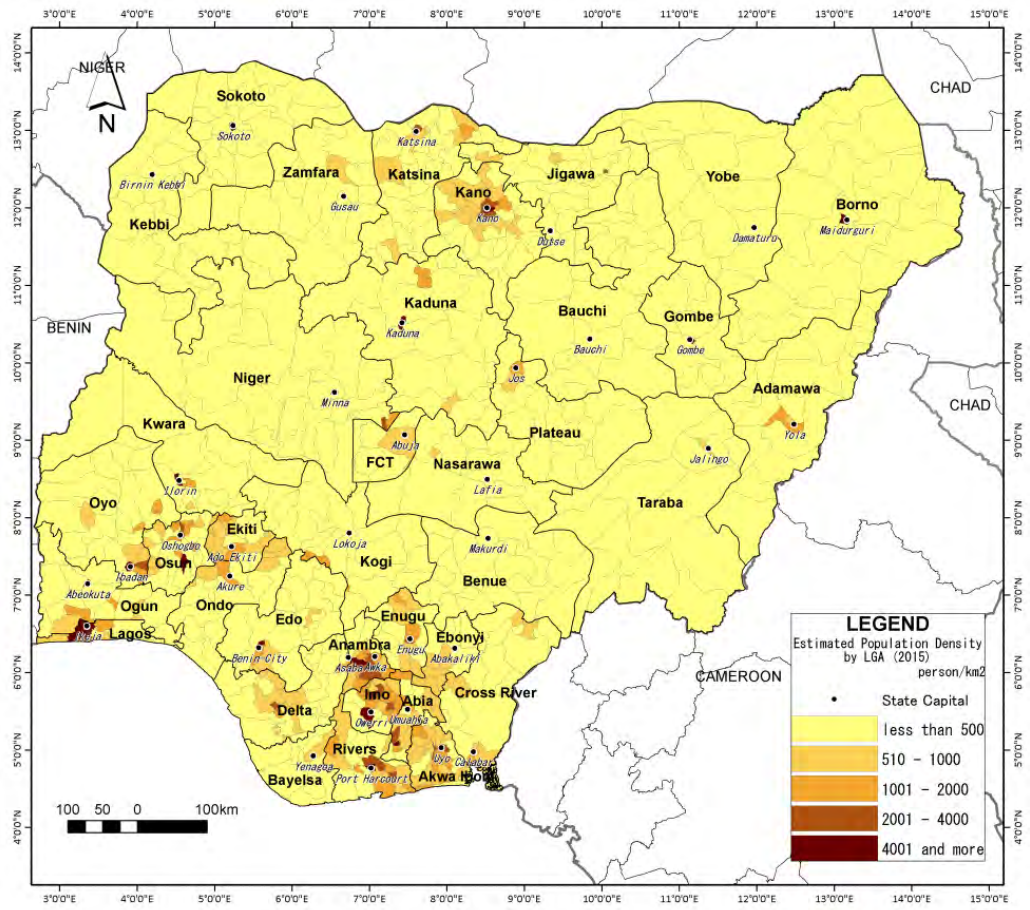


Figure 2-1.6 Estimated Population Density by LGA in 2015

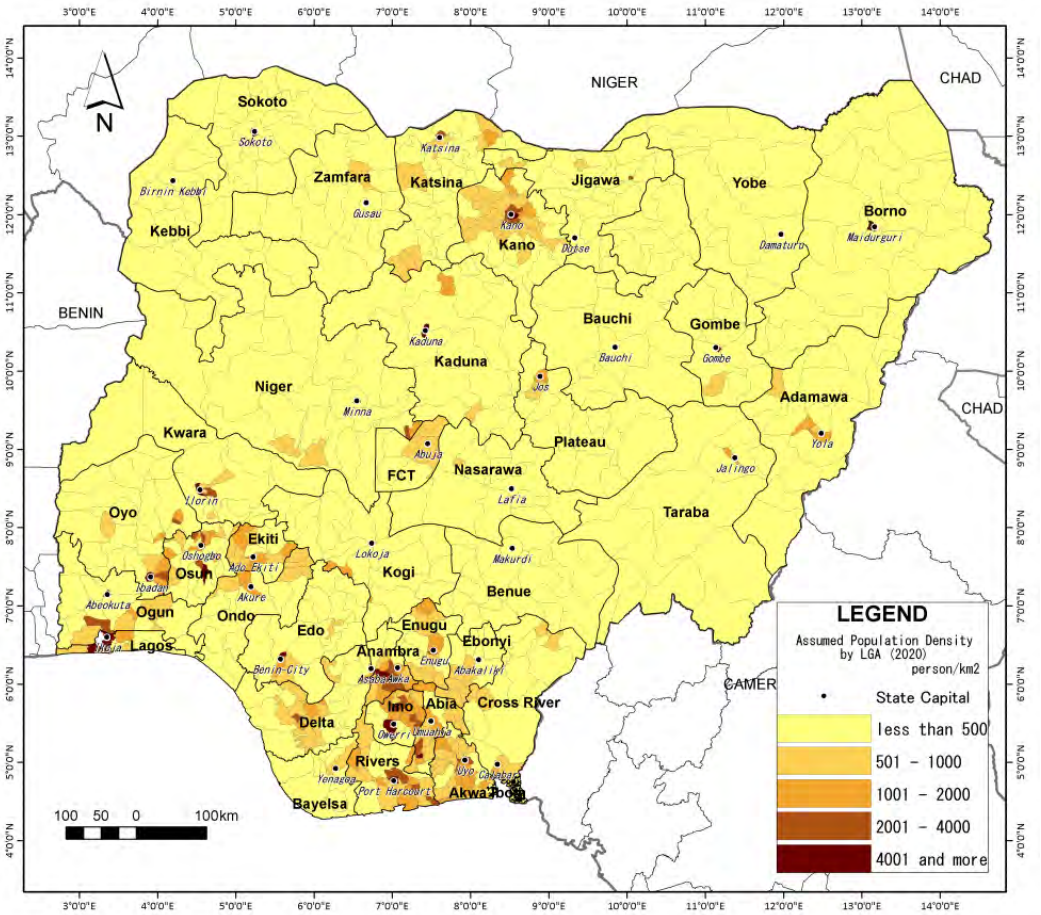


Figure 2-1.7 Assumed Population Density by LGA in 2020

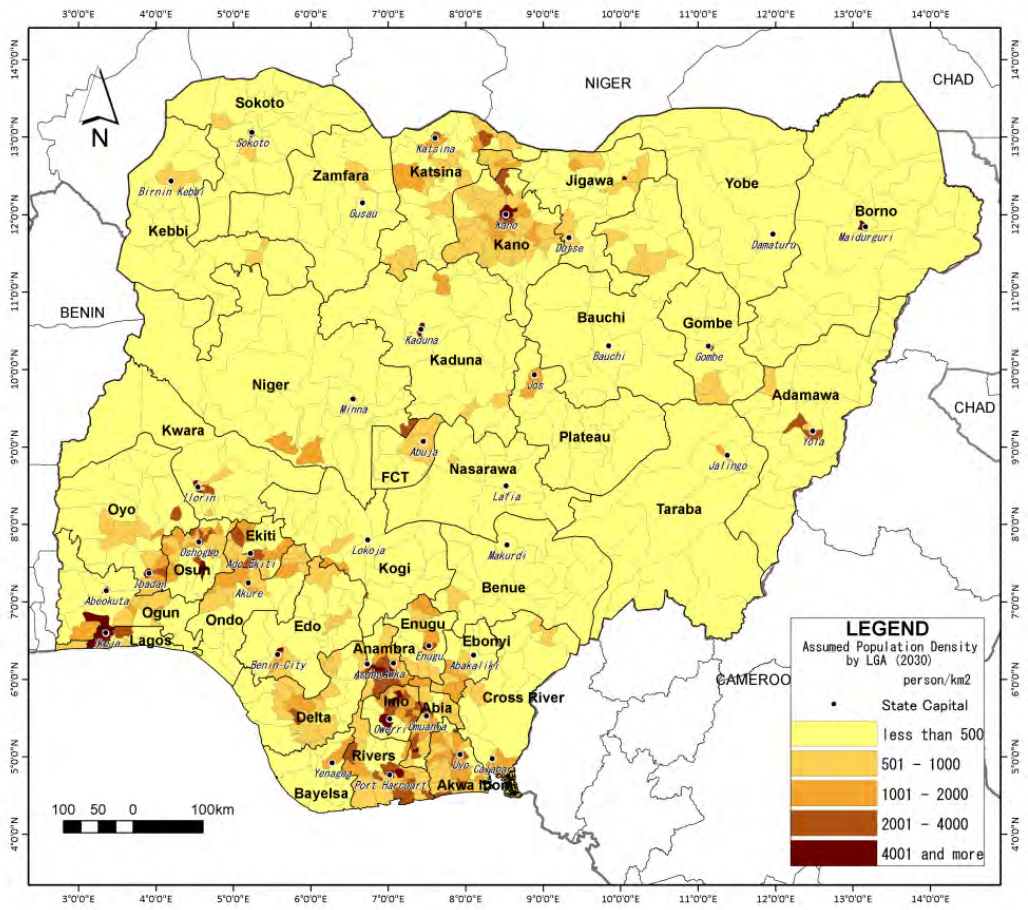


Figure 2-1.8 Assumed Population Density by LGA in 2030

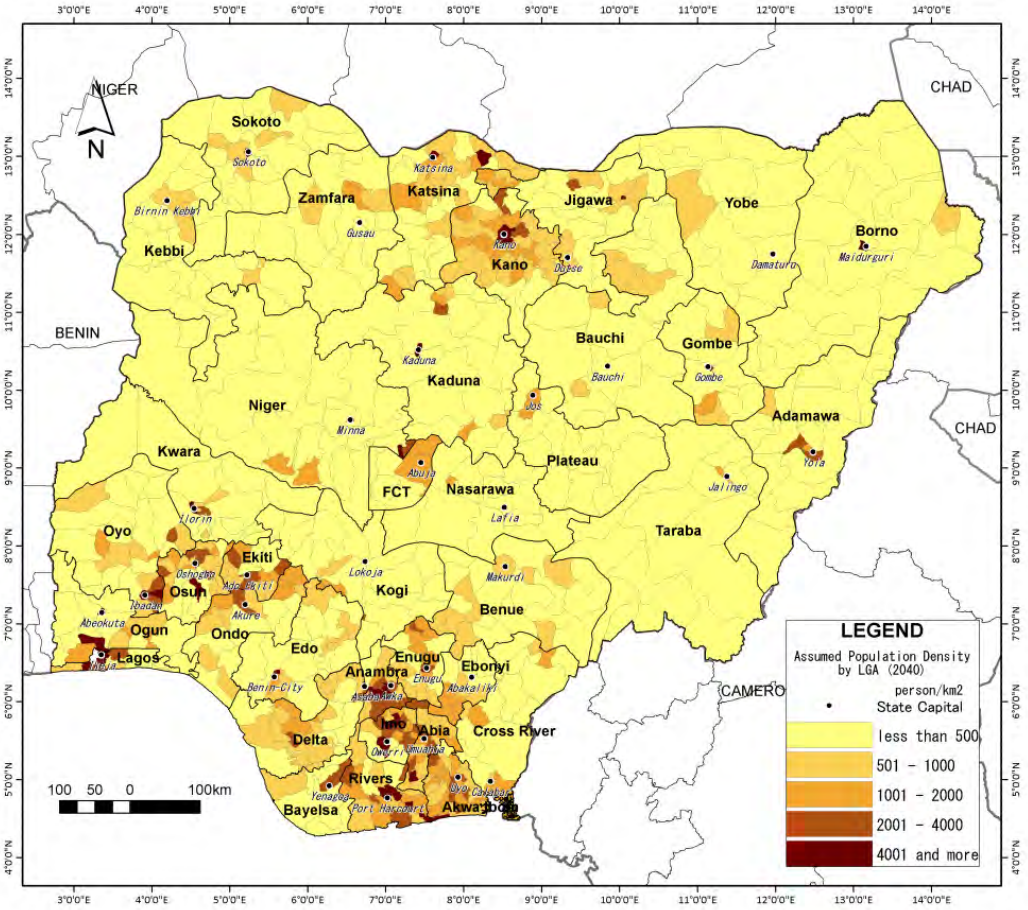


Figure 2-1.9 Assumed Population Density by LGA in 2040

2-1-4 International Cooperation

(1) Relationship with Japan

Bilateral relations between Japan and Nigeria have been progressing since the independence of Nigeria in 1960, mainly focusing on the economy and economic cooperation relations. At one point starting in March 1994, Japan suspended new ODA except emergency aid and humanitarian aid, due to concerns about a movement away from a democratic government, but this policy was withdrawn in recognition of the transition to a democratic government in May 1999. After the establishment of the Obasanjo government, relations with Japan have been re-strengthened. Starting with mutual visits by government officials from the two countries, exchange between private institutions of the two countries have been progressing steadily as well. According to data from the Ministry of Foreign Affairs, Japan provided 86.597 billion yen in loan assistance (excluding deferred debt and exemption from debt), 51.402 billion yen in grant aid, and 20.129 billion yen in technical cooperation from 2011 to 2016 in Nigeria.

(2) Relationship with DAC member countries and international organizations

ODA achievement by DAC member countries is shown in Table 2-1.4, and ODA achievement by international organizations is shown in Table 2-1.5. USA has consistently been ranked in the top of DAC countries for ODA achievement in Nigeria from 2011 to 2015. USA is also in the top of DAC 29 countries for global ODA achievement, and has provided more than 30% of the total ODA achievement in Sub-Sahara Africa since 2000. The International Development Association (IDA), a World Bank institution, has consistently held the highest rank of international organizations for ODA achievement in Nigeria, based on donations from 172 member countries and aid focused on the 82 poorest countries in the world (including 40 countries in Africa).

Table 2-1.4 ODA Achievement by DAC member countries

(Net Disbursement Base, Unit: Million USD)

	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Total
2011	USA 409.23	UK 323.84	Japan 39.20	Canada 28.20	Germany 25.91	886.48
2012	USA 418.24	UK 347.01	Japan 48.12	Canada 39.55	Germany 39.09	934.09
2013	USA 545.71	UK 397.50	Germany 74.06	France 45.89	Japan 40.13	1,171.84
2014	USA 486.17	UK 406.59	France 81.86	Germany 62.20	Japan 35.15	1,120.63
2015	USA 492.84	UK 401.84	Japan 85.33	Germany 34.24	France 32.63	1,127.73

Source: OECD/DAC

Table 2-1.5 ODA Achievement by International Organizations

(Net Disbursement Base, Unit: Million USD)

	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Total
2011	IDA 681.54	GFATM 107.46	EU Institutions 88.18	UNICEF 52.44	AfDB 31.54	1,041.17
2012	IDA 526.51	GFATM 220.21	EU Institutions 133.47	UNICEF 53.58	AfDB 48.82	1,084.10
2013	IDA 739.70	GFATM 209.16	AfDB 158.31	GAVI 146.96	EU Institutions 129.93	1,497.90
2014	IDA 926.14	GFATM 236.77	EU Institutions 122.66	GAVI 76.84	UNICEF 56.04	1,501.55
2015	IDA 774.59	GFATM 176.92	GAVI 130.34	EU Institutions 103.24	AfDB 102.91	1,385.31

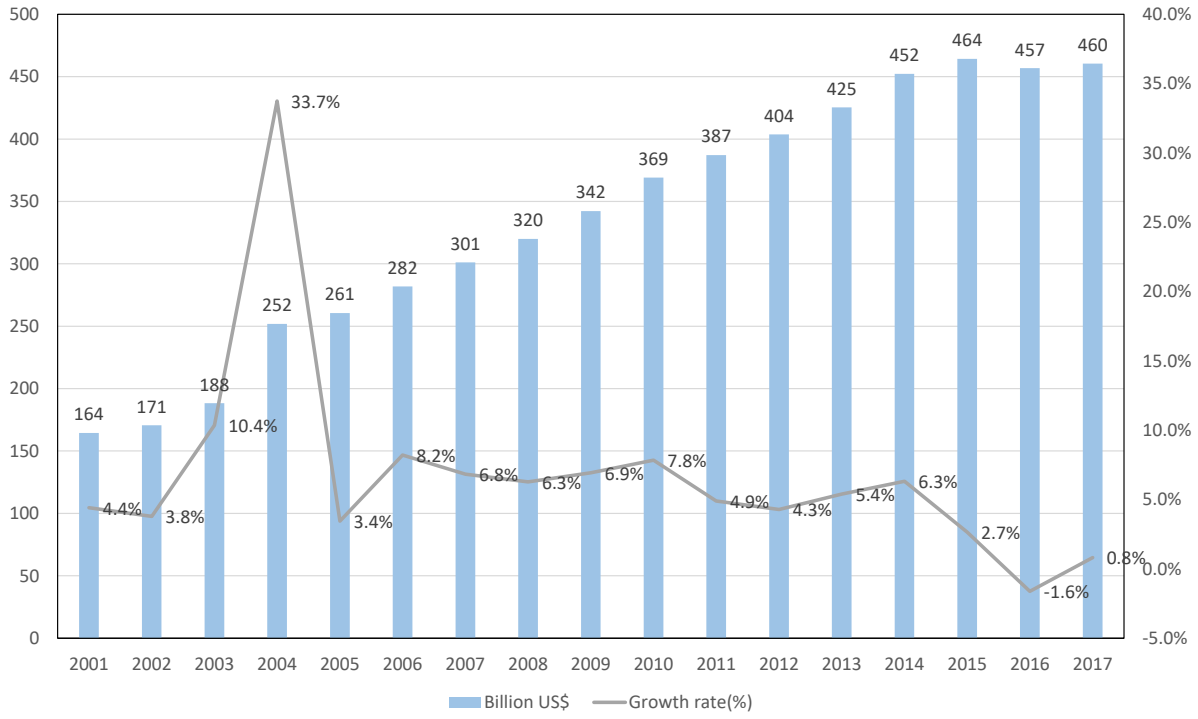
Source: OECD/DAC

2-2 Economic Conditions

2-2-1 GDP

(1) Real GDP

The real GDP of Nigeria (at 2010 constant price, US dollar base) is shown in Figure 2-2.1. From 2006-2014 the annual growth rate has remained within the range of 4.3% to 8.2%. In 2015, real GDP reached 484 billion US dollars. In the future, steady growth of the real GDP of Nigeria is expected. The study team assumed that the slowdown of the real GDP by approximately minus 1.6% in 2016 and 0.8% in 2017 reflects the reduction in the oil price.

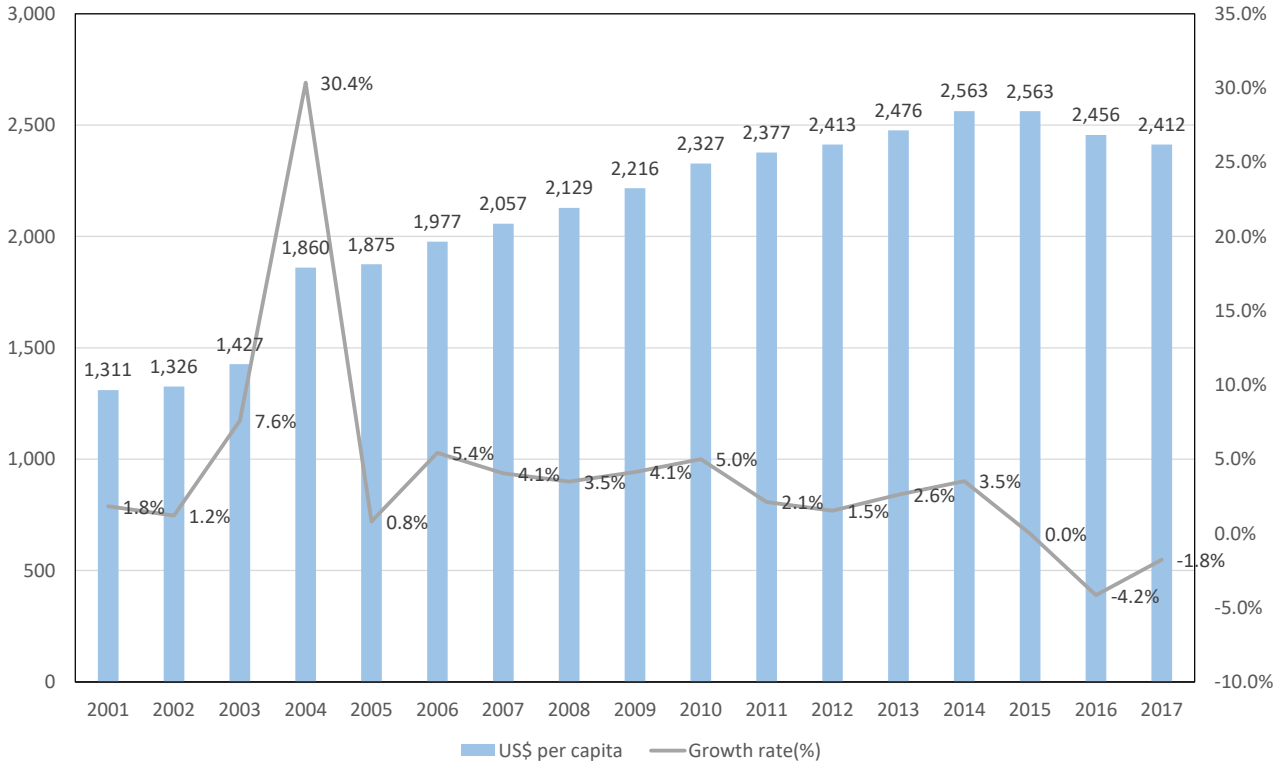


Source: JICA Study Team based on the World Bank database

Figure 2-2.1 Trends in Real GDP of Nigeria

(2) GDP per Capita

The real GDP per capita (at 2010 constant price, US dollar base) is shown in Figure 2-2.2. From 2006-2014 the annual growth rate has been within the range of 1.4% to 5.4%. Although real GDP per capita was more than 2,000 US dollars in 2007, and reached 2,563 US dollar in 2014, it has since decreased in 2016 and 2017.



Source: JICA Study Team based on the World Bank database

Figure 2-2.2 Trends in Real GDP per Capita of Nigeria

(3) GDP by Sector

The GDP by sector in 2011 and 2017 is shown in Table 2-2.1. In 2011, "agriculture, forestry, fishing & hunting," was 22.3% and "oil" was 17.5%, which together accounted for 39.8% of the GDP. The country's economy had been structured as largely dependent on these two sectors. However, in 2017, only 8 years later, "agriculture, forestry, fishing & hunting" was reported at 21.1%, and "oil" at 9.1%, bringing the percentage of these two sectors together down to 30.2% of the GDP.

In contrast, sectors in which the percentage of the GDP has increased include "finance, real estate and business services" (from 13.1% in 2011 to 16.7% in 2017), "wholesale & retail trade; repair of vehicles household goods, restaurants and hotels" (from 16.8% in 2011 to 19.8% in 2017), "manufacturing" (from 7.2% in 2011 to 8.8% in 2017). Economic activity is becoming diversified, and the country is developing a more multi-tiered and stable economic structure.

Table 2-2.1 GDP by Sector (Percentage of GDP at Current Prices)

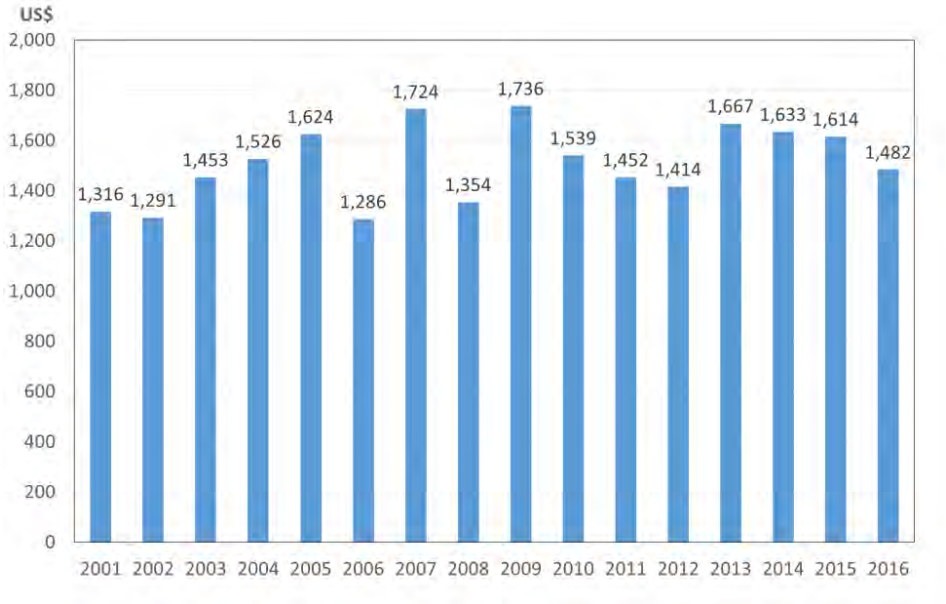
(%)

Content	2011	2017
Agriculture, forestry, fishing & hunting	22.3	21.1
(of which fishing)	0.5	0.5
Mining and quarrying	17.6	9.2
(of which oil)	17.5	9.1
Manufacturing	7.2	8.8
Electricity, gas and water	0.5	0.7
Construction	3.0	3.8
Wholesale & retail trade; repair of vehicles household goods;Restaurants and hotels	16.8	19.8
(of which hotels and restaurants)	0.4	0.9
Transport, storage and communication	11.4	10.5
Finance, real estate and business services	13.1	16.7
Public administration and defence	3.9	2.6
Other services	4.2	6.8
Gross domestic product at basic prices / factor cost	100.0	100.0

Source: African Economic Outlook 2018, AfDB

2-2-2 Household Final Consumption Expenditure

Trends in household final consumption expenditure per capita in Nigeria (at 2010 constant price, US dollar base) is shown in Figure 2-2.3. Increases and decreases from year to year can be seen. Household final consumption expenditure was 1,667 US dollar in 2013 and decreased to 1,482 US dollar in 2016.



Source: JICA Study Team based on the World Bank database

Figure 2-2.3 Household Final Consumption Expenditure per Capita

2-2-3 Inflation Rate and Interest Rate

The inflation rate of Nigeria during a five-year period from 2013 to 2017 has continued to be level at 8% or more, representing a high level of consumer price inflation. Interest rates are at a high level, and the policy interest rate for the most recent four years has been 13% or more. The prime lending rate has been at an even higher level over the last five years at 17% or more.

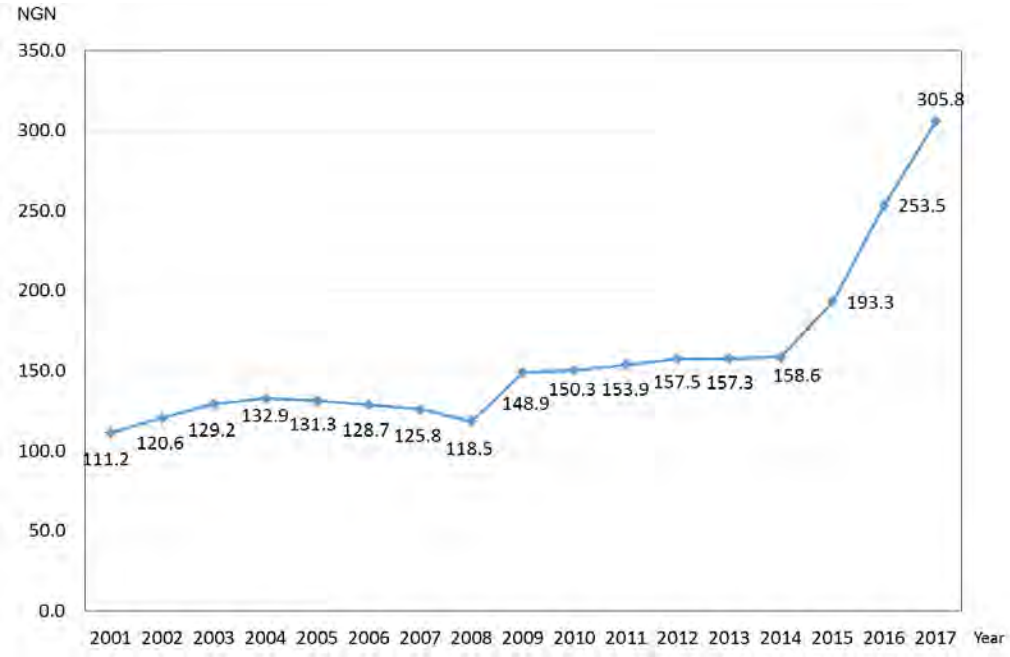
Table 2-2.2 Trends in Inflation Rate and Interest Rate

Year	Monetary Policy Rate	Prime Lending Rate	Inflation Rate (%)
2013	12.0	17.0	8.0
2014	13.0	15.9	8.0
2015	11.0	17.0	9.6
2016	14.0	17.1	18.5
2017	14.0	17.7	15.4
Average in last 3 year(2013-17)	13.0	17.3	14.5
Average in last 5 year (2013-17)	12.8	16.9	11.9

Source: JICA Study Team based on "ANNUAL REPORT 2017", the Central Bank of Nigeria

2-2-4 Exchange Rate

Trends in the exchange rate between the US dollar and Nigerian Naira is shown in Figure 2-2.4. While the exchange rate was relatively stable in the early 2000s, the US dollar exchange rate fell significantly between 2007 to 2009. The rate was 305.8NGN / US $ in 2017.



Source: JICA Study Team from the Central Bank of Nigeria statistical data

Figure 2-2.4 Trends in US dollar exchange rate

2-2-5 Trade

Nigerian import and export trends are shown in US dollar in Table 2-2.3. Exports shifted from 93.2 billion US dollar in 2010 to 129.0 billion US dollar in 2011, and have since remained almost unchanged.

Imports shifted from 64.2 billion US dollar in 2010 to 88.4 billion US dollar in 2011, then decreased again to 59.7 billion dollar in 2012 and have since remained almost unchanged.

Nigeria is the biggest oil exporter in Africa, and crude oil makes a large contribution to exports. Because of this export, a trade balance surplus has been consistently maintained.

Table 2-2.3 Trends in Nigeria Exports and Imports

	2010	2011	2012	2013	2014	2015	2016
Trade Balance (USD billion)	29.1	40.6	85.3	26.0	34.0	0.0	-9.3
Exports (USD billion)	93.2	129.0	144.9	93.0	104.8	51.3	37.3
Imports (USD billion)	64.2	88.4	59.7	66.9	70.8	51.3	46.6
Exports (annual variation in %)	53.5	25.8	-3.6	-21.7	24.1	0.1	11.5
Imports (annual variation in %)	12.7	-7.8	-32.9	12.2	6.0	-25.7	-10.4

Source: JICA Study Team based on the World Bank database

2-2-6 Public Finance

Trends in the percentage of GDP of Nigerian public finances are shown in Table 2-2.4. Looking at the composition in 2016, total revenue and grants had become 5.6% of GDP. Broken down, tax revenue is 3.0%, and oil revenue is 2.1%. While it was the main source of income for public finances in the past, oil revenue has been decreasing year by year since 2009.

On the other hand, the sum of the total expenditure and net lending in 2016 was 9.5% of the GDP. The GDP ratio of current expenditure for this year was reported as 7.6%.

The primary balance and overall balance is nearly balanced in equilibrium, and it can be said that a sustainable and stable national financial structure has been maintained.

Table 2-2.4 Public Finances of Nigeria (Percentage of GDP at Current Price)

Unit: %

	2009	2014	2015	2016	2017(estimated)
Total revenue and grants	**12.0**	**11.4**	**7.6**	**5.6**	**5.7**
Tax revenue	3.8	3.5	3.7	3.0	2.8
Oil revenue	7.9	7.7	3.5	2.1	2.5
Total expenditure and net lending*	**19.1**	**13.0**	**11.1**	**9.5**	**10.8**
Current expenditure	12.0	10.1	8.9	7.6	8.8
Excluding interest	11.0	9.3	8.3	7.1	6.9
Wages and salaries	2.9	2.1	2.0	1.8	1.7
Interest	1.0	0.8	0.6	0.6	1.1
Capital expenditure	7.0	2.8	2.2	1.8	2.0
Primary balance	**-6.1**	**-0.7**	**-2.9**	**-3.4**	**-4.0**
Overall balance	**-7.0**	**-1.5**	**-3.5**	**-3.9**	**-5.1**

Note: *Only major items are reported
Source: "African Economic Outlook 2018", AfDB

2-2-7 Public Debt

The GDP ratio of public debt of Nigeria is shown in Table 2-2.5. In recent years, it has remained stable at a level of about 10%. Because the GDP ratio of public debt has remained at a low level, the financial structure can be considered stable.

Table 2-2.5 GDP ratio of public debt of Nigeria

(%)

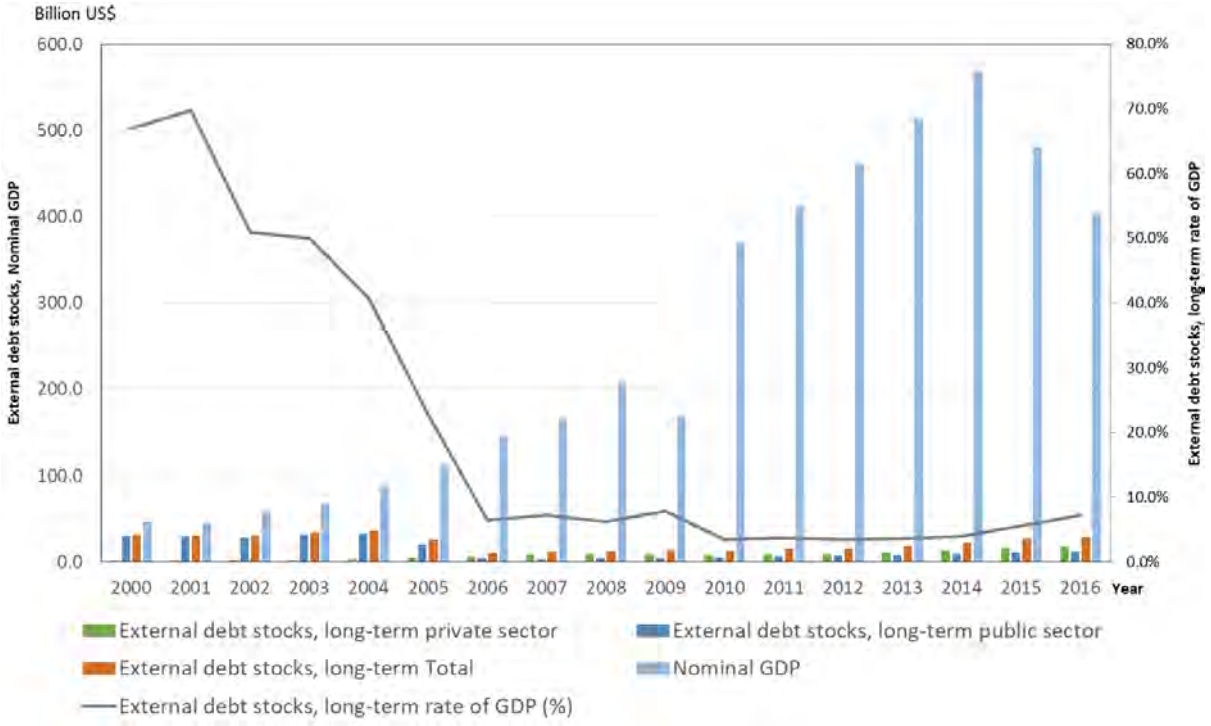
	2013	2014	2015	2016	2017
GDP ratio of Public Debt	10.2	10.3	11.2	14.2	16.0

Source: JICA Study Team based on the World Bank database

2-2-8 External Debt Stocks

The transition of external debt stock in Nigeria is shown in Figure 2-2.5. Although the GDP percentage of external debt remained at a high level until the early 2000s, total external dept has been kept at a low level since 2006. Since the GDP has also expanded, the GDP ratio of external debt is now settled at a very low level.

Currently, external debt can be viewed as stable at healthy levels compared to the first half of the 2000s.



Source: JICA Study Team based on the World Bank database

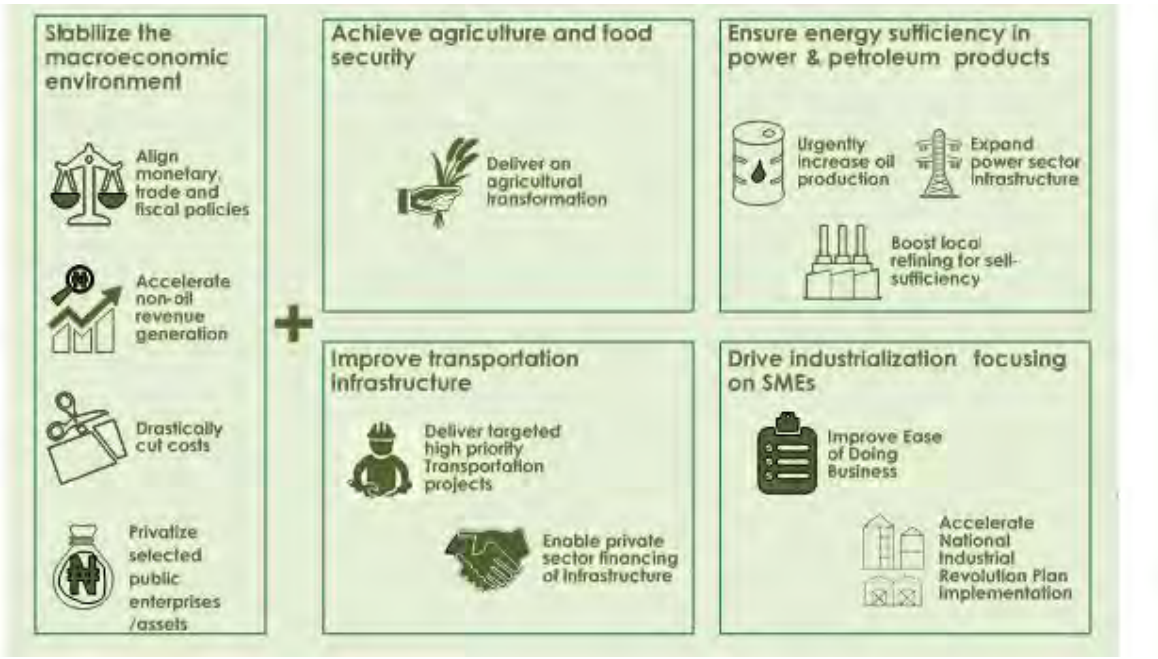
Figure 2-2.5 Trends in external debt stock of Nigeria

2-3 Development Plan

2-3-1 Economic Recovery and Growth Plan 2017-2020：ERGP

The ERGP was formulated in 2014 and aims to improve the resilience of the economy and make it less vulnerable to external shocks through a reduction in dependence on the oil sector, and better implementation of government policies. To achieve the objectives of the ERGP, the key execution priorities, as illustrated in Figure 2-3.1, are:

- Stabilizing the macroeconomic environment
- Achieving agriculture and food security
- Ensuring energy sufficiency (power and petroleum products)
- Improving transportation infrastructure
- Driving industrialization focusing on small and medium scale enterprises



Source: Ministry of Budget and National Planning, "Economic Recovery and Growth Plan 2017-2020", February 2017

Figure 2-3.1 ERGP'S TOP Execution Priorities

The objectives aimed for in the ERGP is to "optimize the delivery of at least 10 GW of operational power capacity by 2020 to boost economic activity across all sectors and improve the quality of life of the citizenry." The Nigerian government has placed the power sector (electric power and transportation) as one of the first priorities in ERGP.

The strategies are as follows:

- With regard to the power value chain, efforts will be concentrated on overcoming the current challenges which relate to governance, funding, legal, regulatory, and pricing issues across the three main power segments of generation, transmission, and distribution, and ensuring stricter contract and regulatory compliance.

- The ERGP aims to optimize the delivery of at least 10 GW of operational capacity by 2020 and to improve the energy mix including greater use of renewable energy.
- The plan also aims to increase power generation by optimizing operational capacity, encouraging small-scale projects, and building more capacity over the long term.
- The Government will also invest in transmission infrastructure.

ERGP reported that ”Nigeria has 12.5 GW of installed capacity, but less than one-third is operational (average 3.9 GW in 2015; 3.2 GW in November 2016).” It is hoped that effective utilization of the capacity of existing power supply facilities, improvement of reliability, and higher quality of electric power supply will be achieved.

2-3-2 Development Plan in the Power Sector

(1) National Energy Master Plan (Draft Revised Edition) 2014

In Nigeria, the National Energy Policy that was decided on in 2003 and revised in 2014 shows the enforcement method and framework.

Moreover, the National Energy Master Plan is scheduled to look forward as far as to 2030, and indicates a tendency for industrialization to progress further as shown in Table 2-3.1 regarding energy demand.

Table 2-3.1 Total Energy Demand Projection

Unit: Mtoe　　Unit: %

Sector	Growth rate(%)	Demand						Share					
	2009-2030	2009	2010	2015	2020	2025	2030	2009	2010	2015	2020	2025	2030
Industry	24.01	1.15	0.47	23.34	46.72	73.80	105.52	3.20	1.30	38.0	49.6	53.2	55.3
Transport	6.46	7.65	9.26	11.63	15.53	21.12	28.51	21.20	24.90	18.9	16.5	15.2	14.9
Household	3.16	24.09	24.68	23.40	27.28	36.46	46.29	66.90	66.50	38.1	28.9	26.3	24.2
Services	6.01	3.13	2.71	3.06	4.76	7.46	10.67	8.70	7.30	5.0	5.0	5.3	5.6
Total		36.02	37.12	61.425	94.29	138.84	190.99	100.00	100.00	100.0	100.0	100.0	100.0

Source: National Energy Master Plan (Draft Revised Edition) 2014

Moreover, a power demand estimate assuming a GDP growth rate of 7% (reference), 10% (high case), and 13% (optimistic) has been formulated in the National Energy Master Plan. The power generation equipment capacity plan based on fuel type is as shown in Table 2-3.2.

Table 2-3.2 Electricity Supply Projections by Fuel Type

Unit: MW

Item	2009	2010	2015	2020	2025	2030
Electricity Demand Projection						
Reference Growth (GDP growth rate: 7%)	4,054	7,440	24,380	45,490	79,748	115,674
High Growth (GDP growth rate: 10%)	4,052	8,420	30,236	63,363	103,859	196,875
Electricity Supply Project by Fuel						
Coal	0	609	1,850	6,527	7,545	10,984
Electricity Import	0	0	0	0	0	31,948
Gas	3,803	4,572	18,679	33,711	61,891	80,560
Hydro (Large and Small)	1,930	1,930	3,043	6,533	6,533	6,533
Nuclear	0	0	1,000	1,500	2,500	3,500
Small Hydro	20	60	172	409	894	1,886

Unit: MW

Item	2009	2010	2015	2020	2025	2030
Solar	0	260	1,369	3,455	7,000	25,917
Wind	0	10	19	22	25	29
Biomass	0	0	3	16	35	54
Supply	5,753	7,440	26,092	52,174	86,422	161,411

Source: National Energy Master Plan 2014 (Draft Revised Edition) 2014

(2) Rural Electrification Goal

In the "Draft Rural Electrification Strategy & Plan" (Revised) which the Nigerian government released in April 2015, and as stated in the "National Electric Power Policy" (2001) and "Rural Electrification Policy" (2005), the target of access to electricity is set as 75% by 2020 and 90% by 2030.

However, for urban areas the required electrification rate is 95% and in rural areas 60%. Moreover, the rural electrification of 10 million households (7 persons / 1 household) is also necessary to achieve the plan. This is estimated to cost 1,440 billion naira (about 9 billion U.S. dollars) for achievement by 2020.

Recognizing this, an interim target proposed for 2016 is to add 1 million connections and 800MW of generation capacity in rural areas. This will require a total capital of 192 billion naira (about 1.2 billion U.S. dollars). Furthermore, it will involve extending service to an additional 1.1 million rural households each year from 2015 to 2030 and, in order to reach the goal of 100% electrification by 2040, 513,000 new rural household connections must be made every single year from 2020 to 2040.

Privatized power distribution companies (DisCos) are contractually burdened to connect electric power to 4 million unelectrified households by 2017.

Table 2-3.3 Household Electrification Rate by State (2014)

	State	Have Electricity	No Electricity	Missing	Number of hh surveyed
1	Abia	81.7%	18.3%	0.0%	644
2	Adamawa	37.6%	62.2%	0.2%	726
3	Akwa Ibom	68.0%	31.8%	0.2%	892
4	Anambra	88.1%	11.8%	0.1%	1,050
5	Bauchi	29.3%	70.3%	0.4%	932
6	Bayelsa	52.5%	47.3%	0.2%	322
7	Benue	22.1%	77.9%	0.0%	1,365
8	Borno	33.0%	66.5%	0.5%	1,560
9	Cross River	57.4%	41.4%	1.2%	848
10	Delta	78.3%	21.6%	0.1%	946
11	Ebonyi	39.2%	60.7%	0.1%	978
12	Edo	82.4%	17.5%	0.1%	702
13	Ekiti	92.7%	7.3%	0.0%	376
14	Enugu	55.4%	44.6%	0.0%	920
15	Gombe	48.1%	51.8%	0.1%	464
16	Imo	69.9%	30.1%	0.0%	1,096
17	Jigawa	26.0%	74.0%	0.0%	1,152
18	Kaduna	53.5%	46.2%	0.3%	1,915
19	Kano	52.1%	47.9%	0.0%	2,606
20	Katsina	31.3%	68.5%	0.2%	1,257
21	Kebbi	44.4%	55.6%	0.0%	1,069
22	Kogi	62.9%	37.1%	0.0%	876
23	Kwara	90.6%	9.1%	0.3%	617

	State	Have Electricity	No Electricity	Missing	Number of hh surveyed
24	Lagos	99.3%	0.5%	0.2%	2,240
25	Nasarawa	33.2%	66.5%	0.3%	550
26	Niger	51.7%	48.2%	0.1%	1,504
27	Ogun	72.0%	27.9%	0.1%	1,355
28	Ondo	66.3%	33.7%	0.0%	920
29	Osun	89.4%	10.6%	0.0%	853
30	Oyo	66.6%	33.3%	0.1%	1,802
31	Plateau	36.3%	63.7%	0.0%	669
32	Rivers	65.1%	34.5%	0.4%	1,529
33	Sokoto	38.9%	60.9%	0.2%	898
34	Taraba	10.9%	88.8%	0.3%	634
35	Yobe	18.1%	81.7%	0.2%	799
36	Zamfara	29.1%	70.6%	0.3%	1,096
37	FCT(Abuja)	77.7%	22.0%	0.3%	361
	Average	55.4%	44.4%	0.2%	38,523

Source: National Bureau of Statistics 2014

(3) Renewable Energy Master Plan

The development plan concerning renewable energy was formulated in 2005 with the support of the UNDP. After that, a revised edition was formulated in 2012 again with the support of the UNDP. In this revised edition, the assumed potential of renewable energy is as shown in Table 2-3.4 below.

Table 2-3.4 Potential of Renewable Energy

Resource	Potential	Current Utilization and further remarks
Large Hydropower	11,250 MW	1,900 MW exploited
Small Hydropower	3,500 MW	64.2 MW exploited
Solar	4.0 kWh/m2/day – 6.5 Wh/m²/day	15 MW dispersed solar PV installations. (estimated)
Wind	2–4m/s @ 10m height mainland	Electronic wind information system (WIS) available;
Biomass (non-fossil organic matter)	Municipal waste	18.5 million tons produced in 2005 and now estimated at 0.5kg/capita/day
	Fuel wood	43.4 million tons/yr. fuel wood consumption
	Animal waste	245 million assorted animals in 2001
	Agricultural residues	91.4 million tons/yr. produced
	Energy crops	28.2 million hectares of arable land; 8.5% cultivated

Source: Renewable Energy Master Plan 2005 (ECN)

Moreover, in the revised edition of the development plan, programs for every framework of the timeline with a short term (2013 - 2015), middle term (2016 - 2020), and a long term period (2021 - 2030) are planned.

- National Biomass Energy Programme
- National Solar Energy Programme
- National Hydropower Programme
- National Wind Energy Programme
- Emerging Energy Programme
- Framework Programme for Renewable Energy Promotion

An introductory target for renewable energy is set for each timeline, and an outline is shown in Table 2-3.5.

Table 2-3.5 Renewal Energy Targets

Unit: MW

Renewable Energy	Short Term	Medium Term	Long Term
Biomass	5	30	100
Solar (PV 1MW Capacity)	80	990	9,990
Large Hydro	4,000	9,000	11,250
Small Hydro	100	760	3,500
Wind	23	40	50

Source: Renewable Energy Master Plan 2005 (ECN)

(4) Grid development plan (TCN Appraisal Report)

With the objective of reinforcing the transmission capacity and improving the reliability of the system, TCN (Transmission Company of Nigeria) has developed a power grid extension plan and the "Appraisal of Transmission Projects (March 2014)" appraisal report summarizing these transmission projects and investment plans in order to raise project funds.

In the appraisal report, TCN provides an investment plan for each section such as TSPs (transmission services providers), SOs (system operators), and MOs (market operators). In regard to TSPs, who are responsible for transmission infrastructure, TCN has compiled a detailed investment plan for each step and year as shown in Table 2-3.6.

Table 2-3.6 Investment plan of TSP

	Construction cost (million US dollars)	Target transmission capacity	Target year of achievement
(1) Rehabilitation of existing facilities	947	—	2015
(2) Project under construction (Package 1)	989	7-8 GW	2015
(3) Transmission capacity 10GW (Package 2)	2,235	10GW	2017
(4) Transmission capacity 13GW (Package 3)	1,570	13GW	2018
(5) Transmission capacity 16GW (Package 4)	1,000	16GW	2019
(6) Transmission capacity 20GW (Package 5)	1,000	20GW	2020
Total	7,742		

Source: Transmission Company of Nigeria (March 2014) “Appraisal of Transmission Projects”

Among the investment projects shown in Table 2-3.6, TCN states that there is a pressing need to implement (1) rehabilitation of existing facilities, (2) projects under construction (Package 1), and (3) transmission capacity 10GW (Package 2). Projects for (3) transmission capacity 10GW (Package 2) are categorized into 5 area groups as shown in Table 2-3.7.

Table 2-3.7 Categorization by area of Transmission capacity 10GW (Package 2) project

Group	Area	Number of Transmission and Transformation Projects	Number of Projects for Voltage Stability	Construction Cost (Million US$)
1	Kainji - Birnin Kebbi - Gusau	11	13	$438
2	Lagos	25	21	$548
3	Jos – Gombe - Damaturu	4	8	$246
4	Awka – Ugwuaji - Jos	16	13	$617
5	Benin - Katampe	5	16	$385
	Total	61	71	$2,235

Source: Transmission Company of Nigeria (March 2014) “Appraisal of Transmission Projects”

CHAPTER 3 Organizations, Policies and Regulations in the Energy and Power Sector

Chapter 3 Organizations, Policies, and Regulations in the Energy and Power Sector

3-1 Present State and Issues of the Power Sector

3-1-1 Organizations and Functions

(1) Power Sector Related Organizations

Federal Ministry of Power, Works and Housing (FMPWH) and its subordinate agencies account for most of the organizations of the power sector. However, new agencies have been established under other ministries mainly to develop and implement on-going sector reform accompanied by the privatization of many operators of the sector.

1) FMPWH and its subordinate agencies

FMPWH and its affiliated agencies are listed as below.

Table 3-1.1 FMPWH and Subordinate Agencies

Organizations	Main Roles and Responsibilities
Federal Ministry of Power, Works and Housing (FMPWH)	FMPWH was established in 2015 by the merger between the Federal Ministry of Power, and the Federal Ministry of Public Works and Housing. The Department of Power is in charge of formulation, implementation supervision, and coordination of the power sector policies and programmes.
National Electricity Regulatory Commission (NERC)	NERC is the regulatory agency for the power sector. The entire power sector including power generation, transmission, distribution, and bulk traders are under the jurisdiction of NERC. NERC is also is responsible for licensing power sector operators.
Transmission Company of Nigeria (TCN)	TCN is the state-run transmission company. It is composed of the following three operating divisions and administrative divisions.
Transmission Service Provider (TSP)	TSP is responsible for managing the assets regarding transmission networks, formulating construction and operation plans for transmission networks and carrying out the construction projects.
System Operator (SO)	SO is in charge of i) dispatching generating units; ii) handling power system emergencies and restoring the system, coordinating generation and transmission outages, reporting scheduled and planned actions and unexpected occurrences to users and the regulator; iii) performing demand forecasting; iv) supervising compliance with, and enforcing the Grid Code, testing and monitoring users' equipment; and v) conducting system tests pertaining to the network, etc.
Market Operator (MO)	MO is charged i) electricity metering at receiving points from generators and transmitting points to distribution companies (DisCos), settlement of the electricity volumes and ii) collection of service charges related to the power system operation, payments to service providers, etc.
Nigerian Bulk Electricity Trading Plc. (NBET)	NBET is the bulk trader of electricity. It purchases power from generation companies (GenCos), including independent power producers (IPPs) and sells it to DisCos.
Power Holding Company of Nigeria (PHCN)	PHCN is the successor company to the assets and businesses of National Electric Power Authority (NEPA), the state-owned power monopoly. It has been established as a temporary entity operated only until unbundling of power generation, transmission, and distribution as well as privatization. On September 30, 2013, the PHCN was dissolved, and the 11 DisCos and 6 GenCos that were under its supervision moved to privatization procedures, and the transmission section began to proceed with the establishment of state-owned companies (TCN).
Niger Delta Power Holding Company (NDPHC)	NDPHC is the implementing agency of NIPP. NDPHC holds and manages the assets developed by NIPP.
Rural Electrification Agency (REA)	REA the implementing agency for rural electrification promotion.

Organizations	Main Roles and Responsibilities
National Power Training Institute of Nigeria (NAPTIN)	NAPTIN is the organization with a mandate to provide training for staff in the power sector. At present, a scheme to provide apprenticeship craft training on electrical techniques to the unemployed, namely, the National Power Sector Apprenticeship Scheme (NAPSAS) is managed by NAPTIN.
Nigeria Electricity Management Services (NEMSA)	NEMSA is the organization with a mandate to provide technical support and inspect the facilities of electricity service operators.

2) Special agencies directly under the President and the Vice President

There are special agencies established by the former and the current presidents as hub agencies to formulate and drive power sector policies.

Table 3-1.2 Special Task Force Related to Power Sector

Organizations	Main Roles and Responsibilities
Presidential Task Force on Power (PTFP)	The PTFP was established as the organization directly controlled by the former President Goodluck Jonathan to formulate the strategy and monitor planning and execution of various projects for the reform and privatization of the power sector. Along with the change of the president, its functions were suspended and it was dissolved in May of 2015.
National Council On Power (NACOP)	NACOP organization has been established under President Jonathan's administration as the highest decision making body regarding the power sector. It consists of the Minister and the secretaries of FMPWH, advisors, CEOs of electricity companies, donors, politicians and assembly members, scholars, representatives of customers, etc.
Advisory Power Team, Office of the Vice President	Along with the inauguration of Buhari administration, the Team was established in the Office of Vice President as the policy advisory body for the power sector.

3) Subordinate agency of Federal Ministry of Finance

The agency related to power sector under Federal Ministry of Finance (FMF) is as follows.

Table 3-1.3 Subordinate Agency of FMF Related to Power Sector

Organizations	Main Roles and Responsibilities
Nigeria Electricity Liability Management Ltd. (NELMCO)	NELMCO has the mandate to assume and manage the pension liabilities of employees of PHCN which has taken them from its predecessor company, and to hold the non-core assets of PHCN and sell or dispose of them or deal with them in any manner for the purpose of financing the repayment of the pension liabilities.

4) Inter-ministerial committees

The following inter-ministerial committees have been established in order to develop reviewable energy and promote energy efficiency.

Table 3-1.4 Inter-Ministerial Committee Related to Power Sector

Organizations	Main Roles and Responsibilities
Inter-Ministerial Committee on Renewable Energy and Energy Efficiency (ICREEE)	ICREEE committee was established in 2014 to develop the country's action agenda for the SE4ALL (Sustainable Energy for All) initiative propounded by United Nations. ICREEE also has a role to address the overlap in activities and shortfalls in regulations and supports programmes for renewable energy and energy efficiency. FMPWH played a leading role to establish the committee, and takes the position of the secretariat.
Renewable Energy Investment Team Committee	This committee was established to promote investment in the field of the renewable energy. It is participated by Nigerian Investment Promotion Commission (NIPC), Customs Office, Federal Inland Revenue Service (FIRS) and Immigrations Office. The secretariat is in the NIPC.

5) Federal Capital Development Authority and the State Ministry

Similarly, with the Federal Government, there are sections responsible for electrification and electricity power supply in the State Ministries too. Though only the Federal Capital Development Authority (FCDA) and Lagos State Ministry are listed in the table below, other State Ministries have also established sections for the similar functions.

Table 3-1.5 FCDA and Lagos State Ministry

Organizations	Main Roles and Responsibilities
Federal Capital Development Authority (FCDA)	FCDA is the authority responsible for the development of the Federal Capital Territory around Abuja. As a part of urban development, it develops expansion plans for distribution networks and constructs them in the cities around Abuja.
Lagos State Ministry of Energy and Mineral Resources	This ministry is carrying out projects for the expansion of power supply and regulating the development and utilization of energy and resources in Lagos State.

6) Others

There are users' associations operating in individual areas.

Table 3-1.6 Other Organizations Related to Power Sector

Organizations	Main Roles and Responsibilities
Rural Electricity Users Associations (REUAs)	REUAs are associations for education and advocacy on electrification in the local communities.

(2) Primary Energy Related Organizations

In this section, the organizations related to the development and utilization of the primary type of energy such as petroleum, natural gas, hydropower, and other renewable energy will be listed and explained.

1) Petroleum and natural gas

Petroleum and natural gas related organizations mainly consist of Federal Ministry of Petroleum Resources (FMPR) and its subordinate organizations.

Table 3-1.7 FMPR and Subordinate Agencies

Organizations		Main Roles and Responsibilities
Federal Ministry of Petroleum Resources (FMPR)		FMPR plans and develops the policies and programmes, and is responsible for permitting, licensing, and supervising projects and businesses in the entire petroleum and natural gas sector.
Nigerian National Petroleum Corporation (NNPC)		NNPC is a parastatal of FMPR that is engaged in commercial ventures in the petroleum industry on behalf of the Government. The organization has the following 11 subsidiaries.
	Nigerian Petroleum Development Company Ltd. (NPDC)	NPDC undertakes exploration and production of petroleum and natural gas in Nigeria and around Equatorial Guinea, both on shore and off shore.
	Nigerian Gas Company Ltd. (NGC)	NGC is responsible for developing and operating an integrated natural gas pipeline network, and also exploring marketing opportunities for natural gas in neighboring countries. It was divided into NGPT: Nigerian Gas Processing and Transmission Company and NGMC: Nigerian Gas Marketing Company in 2016.
	Pipelines and Products Marketing Company Ltd. (PPMC)	PPMC transports crude oil to refineries and moves petroleum products to markets through the pipeline networks.
	Integrated Data Services Ltd. (IDSL)	IDSL provides exploration services related to hydrocarbon.
	National Engineering and Technical Company Ltd. (NETCO)	NETCO provides engineering services for basic/detailed design, procurement, construction supervision, project management, quality control, etc., in the petroleum and gas industries and other industries.

Organizations		Main Roles and Responsibilities
	Hydrocarbon Services Nigeria Ltd. (HYSON)	HYSON is a joint venture between Voitol S.A. and NNPC. HYSON and its sister company "CALSON Bermuda Ltd." trade excess Nigerian products, such as fuel oils, from Nigerian refineries and petrochemical plants to the west and other areas in Africa. It also imports various petroleum products from other countries and sells them in Nigeria because production volumes of Nigerian refineries do not cover the domestic demand.
	Warri Refining and Petrochemical Co. Ltd. (WRPC)	WRPC is one of the refining amd petrochemical companies owned by the Nigerian Government located in Warri.
	Kaduna Refinery and Petrochemical Co. Ltd. (KRPC)	KRPC is one of the refining and petrochemical companies owned by the Nigerian Government located in Kaduna.
	Port Harcourt Refining Co. Ltd. (PHRC)	PHRC is one of the refining and petrochemical companies owned by the Nigerian Government located in Port Harcourt.
	National Petroleum Investment Management Services (NAPIMS)	NAPIMS is responsible for funding, supervising and auditing projects in the oil businesses.
	Duke Oil	Duke Oil is an international oil trading company, which was established to serve as a vehicle for bringing NNPC directly in contact with the international oil market.
Petroleum Training Institute (PTI)		PTI is an organization established to provide training for the staff of related businesses.
Petroleum Technology Development Fund (PTDF)		PTDF agency has the mandate to train and educate the public about the Nigerian oil and gas industry and promote research and acquisition of relevant technologies.
Petroleum Equalization Fund (PEF)		PEF fund has been established to equalize the cost of transporting petroleum products from depots to filling stations and ensure that petroleum products are made available at uniform prices throughout Nigeria.
Petroleum Products Pricing and Regulatory Agency (PPRA)		PPRA agency has the mandate to determine the domestic pricing policy and to regulate the supply and distribution of petroleum products.
Nigerian Content Development and Monitoring Board (NCDMB)		NCDMB an organization established for the purpose of increasing indigenous participation in the oil and gas industry through education for nationals and project operation.
Gas Aggregation Company Nigeria Ltd. (GACN)		GACN an organization that has the mandate to regulate the domestic allocation of natural gas.

2) Coal

The production and sales of coal are under the jurisdiction of the Federal Ministry of Mines & Steel Development (FMMSD). Until 1999, Nigerian Coal Corporation (NCC) monopolized coal mining and production, but private companies have been allowed to develop coal mines since then.

Table 3-1.8 Organizations Related to Coal Production

Organizations	Main Roles and Responsibilities
Federal Ministry of Mines & Steel Development (FMMSD)	FMMSD plans and develops the policies and programmes in mining and related businesses of coal and other resources. In addition, it is authorized to license and approve mining rights, supervise projects, and check the impact on the environment in the mining industry.
Nigerian Coal Corporation (NCC)	NCC undertakes the mining and selling of coal. Up until 1999, it had a monopoly on coal mining and selling in Nigeria.

3) Hydropower

The utilization of hydropower is mainly covered by Federal Ministry of Water Resources (FMWR).

Table 3-1.9 Organizations Related to Hydropower

Organizations	Main Roles and Responsibilities
Federal Ministry of Water Resources (FMWR)	FMWR plans and develops the policies and programs regarding the use of hydropower overall, and also approves and supervise projects and businesses in this sector.
Nigeria Integrated Water Resources Management Commission (NIWRMC)	NIWRMC is responsible for regulating and supervising the use of hydropower.
National Council on Water Resources (NCWR)	NCWR has been organized for policy recommendation regarding the use of hydropower. The council is chaired by the minister of the FMWR and participated in by the responsible persons of state governments for water resources.
National Technical Committee on Water Resources (NTCWR)	NTCWR is a technical advisory committee of NCWR.
National Water Resources Institute (NWRI)	NWRI parastatal of the FMWR that is engaged in research and collection of data, as well as education and advocating programs related to water resources.

4) Atomic energy

The following organizations are involved in atomic energy.

Table 3-1.10 Organizations Related to Atomic Energy

Organizations	Main Roles and Responsibilities
Nigeria Nuclear Regulatory Authority (NNRA)	NNRA is a subordinate organization of the FMPR that is engaged in the regulation and supervision of the use of nuclear devices and radiological materials.
Nigeria Atomic Energy Commission (NAEC)	NAEC is a subordinate organization of the Federal Ministry of Science and Technology established for the promotion and development of nuclear technology.

5) Cross-sectional organizations

As for the utilization of the primary energy sources for electricity generation, FMPWH is in charge of policy making.

Table 3-1.11 Other Organizations Related to Primary Energy Sources

Organizations	Main Roles and Responsibilities
Federal Ministry of Power, Works and Housing (FMPWH)	FMPWH is engaged in the development of policies regarding the utilization of primary energy sources for power generation and transportation, and supervising the implementation of power generation projects.
Energy Commission of Nigeria (ECN)	ECN is a subordinate organization of Federal Ministry of Science and Technology. ECN is responsible for developing and coordinating energy policies, as well as research activities such as data collection and analysis for policy planning.

(3) Other Related Organizations

Other organizations involved in the power and primary energy sector are listed as follows. Overall national policy is formulated by National Planning Commission (NPC).

Table 3-1.12 Other Organizations Involved in Primary Energy Sources

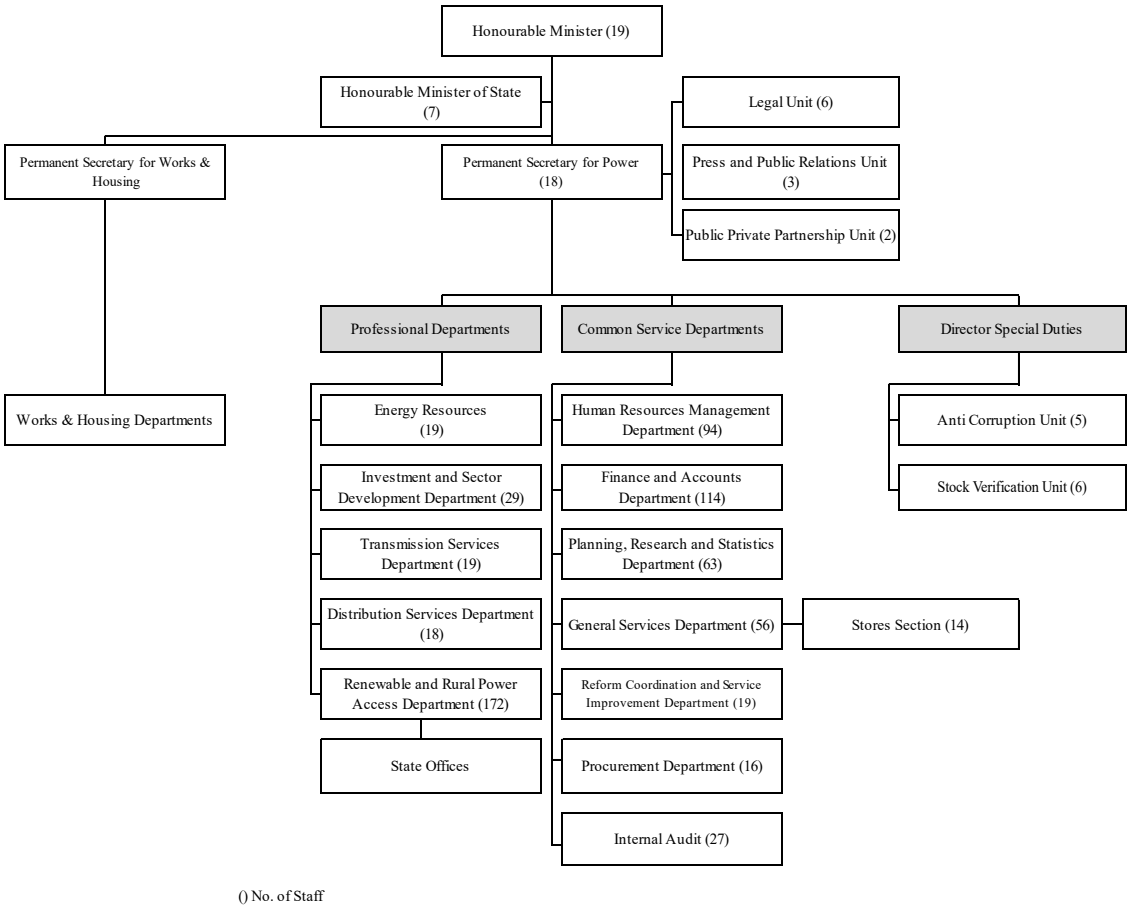
Organizations	Main Roles and Responsibilities
Bureau of Public Enterprises (BPE)	BPE is the implementing organization for the privatization of public agencies and corporations. It also is responsible for monitoring privatized organizations. Currently, it is carrying out on-going power sector reform.
Nigerian Investment Promotion Commission (NIPC)	NIPC facilitates investment to Nigeria. It provides guidance on investment in the country for domestic and international private companies. 26 ministries and agencies including Customs and immigration Offices have established a branch in Abuja at head office of NIPC.
Federal Ministry of Budget and National Planning (FMBNP)	FMBNP develops and plans national development plans and is responsible for overall management of economic policies.

(4) Organograms of FMPWH and TCN

Figure 3-1.1and Figure 3-1.2 show the organizational structures of FMPWH and TCN, which are key organizations in the power sector.

1) Organogram of FMPWH

Two permanent secretaries are appointed under the minister of FMPWH, one is in charge of power and the other is in charge of public works and housing. Figure 3-1.1 only shows the departments related to the power sector.



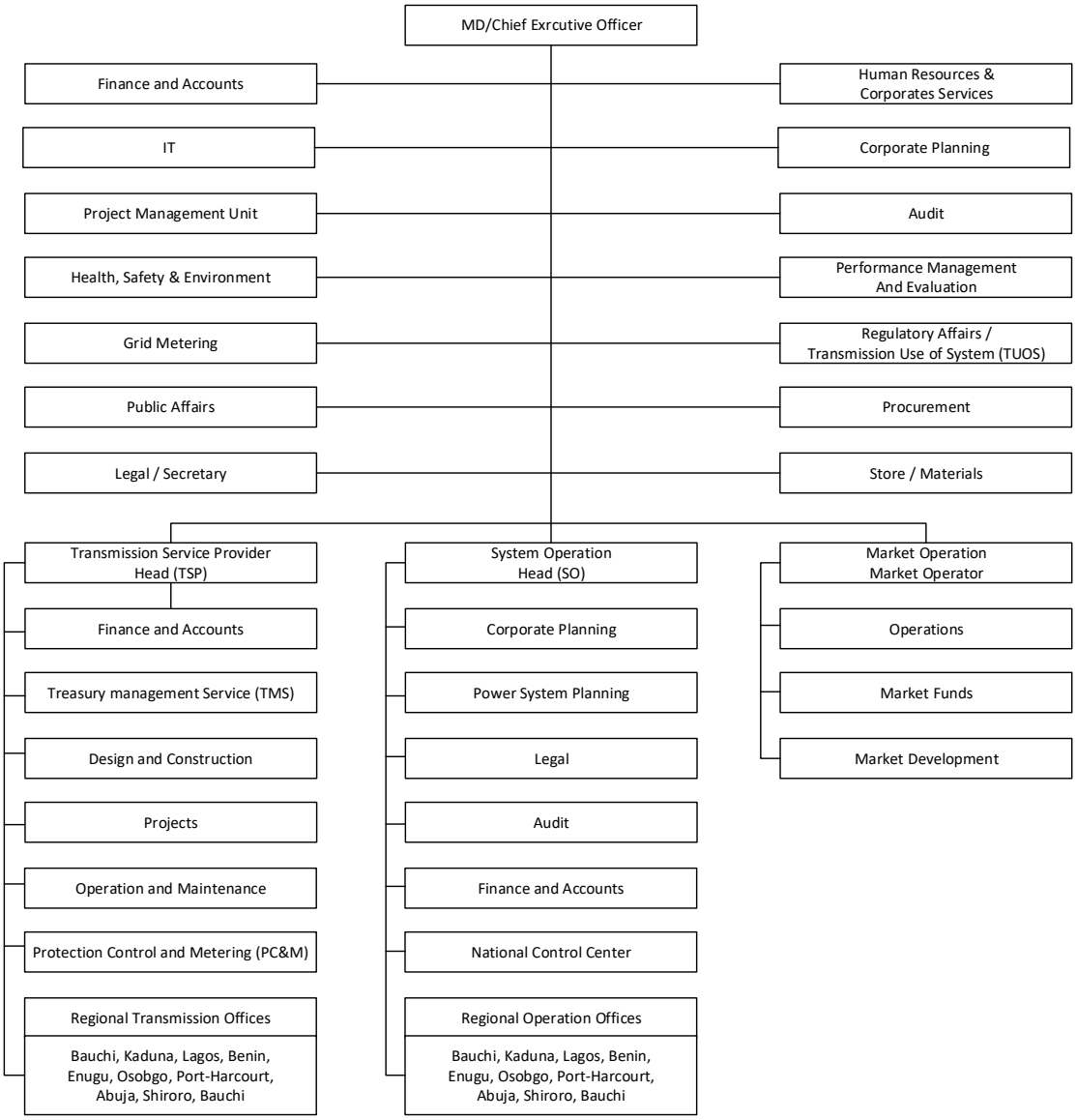
Note: No. of staff in brackets is data as of February 2017
Source: JICA Study Team

Figure 3-1.1 Organogram of FMPWH

2) Organogram of TCN

Power Holding Company of Nigeria (PHCN) was established based on the Electric Power Sector Reform Act (EPSRA), which was enforced in February 2005. The businesses under PHCN were divided into six GenCos, eleven DisCo and TCN to implement sector reform focusing on the division and privatization of the electricity monopoly, National Electric Power Authority (NEPA). BPE sold 51 to100% shares of the GenCos and DisCos to the private sector.

TCN has more than 3,500 employees and consists of three departments, Transmission Service Provider (TSP), System Operator (SO) and Market Operator (MO). Figure 3-1.2 shows the organization chart of TCN.



Source: JICA Study Team

Figure 3-1.2 Organogram of TCN

3-1-2 Power Development Plan

(1) Comprehensive Plan

In Nigeria, in order for power sector reform and privatization in power generation to proceed, it has been decided that power plants, except for new hydropower plants, will be constructed through private investments as a general rule. At present, there are no certain long term comprehensive power development plans in line with the power sector policy, and new power plants are only those scheduled to be developed by National Integrated Power Project (NIPP), which is being implemented by the Government to resolve critically insufficient power generation capacity, and those expected to be developed by independent power

producers (IPPs).

Power development plans should retain objective power supply reliability and should serve as guidance to realize the Nigerian power sector policy, which includes energy security and countermeasure against global warming. Lacking a long-term comprehensive power development plan, optimal power sector development cannot be attained as private sector developers might propose power generation projects only for their financial advantage. For instance, although higher efficiency systems such as combined cycle generation are desirable in terms of efficient utilization of energy and reduction of greenhouse gas emission, most of the planned NIPP and IPP projects adopt low efficiency simple cycle gas turbine systems. Even though the main challenge the Nigerian power sector is facing is satisfying power demand, a comprehensive power development plan in line with power policy should be key issue as well.

(2) Outline of NIPP

In Nigeria, as the drastic shortage of power supply compared to potential power demand causes frequent planned outages and frequent accidents, there is pressure on demand. In order to respond to this situation, the Government, by utilizing the excess crude account, has implemented the NIPP, which allows the construction of thermal power plants and transmission lines. Some lack of capacity of existing power plants with many unavailable generators due to equipment failures and mal-O&M is expected to be supplemented by NIPP projects. Completed generation plants will be sold to the private sector.

3-1-3 Procurement of Power Plant Fuel

According to NERC's quarterly report, Nigeria's total annual power output for the second quarter of 2017 to the first quarter of 2018 was 32.61 TWh, up 13.5% from the total power output of 28.71 TWh (IEA 2014 Database) in 2012. The composition of power generation capacity from primary energy sources was 81.8% for natural gas and 18.2% for hydropower (TCN Technical Report in 2015). Use of oil products, mainly heavy fuel oil and partly diesel, as fuels for power generation ceased by 1986 and thereafter it has been zero to date, except small scale off-grid power stations fueled by diesel. Diesel powered small generators for self-generation have substantially decreased since the tax reduction for diesel was cancelled recently. Use of coal as fuel for power generation had produced around 13GWh and accounted for 0.1% by 1992, and thereafter it has been zero to date.

Natural gas is produced by Chevron, Mobile and other oil major companies (IOC: International Oil Company) under contracts with Nigerian National Petroleum Corporation (NNPC). Nigerian Gas Company Ltd. (NGC, which was divided into NGPT: Nigerian Gas Processing and Transmission Company and NGMC: Nigerian Gas Marketing Company in 2016) is a member of NNPC Group with the role of installing and maintaining pipelines and supplying natural gas to electric power companies. When the IOC enters a natural gas mining contract with NNPC, IOCs enter production and distribution contracts (PSCs: Product Sharing Contracts) concomitantly, and part of the produced natural gas is provided to the NNPC in accordance with PSCs.

The existing gas-fired power plants in Nigeria suffer from a chronic shortage of a gas supply, which results in the continued non-attainment of their full-operations to date. It is understood that the major reasons for the

short supply of gas to power plants are the combine results of the following four major factors.

- Uneven distribution of major natural gas production areas and distributed locations of major domestic and industrial gas consumption centers
- Insufficient transportation capacity and connectivity of the gas pipeline network among the production areas and the major consumption centers
- Lower delivered price of gas from the gas producers specifically set up for gas for domestic use
- Repeated shutdowns in sections of gas pipeline systems due to frequent damage from vandalism attacks, which renders the pipeline system in question inoperable

Supplemental explanations of the four major factors above are follows.

(1) Locations of Production Areas and Major Consumption Centers of Natural Gas

In Nigeria, all oil and gas fields are located in Niger Delta, which is located at South-South Zone and South-East Zone of the geopolitical zones, and the offshore. Hence, natural gas production centers are also located in the Niger Delta. Meanwhile, the current major consumption centers are located in the South-West Zone, especially in Lagos and its vicinity.

(2) Existing Natural Gas Pipeline Network Systems

The existing pipeline network systems in Nigeria cover only the southern states, except Kogi State, which belongs to the North-Central Zone according to the geopolitical zones. In addition, this gas pipeline network is divided into an ELP (Escravos - Lagos Pipeline) system heading toward the Lagos (Lagos) from the Escravos Plant on the west side of the Niger River as a starting point, and a system in the eastern side of the Niger River, and there is no pipeline connecting these two systems at present.

(3) Selling Price of Gas from Gas Producers to the Pipeline Network

Transactions of dry natural gas from gas producers (IOC) to the pipeline networks are conducted at pipeline junctures, called “nodes”, and gas producers are responsible for investment, operation, and maintenance of the all facilities up to the nodes of pipeline networks.

The price of gas delivered from gas producers to the pipeline network for power generation plant use was set at 0.30 US$/MBTU (million British thermal unit) in 2008 and it was raised to 1.5 US$/MBTU by 2013. Even at this price level, it was not attractive for gas producers and they were reluctant to decide to make new investments for the additional facilities to increase gas supply to power plants. In 2014, however, the price was raised again to 2.5 US$/MBTU and the provision by IOCs had been more active as a result.

(4) Disturbance of Gas Related Facilities Operation by Vandalism

According to NNPC Annual Statistical Bulletin (ASB), there were as many as 32 thousands oil and gas pipeline accidents due to vandalism attacks during a 13-years period from f 2004 to 2016. The number of these incidents reached about 70 times that of the incidents of rupture due to normal wear and tear or mal-operations. (Refer to Table 3-1.13)

Table 3-1.13 Records of Pipeline Incidences due to Vandalism 2004-2016

Area	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Port Harcourt	396	1,017	2,091	1,631	557	382	142	336	393	616	269	917	1,596	10,343
Warri	241	769	662	306	745	280	161	548	495	315	378	236	205	5,341
Mosimi	147	194	480	459	516	605	184	463	479	1,078	1,071	1,114	398	7,188
Kaduna	110	237	176	126	110	100	240	571	622	634	657	445	311	4,339
Gombe	1	20	265	702	357	86	109	850	241	862	1,325	71	34	4,923
Total	895	2,237	3,674	3,224	2,285	1,453	836	2,768	2,230	3,505	3,700	2,783	2,534	32,124
Incidences of Rupture	76	21	9	20	33	27	24	19	26	65	32	49	55	456

Source: NNPC Annual Statistical Bulletin (ASB) 2016

The following are some representative incidents of vandalism attack involving gas related facilities and pipelines.

- In late 2008, Shell Soko Gathering Plant suffered from a vandalism attack, which resulted in the shutdown of the plant for more than one year until recover work was completed. During the shutdown period of the plant, Nigeria's dry gas production rate decreased by approximately 20%. (Source: Country Analysis Brief: Nigeria 2015, EIA)
- In August 2012, West Africa Gas Pipeline suffered damage in its submerged pipeline section from a pirate ship's anchor and gas supply to customers of West African countries stopped for more than one year. (Source: Wikipedia and others)

The causes of the vandalism include: i) destructive activity induced by the increased susceptibility to theft because of aging or facilities; ii) the undermining of the expectations of local residents due to the non- or inadequate implementation of measures/projects promised by petroleum development companies and the failure of the Governments to deliver development benefits to local communities, resulting in rebelling; iii) rebellion from local residents due to the lack of appropriate countermeasures against pollution to and deterioration of ecosystems, rivers, groundwater, and farm lands associated with petroleum and natural gas development; iv) increasing dissatisfaction among local residents due to the lack of equitable distribution of resources and development benefits from corruption and bureaucratic behavior; and v) insufficient responses to overwhelming expectations of young people, resulting in defiant actions by them and attempts to take unfair advantage of unhappy members of the young generation by the wealthy through agitation and manipulation of the young. It has also been pointed out that in the background is the historical conflict between tribes in power and local tribes in oil and gas producing regions.

As measures to prevent vandalism to oil and natural gas pipelines, as described in the Power Sector Recovery Programme 2017 2021, the government plans a) to identify and implement development issues and prioritized projects in oil and natural gas production areas, b) to introduce the participation of local residents in resource management and environmental management, c) to formulate and implement strategies to eradicate destruction, d) to promote pipeline development through payment of unpaid bills to the gas companies with Nigerian Electricity Market Stabilization Facility or Payment Assurance Facility (PAF), and e) to support improved management of pipeline development projects.

As for the gas pipeline network improvement project, the Escravos - Lagos Pipeline (ELP) Phase 2, a 40-

inch diameter pipeline connecting two east and west pipeline networks of Nigeria in the southern part of Nigeria across the Niger River, and a pipeline construction project from southeastern Nigeria to Kano in northern part through Ajaokuta of Koji State are in progress, and will be carried out until 2020. When these projects are completed, it will be possible to increase the capacity of gas transport from east to west in southern Nigeria, as well as supply gas to power plants and other facilities that are scheduled to be established in the northern region.

3-1-4 Rural Electrification Target, Policy and Projects

Since its inception in 1981, the key objective of the Nigerian Rural Electrification Programme (NREP) has been to increase electricity access in rural areas of Nigeria. However, rural households have not seen much improvement, and it is estimated that only 34% of rural households have access to electricity (Energy Access Outlook 2017, IEA). The growth in demand for electricity has outpaced supply, and population growth has driven the rate of new household formation higher than the rate of new connections. As a result, rural households still rely on fuel-wood and other expensive, unhealthy, and unsustainable sources of energy. Meanwhile, Nigeria has been blessed with a wealth of natural resources such as gas, oil, solar, biomass, etc. With proper markets, regulatory mechanisms, and cost-reflective and affordable tariffs, it would be possible to provide a reliable supply of electricity to all residential, commercial, industrial, and public sector consumers in rural areas.

The Government has set an ambitious and realizable target to increase electricity access to 75% and 90% of the population by 2020 and 2030 respectively, and at least 10% of renewable energy mix by 2025. Also, the Government has set a target to bring electricity access to 100% of the population by 2040. Currently, as more than 70 million people living in rural areas lack access to a reliable electricity supply, the national target of electricity access 75% can be achieved only if the urban electrification rate reaches 90% and rural electrification (RE) rate reaches 60% by 2020. To achieve the RE target assuming 7 persons per household, connections for more than 10 million additional rural households and a new generating capacity of around 6,000MW are required to serve the additional rural access.

The cost of achieving RE schemes to reach the 2020 target will range from NGN 318 to 526 billion. To reach the 2040 target of universal access, an additional NGN 507 to 830 billion will have to be spent on RE schemes in the subsequent 20-year period. The cost of administering REA will be an estimated NGN 6.8 billion (total) for the period 2015-2020, and NGN 23.2 billion (total) for the period 2020-2040.

The policies of the Government, the shift to combination of centralized and decentralized approach, and type of RE projects to achieve the target above, as well as barriers to decentralized RE are as follows:

(1) Fundamentals of RE

The National Electric Power Policy (NEPP) 2001 states “the primary objective of the NREP is to expand access to electricity as rapidly as can be afforded in a cost-effective manner”.

Electricity Power Reform Act 2005 (EPSR Act 2005) also establishes a basic policy on RE and provides a legal foundation for the establishment of the Rural Electrification Agency (REA), a governmental agency

responsible for formulating and implementing strategies to improve access to electricity for rural residents. Although the EPSR Act 2005 provides a framework for governmental efforts toward RE, there are few detailed Cabinet Orders and Regulations for the implementation of the Rural Electrification Programme.

(2) Shift to Combination of Centralized and Decentralized Approach

To achieve the target and new RE policy, the Government is moving away from a purely centralized decision making approach to RE. Instead, the Government will promote a centrally coordinated but demand-driven approach in recognition of a market-oriented approach to RE. A single national, sector-wide roadmap that identifies the electrification solution with the lowest cost will be applied for every community, across ministries, so that all participants will work towards the same target.

As each role of each participate in the plan above, distribution companies (DisCos) have an obligation to the Bureau of Public Enterprises (BPE) to add four million new connections by 2017. REA will conduct feasibility studies, raise request for proposals (RFPs) for identified projects for the Rural Electrification Fund (REF), and invite prospective developers to the bids. This role by REA and the REF will lead to new, more cost-effective connections and encourage public-private partnerships.

(3) Type of RE Projects

The several different types of RE projects supported by the government fall into two main categories: grid extensions and off-grid, which is further divided to mini-grids and stand-alone systems. The main features of each of the three types of RE projects are as follows:

1) Grid extension

As described above, DisCos are obligated to add four million new connections by 2017 under their contractual obligations with BPE, and required to play a leading role in grid extension. In addition, DisCos are required to provide non-discriminatory access to the existing network for all entities seeking to extend the grid. NERC will establish the rules and regulations for extending the grid to rural customers.

2) Mini-grids

In some remote settlements where the level of power demand and population density is relatively high, mini-grids (with either fossil fuel or renewable resource-powered generation technology) can be the most technically and economically viable approach for RE. In addition, mini-grids can be an important step towards eventual interconnection to grid extensions.

Basically, any person without a license must not construct, own, or operate an undertaking or in any way engage in the business of generation excluding captive level, transmission or distribution in electricity. Meanwhile, a person without a license can construct, own, or operate an undertaking for generation of electricity with a capacity not exceeding 1MW in aggregate at a site or an undertaking for distribution of electricity with a capacity not exceeding 100kW in aggregate at a site.

3) Stand-alone systems

In some localities with low levels of demand and disperse populations, even a mini-grid may not be feasible, and stand-alone systems may instead be more suitable. Individual photovoltaic (PV) systems can provide sufficient electricity to satisfy the needs of households and small commercial enterprises (for lighting, radio, TV, clothes iron, fan, etc.). If they are offered at affordable terms (with significant subsidies and long payback periods for the remaining cost), stand-alone systems can provide crucial services to the hardest-to-reach customers.

(4) Barriers to Decentralized RE

The implementation of NREP should as much as possible encourage the combination of centralized and decentralized configuration approaches and diversity, and make use of all resources (financial, technical and human) available at Federal, State and local levels. The decentralized, demand-driven approaches to RE have a number of barriers that must be overcome through policy and strategy as described below.

(5) Central Planning and Coordination

Though RE projects would be established independently in response to a demand-driven approach based on rural power demand, to ensure that both gaps and overlaps due to targets and efforts by all sectors are minimized, the coordination of activities within the sector will still need to be conducted at Federal, State and local government levels. Also, the REA operation manual should clearly define the responsibilities of the central and zonal REA offices. The RE policy has already delineated the roles of various key stakeholder organizations.

(6) Power Demand

Though rural populations are clearly eager to get access to electricity, it is not obvious that their power demand and willingness to pay for the services will be forthcoming. Local governments tend to regard the provision of subsidized public service infrastructure, such as electricity, as the responsibility of the central government, and therefore need to be aware that service provision arrangements are the responsibility of local people themselves. The scope of the service should be accepted by local governments, and private enterprise management methods should be adopted for local electrification systems so that local people can pay all necessary expenses other than the initial subsidy for the service to be provided.

If local electrification is performed off-grid, there may be differences in tariff policies introduced by local governments due to various factors such as the technology of power generation in each system and the scale of the system. REA will strive to minimize such differences in the burden felt by people through various subsidy schemes.

(7) Power Supply

Progress in off-grid RE that reflects local electricity demand depends on the interest of project proponents, and whether or not proponents enter the project depends on the financial attractiveness of projects. Federal Ministry of Power, Works and Housing (FMPWH) has announced that it will promote nationwide

electrification plans across state boundaries. It is expected that electrification plans will adopt a method of promoting local electrification at the lowest cost in each region and promote areas where additional connections to more distribution systems can be made. The prospective operators of each project are required to participate in areas considered attractive from the project formulation and F/S. Such transparency and widespread analysis are essential to ensure that developers can be attracted and that RE projects can be efficient. In addition, REA would need to ensure that the REF offers funding support that is easy to access and allocated in a transparent way.

(8) Economics

Economic efficiency in providing public services in rural areas is one of the biggest challenges in promoting RE projects. In particular, it should be noted that capital investment in RE tends to be costlier than the payment capacity of rural consumers.

The Government has pledged to improve this situation, both by providing subsidies towards initial capital costs and by guiding the way towards reducing the cost of materials and supplies for RE projects. In RE projects, there are many cases in which project completion has been significantly delayed or the projects are not sustained because the reserve, operation, and maintenance costs are not fully budgeted in the project cost estimation. To combat this problem, business operators are required to demonstrate the operation and maintenance plan for all projects for which REA considers the provision of subsidies, and to fully account for the operation and maintenance cost in the cost estimates. It is necessary for promoters of all projects supported with the REF to prepare enough operation expenditures in operation and maintenance plans and budget. While the costs of RE projects are often high, the expansion of electricity service can be rationalized by examining and comparing the relative cost-effectiveness of both on-grid and off-grid solutions. This will improve the perception of the local people on the underlying economics of RE schemes as well.

(9) Financing

RE projects are characterized by a long cost recovery period in addition to a high initial investment cost. Financial institutions and investors will offer funds only where it is commercially viable. Projects that do not offer realistic profits will not attract financers. If the shortfall in capital costs is to be resolved, it will be necessary for the Government or donors to subsidize the projects to make them commercially viable.

If sufficient subsidies for project implementation cannot be obtained, the remaining challenge is how the private enterprise that is engaged in the project in question can finance the remaining funds on its own. Smaller investors generally have higher financing costs, so a higher portion of loans from the Government or donors are needed to reduce the interest rates on loans from banks to enterprises and reduce credit risk. REA has the potential to play a major role in ensuring the creditworthiness of the projects, and if projects turn commercially viable with support from REA and become achievable, they will be more attractive to private investors.

(10) Technical Capacity

While there are many engineers and other technical professionals in Nigeria, there is a scarcity of qualified personnel who have the high technical capacity required in renewable and off-grid RE projects. In particular, there is a lack of professionals who have enough commercial and financing knowledge and skills necessary for the formation of investment-worthy RE projects. The level of human resources in these areas should be continuously enhanced over the long term to ensure the quality and affordability of RE services.

(11) Justification for Subsidies for RE

Considering the low rate of electrification in Nigeria, it is clear that the RE targets will not be attained if the matter is left to the market alone, because a number of barriers have stood against electricity services, and there has been an insufficient willingness to pay as a result. The necessity for subsidies to lower the entry barrier for initial investment in RE projects by investors and project operators must be acknowledged.

Subsidies will be offered by the REF as capital grants according to the allocation method that is transparent and competitive. Developers will select their projects and apply to the REF considering the allocation method. The REF supports local developers who have shown good practices and offer the best value and score according to the REF selection criteria applied in other localities. All legal persons, corporate or with legal formation should be allowed to compete for the REF subsidies without discrimination.

Subsidies for RE, in this case, will also be used as tools for social justice. The Government has identified RE as measures for alleviating poverty and addressing the needs of rural populations to achieve social justice. Currently, people in rural areas do not enjoy the same level of infrastructure services as urban residents do. Thus, the Government aims to improve the quality of life in rural areas and to reduce population migration from rural to urban areas by improving access to electricity for local people through subsidies.

(12) New Policy Instruments

The Government has established several new policy instruments to promote RE initiative. They are profiled below.

1) Government RE policy

The RE policy of the Government was prepared as a part of the Electric Power Sector Reform Act 2005 (EPSR Act 2005) in 2005 and approved in 2009. The EPSR Act 2005 has developed an ideological framework to guide relevant parties related to RE and defines the framework of governmental activities for RE under the new RE policy. The RE policy also clearly outlines the Government's goals, objectives, and targets with respect to RE. Allocation of funding and other key decisions will be made with the aim of achieving the established goals. The targets will be reviewed over time and revised by the Government if necessary

The EPSR Act 2005 establishes the national power market design. It sets the legal framework for RE and,

in particular, private sector provision of rural electricity services, both on-grid and off-grid. The RE policy further elucidates the power market rules with respect to rural service provision, emphasizing the rights and opportunities of alternative service providers to participate in RE. To achievement of RE goals inter-institutional efforts are required as a part of the Government duties. The RE policy outlines the roles and responsibilities of key government agencies, as well as the guidelines for their cooperation and collaboration.

The EPSR Act 2005 also provided the legal and regulatory framework for the power sector, which will be enforced by the NERC. There are many gaps with respect to RE schemes, which are largely exempt from NERC's economic regulations. The RE policy outlines the general guidelines for regulating RE schemes that fall outside NERC jurisdiction. Details of the regulations will be established based on the principle of self-regulation via bilateral agreements to be enforced by NERC where necessary.

While EPSR Act 2005 establishes a legal basis for initial subsidies for RE projects, RE policies outline procedures and mechanisms for providing subsidies. The EPSR Act 2005, Section 91 describes how REA shall establish a range of mechanisms for allocating funds from the REF. REA has to establish objective and transparent criteria for the geographical allocation of resources from the REF. The objective and criteria should be established in consultation with the Minister.

2) Tariff policy

In accordance with the RE policy and international best practice, tariffs for rural electricity service should be cost-reflective. They shall account for the average annual cost of fuel, operation, maintenance, safety, spare parts, and personnel, as well as expected sales of electricity, generator capacity, the number of connections, volume of consumption, level of service, etc.

For projects that fall within the NERC licensing requirements, tariffs will be examined and determined in the process of licensing. In order to ensure light-handed regulation for RE, the approach taken will be more moderate than for urban tariffs. NERC has established a tariff model that is specifically designed for RE, with its more challenging operating environment, higher risk, and typical lack of attractiveness for investors. The rural model, compared with the current model, will allow for higher margins, a higher safety factor in estimates, higher assumptions on non-collections, and substantially higher rates of return to investors. In the absence of these, the projects will not be accepted by NERC. Because of its high-risk, high-return nature, the adjustment, evaluation, and supervision of rural tariffs is less restrictive for the operators than for the urban distributers.

NERC will also allow a second approach for developers to set the tariff for new projects outside of the tariff model, provided that prospective consumers for at least 60% of the proposed output have signed acknowledgements that they are willing to pay this tariff. This method ensures that a community that wants a new electricity service can access the new service without the risk of the regulator blocking the entire project due to the imposition of tariff constraints.

Tariffs will be reviewed annually and recorded in the electricity supply contract between consumers and RE service providers after obtaining NERC approval. In case of capacity stipulated in EPSR Act 2005,

NERC will retain responsibility for monitoring and enforcing agree-upon tariffs.

3) Regulatory policy

NERC will have overall regulatory powers over RE, according to the provision of EPSR Act 2005, and license the electricity service providers except for RE schemes whose generation capacity at a single site is 1MW and below or whose distribution capacity is 100kW and below.

4) Participation of non-traditional operators

In recognition of the enormity of the challenge posed by fulfilling RE needs, the Government has established a policy to encourage the participation of non-traditional operators, including community-based organizations, private sector entities, and NGOs. Regulations on the electric power market allow the establishment of a wide range of implementation and ownership structures to promote the participation of public corporations, the private sector, and cooperative sector. Capital grants towards initial investment costs will be available for qualified applicants through the REF.

5) Promotion of low-cost technologies

In order to ensure the financial sustainability of RE schemes, and ultimately the achievement of the RE targets, the Government has established a policy to promote the use of low cost (but high quality) options for RE. These include the use of renewable energy technologies (e.g., solar, wind, hydro, biomass), where appropriate. Where such options are not cost-effective, there are low-cost options that can reduce the cost of grid-connected RE. These include single phase lines, single-wire earth return, shield wire technology, fixed-cost supplies, among others. Load limiters, pre-paid and smart meters can be used in either renewable or grid-supplied RE schemes to manage costs to end-users and prevent consumers from overloading the system.

REA requires that REF-funded subsidies be efficiently invested in initial costs by using low-cost options for RE projects. Furthermore, REA will advocate, based on established feasibility studies, for the broader availability and use of such low-cost equipment and materials so that all RE projects (and consumers) may benefit from the potential cost reductions.

6) Efforts to reduce equipment costs

Further reductions in RE equipment costs require coordinated efforts across sectors and agencies to revitalize both rural electricity demand and supply. To increase the rural electricity demand, REA needs to raise awareness of their benefits and availability. A list of useful appliances approved by the regulators will be prepared by REA for all local electrification promoters.

To increase the supply, to decrease the cost for more affordable one, to deliver high quality products, and to realize the sustainable development, the Government will support the participation of new market entrants to local ventures whose activities may include the production, installation, operation, maintenance, and the distribution/sale of equipment, systems, and services related to rural power supply. REA will advocate for tax incentives, investment capital allowances, and low-interest loans for local producers of

RE equipment and materials.

In the meantime, there is a need to reduce and exempt import duties imposed on renewable power generation equipment and low-cost equipment. Nigerian industries are ready to compete for cost savings, but realization requires fair use of RE technology without high taxes on imported raw materials, components, and equipment for the RE.

7) Capital subsidies

The Government provides subsidies for the initial investment of RE to promoters qualified for the REF scheme. The subsidy will be provided for selected projects that have undergone prescribed procedures in accordance with international best practices to achieve government goals. The process of selecting projects to receive the fund is designed to maximize transparency, efficiency, competitiveness, and sustainability.

Subsidies will be allocated to the initial cost of RE projects to overcome widely recognized barriers. By providing subsidies for launching of RE projects, the Government will encourage potential operators, such as local government-based organizations, private sector companies, NGOs, cooperatives, etc., that have been excluded in the past from the market due to excessive initial costs to enter the RE market. Through such support, the Government can provide optimal financial support for RE projects.

8) Promotion of RE as a catalyst for rural development

Promoting RE can be a powerful and efficient tool for achieving rural development. Electrification is both an important prerequisite to and stimulant of economic growth and development, particularly for rural areas. Reliable and affordable electricity supply enables rural households to devote less of their time and income to procuring energy supplies, freeing them up for productive works. In addition, if time is not required for getting electricity or energy supply, informal household labor becomes formal economic activities, which eventually leads to increased productivity in agriculture, agriculture-related industries, manufacturing industries, heavy and light industries, and service industries.

9) Regional equitability

As a nation characterized by religious, ethnic, and cultural diversity, Nigeria's efforts to promote RE emphasizes equitability across regions and population groups. The RE policy aims to achieve more equitable access to electricity across regions.

Regional equitability will be a driving force in determining the allocation of funds for subsidy grants. The REF will be made available in equal measure to each of the six geo-political zones. Arising from the RFP issued by REA projects within each zone, projects will compete for funding. Those projects that would serve populations within the most infrastructure-poor areas will be prioritized, in order to achieve, on a larger scale, more equitable access to service delivery. All decisions on the allocation of the REF among projects will, however, be made centrally: Local governments will make recommendations, but the decisions will be made centrally, ensuring the full application of the eligibility and selection criteria and transparent selection processes. At a certain stage in the future, some regions will achieve universal electrification, thus, the REF will be prioritized to focus support to regions with electrification gaps.

10) Capacity and awareness building

The Government understands that the success of a decentralized approach to RE hinges on the participation of project developers. The broad range of individuals and organizations that are potential candidates for establishing and operating RE projects should be made aware of such opportunities. Besides, many individuals and organizations lack experience in RE, and therefore they should be provided with training opportunities to improve knowledge and skills for the development and operation of RE projects, including the safety of electricity. The Government, largely through REA, will take action to raise awareness of RE projects and promote opportunities for public participation and to build strong counterparts within communities and the private sector.

11) Dealing with legacy RE projects

The Government is concerned about several on-going RE project spread across the country, some of which have been abandoned by contractors for more than five years. These projects number about 1,600 as of 2012, could be found in all the States of the Federation, and it was estimated that close to N40 billion (USD 205 million) is required to complete the projects in 2012. A critical assessment of these projects indicates that most of them were abandoned due to poor funding and lack of proper planning before they were awarded. Almost all of them are grid extension RE projects, and many of them even after completion may not be put to any meaningful use, due to the lack of reliable source of power supply.

In dealing with the problems associated with completing legacy RE projects, the Government will engage all relevant stakeholders involved in the implementation of RE projects through REA: states and their RE agencies, local governments, communities, industry, civil society groups, and financers. Engagement will include workshops, public consultations, private meetings, and capacity building to create the necessary interest and encourage the various actors to take over and complete some of the viable RE projects that are on-going but with no clear source of funding. The REF will be used to provide financial support to those prioritized projects that meet the selection criteria established by REA. REA would develop a comprehensive plan for the handing over of these projects for completion by stakeholders.

12) Constituency projects

The Government intends to continue implementation of a limited number of constituency RE projects. These projects are prioritized because they are being promoted by leading politicians. The constituency projects are prioritized with special budgetary allocations. Based on the EPSR Act 2005, REA has formulated procedures for the constituency project selection and fund allocation, and is preparing for approval from the Ministers, in order to achieve the overall objective of the Strategic and Implementation Plan for RE and to ensure the economic sustainability of the project. The National Assembly will be involved in the process of identifying candidate projects.

13) Capacity building for RE

Significant capacity building is required across the country. In particular, it is necessary to promote the utilization of low-cost renewable clean energy technologies in certain areas where RE projects are being

implemented by the private sector so that the industry can play an important role in manufacturing, supply and operation. Each ministry and agency play a leading role in capacity building through REA. Universities, industries, research institutes, and training organizations are also included as entities that play a role in capacity building

14) Local assets and participation in RE

REA encourages effective use of locally owned assets and participation of local communities in RE projects, including stock ownership by residents. Effective use of local assets and participation by the local communities include the use and participation of local people and goods at the planning, development, and operation stages. These recommendations will help local industries acquire skills and expand their scale. The development of the local industries will be achieved by giving additional points to projects in which the local assets are effectively used, and the local communities participate, in selecting the projects funded by the REF.

REA will also work with the local industry to help improve the production capacity of the required products. However, REF funding will not be used for this support. To assist the development and adaptation of the local industries, the Government will seek financial and technical support from multilateral and bilateral donors for assisting industries and research institutes.

15) Energy efficiency in RE.

Energy efficiency is an important factor in reducing overall investment and operation costs and for avoiding delay in investment, etc. Important factors in energy efficiency include the distribution system and the end-use forms of electricity. Although the challenge of energy efficiency is a wide-ranging concern beyond RE, the impact on RE is significant. FMPWH is working to improve the energy efficiency in national transmission and distribution systems. Through REA, the FMPWH is encouraging RE to use facilities and equipment that improve energy efficiency. .

16) Dealing with network expansion and ownership

There are several options for orderly and efficient procedures when RE progresses and meets urban electrification front areas owned by DisCos. In selecting a process, it is necessary to consider a variety of aspects, such as legal authority over private assets, technical compatibility, and the risk that the DisCos will acquire private assets free of charge due to the wrong incentives.

The stand-alone or dedicated power generation system is not affected by the selected process. There is no change in ownership. If the owner of the facility refuses to connect to the grid of a DisCo, it is a matter of ordinary commercial negotiation with the DisCo. Mini-grids for fixed customers in housing and industrial estates, which are single-name assets, are not affected by the process and can be treated in the same manner as the dedicated systems. Mini-grids serving captive customers on private land, such as a housing or industrial estate under a single property title, will be unaffected and can be treated the same way as captive systems.

The choice of transfer of the asset or exit paths is a matter of business contracts that are agreed upon among

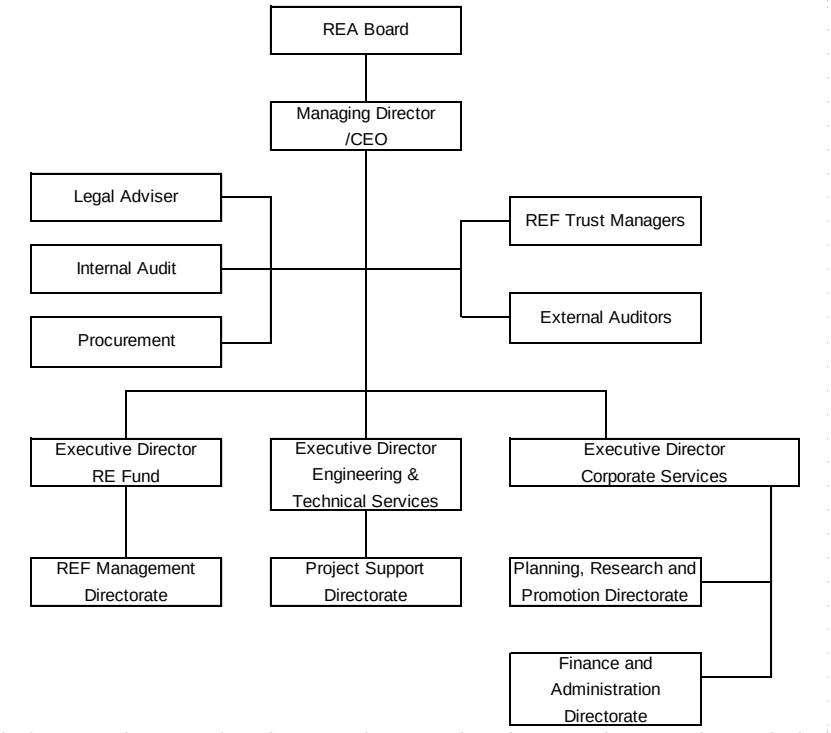
the parties with a cooperation of the NERC. Conventional licensees have certain rights for operating until the final license expires.

(13) REA and its Board

While many organizations, such as the Government, FMPWH, NERC, state governments, project sponsors, will have roles related to the RE sector, REA is the only institution whose sole mission is to promote RE. REA was established as an independent and accountable agency, responsible for the coordination of RE activities in Nigeria. The legal framework for REA is outlined in the Electric Power Sector Reform Act 2005 (EPSR Act 2005). REA will provide financial and technical support for RE based on its own principles and policies. In addition, REA will advocate for needed developments in the RE sector, including lowering import duties on RE equipment and materials, favorable tax policy for RE schemes, government support for research and development of RE technology, and sufficient allocation of funds to REA and the REF.

In order to make REA's organizational management and the allocation of its resources effective, and to deepen the development of the RE sector, REA is divided into four Directorates operating under the supervision of three Executive Directors. The organizational chart of REA is shown in Figure 3-1.3.

REA Board will be responsible for overseeing REA and guiding its actions. It will approve REA's internal guidelines, including funding decisions and other RE support procedures.



Source: JICA Study Team

Figure 3-1.3 Organizational Chart of Regional Electrification Agency (REA)

The main roles of each Board of Directors in REA are as follows.

1) REF Management Directorate

The Executive Director of REF will oversee the REF Management Directorate to allocate and manage the REF. The REF Management Directorate of REA will be responsible for administering the REF to provide capital investment subsidies, in a clear, transparent, and competitive process, to qualified RE schemes developed by public and private sector entities.

The REF management unit will develop policy guidelines and procedures for administering the REF, which include: i) criteria for subsidy awarding; ii) transparent procedures for bidding; and iii) accountability instruments, such as independent audit, effective monitoring and reporting procedures.

2) Project Support Directorate

The Executive Director of Engineering & Technical Services will oversee RE Project Support Directorate to provide project support to developers. The Project Support Directorate will provide technical support to RE projects in accordance with policies designed to protect both consumers and service providers and on the basis of bilateral agreements signed between REA and the project operators. It monitors project progress and supervises project implementation to ensure compliance with standards and specifications use for project supported with the REF, such as i) minimum safety and technical standards, ii) required quality of materials, iii) appropriate design and proper use of the network equipment, iv) reasonable cost effectiveness, and v) technical, economic, financial, environmental and social feasibility and viability. These requirements are without prejudice to any regulatory requirements set up by NERC.

3) RE Planning, Research and Promotion Directorate

The Executive Director, Corporate Services will oversee RE Planning, Research and Promotion Directorate to promote RE and create awareness of the general public. The RE Planning, Research and Promotion Directorate will serve as an information clearing house and public outreach body. It will work closely with the Ministry to collect and maintain information on RE, including existing and planned projects, renewable resources, rural load, equipment and material suppliers, and technological innovations for cost-effective power supply, etc.

4) RE Finance and Administration Directorate

The Executive Director, Corporate Services will oversee the RE Finance and Administration Directorate to manage the agency's internal finances and administration. The Finance and Administration Directorate is responsible for the internal finances and administrative management of the agency.

(14) Principles and Source of REF

The primary objectives of the REF are to i) achieve more equitable access to electricity across regions, ii) maximize the economic, social and environmental benefits of RE subsidies, iii) promote expansion of the grid and development of off-grid electrification, and iv) stimulate innovative approaches to RE, in accordance with the EPSR Act 2005. The Fund will provide subsidies towards the initial capital costs of RE schemes. Funding will take the form of grants to be applied to project start-up costs. Grants will not

be made for operational or maintenance costs.

Source of funds are also in accordance with EPSR Act 2005, any surplus in RE projects, any fines obtained by NERC, and any contribution that may be made pursuant to EPSR Act 2005, and interest and other benefits are accrued to the Fund when, any donations, gifts, or loans are made by international agencies, State Governments, the Federal Government, local communities, business or any other entity. In accordance with the EPSR Act 2005, to the extent required by the NREP and to cover any shortfall in the capital and assets of the REF, NERC may determine contribution rates to be sent to the REF by market participants. In addition to producers and consumers in the sector, the Government and REA will strive to attract contributions from domestic and international parties such as commercial banks, NGOs, bilateral and multilateral donors and development banks, project sponsors and end-users, as well as other relevant groups.

(15) Rural Electrification Demand Profile

Table 3-1.14 shows the estimated demand for RE by 2020.

Table 3-1.14 Estimated Demand for Rural Electrification by 2020

Item	Unit	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Population	[million]	148.3	151.9	155.4	159.2	162.7	166.2	170.5	174.4	177.5	181.3	183.9	187.4
Population Growth Rate	[%]	2.7	2.7	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.4	2.4	2.4
Capita/Households	No.	5.9	5.8	5.8	5.7	5.7	5.6	5.6	5.6	5.5	5.5	5.4	5.4
Households	[million]	25.1	26.2	26.8	27.9	28.5	29.7	30.4	31.1	32.3	33.0	34.1	34.7
Rural Population	[%]	57.1	56.5	56	55.4	54.9	54.3	53.8	53.2	52.7	52.1	51.6	51
Rural Households	[million]	14.4	14.8	15.0	15.5	15.7	16.1	16.4	16.6	17.0	17.2	17.6	17.7
% of Electrified Rural Households	[%]	22.9	23.8	24.6	25.4	26.2	27.1	27.9	28.7	29.5	30.4	31.2	32
No. of Electrified Rural Households	[million]	3.3	3.5	3.7	3.9	4.1	4.4	4.6	4.8	5.0	5.2	5.5	5.7
Additional Electrified Rural Households	[million]	0.3	0.4	0.3	0.3	0.3	0.3	0.4	0.3	0.2	0.3	0.2	0.3
Ave. Per Capita Electricity Consumption in Rural Areas	kW	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Rural Household Electricity Consumption	MW	3586.7	3921.7	3991.0	4230.2	4405.7	4667.3	4970.1	5055.0	5217.3	5520.9	5682.7	5963.6
Additional Households Demand	MW	63.2	73.6	59	65	58.7	58.8	72.4	64.4	47.5	61.9	38	53.2
Commercial Demand	MW	9.5	11	8.9	9.8	8.8	8.8	10.9	9.7	7.1	9.3	5.7	8
Service Sector Demand [School, Clinics, Community Centers, Religious, etc.,]	MW	15.8	18.4	14.8	16.3	14.7	14.7	18.1	16.1	11.9	15.5	9.5	13.3
Total Other Demand	MW	88.5	103	82.7	91.1	82.2	82.3	101.4	90.2	66.5	86.7	53.2	74.5
Cumulative Capacity	MW	3675.2	4024.7	4073.7	4321.3	4487.9	4749.6	5071.5	5145.2	5283.8	5607.6	5735.9	6038.1

Source: JICA Study Team

3-1-5 International Cooperation with Donor Organizations

International cooperation between Nigeria and Japan and other donor organizations is described below.

(1) Cooperation with the Government of Japan

Bilateral relations between Japan and Nigeria have been progressing, mainly on economy and economic cooperation relations, since the independence of Nigeria in 1960. Japan once suspended new Official Development Assistance (ODA) except emergency and humanitarian aid since March 1994, concerned about a movement away from a democratic government. This policy, however, was withdrawn in recognition of the transition to democratic government in May 1999. After the establishment of Obasanjo administration, the relations with Japan have been re-strengthened. Starting with mutual visits of government officials from the two countries, exchanges among private institutions of the two countries have been conducted steadily as well. According to the data of the Ministry of Foreign Affairs, Japan provided 86.60 billion yen in loan assistance (excluding deferred debt and exemption from debt), 51.40 billion in yen grant aid, and 20.13 billion yen in technical cooperation to Nigeria from 2011 to 2016. The policy and trends for grant aid and technical cooperation are described below.

1) Basic policy of ODA by the Government of Japan

Since Nigeria has strengthened diplomatic presence as a member nation of ECOWAS (Economic Community of West African States) and become a country with the biggest economy in Africa, the Government of Japan places considerable importance on keeping and strengthening international cooperative ties with Nigeria. In order to enhance the international cooperative ties regarding economic and diplomatic development of Nigeria and West African countries, maintain the energy security, and support the trade and investments of Japanese companies, the Government of Japan announces the basic policy of ODA shown below.

Basic Assistance Policy by Japanese Government:

Promotion of high-quality, inclusive economic and social development, and social stabilization in Nigeria

Priority Area:

1) **Establish a foundation for high-quality economic growth**
2) **Develop inclusive and resilient health and medical systems**
3) **Promote peace and stability, including reconstruction assistance in the Northern (Eastern) region**

Among the above-mentioned mid-term goals, “Establish a foundation for high-quality economic growth (Middle Target)” states that "Stable supply of electric power through the expansion and improvement of power generation, transmission and distribution facilities is indispensable for achieving sustainable economic development," and the formulation and implementation of projects for comprehensive support in the power sector are proceeding. “The Project for Master Plan Study on National Power System Development in the Federal Republic of Nigeria” is executed as part of comprehensive support for strengthening the capability of the Nigerian power sector.

2) Grant aids by the Government of Japan (Power Sector)

As a part of grant aid, as a preparation for core infrastructure for continuous social development, the Government of Japan of has executed some rural electrification (RE) projects since 2000 until 2008. The purpose of the implementation of these projects is to improve power supply in rural areas with low electrification rate and to support to achieve electrification target by the Government. The outline of recent grant aid projects executed by the Government of Japan so far is shown in Table 3-1.15 below.

Table 3-1.15 Outline of Grant Aid Projects for Power Sector by the Government of Japan

Project Name	E/N Agreement Date	E/N Amount (hundred million yen)	Areas
Project for Rural Electrification (1/3 Period)	21-November-2000	12.00	Nasarawa State Bauchi State Gombe State Borno State
Project for Rural Electrification (2/3 Period)	7-August-2001	6.53	
Project for Rural Electrification (3/3 Period)	11-July-2002	16.28	
Project for Rural Electrification in Cross River and Akwa Ibom States (1/3 Period)	22-June-2006	9.32	Cross River State Akwa Ibom State
Project for Rural Electrification in Cross River and Akwa Ibom States (2/3 Period)	16-August-2007	8.99	
Project for Rural Electrification in Cross River and Akwa Ibom States (3/3 Period)	11-July-2008	5.74	
The Project for Emergency Repair and Overhaul Works for the Jebba Hydro Power Station	11-April-2011	19.90	Niger State
The Project for Introduction of Clean Energy by Solar Electrification Generation	16-May-2012	9.80	FCT (Federal Capital Territory)
The Project for Emergency Rehabilitation of Abuja Electric Power Supply Facilities	February 11, 2016	13.17	Federal Metropolitan Area
Project for Emergency Rehabilitation and Reinforcement of Lagos Transmission Substations	November 23, 2018	23.49	Lagos State

Source: JICA Study Team

3) Technical Cooperation by Japanese Government (Power Sector)

Technical Cooperation projects implemented by the Government of Japan so far are shown in Table 3-1.16 below.

Table 3-1.16 Technical Cooperation Projects for the Power Sector by the Government of Japan

Year	Project Name	Project Outline
2004 ~2006	Master Plan Study for Utilization of Solar Energy	The project team suggested methods for promotion of utilizing solar power energy to Nigeria government through formulation of a master plan and advice on using solar power energy, and supported the Government to strengthen the capacity of the counterpart personnel to take the leading role for using solar power energy.
2012 ~2013	Advisors for Power Development Planning	The advisory team gave technical advice to the counterpart (then Federal Ministry of Power) for formulating policies managing existing projects, and identifying new projects. The team also assisted the ministry to strengthen their capacity for policy formulation and planning.

Source: JICA Study Team

(2) Relationship with DAC Member Countries and International Organizations

ODA achievement by DAC member countries is shown in Table 2-1.4, and ODA achievement by international organizations is shown in Table 2-1.5. The USA has been the top of DAC countries for ODA achievement for Nigeria consistently from 2010 to 2014. The USA is also top of DAC 29 countries of ODA achievement for the whole world, and the USA has provided more than 30% of total ODA

achievement to Sub-Sahara Africa since 2000. The International Development Association (IDA), one of the World Bank Group's institutions, has consistently been among the top of international organizations for ODA achievement in Nigeria, as its aid is formed of donations from 172 member countries and focused on the 82 poorest countries in the world (including 40 countries in Africa).

(3) Financial Development Assistance by Other Donors (Power Sector)

Table 3-1.17 shows the amount to be borrowed from donors and others for capital investment in power transmission infrastructure. The funding of the African Development Bank (AfDB) is primarily used to compensate for funding shortages in on-going projects. As the generation and the distribution sub-sectors are privatized, financial assistance from donors is concentrated in the transmission sub-sectors.

Table 3-1.17 Prospects for Donor Support for Investment in Transmission Facilities

Annex number	Development Bank (Donor)	Amount (Millions of U.S. dollars)
Annex 7.2e1*	Abuja transmission ring Project (AFD: French Development Agency)	170
Annex 7.2e2	Lagos-Ogun Transmission Project (JICA: Japan International Cooperation Agency)	TBD
Annex 7.2e3	North East Transmission Infrastructure Project (AFDB: African Development Bank)	200
Annex 7.2e4	NETAP Package (WB: World Bank)	486
Annex 7.2e5	Nigeria Transmission Expansion Project (IDB: Islamic Development Bank)	210
Annex 7.2e6	Northern Corridor Transmission Project (AFD: French Development Agency)	272
Total		1,338**

Note: * Section number of the Annex 7 of this report (detailed components are described in the sections).
** Total amount excluding JICA projects
Source: Prepared by the JICA Study Team

According to the TCN, investment in the transmission sector will require US$7,742 million by 2020, but projects with plans to raise their own funds or be supported by donors will not be able to meet the requirement and will require further funding. The TCN is therefore exploring a variety of financing possibilities, including investment by Chinese enterprises using loans from the China EximBank and further donor support.

In recent years, China has been actively supporting hydroelectric power projects in various African countries. In Nigeria, China has also provided loans of more than USD 5.9 billion through the China EximBank for the Project for Construction of the Zungel/Mmambilla hydroelectric power project. Some pointed out that "it is not environmentally friendly," "it does not contribute to the promotion of local employment," or "it aims at export of surplus capacity after the construction of the Three Gorges Dam to Africa." China has also supported solar power generation recently.

3-1-6 Selling NDPHC Generation Companies to the Private Sector

Power stations constructed by National Integrated Power Project (NIPP) are under the ownership of Niger Delta Power Holding Company (NDPHC). The Government is planning to sell the completed eight power stations, as listed below, to the private sector.

1) Alaoji
2) Geregu (Power)
3) Odukpani (Calabar)
4) Olorunsogo (Power)

5) Omotosho GenCo.
6) Sapele (Ogorode)
7) Ihovor
8) Gbarain

The Government is preparing a set of drafts of the following four contract forms for each of the eight power stations together with NBET. Under the conditions prepared by the Government, tenderers will compete for buying a power o or a power company, and the one who bids with highest amount will be awarded the contract.

a) Power Purchase Agreement: PPA
   * Long term (10 or 20 years) contract to purchase electricity
   * Two tiers of a contract; for capacity (W) and for energy (Wh)
   * Take or pay contract with which the purchaser has to pay the supplier for a certain volume of electricity even if the purchaser does not take.

b) Gas Sale Aggregated Agreement: GSAA
   * Long term (10 or 20 years) contract, generally same period as PPA
   * Take or pay contract as PPA
   * Tenderer has to prepare a draft GASS with a gas company before bidding.

c) Put and Call Option Agreement: PCOA
   * With a PCOA, the buyer of the power plant/power company can get better access to a bank loan. The Government through NBET will enter to a PCOA with the buyer.
   * The buyer, with a put option, will have the right to require the Government to purchase (a part of) assets of the plant or shares of the company on trigger events, while the Government, with a call option, will have the right to require the buyer to sell (a part of) assets of the plant or shares of the company on trigger events.

d) Partial Risk Guarantee: PRG
   * If the buyer cannot repay to the lending or L/C bank, the guarantor, such as the World Bank, will repay instead.
   * The Government will enter an indemnity agreement with the guarantor

The Government has not decided whether it will sell all or a part of shares of each power company. Meanwhile, the private sector shows an interest in buying 100% shares as they do not want to be interfered by the Government while they manage the company. Currently, the power companies under NDPHC, except Odukpani (Calabar), have PPAs only for the energy trading, and the Government is examining what to do with the PPAs for selling the companies.

3-1-7 Current Status of IPPs

Investment in independent power producers (IPP) of new thermal power plants by the private sector has been conducted since 2001 in Nigeria. The Government takes a policy to sell power plants excluding hydro-power plants to the private sector. In the future, IPPs are expected to grow and take important roles, as many existing thermal power plants are seriously malfunctioning. For projects that have already acquired PPA licenses from

NERC, F/S and EIA surveys have been approved by the NERC.

(1) Outline of IPP and Promotion System for Private Investment

In the power sector of Nigeria, it is imperative that the private investment is facilitated in the generating business in order to reduce the shortage of power generation volume. Annex 3a shows IPPs (private on-grid power suppliers, excluding those developed by the NIPP, or previously affiliated with former PHCN) that have been licensed by NERC. Although 75 companies are listed in the annex, only Azura-Edos started operation as an IPP, except for those managed by the major IOC, which produces natural gas and also operates power generation stations.

(2) Procedure to Apply the License for Power Generation

NERC has authorities to grant licenses to electricity generation on-grid including IPPs. Application procedure for the license is as follows. An application fee is required for application according to the planned generation capacity.

a) Submission of application forms to NERC. The following information is required at the time of application.
   - Corporate information
   - Financial statements of the company
   - Type of application license
   - Method of fund raising for the project
   - Impacts of the project including EIA
   - Ten-year business plan and Power Purchase Agreement (PPA)

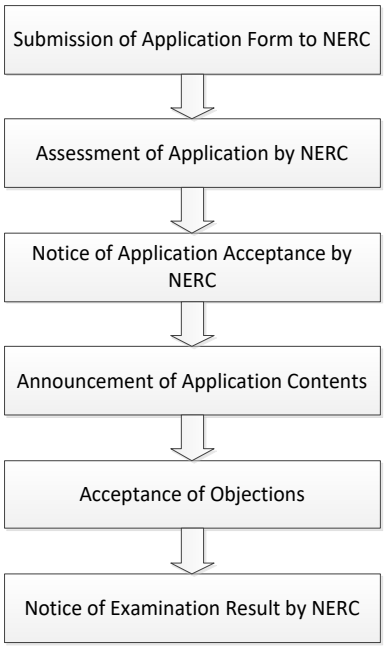
b) Assessment of application by NERC
   Additional information should be submitted according to request by NERC.

c) Notice of application acceptance by NERC
   NERC will provide notice of the result of application acceptance in writing.

d) Announcement of application contents
   Within 30 days from the notice of application acceptance by NERC, the applicant must make an announcement regarding the license through daily papers and other media at the expense of the applicant.

e) Acceptance of objections
   Objections will be accepted. Objections should be made within 21 days from the announcement.

f) Notice of examination result by NERC
   Usually the examination result will be notified within 6 months from the submission of the application form.



Source: JICA Study Team

Figure 3-1.4 Application Flow of Electricity Business License

(3) Policy on Promotion of Investments for IPPs

There are tax exemption and tax reduction schemes for IPPs.

- Exemption of import taxes for generating facilities and equipment
- Three-year exemption of companies' income tax from the start of business, and maximum two-year extension of the exemption period can be granted depending on business evaluation result.

Furthermore, investment activities in rural areas are eligible for the following tax exemption.

- Maximum seven-year exemption of companies' income tax from the start of business

However, in order to facilitate the private investment as IPPs, it seems to be urgent to ensure the stability of fuel supply such as providing the guarantee by the Government, and to restore civil order at first. For promotion of IPPs, sets of the four contract forms, namely, i) Power Purchase Agreement (PPA), ii) Gas Sale Aggregated Agreement (GSAA), iii) Put and Call Option Agreement (PCOA), iv) Partial Risk Guarantee (PRG), should be applied as currently prepared for selling the eight generation plants/ companies under Niger Delta Power Holding Company (NDPHC), as well started to be applied for an IPP project of solar power generation. In case of IPP projects, tenderers will compete in the generation price, and the bidder with the lowest generation price will be awarded the bid.

3-2 Policies of Power and Primary Energy Sectors

3-2-1 Policies Regarding Power and Utilization of Primary Energy Sources

In this section, current policies on power and utilization of primary energy sources are listed and summarized in order to elucidate the role and function of this Master Plan.

(1) List of Policies of the Power and the Primary Energy Sectors

Table 3-2.1 below is the list of policies of the power sector and the primary energy sector. Although there are other preceding policies than those in the list below, only policies effective at the moment, which are to be referred for the Master Plan Study, are described.

Table 3-2.1 List of Power and Primary Energy Policies

Related Policies	Year Issued	Responsible Organization	Outline
National Plan			
Vision 20-2020	2009	National Planning Commission (NPC)	Long-term national development plan until year 2020. 40,000 MW power supply is targeted to be achieved by 2020.
Economic Recovery & Growth Plan	2017	Federal Ministry of Budget and National Planning (FMBNP)	Economic recovery plans from the financial crisis and recession mainly caused by a decline in the oil price from 2014.
National Integrated Infrastructure Master Plan (NIIMP)	2014	Federal Ministry of Budget and National Planning (FMBNP)	Comprehensive development plans for national infrastructure including the energy sector.
Comprehensive Energy Policy			
National Energy Policy (NEP)	2003	Energy Commission of Nigeria (ECN)	Basic policy for energy sector. It covers the entire energy sector including primary energy sources, renewable energy, the utilization of energy as power, etc. Currently it is being revised. The national electrification rate is targeted as 75% of the population by 2020, and 100% by 2030.
[Draft Revised Edition]	2014		
National Energy Master Plan (NEMP)	2007	Energy Commission of Nigeria (ECN)	Implementation plans and frameworks for National Energy Policy (NEP). A draft of the revised edition has been prepared now along with the amendment of NEP.
[Draft Revised Edition]	2014		
Comprehensive Power Sector Policy			
Power Sector Recovery Programme 2017-2021	2018	Federal Government	Five-year action plans for fiscal, operational/technical, governance, and policy-interventions to reset the power sector reforms.
Roadmap for Power Sector Reform	2010	Presidential Task Force on Power (PTFP)	Implementation plan and milestones for the power sector reform.
[Revision 1]	2013		
Power Sector Reform Act			
Electric Power Sector Reform Act (EPSRA)	2005	Electric Power Sector Reform Implementation Committee (EPIC) (An organization established by BPE to formulate the power sector reform act)	The legal basis for on-going power sector reform. It is formulated to implement the sector reform focusing on the division and privatization of the electricity monopoly, National Electric Power Authority (NEPA).
Policy for Strengthening Electric Power Systems			
Transmission Expansion Plan	2017	Transmission Public Corporation (TCN)	Master plan for reinforcement of the transmission network, formulated with the support of the World Bank.
Renewable Energy and Energy Efficiency Related Policy			
National Renewable Energy Action Plans (NREAP)	2016	Federal Ministry of Power, Works and Housing (FMPWH)	Action plans indicating specific targets and methods of achievement regarding renewable energy.
National Energy Efficiency Action Plans (NEEAP)	2016	Federal Ministry of Power, Works and Housing (FMPWH)	Action plans indicating specific targets and methods of achievement regarding energy efficiency.
Sustainable Energy for All Action Agenda (SE4ALL-AA)	2016	Federal Ministry of Power, Works and Housing (FMPWH)	National action agenda of Nigeria for SE4ALL (Sustainable Energy for All), a global initiative led by the Secretary-General of the United Nations.

Related Policies	Year Issued	Responsible Organization	Outline
National Renewable Energy and Energy Efficiency Policy (NREEEP)	2015	Federal Ministry of Power, Works and Housing (FMPWH)	Frameworks of policies for renewable energy and energy efficiency.
Hydropower Master Plans	2013	Japan International Cooperation Agency (JICA) together with the Federal Ministry of Water Resources (FMWR)	Master plan on hydropower.
Solar Energy Master Plan	2007	Japan International Cooperation Agency (JICA), Federal Ministry of Power and Steel (FMPS), Federal Ministry of Science and Technology (FMST), Energy Commission of Nigeria (ECN), Rural Electrification Agency (REA)	Master plan on solar energy.
National Bio-fuel Policy and Incentives	2007	Nigerian National Petroleum Corporation (NNPC)	Policy to promote utilization of biofuels.
Renewable Electricity Policy Guidelines	2006	Federal Ministry of Power, Works and Housing (FMPWH)	Guideline for utilization of renewable energy.
Renewable Energy Master Plan	2005	United Nations Development Programme (UNDP), Energy Commission of Nigeria (ECN)	Master Plan on Renewable Energy
(Updated)	2012		
Rural Electrification Related Policy			
Rural Electrification Strategy and Implementation Plan	2016	National Rural Electrification Agency (REA)	Promotion strategy and plan to set the planning target values of RE. It is the updated version of the 2006 implementation plan.
Rural Electrification Strategy and Implementation Plan of the Federal Republic of Nigeria	2006	Bureau of Public Enterprises (BPE)	Implementation plans of RE indicating organization structures and systems, fund raising methods, regulation structures, and target values.

Source: JICA Study Team

Policies in the power sector are concentrated on renewable energy and energy efficiency now. Overall and inclusive policy is covered by this Master Plan.

(2) Main Ministries and Agencies Responsible for Policy Formulation

The main ministries and agencies responsible for the formulation of policies for the sub-sectors of the power and primary energy sector are identified in Table 3-2.2 according to the list of related policies and their responsible organizations given in Table 3-2.1.

Table 3-2.2 Responsible Organization for Power and Energy Sector

Heading of Policies	Responsible Ministry/Agency
Overall Power Sector	FMPWH
Overall Primary Energy Utilization	ECN
Individual Primary Energy Sources	Individual responsible ministries
Renewable Energy	FMPWH, ECN, etc.
Rural Electrification	FMPWH, REA

Source: JICA Study Team

Some overlaps and inconsistencies are found in the sub-sectors as information sharing and coordination regarding basic data, policy contents, and target indicators are not sufficiently conducted. Actions have to be taken to improve the coordination among related ministries and agencies of the sub-sectors. The Energy Commission of Nigeria (ECN) is expected to take a leading role in the coordination in the power and the primary energy sectors.

3-2-2 Laws, Regulations, Guidelines and Codes of the Power Sector

This section describes the acts, regulations, guidelines, codes, etc., of the power sector. The Electric Power Sector Reform Act (EPSR Act. 2005) is the fundamental law of the power sector.

Table 3-2.3 Power Sector Related Act

Related Act	Year Issued	Responsible Agency	Outline
Electric Power Sector Reform Act (EPSR Act. 2005)	2005	Electric Power Sector Reform Implementation Committee (EPIC) (An organization established by BPE to formulate the Power Sector Reform Act)	The legal basis for on-going power sector reform. It has been formulated to implement sector reform focusing on the division and privatization of the electricity monopoly, National Electric Power Authority (NEPA).

Source: JICA Study Team

The Nigerian Electricity Regulatory Commission (NERC) takes on a wide-ranging role, which includes regulating, and supervising, permitting and electricity charge setting in the power sector of Nigeria, and most regulations for the power sector are also prepared by NERC. Table 3-2.4 lists major regulations, guidelines, and codes instituted by NERC.

Table 3-2.4 Regulations, Guidelines and Notices by NERC

Type	Title of Regulation and Guidelines (Year of Publication)	Contents
Regulation	Feed in Tariff for Renewable Energy Sourced Electricity in Nigeria (2015)	Regulation of Feed in Tariffs for Renewable Energy Sources.
	Electricity Industry Enforcement Regulation (2014)	Regulation on the role and authorities of NERC.
	Nigerian Electricity Supply and Installation Standards Regulations (2015)	Regulations on standards of design, installation, testing operation, maintenance, etc. of the equipment and facilities in the electricity businesses.
	Regulations on Procedure for Electricity Tariff Reviews in the NESI (2014)	Regulations on the process to revise the electricity charges.
	Regulations for Investments in Electricity Network in Nigeria (2015)	Regulations on qualifications and preliminary studies for proper investments on transmission networks and distribution networks.
	Regulations on National Content Development for the Power Sector (2014)	Regulations to facilitate domestic employment and usage of domestic products in the power sector.
	NERC (Methodology for the Determination of Connection Charges for Electricity Supply) Regulations (2012)	Regulations on contract fees for new contracts.
	NERC (Independent Electricity Distribution Networks) Regulations (2012)	Regulations on permission of DisCos and operating methods of networks so that distribution networks can be divided into DisCos.
	NERC (Embedded Generation) Regulations (2012)	Regulations on embedded generation.
	NERC (Methodology for Estimated Billing) Regulations (2012)	Regulations on how to estimate the usage volume if the electricity meter of user is broken or impossible to read.
	NERC (Acquisition of Land and Access Rights for Electricity Projects) Regulations (2012)	Regulations on land acquisition in power sector businesses.

Type	Title of Regulation and Guidelines (Year of Publication)	Contents
	Regulation for the Procurement of Generation Capacity (2014)	Regulation on qualification and process of tendering in the power sector.
	Connection and Disconnection Procedures for electricity services (2007)	Regulations on processes for new contracts and the cancellation of contracts with users.
	Customer Complaints Handling Standards and Procedures	Regulations on customer complaints handling.
	Customer Service Standards of performance for distribution companies (2007)	Regulations on customer service of DisCos.
	Meter Reading, Billing, Cash Collections and Credit Management for Electricity Supplies Regulations (2007)	Regulations on meter reading, billing, and customer management of DisCos.
	NERC License and Operating Fees Regulation (2010)	Regulations on commission fee and permission fee of power sector businesses.
	Permits for Captive Power Generation Regulations (2008)	Regulations on captive power generation.
	Application for Licenses (Generation, Transmission, System Operations, Distribution & Trading) Regulations (2010)	Regulations on permissions for power sector businesses.
	Reporting Compliance Regulation (2009)	Regulations on compliance with reporting to NERC in the power sector business.
	Business Rules of the commission (2006)	Business rules of NERC.
	NERC (Independent Electricity Distribution Networks) Regulations (2012)	Regulations on Independent Electricity Distribution Networks.
	Electricity Theft and Other Related Regulations, 201 Offences (2014)	Regulations on penalties for electricity theft and destroy of facilities.
	Generation Procurement Regulations (2012)	Regulations applied for investments in power plants and newly establishment of IPPs.
Guideline	Guidelines and Assessment Criteria for Fit and Proper Persons for Corporate and Individual Participation in Regulated Electricity Undertakings (2012)	Guidelines of criteria and qualification of employment and promotion of staff in the power sector.
	Generation Procurement Guidelines (2014)	Guidelines for application of Generation Procurement Regulations. It aims to increase power generating capacity by IPPs.
	Guidelines for Consumer Consultation by DisCo Before Applying to NERC for Approval of Applications for Revenue Requirement Rate Design and Consumer Reclassification	Guidelines of customer consultation meetings at the time of revision of electricity charge by DisCos.
	Guidelines for obtaining Clearance Certificate for the importation of generating sets and related matters (2011)	Guidelines for obtaining clearance certificate at the time of importing the equipment of power plants.
	Guidelines for Certification of Metering Service Providers and Related Matters (2013)	Guidelines of certification of metering service providers.
	NERC Guidelines on Rate Review (2014)	Guideline on rate review.
	Guidelines for Obtaining Clearance Certificate for the Importation, Production or Supply of Electric Energy Meters and Related Matters	Guidelines for importation, production and sales of electricity meters.
	Guidelines on National Content Development for the NESI (2013)	Guidelines to facilitate domestic employment and usage of domestic products in the power sector.
Codes/ Standards/ Manuals	Metering Code (2013)	Code for installation, operation and maintenance of grid meters and distribution meters.
	The Grid Code for the Nigeria Electricity Transmission System	Code for operation and maintenance of grid systems of transmission network.
	The Distribution Code for The Nigeria Electricity Distribution System	Code for development plan and operation of distribution network.
	Nigerian Electricity Health and Safety Standards	Standards for work safety in the power sector.

Type	Title of Regulation and Guidelines (Year of Publication)	Contents
	Draft Instruction Paper on the terms and conditions for establishment of an independence system operator (2015)	Draft instruction paper defining the role of Independent System Operator (ISO) and establishment of it.
Order	Order on the Imbalance Application Mechanism during the Transitional Electricity Market (TEM) (2015)	Order on resolving the imbalance of demand and supply of the power during TEM.
	Order on Refund of Overbilled Customers by AEDC	Order on refunds of overbills.
	Supplementary Order on TEM (2015)	Additional order on TEM.
	Order directing the commencement of the transitional Stage Electricity Market (TEM) (2015)	Order on implementation of TEM.
	Order - Procedure for Obtaining Approval for Assignment, Ceding of a License, Transfer of Undertaking or Change in Shareholding of Licensed Entities	Order on procedure for obtaining and transferring licenses of the electricity business operators.
	Order Abolishing Meter Maintenance Fee (2011)	Order to abolish the meter maintenance fee that was charged to customers by DisCos.
Market Rules/Tariff Order, etc.	Bulk Generation Procurement Guidelines and Codes	Guidelines and codes on power generation business plan and selection of business operators. They are applied for investment in and the establishment of power plants and IPPs.
	Market Rules for Transitional and Medium Term1 Stages of the Nigerian Electricity Supply Industry (2014)	Market rules during TEM and Medium Term Market.
	Rules for the Interim Period between Completion of Privatization and the Start of the TEM (2013)	Interim rules for privatization of power business operators and starting period of TEM.
	MYTO 2015 Distribution Tariff (2015 - 2024)	Distribution tariff of each DisCos (revised in 2015)
	MYTO 2015 TCN Tariff Order	Transmission tariff of TCN (revised in 2015)

Source: JICA Study Team

Upon the unbundling of the power sector, it became necessary to decide on the prices the power generators could sell electricity for and how much the transmission sub-sector could charge the distribution sub-sector. As for the power generation charge, the price can be determined through negotiations between the generation and distribution sub-sectors in the market. Before the market matures, however, a mediator is necessary for trading among the sub-sectors. In Nigeria, Nigerian Bulk Trading Company (NBET) takes the role of the mediator. Having this as a background, NERC established Multi-year Tariff Order (MYTO) based on EPSR Act 2005 to determine the generation tariff (wholesale price), end-user tariff (retail tariff), and charges use of the system for transmission, such as transmission tariffs for service providers, Market Rules to provide to provide rules of the temporary electricity market, and the Grid Code to stipulate technical requirement to connect with the national grid. Outlines of the three orders are given below.

(1) Multi-year Tariff Order (MYTO)

MYTO defines generation tariffs (generation charges or wholesale prices, charges for use of transmission network chargeable by the transmission company (TCN) to distribution companies (DisCos), and tariffs for DisCos to collect from the users (end-user tariff or retail tariffs). In the MYTO II prescribed in 2012, generation tariffs were provided by type of source energy, such as hydro (middle to large scale and small scale), thermal (natural gas and coal), and renewable energy (solar, wind and biomass). Generation tariffs are no more provided due to a policy for competitive generation tariffs. Underlying guiding principles for the pricing are as follows:

a) Cost recovery/financial viability
b) Signal for investment
c) Certainty and stability
d) Efficient use of the network
e) Allocation of risks
f) Simplicity and cost-effectiveness
g) Incentive for improving performance
h) Transparency/fairness
i) Flexibility/robustness
j) Social and political objectives

(2) Market Rule

The Market Rules stipulates i) system operators and markets operator, ii) admission and withdrawal of participation in the market, iii) the contract market, iv) generation adequacy and power procurement, v) settlement and payment system, and vi) communications during the transitional and medium term markets aiming at an efficient, competitive, transparent, and reliable market.

(3) Grid Code

The Grid Code contains provisions on i) grid planning, ii) connection conditions, iii) operation of the grid for an effective, well-coordinated, and economic transmission system.

3-3 Structure and Issues of Nigerian Power Sectors

3-3-1 Reform Trend of Power Sectors

Currently in the power sector, the power sector reform "Roadmap for Power Sector Reform" focused on privatization of electric power companies is in progress. The status of progress in power sector reform is as follows.

Table 3-3.1 Status of the Power Sector Reform

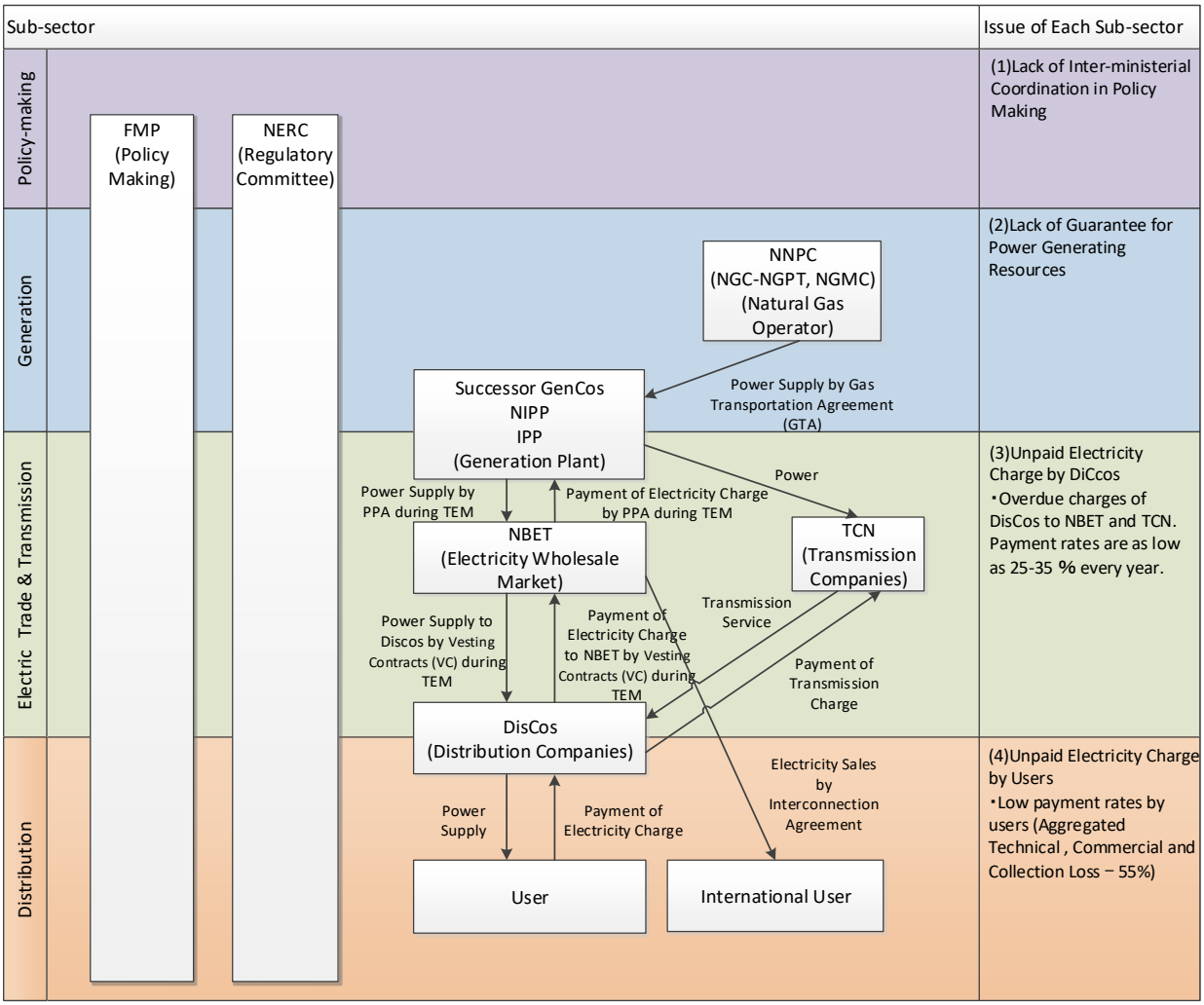
Date	Reform Status
March,2005	Enforcement of the Electricity Power Sector Reform Act
May, 2005	Unbundling of NEPA, establishment of Power Holding Company of Nigeria (PHCN)
October, 2005	Establishment of Nigeria Electricity Regulatory Commission (NERC)
November, 2005	PHCN is disassembled into 6 GenCos, TCN, and 11 DisCos
March, 2006	Establishment of Rural Electrification Agency (REA)
July, 2008	Issuance of Multi-Year Tariff Order (MYTO)
June, 2010	Establishment of Presidential Task Force on Power (PTFP)
July, 2010	Establishment of Nigerian Bulk Trading Company (NBET)
August, 2010	Issuance of Power Sector Reform Roadmap
May, 2012	Issuance of Multi-Year Tariff Order - 2nd edition (MYTO-II)
July, 2012	Management contract concluded between TCN and Manitoba Hydro International (MHI)
August, 2013	Issuance of Power Sector Reform Roadmap (revised version)
November, 2013	6 GenCos and 11 DisCos start to shift to private capital
February, 2015	Electricity Bulk Trading by NBRT started
March, 2015	Revised Multi-Year Tariff Order - second edition (MYTO-II) (MYTO 2.1)
May, 2015	Presidential Task Force on Power (PTFP) dissolution
2015	Establishment of Advisory Power Team, Office of the Vice President
June, 2015	Federal Ministry of Power (FMP) and Federal Ministry of Public Works were merge to Federal Ministry of Power, Works and Housing (FMPWH)

Date	Reform Status
July, 2015	TCN and Manitoba Hydro International (MHI) management contract expired, renewal agreement signed until July 31, 2016
December,2016	Agreed with the World Bank to implement the Power Sector Recovery Plan
January, 2018	Issuance of Public Sector Recovery Programme 2017-2021

Source: JICA Study Team

A transition period for the power market (Transitional Electricity Market: TEM) is set up in advance to establish a fully competitive market, and NBET mediates as a bulk trade in the TEM between generation companies (GenCos) and DisCos. In the bulk trading GenCos and NEBET conclude Power Purchase Agreements (PPAs) and NBET sells the electricity to DisCos with vesting contracts.

The figure below shows the flow of power supply, as well as issues and challenges faced by the power sector. In order to develop the power sector, these issues must be overcome to achieve the power supply target along with sector reform. They are the major obstacles for private investment in IPPs and others.



Source: JICA Study Team

Figure 3-3.1 Power Supply Flow and Major Issues

Details of each of the issues are as described in Section (1) - (4) below.

(1) Lack of Coordination among Ministries Related to Policy-making

In the power sector, many institutions are involved with policy measures and their implementation. However, policy formulation is not carried out with coordination among relevant ministries and agencies. Adjustments and information sharing information are not carried out sufficiently for the target values, and there are often cases in which some policies are not consistent with others. For example, Table 3-3.2 shows target values and predicted values of power generation up to 2020 indicated in important policies.

Table 3-3.2 Target and Predicted Power Supply

(MW)

Policy	Year	Policy Organization	Policy figure	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Nigeria Vision 20: 2020	2010	FMBNP	Target	6,000	8,000					20,000					35,000
National Integrated Infra-structure Master Plan (NIIMP)	2014	FMBNP	Target					7,000					20,000		
Roadmap for Power Sector Reform - Revision 1	2013	PTFP	Predicted					8,664	10,454	12,106	15,636	21,237	23,311	24,961	28,261
National Energy Master Plan (NEMP) (draft)	2014	ECN	Predicted	5,753	7,440					26,092					52,174

Source: JICA Study Team

The target value of power generation in the National Integrated Infrastructure Master Plan (NIIMP) formulated by the Federal Ministry of Budget and National Planning (FMBNP) is significantly lower than the target value set in Nigeria Vision 20: 2020. Considering the progress of the situations in 2014, it seems that the target value has been lowered to a more realistic one. In addition, this value is set below the predicted power generation capacity of the Roadmap for Power Sector Reform - Revision 1 issued in 2013. The Roadmap was issued in 2013 and the National Energy Master Plan (NEMP) (draft) was issued in 2014. The predicted values of power generation are greatly different from one another, and the latter set of values in 2020 are about 1.8 times of the former. The method of setting and estimating each policy value is completely different from each other, and therefore the values for each policy are not consistent. Methods to set the estimated and targeted values in the policies are shown in Table 3-3.3 below.

Table 3-3.3 Estimation Method of Power Supply Future Targets of Major Policies

Policy	Year	Organization	Method for estimating and targeting in policy-making
National Integrated Infrastructure Master Plan (NIIMP)	2014	FMBNP	The goal is set so that Nigeria's per capita generation capacity will achieve 80% of the current level in the United States by 2043.
Roadmap for Power Sector Reform - Revision 1	2013	PTFP	The prediction is made based on the accumulation of electric power that can be generated in the future, which is projected from the capital investment plan of each power plant and the development plan of the new power plant.
National Energy Master Plan (NEMP) (draft)	2014	ECN	Future demand and electricity supply forecast made by model MAED and MESSAGE used by IAEA.

Source: JICA Study Team

In addition, predicted values estimated by the ECN in 2012 are used in major policies for the power demand forecast. The predicted value of ECN is estimated by MAED as shown in the table above.

Table 3-3.4 Power Demand Forecasted for Major Policies

(MW)

Policy	Year	Organization	Policy figure	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Renewable Energy Master Plan	2012	ECN	forecast	4,052	7,440					24,380					45,490
National Energy Master Plan (NEMP) (draft)	2014	ECN	forecast	4,052	7,440					24,380					45,490
National Renewable Energy and Energy Efficiency Policy (NREEEP)	2015	FMPWH	forecast				21,200			24,380					45,490

Source: Respective policies written in the above in table.

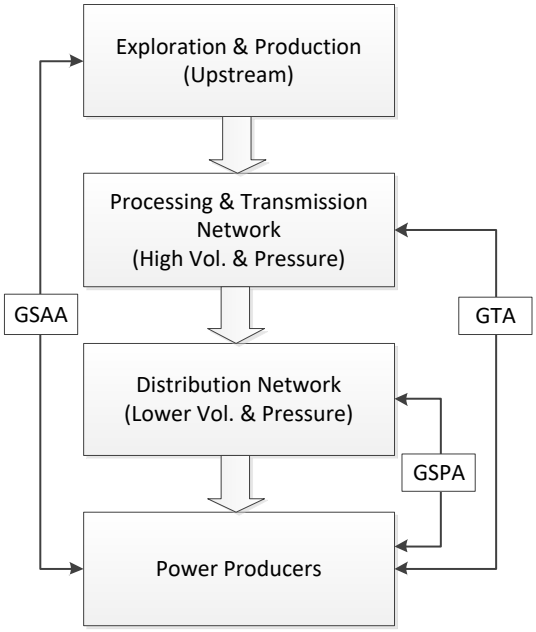
(2) Uncertainty of Securing Power Generation Sources for Energy

Although private investment is actively promoted in the power generation sub-sector in order to achieve the target value of generated electricity, private capital investment in IPP is not advancing as expected. One of the main reasons for this is the securing of fuel at power plants, as well as the issue of a low electricity toll collection rate.

There are several issues with securing primary energy resources. First of all, the only energy source for thermal power generation in Nigeria, except minor ones, is currently natural gas due to economic conditions, supply volume, and infrastructure. Since Nigeria produces petroleum and coal besides natural gas, it seems likely that there will be sufficient natural resources as these also can be used as a power generation source in the future. The current situation of these natural resources in Nigeria is as described below.

1) Natural gas

All natural gas for the power plants is supplied by the Nigerian Gas Company (NGC), a subordinate organization of the Nigerian National Petroleum Corporation (NNPC), which was split into two companies in 2016; Nigerian Gas Processing and Transmission Company (NGPT) and Nigerian Gas Marketing Company (NGMC). Figure 3-3.2 shows the flow of natural gas supply in the power sector. Natural gas that is produced by Exploration & Production business operators (private business operators) is processed through processing facilities (presently owned by private exploration & production business operators or NGC- NGPT), then supplied to power producers through supply networks.



Source: JICA Study Team

Figure 3-3.2 Supply Flow of Natural Gas to Power Producers

Power producers are required to enter contracts with each operator on gas supply: all users should enter a Gas Sales and Aggregation Agreement (GSAA) with exploration and production business operators; for transportation, large-scale users should enter Gas Transportation Agreement (GTA) with transmission network operators (private operators or NGC-NGPT), and relatively small-scale users should enter Gas Sales and Purchase Agreement (GSPA) with suppliers.

However, gas supply in Nigeria is far from stable. The supply is frequently stopped due to strikes and destructive actions, such as staving holes in gas and oil pipelines for theft or political reasons. Such destructive actions cause serious accidents with over 100 casualties once or twice every few years. Under these situations, there is a need to take measures including the government guarantee on generating energy supply in order to promote private investments in the power sector. Details on the issue of unstable gas supply are described in Section 3-1-3 of this report.

2) Oil

As the refining capacity in Nigeria is very low, the oil produced there is refined overseas. Therefore, the oil used in the country needs to be reimported, and the domestic oil price is high. Oil is less economically efficient than gas, and that is why oil has not been used for power generation.

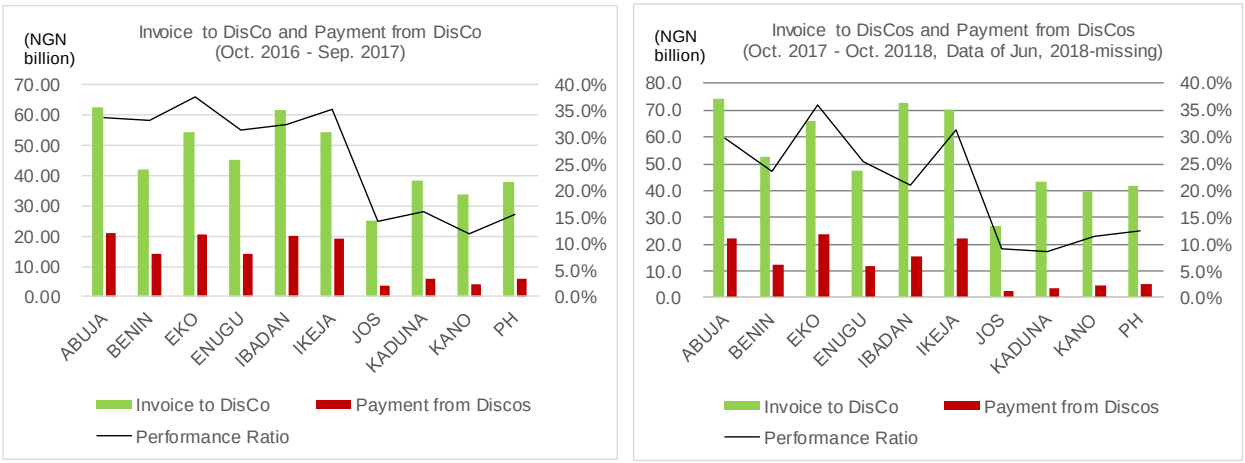
3) Coal

Coal is also a resource that can be produced domestically, and its usage is less costly. Nevertheless, the coal production volume in Nigeria has decreased from its peak in the 1950s.

(3) Unpaid Generation and Transmission Charge by DisCos

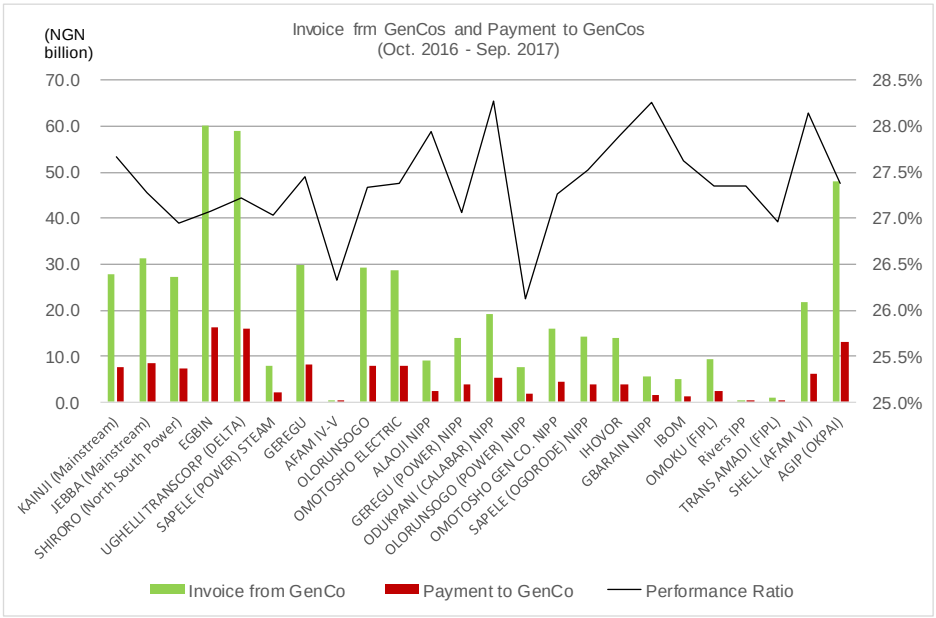
Before Nigerian Bulk Electricity Trading Plc (NBET) was established, all DisCos had paid 40-70% of the

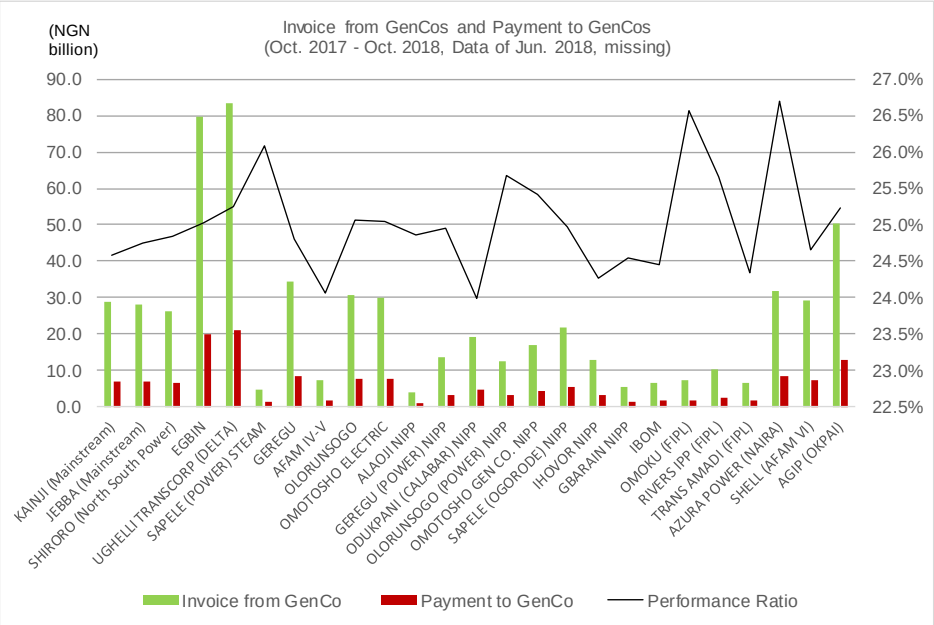
bills to them, leaving the accounts unrecoverable. This situation has got worse after the NBET began operations. As can be seen in Figure 3-3.3 and Figure 3-3.4, during October 2016 to October 2018, the amounts paid from DisCos to the NBET and from the NBET to GenCos were around one fourth of the billed amounts. As shown in Figure 3-3.4, DisCos' payment rates, defined as the ratio of paid amounts by DisCos to billed amounts to the respective DisCos, are relatively high in the DisCos of Abuja, Eko and Ikeja, where large cities are located, and lower in other DisCos as people in rural areas generally still think that electricity is supplied by the Government for free. Meanwhile, NBET every month pays to all GenCos with same rates, i.e., ratio of amounts paid to GenCos to billed amounts by the respective GenCos. Monthly data of amounts billed to DisCos and by GenCos, and paid amounts by DisCos and to GenCos during October 2016 to October 2018 are provided in Annex 3b and 3c, respectively.



Source: NBET

Figure 3-3.3 Invoiced Amounts to DisCos and Paid amount from DisCos
(from October 2016 to September 2017, and October 2017 to October 2018, data of June 2018-missing)





Source: NBET

Figure 3-3.4 Invoiced Amount from GenCos and Paid Amounts to GenCos (from October 2016 to September 2017, and October 2017 to October 2018, data of June 2018-missing)

As a result, the financial conditions of GenCos, TCN, and DisCos, which constitute the electric power sector, have become critical. For this reason, the Government decided to launch the Payment Assurance Facility (PAF) as a financial intervention included in Power Sector Recovery Programme 2017 2021 (PSRP). The procedure for payment by PAF is; in case of unpaid generation charge is as follows: i) GenCos request NBET to confirm the unpaid amount, ii) NBET confirms the unpaid amount, iii) with the confirmation, GenCos request the Central Bank of Nigeria (CBN) for the payment, iv) CBN pays the unpaid amount to the GenCo directly. PAF also covers gas costs unpaid by GenCos due to the unpaid generation charges from DisCos, and CBN pays the unpaid amount directly to the gas suppliers. PAF covers 80% of unpaid generation charges and 90% of the unpaid gas costs. For the new entrant IPP, however, PAF covers 100% of both unpaid amounts. Continuation of payments by PAF after its closing in December 2018 has not been decided on yet. Since there will be direct dealings between the GenCos and DisCos after the end of the TEM, DisCos' unpaid fee will be a big risk for power generation companies. According to NERC, although the end of the TEM period has not been defined as of yet, it is difficult to completely shift to an electric wholesale market unless the problem of unpaid fees is solved, and these problems cause a major obstacle for the entry of IPPs.

In addition, payment rates from DisCos to TCN have decreased from 61% to 34% during 2013 to 2016, which is has been a cause of TCN's financial pressure.

(4) Unpaid Electricity Charge by Users

The direct cause of DisCos' payment problem mentioned in the above Section (3) is the low rate of collecting electricity charge from the consumers, which was 62%[1] on average in the first quarter of 2018.

Table 3-3.5 DisCos' Performance of Charges from Consumers

DisCos	Total Billings (NGN Billion)		Revenue Collected (NGN Billion)		Collection Efficiency (%)	
	2017Q4	2018Q1	2017Q4	2018Q1	2017Q4	2018Q1
Abuja	23.2	24.0	15.5	16.1	66.8	67.0
Benin	17.8	18.3	9.5	10.1	53.3	55.3
Eko	19.9	21.5	16.7	17.7	84.1	82.2
Enugu	14.6	15.9	9	9.9	61.6	62.1
Ibadan	18.9	20.8	13.5	13.1	71.8	63.0
Ikeja	18.8	21.2	16.2	17.5	86.2	82.6
Jos	8.8	8.7	2.9	3.3	33.1	37.8
Kaduna	9.8	11.5	3.7	4.7	37.7	41.0
Kano	11.6	11.6	5.7	6.0	49.3	52.0
Port Harcourt	14.2	13.3	6.2	6.1	44	45.9
Yola	4.3	4.3	2.2	2.1	50.4	48.7
All DisCos	161.8	171.2	101.0	106.6	62.5	62.3

Source: First Quarterly Report of NERC, 2018

In addition to private consumers, government organizations such as ministries and agencies, which are large consumers, neglect to pay electricity charges. This is caused by the fact that the budget to the ministries and agencies is not being disbursed as planned. To improve this situation, in March 2017 the Government pledged to pay a total of NGN 26 billion (USD 85 million) of the unpaid amount of the charges of government organizations owed to electric power companies. Details such as the timing of enforcement are unknown at present.

(5) High Loss Rate in the Distribution Sub-sector

According to Advisory Power Team's Power Baseline Report (2015), the distribution sector had a technical loss of 12.5%, a commercial loss of 6.9%, and an uncollected rate of 36.5%. According to the NERC's report for the first quarter of 2018, the aggregated technical, commercial and commercial (ATC&C) loss rate of eleven DisCos was 55%.

[1] This collection rate is the rate of collected amounts to the invoiced amounts, and losses due to power loss rate due to technical factors or theft are not considered.

Table 3-3.6 Power Losses at Each DisCo

DisCos	MYTO Target for 2018	Average Quarterly ATC & C Loss	
		2017Q4	2018Q1
Abuja	22.33%	44%	45%
Benin	23.91%	58%	55%
Eko	11.23%	26%	26%
Enugu	20.56%	56%	57%
Ibadan	19.67%	48%	51%
Ikeja	10.81%	33%	35%
Jos	39.12%	77%	74%
Kaduna	12.47%	76%	71%
Kano	22.06%	59%	57%
Port Harcourt	29.70%	68%	67%
Yola	23.71%	66%	67%
All DisCos	20%	56%	55%

(Note) MYTO: Multi-year Tariff Order
ATC&C Loss: Aggregated Technical, Commercial and Collection Loss
Source: First Quarterly Report of NERC, 2018

Commercial losses include power theft as well as uninstallation and breakage of electricity meters. Electricity meters installed in individual houses are often damaged (or intentionally destroyed), making it difficult to measure the correct amount of use. If the meter is damaged, however, charges are often made by estimation, which is a cause of customer complaints. Legislation to prohibit billing by estimates has been submitted to the National Assembly.

Table 3-3.7 Status of Installation of Meters at Each DisCo

DisCos	Registered Customer as of March 2018	No. of Metered Customer as of March 2018	No. of Metered Customer as of December 2017	Metering Rate as of March 2018
Abuja	1,129,521	430,098	699,423	38%
Benin	856,292	544,828	311,464	64%
Eko	470,766	215,987	254,779	46%
Enugu	884,992	409,748	475,244	46%
Ibadan	1,613,635	665,609	948,026	41%
Ikeja	910,338	311,332	599,006	34%
Jos	486,198	170,409	315,789	35%
Kaduna	484,310	136,037	348,273	28%
Kano	508,640	126,539	382,101	25%
Port Harcourt	453,818	352,533	101,285	78%
Yola	337,220	70,883	266,337	21%
Total	8,135,730	3,434,003	4,701,727	42%

Source: First Quarterly Report of NERC, 2018

(6) Low Electrification Rate

The electrification rate of Nigeria is as low as only 61% of the population. This is lower than other African countries such as Ghana (82%) and South Africa (86%). Even in the electrified area, many businesses and families rely on private power generation due to instability of the power supply. The low electrification rate and unstable power supply are major obstacles to national economic growth.

3-3-2 Power Sector Recovery Programme (2017-2021)

Power Sector Recovery Programme (PSRP) describes detailed action plans regarding i) financial interventions, ii) operational/technical interventions, iii) governance interventions, and iv) policy interventions. These action plans are formulated carefully with a clear and deep understanding and analysis of the issues and challenges of the Nigerian power sector. Without the ensuing implementation of all of the action plans described below, the power sector in Nigeria would not function properly.

(1) Financial Interventions

1) Establishment of Sustainable and Appropriate Electricity Tariffs

i) Issuance of Guidelines for DisCos to prepare Performance Improvement Plans (PIP) as part of MYTO Major Review (Reset) by NERC;

ii) Finalization and approval by NERC, after consultation with DisCos, of the refined MYTO methodology on the revenue requirements of DisCos and TCN, taking into consideration the government tariff policy and inputs by the system operator, including procedures and formulae for periodic adjustment;

iii) Filing of new MYTO revenue requirements by TCN, following the revised methodology, including the transmission investment plan, and review, consultation, and determination by NERC;

iv) Preparation and submission of the Performance Improvement Plan (PIP) to NERC by each DisCo covering the requirements and procedures described in NERC guidelines;

v) Review of the tariff application (based on their revenue requirement) filed by each DisCo by NERC, following the MYTO methodology, including the PIP, and the setting of performance baselines and targets, and carrying out consultations and hearings;

vi) Issuance the MYTO order by NERC for each DisCo and for TCN;

vii) Monitoring implementation of approved PIP, and of performance results compared to baseline and targets by NERC to evaluate improvement of each DisCo, and reporting by NERC on its website about each DisCo progress in implementation of the PIP and evolution of performance compared to baseline and targets; and

viii) Automatic adjustments (minor reviews) required in the methodology subject to the tariff trajectory policy for each DisCo and for TCN.

2) Commitment to Fully Fund Future Sector Deficits (2017-2021, USD 3,770 million)

i) Estimation of income deficit and loan repayment based on loan plans for 2017-2021

ii) Identification of funding sources by the Financing Plan, such as the Central Bank (CBN), the government budgetary contribution, and the World Bank Performance Based Loan (PBL).

iii) Formulation of fund input plan;

iv) Analysis of fiscal sustainability, contingent liabilities of the sector and the multiplier effect of the proposed government support; and

v) Developing detailed funds flow mechanism for the payment of tariff shortfalls

3) Clearing Historical Sector Deficits due to Tariff Shortfall (2015-2016, USD 1,378 million)

i) Agreement on a process for settlement of deficits between DisCos, NBET, and the MO and reporting to Ministry of Finance, Ministry of Budget and Planning and the Ministry of Power, Works and Housing (FMPWH); and

ii) Preparation of liability management strategy for the Nigerian Electricity Liability Management Company (NELMCO)

4) Securing Financing Sources

i) Securing funding for historical debt and future revenue shortfalls until tariffs are appropriate and sustainable;

ii) Securing funding to address system constraints such as transmission/distribution interface bottlenecks;

iii) Quarterly reviews and updating of the Financing Plan by PSRP Implementation Monitoring Team with the support of the multi-agency financing working team;

iv) Timely payment to GenCos by CBN, NBET and FMPWH; and

v) Adequate funding provision and timely disbursements by FMPWH and the Budget Office.

5) Clearing Historical MDA (Ministries, Departments and Agencies) Debts (USD 85 million) and Automatic Future Payments

i) Clearing historical debt of MDAs;

ii) Issuance of a directive specifying the mechanism by the Government to ensure timely payment of future electricity bills by all MDAs;

iii) Implementation of the government directive and encouragement of energy efficiency at all MDAs;

iv) Monthly reporting to NERC by DisCos on late or non-payment by each MDA customer and the accumulated debt; and

v) Reporting by NERC to the Government and in its website progress in payment by MDAs and in implementation of the mechanism in the directive.

6) World Bank Financial Support

i) Clarification by the World Bank of the internal processes to the Government; and

ii) Fulfilment by the Government of the conditions agreed to in advance with the World Bank for timely drawdown and utilization of the funds.

(2) Operational/Technical Interventions

1) Baseline Power Generation, Transmission, and Distribution (on grid, 4,500W) by 2021

i) Identification and prioritization of power plants to achieve the minimum 4,500 MW baseline;

ii) Preparation of a transmission expansion plan and submission to NERC for the approval by TCN as part of the MYTO reset process;

iii) Publishing the approved transmission expansion plan by TCN in its website;

iv) Monitoring by NERC on the progress of TCN implementation of the transmission investment plan approved in the tariff order, and publishing the results quarterly/annually on its website;

v) Preparation of annual generation operation plans, including an assessment of transmission and system security constraints by the system operator; and

vi) Updating annual transmission expansion plan TCN.

2) Improving DisCo Performance

i) Ensuring the commencement and updating of a complete customer database in each DisCo by NERC to identify DisCos' customers and the commencement of a metering programme;

ii) Reviews and approval of the PIP of each DisCo by NERC;

iii) Monitoring by NERC on each DisCo's progress in implementation of PIP, changes in performance indicators, and enforcement by NERC of DisCos' compliance with committed investments;

iv) Finalization by NERC of DisCos' business continuity regulation after consulting with stakeholders including investors and management of DisCos;

v) Updating performance agreements by Bureau of Public Enterprises (BPE) with the private investor of each DisCo, based on approved targets and baseline in MYTO reset for each DisCo, to incorporate key performance indicators in MYTO reset, and clarification by BPE of each party's obligations and the consequence(s) in case of performance failure; and

vi) Monitoring by BPE of performance agreements based on information provided by NERC and assessment of compliance by BPE.

3) Adequate Gas Supply for Power Generation

i) Strategic level engagement led by the Vice President with Minister of State for Petroleum and nine state governors to identify critical development priorities for each state in the region;

ii) Operational engagement by representatives of various MDAs, including the Office of the Vice President to convert the region's development priorities into specific projects;

iii) Ownership stakes by host communities in oil and gas assets to create incentives to safeguard these assets;

iv) Engagement of host communities to secure assets in their townships;

v) Completion of critical projects in the affected Niger Delta communities;

vi) Full disbursements of Nigerian Electricity Market Stabilisation Facility (NEMSF) to ensure historical debts are paid to gas suppliers;

vii) Development of a clear plan on gas vandalism prevention strategy by the Federal Ministry of Petroleum Resources; and

viii) Project management for key gas pipeline infrastructure.

(3) Governance Interventions

1) Restoring Proper Sector Governance

i) Replacement of current BPE directors in DisCos' Board by qualified independent professionals through a transparent process;

ii) Identification and appointment of qualified board of sector agencies including NBET, TCN, NELMCO, Nigerian Electricity Management Services Agency (NEMSA), Niger Delta Power Holding Company (NDPHC), and Rural Electrification Agency (REA);

iii) Provision of extensive and continuous training for the government board representatives;

iv) Establishment of a special police department or provision of required police staff to DisCos by the Government to help them enforcing payment discipline and use of local courts to adjudicate energy offences by State governments.

v) Obtaining all management accounts from each DisCo monthly and all audited accounts yearly; and

vi) Developing continuity process in the event of DisCo failure.

2) Improving Sector Transparency

i) Publishing audited financial statements of GenCos, DisCos, NBET and TCN, and NERC monitoring report by NERC on its website at the end of each fiscal year;

ii) Publishing quarterly by NERC in its website operational and financial (market settlement) data of DisCos and TCN, and operational data of GenCos, the System Operator and the Market Operators; and

iii) Management of a centralized website (NESISTATS) by the Government to provide up to date information and a feedback loop for checking the progress and activities of PSRP.

3) Ensuring Contracts are Fully Effective

i) Preparation of an operational plan of generation in each year by the System Operator based on economic dispatch of planned available generation, within system constraints, and demand forecast developed in consultation with DisCos;

ii) Updating the annual generation operation plan after six months by the System Operator;

iii) Designing a plan for the phased activation of Power Purchase Agreements (PPAs) and Gas Supply and Aggregation Agreements (GSAAs) by NBET in coordination with NERC to meet the baseline generation capacity of 4,500 MW and the operational plan of the System Operator;

iv) Issuance by NERC of orders to NBET on power purchase costs allowable to DisCos in vesting contract invoices;

v) Making vesting contracts effective by NBET up to the invoice cap in NERC orders subject to DisCos' posting of required LC; and

vi) Increasing the PPA activation level each year by NBET.

4) Clear Communications of PSRP

i) Implementation of a communication strategy to promote understanding and buy-in of PSRP by all sector stakeholders, and involving core messages for key stakeholders, stakeholder engagement, and media communications with the public;

ii) Engagement of services of a reputable communications firm to lead the communication strategy implementation and tactical activities of the nationwide PSRP campaign to build public confidence and trust in the Government's plans;

iii) Establishment of the Power Sector Communication Team (PSCT), comprising of MDA media and communication representatives to execute various aspects of the communication and stakeholder engagement strategy; and

iv) Engagement of all arms of government (Executive, Judiciary) to promote and facilitate knowledge building and alignment within the Government.

5) Establishment of PSRP Implementation Monitoring Team

i) Identification of critical roles for PSRP Implementation Monitoring Team;

ii) Commencement of resourcing process to identify and recruit suitable candidates;

iii) Commencement of on-boarding process and inauguration of team members;

iv) Organizing and operationalizing a multi-agency financial team; and

v) Organizing and operationalizing a multi-agency Lease Cost Development Plan (LCDP) team.

(4) Policy Interventions

1) Fiscal and Monetary Policies to Encourage Private Sector Investments

i) Review and updating of existing policies and incentives to ensure alignment with PSRP objectives;

ii) Development of simplified templates for IPP key project documents by NBET; and

iii) Recommendation of measures for adoption across PSRP interventions;

2) Increase in Electricity Access

* Developing and implementing an off-grid master plan (omitted from this report)

3) Economic Procurement of Power

i) Issuance of a policy/strategy by the Government to guide generation mix, including targets on renewable energy resources and interconnections;

ii) Preparation of demand projection in each year by the System Operator based on the Grid Code and the Market Rules, working closely with DisCos, following NERC's reviews and approval;

iii) Preparation of the generation adequacy report mentioned in the Market Rules every year by the Market Operator based on the System Operator Load Projection approved by NERC

iv) Establishment of a planning multi-agency working group led by the System Operator and under oversight and coordination of the FMPWH to prepare generation expansion plans based on demand projection scenarios and generation mix policy;

v) Development of transmission expansion plans by the System Operator together with TCN in coordination with the LCDP team and standards established in the Grid Code;

vi) Submission of the LCDP with the generation expansion plan and the System Operator's transmission expansion plan to NERC for its review and approval;

vii) Annual review of the LCDP;

viii) Clarification of the entity responsible for the preparation of the LCDP;

ix) Updating the adjusted power procurement regulations by NERC for competitive procurement of new generation capacity and for consistency with the generation expansion approved in the LCDP;

x) Preparation of standard bidding documents by NBET for competitive procurement of new generation capacity, consistent with NERC regulations; and

xi) Assessment of the need for new generation and authorization of tenders by NERC for new power procurement based on generation adequacy report and the LCDP.

It appears that only limited actions have been implemented by now, when around a year has passed since the issuance of PSRP. In the interviews conducted by JICA Study Team, some said, "PSRP is well planned and no one can deny it. At the same time, no one know how to start the implementation" and another said, "It is beautifully planned but its effective is doubtful." It was found the NERC has started to formulate the detailed implementation plan.

CHAPTER 4 Power Demand Forecasts

Chapter 4 Power Demand Forecasts

4-1 Current Power Demand Situation

4-1-1 Power Consumption On-grid

(1) Trends of power energy consumption

Nigeria has long suffered from chronic power shortages and according to the Statistical Yearbooks of the FMPWH (Federal Ministry of Power, Works & Housing), reasons include the low operation load of hydro power plants and poor maintenance at all kinds of power stations. When calculating the growth rates of domestic power demands at the transmission point (power energy base) by using TCN data, the average growth rate from 2005 to 2016 was 3.2% per year, whereas as a general rule, the power demand elasticity relative to GDP in developing and emerging countries is within the range 1.2 – 2.0. As the Nigerian average GDP growth rate was 6.9% from 2005 to 2014 (despite the drop in GDP growth rates from 2015 and 2016 due to the decline in world crude oil price), Nigerian power demand is expected to grow from 8 to 14% annually under the above economic conditions.

In some countries, the actual power supply data sometimes lacks details of the power demand size, which means the real power demand is shown by "Actual power supply + α" and in other words, the actual power supply does not suffice to meet demand around the clock (24 hours) due to power and fuel energy shortages. The distribution companies implement chronic planned outages (shedding) in response, so larger factories and commercial facilities have their own power generators.

In this project, power demand forecasts are implemented with "Computed data", which refers to unhindered power demand. The "National Load Demand Supply in 2009" is established without constraint data, so the forecast values from 2009 to 2014 in the report are used as "Without constrain data" and the actual values from TCN are used as "With constrain data". The latter are referred to as "Recorded data" in this Chapter.

The difference between computed and recorded data can be considered a shortage, which should be eliminated in future. The current recorded data come from TCN, while the computed data come from a regional survey implemented by TCN in 2016. The past computed and recorded data are as per the following table:

Table 4-1.1 Actual power demand in Nigeria

Unit: GWh

Year	Peak demand			Load factor
	Recorded	Computed	Shortage	
	MW	MW	MW	%
2005	3,577	4,222	645	73
2006	3,508	4,756	1,248	72
2007	3,445	5,004	1,559	73
2008	3,166	5,473	2,307	73
2009	3,104	5,942	2,838	73
2010	3,717	6,411	2,694	73

Year	Peak demand			Load factor
	Recorded	Computed	Shortage	
	MW	MW	MW	%
2011	4,058	6,942	2,884	74
2012	4,288	7,631	3,343	75
2013	4,228	7,961	3,733	76
2014	4,299	8,563	4,264	76
2015	4,880	9,237	4,357	
2016	5,074	9,571	4,497	
2016/05	3.2%	7.7%	19.3%	

Source: Recorded data are the actual TCN data,

Note: Computed data are estimated with reference made to the 2016 regional survey by the Study Team.

(2) Current peak demand

According to the "Analysis of Nigeria's National Electricity Demand Forecast in 2009" published in March 2014 (and studied by staff and professors of Nigerian universities.), the peak time and season are analyzed as per the following table:

Table 4-1.2 Daily load demand

Time	Demand	Reasons
00-05	Low	Relatively low demand from Residential and Commercial sectors.
05-08	High	Considerable power demand from residences.
08-18	Low	Low power demand due to many people working outside their houses.
18-24	High	Considerable power demand from residences.

Source: Analysis of Nigeria National Electricity Demand Forecast in 2009

Table 4-1.3 Annual load demand

Months	Load	Reasons
Jan. – Apr.	High load	High temperature and low humidity during these months
Jun. – Sep.	Low load	Power demand lower during these months

Source: Analysis of the Nigeria National Electricity Demand Forecast

The peak demand (MW) of computed data is 9,571 MW and the actual peak demand for recorded data was 5,074 MW. In 2016, the power supply covered around half the computed demand. In the recorded demand, Off-grid power demand in regional areas is excluded.

(3) Power demand by sector

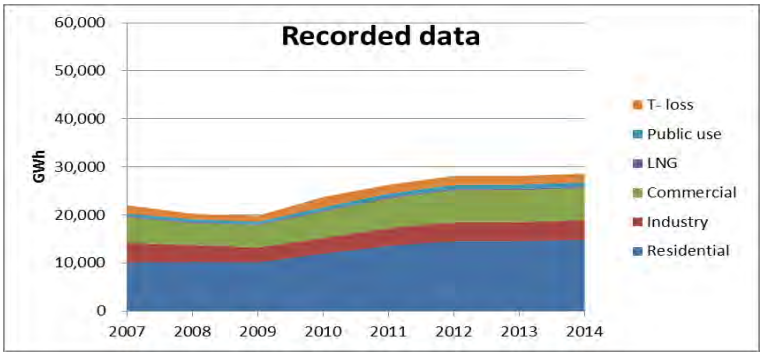
The latest sectoral power demand is for 2014 and the following table shows Residential 52%, Commercial (Including Government sector) 24%, Industry 14%, Power demand for LNG 1%, Public sector 3% and Transmission loss (T-loss) 6% in 2014. Moreover, the total demand is 28.6TWh as recorded data. (Distribution losses are included in the demand of the distribution companies).

Table 4-1.4 Sectoral power demand

Unit: GWh

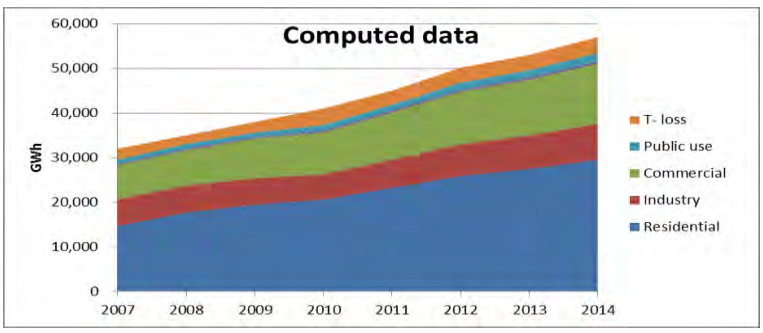
	Sector	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Recorded	Residential	10,302	7,832	10,091	10,240	10,163	11,962	13,568	14,549	14,577	14,821
	Industry	2,119	3,198	4,128	3,502	3,109	3,249	3,699	3,983	3,991	4,058
	Commercial	4,754	4,077	5,252	4,574	4,639	5,449	6,180	6,627	6,640	6,751
	LNG	111	161	200	201	140	216	232	240	240	244
	Public	673	661	657	604	566	748	774	900	898	935
	T/D-loss	4,914	6,194	1,699	1,123	1,232	2,145	1,854	1,873	1,802	1,814
	Supply total	22,873	22,123	22,027	20,244	19,849	23,769	26,307	28,172	28,146	28,623
Shortage	Residential	1,859	2,789	4,569	7,464	9,294	8,671	9,641	11,344	12,870	14,697
	Industry	382	1,139	1,869	2,553	2,843	2,355	2,628	3,106	3,523	4,024
	Commercial	858	1,452	2,378	3,334	4,242	3,950	4,391	5,167	5,862	6,694
	LNG	20	57	91	147	128	157	165	187	212	242
	Public	121	235	297	440	518	542	550	702	792	928
	T/D-loss	887	2,205	769	818	1,126	1,555	1,318	1,461	1,591	1,798
	Shortage total	4,127	7,877	9,973	14,756	18,151	17,231	18,693	21,967	24,852	28,384
Computed	Residential	12,161	10,621	14,660	17,704	19,457	20,633	23,209	25,893	27,447	29,518
	Industry	2,501	4,337	5,997	6,055	5,952	5,604	6,327	7,089	7,514	8,081
	Commercial	5,612	5,529	7,630	7,908	8,881	9,399	10,571	11,794	12,502	13,445
	LNG	131	218	291	348	268	373	397	427	453	487
	Public	794	896	954	1,044	1,084	1,290	1,324	1,602	1,690	1,863
	T/D-loss	5,800	8,399	2,469	1,941	2,358	3,700	3,172	3,334	3,392	3,612
	Computed total	27,000	30,000	32,000	35,000	38,000	41,000	45,000	50,139	52,998	57,007

Source: Recorded total from TCN and Sectoral data from the IEA (International Energy Agency) energy database 2014



Source: JICA Study Team

Figure 4-1.1 Sectoral recorded data trends



Source: JICA Study Team

Figure 4-1.2 Sectoral computed data trends

4-1-2 Off-grid Demand

According to the "National Renewable Energy and Energy Efficiency Policy 2015" published by the FMPWH (Federal Ministry of Power, Works & Housing), renewable energy capacities like solar power and small hydel are as per the following table. Although not all the capacities in the following table can be considered Off-grid power sources, the use of the majority as regional Off-grid sources and independent power sources of individual houses is feasible.

As a general rule, the capacity factors for renewable energy equipment are lower than for fossil fuel power plants; the capacity factor of solar power is around 20～30% and that for small hydel is around 50%. Accordingly, when setting the country average capacity factor for the above renewable energy equipment at 20%, the estimated power generation was 267GWh in 2014. As the computed demand for the same year was 57,600 GWh (TCN + Auto producers + Off-grid), the Off-grid power demand share relative to total computed power demand was less than only 0.5% in 2014, which is considered a very small share under current circumstances.

Table 4-1.5 Power energy demand of Off-grid

Items	Unit	2010	2011	2012	2013	2014
Energy demand (Off-grid)	GWh	131	158	184	197	267
Power demand (Off-grid)	MW	15	18	21	23	30
Capacity (Off-grid)	MW	50	60	70	75	102
Computed demand (On + Off-grid)	GWh	41,215	45,258	50,439	53,320	57,608
Share of Off-grid	%	0.3%	0.3%	0.4%	0.4%	0.5%

Source: National Renewable Energy and Energy Efficiency Policy 2015 by FMPWH

4-1-3 Power Export

According to the "MYTO II MODEL" edited by the NERC (Nigerian Electricity Regulatory Commission) and TCN, the shares of Nigerian power exports of computed data (TCN + Auto producers + Off-grid + Export) after 2013 and 2014 were less than 5% as shown in the following table. Exports proceed to neighboring countries under Nigerian political considerations.

Table 4-1.6 Power exports

Items	Unit	2010	2011	2012	2013	2014
Power export	GWh	967	967	1,538	2,094	2,217
Average power export	MW	110	110	180	240	250
Power export at peak time	MW	157	157	257	343	375
Computed demand (On + Off-grid + exports)	GWh	42,182	46,225	51,977	55,414	59,825
Share of Export	%	2.3%	2.1%	3.0%	3.8%	3.7%

Source: NERC and TCN

< Further notes for data collection >

The Study Team implemented a survey for collecting related data and planned documents in Nigeria from September 2015 to May 2016 and obtained actual data and plans as shown in the following table. The team also visited ministries and authorities and interviewed experts on future economic plans and power development plans. This data and information were used when making power demand forecasting for

actual and future given data. The following table shows the actual data and estimation methods (for 2015 and 2016).

Table 4-1.7 Collected actual data and estimated future data

Items	Actual Data start	Actual Data latest	Estimation of data on 2015 & 2016
Population	1990	2015	Data 2016~2020 estimated by the NBS
Foreign Exchange rate	2000	2017	Data of 2018～2040 forecast by USA inflation rate
GDP (Nominal / Real)	2000	2015	Data of 2016～2020 forecast by the MBNP
Inflation rate	2000	2015	Data of 2016～2020 estimated by MBNP
Crude oil price WTI	2000	2017	Data of 2018～2040 forecast by IEA and IEEJ
Power tariff	2001	2015	Data of 2016～2020 estimated by NERC
Residential demand	2000	2014	Data of 2015 & 2016 estimated by TCN
Commercial demand	2000	2014	Data of 2015 & 2016 estimated by TCN
Industry demand	2000	2014	Data of 2015 & 2016 estimated by TCN
Public demand	2000	2014	Data of 2015 & 2016 estimated by TCN
LNG use	2000	2014	Data of 2015 & 2016 estimated by TCN
Population by DisCo	1990	2015	Data of 2015 & 2016 estimated from Regional population
Electrification rate by DisCo	2000	2014	Data of 2015 & 2016 estimated by TCN
Customer by DisCo	2012	2016	Data after 2017 forecast from Population and Electrified rate
Power demand by DisCo	2000	2014	Data of 2015 & 2016 estimated by TCN
Generation of TCN	2000	2016	Future data forecast by future power demands
Generation loss of TCN	2000	2016	Future data depending on TCN policy
Power shortage of TCN	2000	2016	Future data depending on TCN policy
T/D-loss of TCN	2000	2016	Future T/D-loss depending on TCN Loss reduction policy
Off-grid demand	2000	2016	Future data depending on REA policy
Export	2000	2016	Future data depending on elasticity 0.7 to TCN domestic demand
Power demands of countries	2000	2012	Future data unused
DisCo power balance survey		2016	The survey implemented by TCN in 2016

Source: JICA Study Team

Note:
NBS National Bureau of Statistics
IEA International Energy Agency
TCN Transmission Company of Nigeria
IEEJ The Institute of Energy Economics, Japan
MBNP Ministry of Budget and National Planning
NERC Nigerian Electricity Regulatory Commission
DisCo Distribution Company
REA Rural Electrification Agency

4-2 Methodologies for Power Demand Forecasts

4-2-1 Required Functions of Power Demand Forecasts

The trends of past power consumptions and the current circumstances should be analyzed to forecast future power demand in Nigeria and there is also a need to determine the structural factors behind the forecasts. Power demands are deemed to be reflected by changes in socioeconomic activities, so the structures of the power demand model should be designed to analyze such changes. The following functions are required for the demand model used in this project:

- Socioeconomic changes should be linked to the model
- The impact of any power tariff increase should be considered in the model
- Scope to analyze the capability of sectoral power demand should be established in the model
- Power demand forecasting functions of the distribution companies should be established in the model
- International comparisons with Nigeria on power demand should be established in the model

4-2-2 Structure of the Power Demand Forecasting Model

This model forecasts sector-wise power energy demands, whereupon peak demand and power generation are calculated and DisCo-wise power demands are forecast. The power demand flow chart is as follows:

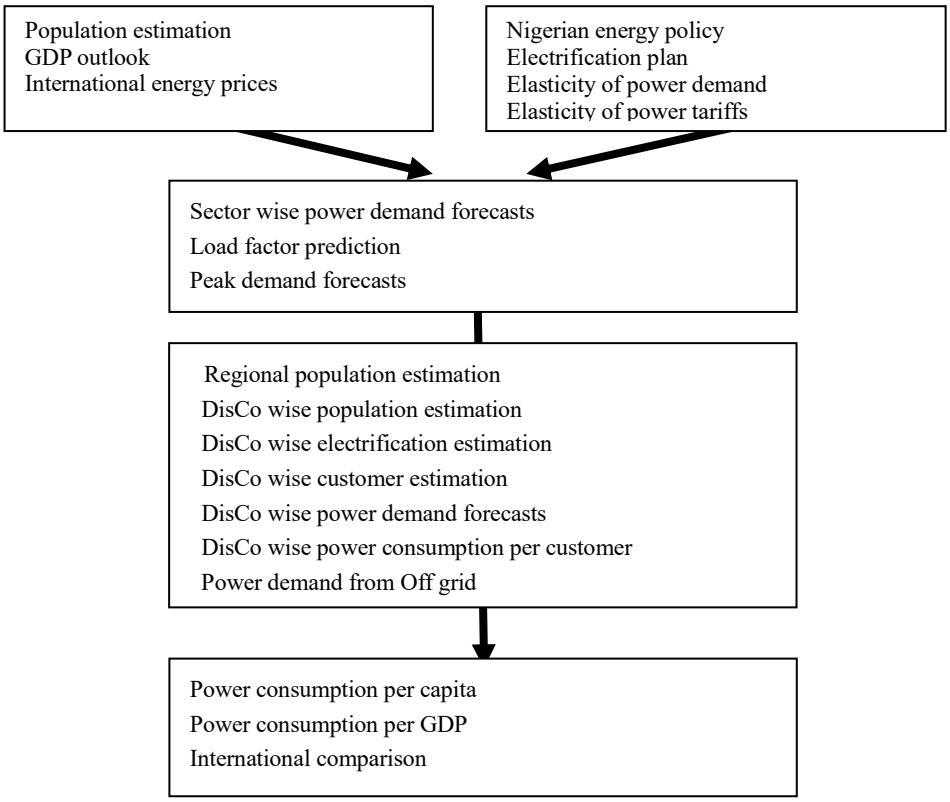
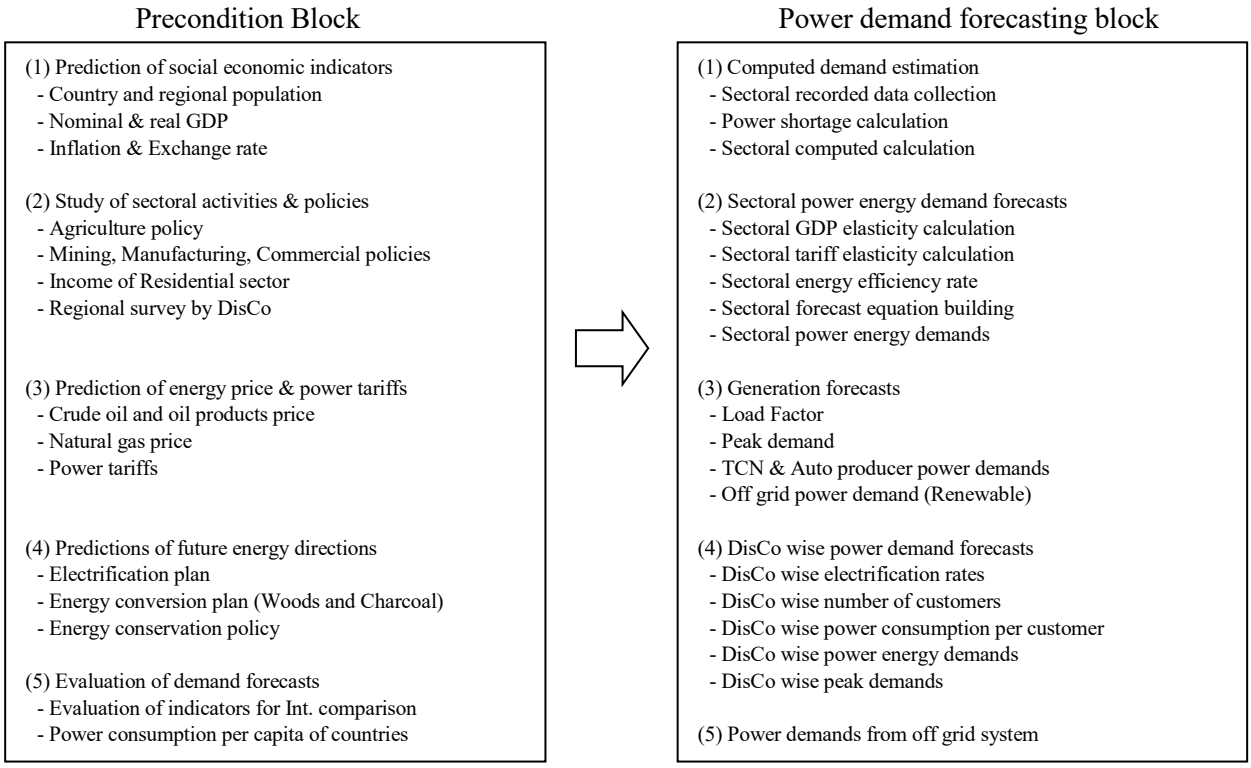


Figure 4-2.1 Power demand forecast flow

The power demand model is built up in line with the previous flow, with model procedures as follows:

- Regarding future socioeconomic activities, those are decided after evaluating existing socioeconomic strategies, power development plans and policies.
- Power demand and supply balance are made in line with the balance definition of the IEA (International Energy Agency). Regarding sectoral power demand, additional sectoral power demands of Nigeria are added to IEA sector definitions such as Agriculture, Industry, Commercial and Residential sectors.
- Regarding model building technology, the econometric method is used, while the model building application "Simple.E" is also used as a piece of MS Excel add-in software.
- The structural flow for the power demand forecasting model is as shown in the following figure. "Precondition block" includes socioeconomic strategies and plans, energy prices, power tariffs, target indicators for power development plans and so on. The "Power demand forecasting block" includes sectoral power demand forecasts, power supply forecasts and regional power demand forecasts.



Note 1: Computed demand = Recorded demand + Shortage
Note 2: The sectors include Residential, Industry, Commercial, Public, Power for LNG and Transmission – loss (T-loss).

Figure 4-2.2 Block flow for the power demand forecasting model

4-2-3 Power Demand Forecasting Equations

The calculated power consumer sectors are Agriculture, Industry (including Mining and power consumption for LNG), Commercial (including Service) and Public, Residential. The nationwide power demand is calculated by the summing up the above sectoral demands, via the following forecasting procedures:

(1) Calculating elasticities

The elasticities between GDP and sectoral power demands are estimated by using past data, while long- and short-term elasticities are calculated under data from 2000 to 2014 and 2007 to 2014 respectively. After calculating both types of elasticities, elasticities for power demand forecasting equations are estimated by analyzers. The forecasting equation formations are as follows:

- For productive sectors (Agriculture, Industry, Commercial and Public)

  Ln (Sectoral power demand) = a*Ln (Sectoral GDP) - b*Ln (sectoral tariff) + c
- For the Residential sector

  Ln (Residential power demand) = a*Ln (Income per capita) - b*Ln (Residential tariff) + c

In the above equations, "Ln" is natural logarithm, "a" is GDP elasticity and "b" is tariff elasticity.

(2) Setting forecasting equations

The power demands for "Productive sectors" and "Residential sector" are forecast using the above elasticities after evaluating them and the power demand equations are as follows:

< Forecasting equation for Productive sectors >

Yt: Power demand of sectors (t year) Unit: GWh
a: Elasticities to sectoral GDP
b: Elasticities to tariffs
Energy Efficiency & Conservation rate (EE&C rate): The effects of EE&C activities are defined by "Power energy savings / Power energy demand". It is used by the expression of "1- EE&C rate /100".

$Yt = Yt-_1*(1 + a*\text{Sectoral GDP growth rate})*(1- b*\text{Tariff growth rate})*(1- \text{EE\&C rate}/100)$

< Forecasting equation for Residential sectors >

Yt: Power demand of sector (t year)
a: Elasticity to income per capita
b: Elasticity to Tariff

Energy Efficiency & Conservation rate (EE&C rate): the same as productive sectors

Electrification rate growth rate: Electrification rate (t) / Electrification rate (t - 1) (unit%)

$Yt = Yt-1*(1 + a*\text{Income per-capita growth rate}) * (1 - b * \text{Tariff growth rate})$

$* (1 - \text{EE\&C rate}/100) * (\text{Electrification rate growth rate})$

4-3 Preconditions and Scenario Setting for Power Demand Forecasts

4-3-1 Preconditions of Socioeconomic Predictions

(1) Population growth rate

According to a census implemented by the NBS (National Bureau of Statistics) in 1991 and 2006, the

population growth rate was 3.07% during the term (2.9% in 2006) and future population growth rates seem to be in gradual decline. The population growth rate in 2040 was 2.5% according to the "World Population Prospects 2012 Division" of the United Nations) Population study.

Table 4-3.1 Future population by UN Population study

	Country	Urban	Rural share	Urban share	Rural share	Country growth rate	Urban growth rate	Rural growth rate
	1000psn	1000psn	1000psn	%	%	%	%	%
2014	178,517	91,821	86,696	51.4	48.6	2.8	4.1	1.5
2015	183,523	95,564	87,959	52.1	47.9	2.8	4.1	1.5
2020	210,158	115,618	94,540	55.0	45.0	2.7	3.9	1.4
2025	239,874	138,944	100,930	57.9	42.1	2.7	3.7	1.3
2030	273,120	165,999	107,121	60.8	39.2	2.6	3.6	1.1
2035	310,125	197,121	113,004	63.6	36.4	2.6	3.5	1.0
2040	350,720	232,376	118,344	66.3	33.7	2.5	3.3	0.9

Source: Forecasts up to 2030 are UN Population Prospects 2012 Division, followed by Study Team forecasting

According to data of middle-income and developing countries, the population growth rate will decline in line with increasing per-capita income.

Regarding the Nigerian population growth rate, the NBS (National Bureau of Statistics) cited a population growth rate in the 2006 census of 2.9%, whereupon a growth rate of 2.8% in 2015 can be considered. Moreover, there is scope for the future population growth rate to decline to 2.0% when the long-term period is considered. This is why the Nigerian population growth rate was recorded at 1.8% in the 1991 census. The Government recently advised that women should reduce their birth rate below four children (without mandating the same), so the future population growth rate is set to decline in the longer term.

For the above reasons, the Study Team set a lower population growth rate for Nigeria future population growth than the UN Population study. The following table shows the population forecasts of the Study Team after referring to the growth rates forecast by the UN Population study.

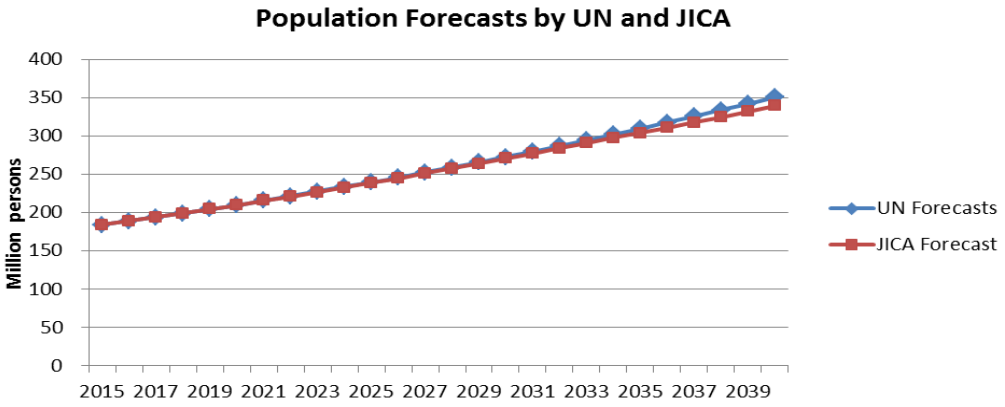
The population in Nigeria is rising to 340 million, smaller than the UN Population study by 10 million.

Table 4-3.2 Population prediction

	Country	Urban	Rural share	Urban share	Rural share	National growth rate	Urban growth rate	Rural growth rate
	1000psn	1000psn	1000psn	%	%	%	%	%
2010	159,700	78,300	81,400	49.0	51.0	2.78	4.15	1.51
2011	164,200	81,400	82,700	49.6	50.4	2.81	4.08	1.59
2012	168,800	84,800	84,100	50.2	49.8	2.83	4.08	1.60
2013	173,600	88,200	85,400	50.8	49.2	2.83	4.08	1.58
2014	178,500	91,800	86,700	51.4	48.6	2.82	4.08	1.53
2015	183,500	95,600	88,000	52.1	47.9	2.80	4.08	1.46
2016	188,600	99,300	89,300	52.6	47.4	2.78	3.92	1.55
2017	193,800	103,200	90,700	53.2	46.8	2.76	3.90	1.50
2018	199,200	107,200	92,000	53.8	46.2	2.74	3.88	1.45
2019	204,600	111,300	93,300	54.4	45.6	2.72	3.86	1.40
2020	210,100	115,600	94,500	55.0	45.0	2.70	3.84	1.34
2021	215,700	119,900	95,800	55.6	44.4	2.68	3.74	1.38

	Country	Urban	Rural share	Urban share	Rural share	National growth rate	Urban growth rate	Rural growth rate
	1000psn	1000psn	1000psn	%	%	%	%	%
2022	221,500	124,400	97,100	56.2	43.8	2.66	3.72	1.33
2023	227,300	129,000	98,300	56.7	43.3	2.64	3.70	1.28
2024	233,300	133,700	99,500	57.3	42.7	2.62	3.68	1.23
2025	239,300	138,600	100,700	57.9	42.1	2.60	3.66	1.17
2026	245,500	143,600	101,900	58.5	41.5	2.57	3.56	1.20
2027	251,700	148,600	103,100	59.0	41.0	2.54	3.53	1.14
2028	258,000	153,800	104,200	59.6	40.4	2.51	3.50	1.08
2029	264,400	159,200	105,200	60.2	39.8	2.48	3.47	1.02
2030	270,900	164,700	106,300	60.8	39.2	2.45	3.44	0.95
2031	277,500	170,200	107,300	61.3	38.7	2.42	3.34	0.99
2032	284,100	175,800	108,300	61.9	38.1	2.39	3.31	0.93
2033	290,800	181,500	109,200	62.4	37.6	2.36	3.28	0.86
2034	297,600	187,400	110,100	63.0	37.0	2.33	3.25	0.80
2035	304,400	193,500	110,900	63.6	36.4	2.30	3.22	0.73
2036	311,300	199,500	111,800	64.1	35.9	2.27	3.12	0.78
2037	318,300	205,700	112,600	64.6	35.4	2.24	3.09	0.72
2038	325,300	212,000	113,300	65.2	34.8	2.21	3.06	0.65
2039	332,400	218,400	114,000	65.7	34.3	2.18	3.03	0.59
2040	339,500	225,000	114,600	66.3	33.7	2.15	3.00	0.52

Source: JICA Study Team estimation, the original forecasts are made by the UN Population study



Source: Made by the JICA Study Team

Figure 4-3.1 Population forecasts of the UN Population study and Study Team

(2) GDP growth rate

As shown in the following figure, the average GDP growth rate was 6.6% per year from 2006 to 2014, but the GDP from 2015 to 2016 declined rapidly due to the fall in crude oil prices. Accordingly, the GDP of domestic economic activities alone in Nigeria are assumed from 2015 to 2016 was estimated at 3% in 2015 and 1% in 2016.

Source: Made by the JICA Study Team

Figure 4-3.2 Trends of GDP growth rates from 2006 to 2016

The following table shows several future GDP growth rates from "Vision 20 2020" (Long Development Strategy of Nigeria), "GDP outlook from 2015 to 2020" published by the MBNP (Ministry of Budget and National Planning), "Nigeria economic outlook 2015" published by the AfDB and the "Regional Economic Outlook April 2015" published by the International Monetary Fund (IMF).

Table 4-3.3 GDP outlook from Nigeria and international organizations

Documents	Organizations	GDP growth rates	Period
Vision 20 2020	Nigeria Gov.	13% per year	2015 - 2020
GDP outlook from 2015 to 2020	MBNP	5 - 6% per year	2015 - 2020
Nigeria economic outlook 2015	AfDB	7% per year excluding oil sector	2015 - 2020
Regional economic outlook April 2015	IMF	6% per year excluding oil sector	2015 - 2020

Source: Same as organizations in the table

Note: The GDP growth rate of Vision 20 2020 has been studied before the oil price decrease since 2014.

By referring to the current GDP growth rate and the outlook of the above organizations, the GDP growth rates used in power demand forecasting model are set as per the following tables:

Table 4-3.4 Real GDP growth rate of base case

	2015-2020	2020-2025	2025-2030	2030-2035	2035-2040
GDP including oil	4.3%	6.5%	6.5%	6.5%	6.5%

Source: JICA Study Team

In the base case, the GDP growth rate per year is 5.0% from 2015 to 2020 and 6.5% from 2020 to 2040. The GDP growth rates include oil and gas sectors. Two kinds of GDP are published in Nigeria, one of which comprises GDP statistics excluding the oil and gas sector and other GDP statistics, including the oil and gas sector. GDP including the oil and gas sector is used in the model except for values in 2015 and 2016.

Table 4-3.5 Real GDP growth rate of High case

	2015-2020	2020-2025	2025-2030	2030-2035	2035-2040
GDP including oil	4.3%	8.0%	8.0%	8.0%	8.0%

Source: JICA Study Team

A High case assumes that the Government targets in Vision 20 2020 are achieved as much as possible and growth rates of the High case from 2020 to 2040 are 8.0% per year.

Table 4-3.6 Real GDP growth rate of Low case

	2015-2020	2020-2025	2025-2030	2030-2035	2035-2040
GDP including oil	4.3%	5.0%	5.0%	5.0%	5.0%

Source: JICA Study Team

In the Low case, predictions state that the current GDP growth rate will continue in future, meaning that no significant higher growth rates in future can be expected in the manufacturing and commercial sectors.

Moreover, the elasticities between the sectoral GDP growth rates and nationwide GDP growth rate in the base case are as per the following table:

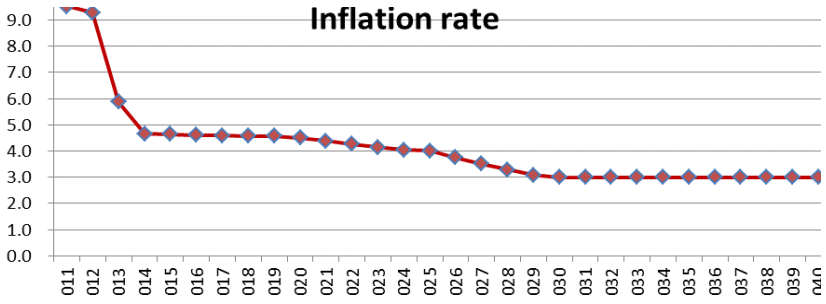
Table 4-3.7 Elasticities between sectoral and country GDPs

Sector	2020		2030		2040	
	Elasticity	GDP G.R.	Elasticity	GDP G.R.	Elasticity	GDP G.R.
Agriculture	0.60	4.1%	0.60	4.0%	0.60	3.8%
Industry	1.10	7.4%	1.10	7.3%	1.10	7.0%
Manufacturing	1.20	8.1%	1.20	7.9%	1.20	7.7%
Oil and gas	0.90	6.1%	0.70	4.7%	0.50	3.1%
Commercial & services	1.20	8.1%	1.15	7.6%	1.15	7.4%
GDP growth rate (Average)	1.00	6.5%	1.00	6.5%	1.00	6.5%

Source: JICA Study Team

(3) Inflation rate

Under a stable inflation rate (2 - 3%), it is generally expected that the national economy will actively increase due to growth in domestic savings. However, high GDP growth rate cannot be expected with a high inflation rate. Nigeria had inflation rates exceeding 10% per year from 2002 to 2010, but current inflation rates stabilized after 2011 and inflation rates of around 4.5% per year are expected from 2015 to 2020 and around 3% after 2030. In the power demand forecasting model, power demand is forecast under real economic indicators, with energy prices and power tariffs assumed to be at prices equivalent to 2015 levels in Nigeria. Long-term nominal prices are defined by “Real price * Inflation rate”.



Source: Actual data from NBS statistics, forecast values estimated by the Study Team

Figure 4-3.3 Trends of inflation rates

Table 4-3.8 Average inflation rate

Period	2013-15	2015-20	2020-25	2025-30	2030-35	2035-40
Inflation rate	6.8%	4.6%	4.2%	3.3%	3.0%	3.0%

Source: Actual data from NBS statistics, forecast values estimated by the Study Team

(4) Foreign exchange rate

The volatility of the foreign exchange rate affects domestic investment and the inflation rate and with recent US dollar and Euro volatility in mind, the Nigerian currency NGN (Nigerian Naira) is not deemed to have devalued drastically against the US dollar and Euro. Based on the following equation, the NGN per US dollar is calculated (as a variable of Nt in the equation) from 2016 to 2040. NGN moves in proportion to the difference between US and Nigeria inflation.

$Nt = Nt_{-1} * (1 + (Nigeria - US\ inflation\ rates))$

The following table shows the estimated results of the NGN foreign exchange rate (Nigerian currency unit) to the US dollar:

Table 4-3.9 Foreign exchange rate forecasts

Years	Exchange rate (NGN/USD)	Changes (%)	Nigeria inflation (%)	USA Inflation (%)
2015	190	19.83	4.6	2.0
2016	295	55.26	4.6	2.0
2017	303	2.59	4.6	2.0
2018	310	2.58	4.6	2.0
2019	318	2.56	4.6	2.0
2020	326	2.50	4.5	2.0
2021	334	2.38	4.4	2.0
2022	342	2.26	4.3	2.0
2023	349	2.15	4.2	2.0
2024	356	2.04	4.0	2.0
2025	363	2.00	4.0	2.0
2026	370	1.75	3.7	2.0
2027	375	1.51	3.5	2.0
2028	380	1.29	3.3	2.0
2029	384	1.09	3.1	2.0
2030	388	1.00	3.0	2.0
2035	408	1.00	3.0	2.0
2040	429	1.00	3.0	2.0

Source: JICA Study Team
Note: NGN: /USD: Nigerian currency / US dollar

(5) Crude oil price

As of October 2018, WTI (West Texas intermediate) in the New York market is $68/bbl. Crude oil exporting countries like Saudi Arabia expect the crude oil price to be increased to offset benefits from US dollar devaluation (assuming a US inflation rate of around 2%). However, according to oil market information, when examining recent energy market to which shale oil & gas are supplied, it is predicted that in the near future, the crude oil price will remain at its current level or increase slightly by 2020, whereupon the crude oil price will once again gradually increase in line with the USA inflation rate (2% per year). With such international oil market in mind, the WTI price is assumed in the following table:

Table 4-3.10 West Texas Intermediate (WTI) crude oil price

year	WTI		USA inflation		year	WTI		USA inflation	
	US$/bbl.	%	2015=100	%		US$/bbl.	%	2015=100	%
2015	50	-23.1	100.0	2.0	2028	96	2.1	129.4	2.0
2016	40	3.0	102.0	2.0	2029	98	2.0	131.9	2.0
2017	50	25.0	104.0	2.0	2030	100	2.0	134.6	2.0
2018	68	36.0	106.1	2.0	2031	102	2.0	137.3	2.0
2019	70	2.9	108.2	2.0	2032	104	1.9	140.0	2.0
2020	80	14.2	110.4	2.0	2033	106	1.9	142.8	2.0
2021	82	2.4	112.6	2.0	2034	108	1.8	145.7	2.0
2022	84	2.4	114.9	2.0	2035	110	1.8	148.6	2.0
2023	86	2.3	117.2	2.0	2036	112	1.8	151.6	2.0
2024	88	2.3	119.5	2.0	2037	114	1.7	154.6	2.0
2025	90	2.2	121.9	2.0	2038	116	1.7	157.7	2.0
2026	92	2.2	124.3	2.0	2039	118	1.7	160.8	2.0
2027	94	2.1	126.8	2.0	2040	120	1.6	164.1	2.0

Source: Actual data from BP statistics. Recent data from The Institute of Energy Economics, Japan
Note: The base price is 2015. Brent oil price as of March 2017 exceeds WTI by more than $5 / bbl.
Note: WTI in 2018 is a value as of October 2018

(6) Power tariff

The standardized national power tariff system is defined in the "Multi Year Tariff Order (MYTO)" by the NERC (Nigerian Electricity Regulatory Commission), while DisCo- and sector-wise category power tariff systems are prepared and two types of power tariff systems are prepared in the "Multi Year Tariff Order (MYTO) 2015 - 2018". One of them is a fixed tariff system and another is a metering system. Regarding post-2015 power tariffs, "MYTO - 2015 Distribution Tariffs (2015 - 2024)" shows power tariff forecasts up to 2024. The tariffs in the MYTO are as per the following table: In the table, power tariffs from 2025 to 2040 are predicted by the Study Team.

Table 4-3.11 Power tariff forecasts (Abuja Distribution Co)

NGN/kWh

	Average	Domestic	Commercial	Industry	Use for LNG	Street light
2008	8.00	6.00	8.50	8.50	5.70	6.50
2009	9.00	6.60	9.70	10.30	6.90	5.90
2010	11.00	8.90	12.30	12.90	8.60	6.80
2011	13.00	11.00	14.50	15.20	11.20	8.60
2012	15.00	11.70	21.03	22.04	16.24	12.47
2013	16.00	12.62	21.03	22.04	16.24	13.41
2014	17.00	13.25	22.08	23.14	17.05	14.08
2015	18.00	14.70	29.98	31.43	17.10	19.11
2016	17.76	24.30	46.23	46.23	25.43	26.84
2017	27.24	24.30	47.09	47.09	25.90	27.14
2018	27.65	24.03	45.72	45.72	25.15	26.54
2019	26.94	20.40	38.82	38.82	21.35	22.53
2020	22.88	19.69	37.46	37.46	20.60	21.75
2021	22.34	20.08	37.83	37.83	20.81	21.97
2022	22.61	20.49	38.21	38.21	21.02	22.19
2023	22.89	20.90	38.60	38.60	21.23	22.41
2024	23.16	21.31	38.98	38.98	21.44	22.63
2025	23.45	21.74	39.37	39.37	21.65	22.86
2026	23.82	22.17	39.96	39.96	21.98	23.20
2027	24.21	22.62	40.56	40.56	22.31	23.55
2028	24.60	23.07	41.17	41.17	22.64	23.90

	Average	Domestic	Commercial	Industry	Use for LNG	Street light
2029	24.99	23.53	41.79	41.79	22.98	24.26
2030	25.39	24.00	42.41	42.41	23.33	24.63
2031	25.80	24.48	43.05	43.05	23.68	25.00
2032	26.22	24.97	43.70	43.70	24.03	25.37
2033	26.64	25.47	44.35	44.35	24.39	25.75
2034	27.07	25.98	45.02	45.02	24.76	26.14
2035	27.51	26.50	45.69	45.69	25.13	26.53
2036	27.95	27.03	46.38	46.38	25.51	26.93
2037	28.40	27.57	47.07	47.07	25.89	27.33
2038	28.86	28.12	47.78	47.78	26.28	27.74
2039	29.32	28.68	48.50	48.50	26.67	28.16
2040	29.80	29.26	49.22	49.22	27.07	28.58

Source: The forecast tariffs from 2015 to 2024 refer to "MYTO -2015 Distribution Tariffs (2015-2024) Dec 2015" and tariffs after 2025 are estimated by the Study Team

Note: The above are not country average power tariffs, they are tariffs of the Abuja distribution company, while the Residential tariff is the R2 category of the company, Commercial tariff is the C2 category, Industry tariff is the D2 category, Special tariff is A2 and Streel light tariff is S1. Post-2015 tariffs exclude inflation.

Note: The power tariff for LNG is cheaper than the industry power tariff under government policy

< Further note on Power tariff >

The power tariffs in the previous table are described in terms of a single power tariff formula. However, the Nigerian power tariff system actually comprises two types of formula. One is a "Fixed charge tariff per month" and another is a "Metering rate tariff". The system is the same as Japan. For example, the power tariffs of the Abuja Distribution Company from 2012 to 2015 are as per the following tables:

< Fixed charge tariff of Abuja DisCo >

Unit: NGN / Month

Category	2012	2013	2014	2015
Residential R1	-	-	-	-
Residential R2	500	702	986	1,384
Residential R3	37,527	52,696	73,997	103,908
Residential R4	113,358	136,030	191,016	268,228
Commercial C1	500	702	986	1,384
Commercial C2	34,020	47,772	67,082	94,197
Commercial C3	102,767	123,321	173,169	243,168
Industrial D1	10,000	10,000	14,042	19,718
Industrial D2	101,113	101,113	141,985	199,378
Industrial D3	102,767	123,321	173,169	243,168
Special 1	500	702	986	1,384
Special 2	35,938	43,125	60,557	85,035
Special 3	45,313	54,375	76,354	107,218
Street Lighting S1	500	600	843	1,183

Source: Abuja DisCo

Note: The special tariff category includes power utilization for the agricultural sector, drink water factory, TCN local offices, governmental offices, hospital, public and educational sectors.

< Metering rate tariff of Abuja DisCo >

Unit: NGN /kWh

Category	2012	2013	2014	2015
Residential R1	4.00	4.00	4.00	4.00
Residential R2	11.74	12.62	13.25	13.91

Category	2012	2013	2014	2015
Residential R3	22.62	22.62	23.75	24.94
Residential R4	22.62	22.62	23.75	24.94
Commercial C1	16.56	16.56	17.39	18.26
Commercial C2	21.03	21.03	22.08	23.18
Commercial C3	21.03	21.03	22.08	23.18
Industrial D1	16.97	16.97	17.81	18.70
Industrial D2	22.04	22.04	23.14	24.30
Industrial D3	22.04	22.04	23.14	24.30
Special 1	16.24	16.24	17.05	17.90
Special 2	16.24	16.24	17.05	17.90
Special 3	16.24	16.24	17.05	17.90
Street Lighting S1	12.47	13.41	14.08	14.78

Source: Abuja DisCo

4-3-2 Preconditions for Power Demand Forecasts

(1) Calculation of the actual potential demand

The calculation of the actual potential power demand (known as computed data) involves adding shortage power to actual power consumption (known as recorded data). The power consumption is known as "Computed data" or "Computed demand". The shortage in terms of an inability to supply to consumers is one part of the power demand, while a shortage of power data should be added to actual power demand. The relations between the shortage and computed demand are as per the following expressions:

Shortage power (GWh) = Σ (Send out power before shedding (MW) * Shedding hours)
Computed data = Recorded data (GWh) + Shortage power (GWh)

The computed data are applied to Residential, Industry (including power for LNG), Commercial & Services, Public, Own use in power sectors and Transmission loss. The calculation procedures are as follows:

a. The actual power supply data from TCN are set as recorded data. The data period is from 2005 to 2015.
b. The computed data from 2005 to 2016 are estimated with the above recorded data and the results of the regional survey implemented in 2016.
c. Shortage data are defined by the difference between Recorded data and Computed data.
d. The data from 2000 to 2004 show the same values for Recorded data and Computed data.

Table 4-3.12 Calculation of Recorded data

Unit: GWh

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Industry	2,119	3,198	4,128	3,502	3,109	3,249	3,699	3,983	3,991	4,058
LNG	111	161	200	201	140	216	232	240	240	244
Power sector	673	661	657	604	566	748	774	822	824	837
Commercial	4,754	4,077	5,252	4,574	4,639	5,449	6,180	6,627	6,640	6,751
Residential	10,302	7,832	10,091	10,240	10,163	11,962	13,568	14,549	14,577	14,821
Public use (Street light)	0	0	0	0	0	0	0	78	74	98
Loss	4,914	6,194	1,699	1,123	1,232	2,145	1,854	1,873	1,802	1,814

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Summation	22,873	22,123	22,027	20,244	19,849	23,769	26,307	28,172	28,146	28,623
Total (TCN*0.95)	22,873	22,123	22,027	20,244	19,849	23,769	26,307	28,094	28,147	28,620
(Auto generation)	6,096	5,986	5,951	5,468	5,122	6,765	7,002	7,435	7,774	8,128
Total generation from TCN	24,077	23,287	23,187	21,309	20,893	25,020	27,692	29,573	29,629	30,126

Source: TCN

Note: Actual generation data from 2005 to 2014 are provided by TCN and Send out power (Total (TCN*0.95 in the table)) are defined by "Generation *0.95". Moreover, the total sectoral data coming from the IEA are adjusted to match TCN data

The computed data from 2004 to 2016 is calculated with reference to the regional survey and the estimated computed data are as follows:

Table 4-3.13 Calculation of Computed data

Unit: GWh

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
TCN demand (Gen *0.95)	22,873	22,123	22,027	20,244	19,849	23,769	26,307	28,094	28,147	28,620
Estimated shortage	4,127	7,877	9,973	14,756	18,151	17,231	18,693	22,046	24,853	28,390
Total computed demand	27,000	30,000	32,000	35,000	38,000	41,000	45,000	50,140	53,000	57,010
Shortage rate (%)	15.3	26.3	31.2	42.2	47.8	42.0	41.5	44.0	46.9	49.8

Source: TCN and National Load demand Forecasts in 2009

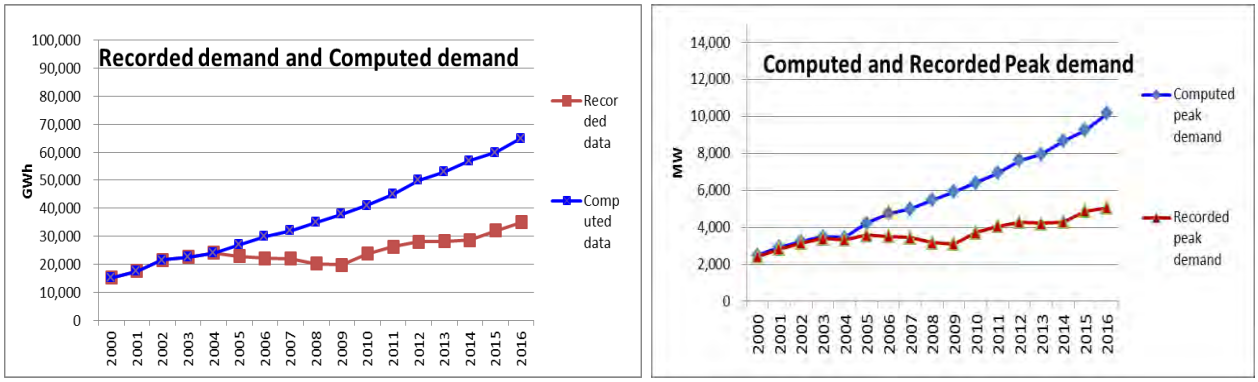
Table 4-3.14 Calculation of Sectoral Computed data

Unit: GWh

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Industry	2,501	4,337	5,997	6,055	5,952	5,604	6,327	7,089	7,514	8,081
LNG	131	218	291	348	268	373	397	427	453	487
Power sector	794	896	954	1,044	1,084	1,290	1,324	1,463	1,551	1,668
Commercial	5,612	5,529	7,630	7,908	8,881	9,399	10,571	11,794	12,502	13,445
Residential	12,161	10,621	14,660	17,704	19,457	20,633	23,209	25,893	27,447	29,518
Public use (Light)	0	0	0	0	0	0	0	139	139	195
Loss	5,800	8,399	2,469	1,941	2,358	3,700	3,172	3,334	3,392	3,612
Computed total demand	27,000	30,000	32,000	35,000	38,000	41,000	45,000	50,000	53,000	57,000

Source: TCN and the results of the regional survey

Note: Sectoral computed data are calculated by sectoral Recorded data and Computed total data.



Source: Made by the JICA Study Team

Figure 4-3.4 Trends of Computed and recorded data

(2) Transmission-loss rate (T-loss)

The following table shows the total power demand and T-loss of computed and recorded data. When examining the T-loss rate trend, the values decline after 2007, which is why the distribution loss is not

added to the loss. The distribution loss is included in the DisCo demand category as one of DisCo demands.

Table 4-3.15 T-loss and T-loss rate

	T-loss (A)		Total demand (B)		T-loss rate ((A)/(B)	
	Recorded data	Computed data	Recorded data	Computed data	Recorded data	Computed data
Year	GWh	GWh	GWh	GWh	%	%
2005	4,914	5,800	22,873	27,000	21.5	21.5
2006	6,194	8,399	22,123	30,000	28.0	28.0
2007	1,699	2,469	22,027	32,000	7.7	7.7
2008	1,123	1,941	20,244	35,000	5.5	5.5
2009	1,232	2,358	19,849	38,000	6.2	6.2
2010	2,145	3,700	23,769	41,000	9.0	9.0
2011	1,854	3,172	26,307	45,000	7.0	7.0
2012	1,873	3,334	28,094	50,000	6.7	6.7
2013	1,802	3,392	28,147	53,000	6.4	6.4
2014	1,814	3,612	28,620	57,000	6.3	6.3

Source: Recorded data come from TCN and Computed data come from the Regional survey conducted by TCN

(3) Load factor

Load factor is calculated by the following expression including actual peak demand (MW) and net power demand (GWh). Regarding the future load factor, the targeted load factor of 70% shown in MYTO II is used for power demand forecasting.

Load Factor = Net power demand (GWh)*1000 / (24hours*365days) / Peak demand (MW)*100

Table 4-3.16 Load factor forecasts

Year (2001-2010)		Year (2011-2020)		Year (2021-2030)		Year (2031-2040)	
Year	%	Year	%	Year	%	Year	%
2001	69.0	2011	74.0	2021	70.0	2031	70.0
2002	76.0	2012	75.0	2022	70.0	2032	70.0
2003	74.0	2013	76.0	2023	70.0	2033	70.0
2004	80.0	2014	76.0	2024	70.0	2034	70.0
2005	73.0	2015	73.0	2025	70.0	2035	70.0
2006	72.0	2016	72.5	2026	70.0	2036	70.0
2007	73.0	2017	72.0	2027	70.0	2037	70.0
2008	73.0	2018	71.5	2028	70.0	2038	70.0
2009	73.0	2019	71.0	2029	70.0	2039	70.0
2010	73.0	2020	70.0	2030	70.0	2040	70.0

Source: MYTO II Model sheet in 2014

4-4 Power Demand Forecasts

4-4-1 Elasticity and Coefficients for Sectoral Power Demand Forecasts

The elasticity and other preconditions used in the forecasting expressions are as following items.

- Sectoral power demands are forecast by sectoral elasticity to sectoral GDP.
- Power tariff impacts to power demands are calculated by sectoral elasticity to sectoral power tariff.
- The growth rate of power demand for LNG production process is 3% (It is the growth rate in the LNG world market as announced by the IEA in 2016).
- Power demand for public sector is forecast by elasticity to GDP. (It is mainly for street lights and the power sector own use).
- T-loss is forecast with 8% to power send out. The rate is quoted from the T-loss rate in "MYTO Model II".
- D-loss is included in the uncollected category of DisCo power consumption.

Table 4-4.1 Elasticity and coefficients of sectoral power demand forecasts

year	Residential				Industry			Commercial		
	Elasticity to GDP per capita	Elasticity to tariff	Electrification rate	EE&C rate	Elasticity to Ind. GDP	Elasticity to tariff	EE&C rate	Elasticity to Com. GDP	Elasticity to tariff	EE&C rate
	a.n.	a.n.	%	%	a.n.	a.n.	%	a.n.	a.n.	%
2015	2.2	-0.01	60.3	0.0	1.0	-0.01	0.0	1.1	-0.01	0.0
2016	2.1	-0.01	62.4	0.0	1.1	-0.01	0.0	1.1	-0.01	0.0
2017	2.0	-0.01	64.6	0.0	1.1	-0.01	0.0	1.2	-0.01	0.0
2018	2.0	-0.01	66.9	0.0	1.1	-0.01	0.0	1.2	-0.01	0.0
2019	2.0	-0.01	69.2	0.0	1.1	-0.01	0.0	1.2	-0.01	0.0
2020	1.9	-0.01	71.6	0.0	1.1	-0.01	0.0	1.2	-0.01	0.0
2021	1.9	-0.01	74.1	0.5	1.1	-0.01	0.5	1.2	-0.01	0.5
2022	1.9	-0.01	76.7	0.5	1.1	-0.01	0.5	1.1	-0.01	0.5
2023	1.9	-0.01	79.4	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2024	1.9	-0.01	82.2	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2025	1.8	-0.01	85.1	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2026	1.8	-0.01	88.0	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2027	1.8	-0.01	91.1	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2028	1.8	-0.01	94.3	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2029	1.8	-0.01	97.6	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2030	1.7	-0.01	100.0	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2031	1.7	-0.01	100.0	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2032	1.7	-0.01	100.0	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2033	1.7	-0.01	100.0	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2034	1.7	-0.01	100.0	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2035	1.6	-0.01	100.0	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2036	1.6	-0.01	100.0	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2037	1.6	-0.01	100.0	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2038	1.6	-0.01	100.0	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2039	1.6	-0.01	100.0	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5
2040	1.6	-0.01	100.0	0.5	1.2	-0.01	0.5	1.1	-0.01	0.5

Source: JICA Study Team

4-4-2 Sector-wise Power Demand Forecasts

The power demand for Residential, Industry and Commercial, LNG use, Public sectors and T-loss are forecast under the GDP growth rate of the base case described in Table 4-3.4. The results are as shown in the following table, which shows the sectoral computed demands of TCN and Auto producers. The annual average demand growth rate is 7.4% from 2015 to 2040 and the growth rate from 2020 to 2030 is comparatively higher, from 9 - 10% per year.

Table 4-4.2 Power demand forecasts by sector

Unit: GWh

	Residential	Industry	Commercial	LNG	Public use	T-loss	Total
2015	30,210	9,220	14,710	500	1,930	4,920	61,490
2016	29,010	9,470	14,970	520	1,950	4,860	60,790
2017	29,850	10,250	15,920	530	2,020	5,090	63,680
2018	32,530	11,460	17,460	550	2,140	5,580	69,720
2019	36,410	12,840	19,320	560	2,300	6,210	77,640
2020	41,130	14,050	21,130	580	2,480	6,900	86,270
2021	46,110	15,290	22,970	600	2,650	7,620	95,240
2022	51,570	16,630	24,960	620	2,840	8,400	105,030
2023	57,560	18,100	27,100	640	3,050	9,260	115,700
2024	64,110	19,690	29,400	650	3,270	10,180	127,300
2025	71,240	21,420	31,870	670	3,500	11,190	139,900
2026	78,920	23,290	34,530	690	3,730	12,270	153,430
2027	87,170	25,290	37,380	720	3,970	13,440	167,960
2028	95,980	27,450	40,440	740	4,230	14,680	183,520
2029	105,340	29,780	43,720	760	4,500	16,010	200,110
2030	114,110	32,280	47,240	780	4,790	17,320	216,520
2031	120,320	34,930	50,950	800	5,110	18,440	230,550
2032	126,440	37,730	54,850	830	5,440	19,590	244,880
2033	132,400	40,680	58,960	850	5,790	20,760	259,450
2034	138,160	43,790	63,270	880	6,170	21,940	274,210
2035	143,640	47,060	67,780	910	6,570	23,130	289,080
2036	148,790	50,520	72,480	930	7,000	24,320	304,050
2037	153,550	54,180	77,380	960	7,450	25,520	319,050
2038	158,510	58,050	82,470	990	7,930	26,780	334,730
2039	163,670	62,130	87,750	1,020	8,450	28,090	351,100
2040	169,050	66,420	93,200	1,050	9,000	29,450	368,180
2040/15	7.1%	8.2%	7.7%	3.0%	6.4%	7.4%	7.4%

Source: JICA Study Team

Note: "2040/15" means the growth rate from 2015 to 2040.

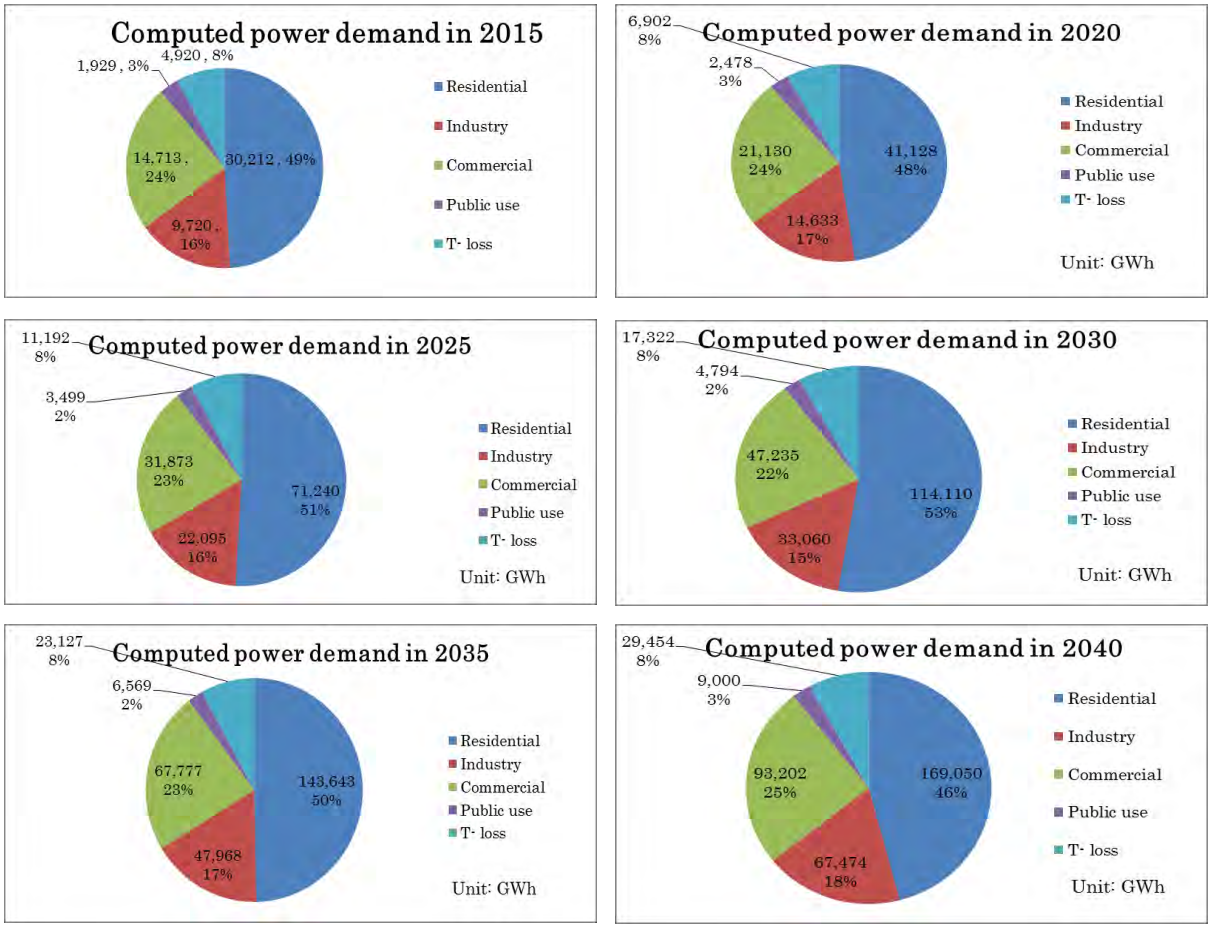
Note: The above demand forecast is base case and high and Low cases are described in later sessions.

Table 4-4.3 Growth rate of power demand

Unit: %

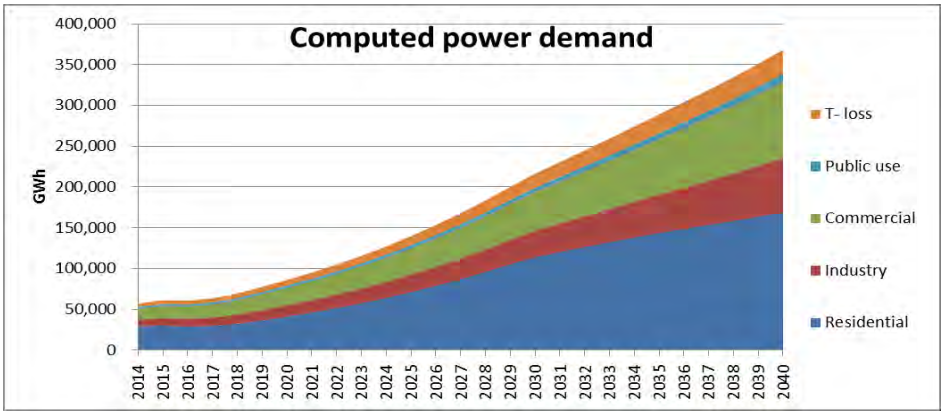
	2015/ 2010	2020/ 2015	2025/ 2020	2030/ 2025	2035/ 2030	2040/ 2035	2040/ 2015
Residential	7.9	6.4	11.6	9.9	4.7	3.3	7.1
Industry	10.5	8.8	8.8	8.5	7.8	7.1	8.2
Commercial	9.4	7.5	8.6	8.2	7.5	6.6	7.7
LNG	6.1	3.0	3.0	3.0	3.0	3.0	3.0
Public use	8.4	5.1	7.1	6.5	6.5	6.5	6.4
T-loss	5.9	7.0	10.2	9.1	6.0	5.0	7.4
Computed total	8.4	7.0	10.2	9.1	6.0	5.0	7.4

Source: JICA Study Team



Source: JICA Study Team
Note: Industry includes power demand for LNG

Figure 4-4.1 Sectoral contribution of power demand



Source: JICA Study Team

Figure 4-4.2 Trends of sectoral power demands

4-4-3 Power Demand Forecasts of TCN (Include Auto Producers)

Under the above preconditions, net peak demand, net power energy demand and generation of TCN are as shown in the following table. The average annual growth rates from 2015 to 2040 are 7.8% per year for peak demand, 7.4% for power energy demand and 7.4% for generation respectively.

Table 4-4.4 Power demand forecasts of TCN and Auto producers

	Gross generation	Load factor	Gross peak generation	Net demand	Net peak demand	Shortage	Shortage at peak demand	Shortage rate
	GWh	%	MW	GWh	MW	GWh	MW	%
2015	63,307	76	9,509	61,494	9,237	30,747	4,618	50
2016	62,579	73	9,853	60,787	9,571	28,570	4,499	47
2017	65,555	72	10,394	63,678	10,096	29,292	4,644	46
2018	71,771	72	11,459	69,715	11,131	31,372	5,009	45
2019	79,928	71	12,851	77,639	12,483	31,056	4,993	40
2020	88,813	70	14,484	86,270	14,069	30,195	4,924	35
2021	98,047	70	15,989	95,240	15,532	28,572	4,659	30
2022	108,127	70	17,633	105,031	17,128	21,006	3,426	20
2023	119,110	70	19,424	115,699	18,868	17,355	2,830	15
2024	131,056	70	21,373	127,304	20,761	12,730	2,076	10
2025	144,023	70	23,487	139,898	22,814	6,995	1,141	5
2026	157,957	70	25,759	153,434	25,022	0	0	0
2027	172,916	70	28,199	167,964	27,391	0	0	0
2028	188,927	70	30,810	183,517	29,928	0	0	0
2029	206,012	70	33,596	200,113	32,634	0	0	0
2030	222,905	70	36,351	216,522	35,310	0	0	0
2031	237,345	70	38,706	230,548	37,598	0	0	0
2032	252,096	70	41,111	244,877	39,934	0	0	0
2033	267,099	70	43,558	259,450	42,311	0	0	0
2034	282,291	70	46,036	274,207	44,717	0	0	0
2035	297,605	70	48,533	289,083	47,143	0	0	0
2036	313,015	70	51,046	304,051	49,584	0	0	0
2037	328,458	70	53,565	319,052	52,031	0	0	0
2038	344,600	70	56,197	334,732	54,588	0	0	0
2039	361,454	70	58,946	351,104	57,258	0	0	0
2040	379,033	70	61,812	368,179	60,042	0	0	0
2040/15	7.4		7.8	7.4	7.8			

Source: JICA Study Team

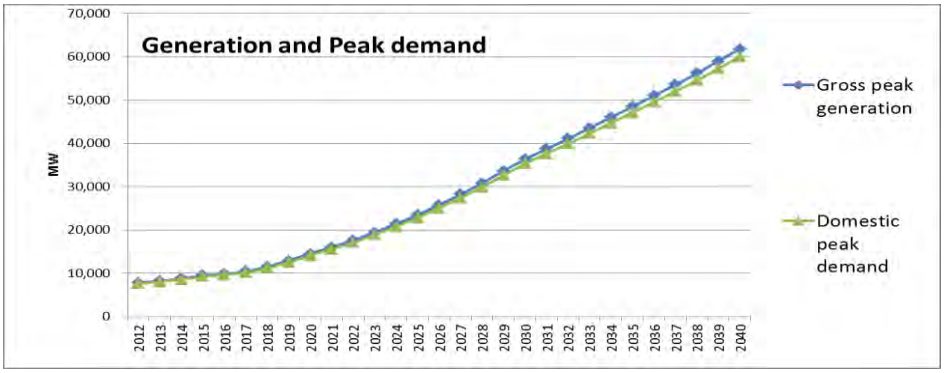
All five-year growth rates for gross generation, gross peak generation, net peak demand and net demand of TCN and Auto producers from 2015 to 2040 are as shown in the following table:

Table 4-4.5 Power demand growth rates of TCN (Includes Auto producers)

Unit: %

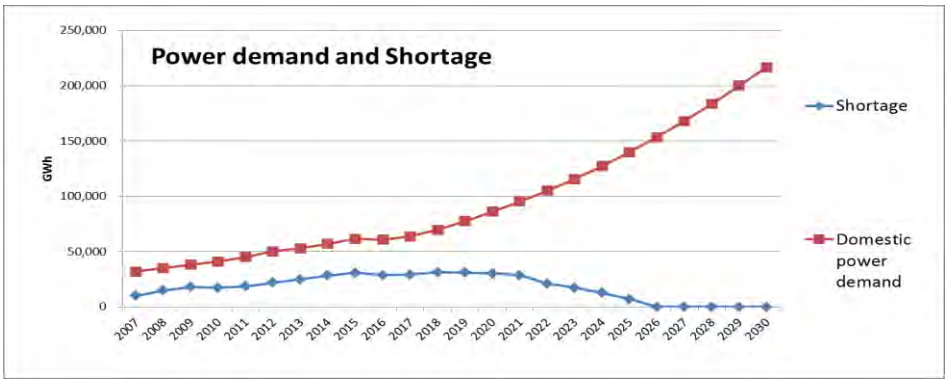
	2015/ 2010	2020/ 2015	2025/ 2020	2030/ 2025	2035/ 2030	2040/ 2035	2040/ 2015
Gross generation	8.4	7.0	10.2	9.1	6.0	5.0	7.4
Gross peak demand	7.5	8.8	10.2	9.1	6.0	5.0	7.8
Net demand (Energy)	8.4	7.0	10.2	9.1	6.0	5.0	7.4
Net peak demand	7.6	8.8	10.2	9.1	6.0	5.0	7.8

Source: JICA Study Team



Source: JICA Study Team

Figure 4-4.3 Trends of power demand growth rates of TCN (Includes Auto producers)



Source: JICA Study Team

Note: The shortage is zero from 2026 to 2030 and zero during 2031 -2040.

Figure 4-4.4 Peak demand and Shortage at peak demand

4-4-4 Demand Share of TCN and Auto Producers

The power energy demand shares of TCN and Auto producers are as shown in the following table: The share of Auto producers in 2015 is 16.6%, while the future share will be decreased due to the expected increase in the TCN power supply. However, it can be considered that big factories will use both steam and electricity as well as their own power generated in their power plants. According to NERC, Auto producers will be eliminated in future, accordingly, it is predicted that Auto producer generation will gradually decline to reach zero by 2033 in the mode.

Table 4-4.6 Shares of TCN and Auto producers

	TCN demand	Auto producer's demand	Total	Auto producer share	TCN peak demand	Auto producer's peak demand	Total
	GWh	GWh	GWh	%	MW	MW	MW
2015	51,269	10,225	61,494	16.6	7,701	1,536	9,237
2016	50,680	10,108	60,787	16.6	7,980	1,591	9,571
2017	53,090	10,588	63,678	16.6	8,417	1,679	10,096
2018	58,123	11,592	69,715	16.6	9,280	1,851	11,131
2019	64,730	12,910	77,639	16.6	10,407	2,076	12,483
2020	71,925	14,345	86,270	16.6	11,729	2,339	14,069

	TCN demand	Auto producer's demand	Total	Auto producer share	TCN peak demand	Auto producer's peak demand	Total
	GWh	GWh	GWh	%	MW	MW	MW
2021	80,987	14,253	95,240	15.0	13,207	2,324	15,532
2022	90,885	14,146	105,031	13.5	14,821	2,307	17,128
2023	101,675	14,025	115,699	12.1	16,581	2,287	18,868
2024	113,415	13,888	127,304	10.9	18,496	2,265	20,761
2025	126,162	13,736	139,898	9.8	20,574	2,240	22,814
2026	141,382	12,052	153,434	7.9	23,056	1,965	25,022
2027	157,410	10,555	167,964	6.3	25,670	1,721	27,391
2028	174,292	9,226	183,517	5.0	28,423	1,504	29,928
2029	192,065	8,048	200,113	4.0	31,322	1,312	32,634
2030	209,556	6,966	216,522	3.2	34,174	1,136	35,310
2031	224,614	5,934	230,548	2.6	36,630	968	37,598
2032	239,835	5,042	244,877	2.1	39,112	822	39,934
2033	255,176	4,274	259,450	1.6	41,614	697	42,311
2034	274,207	0	274,207	0.0	44,717	0	44,717
2035	289,083	0	289,083	0.0	47,143	0	47,143
2036	304,051	0	304,051	0.0	49,584	0	49,584
2037	319,052	0	319,052	0.0	52,031	0	52,031
2038	334,732	0	334,732	0.0	54,588	0	54,588
2039	351,104	0	351,104	0.0	57,258	0	57,258
2040	368,179	0	368,179	0.0	60,042	0	60,042
2040/15	8.2		7.4		8.6		7.8

Source: JICA Study Team

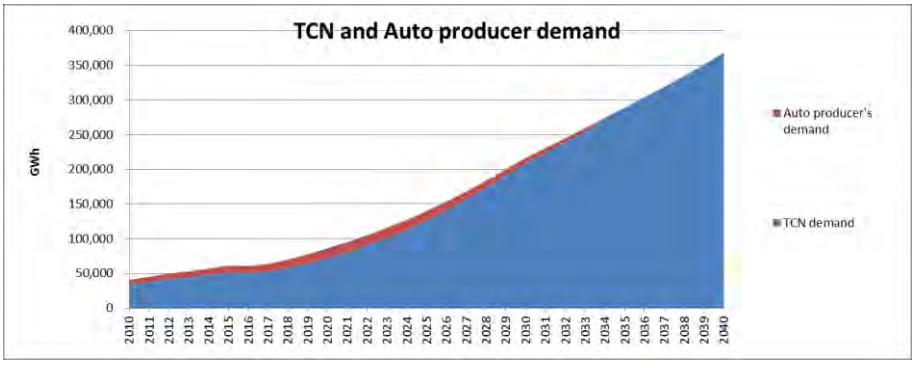
Note: 2040/15 means the average growth rate from 2015 to 2040, as a percentage (%).

Table 4-4.7 Power growth rate of TCN and Auto producers

Unit: %

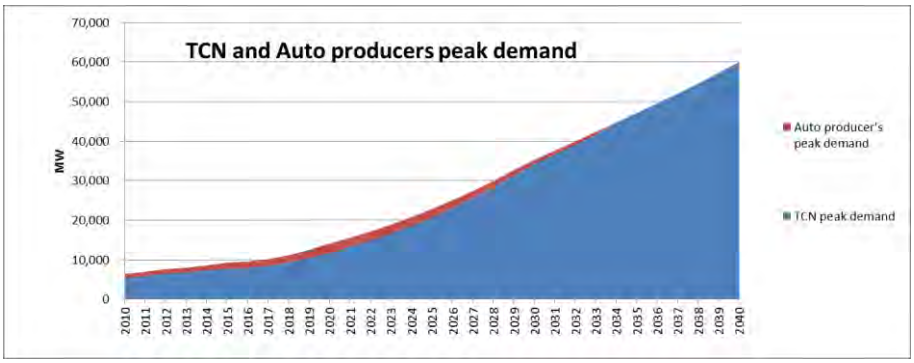
	2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2040/15
TCN demand	8.4	7.0	11.9	10.7	6.6	5.0	8.2
Auto producer's demand	8.6	7.0	-0.9	-12.7			
TCN peak demand	7.5	8.8	11.9	10.7	6.6	5.0	8.6
Auto producer's peak demand	7.7	8.8	-0.9	-12.7			

Source: JICA Study Team



Source: JICA Study Team

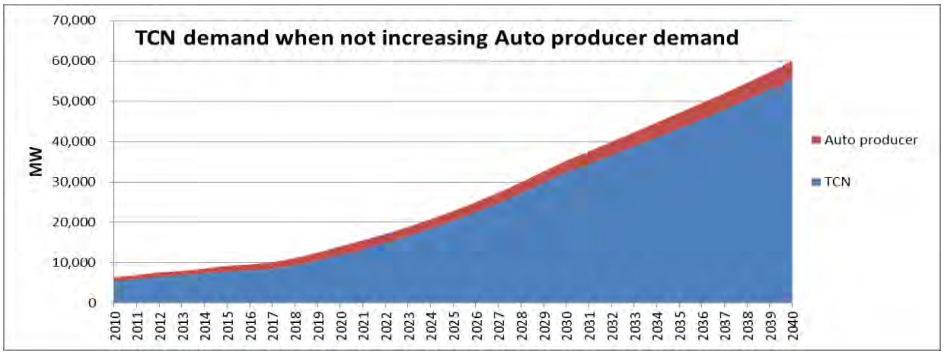
Figure 4-4.5 Trends of power demand shares of TCN and Auto producers



Source: JICA Study Team

Figure 4-4.6 Trends of peak demand shares of TCN and Auto producers

In Commercial and Industry sectors, Auto producers (private generators) are useful for factories using steam and electric power in parallel. However, most factories and buildings have their own private generators with power shortages and failure of the TCN power supply in mind. Auto producers are gradually declining with the increasing stabilization of power supply from TCN in mind. Power demand forecasts assume that Auto producers will be unnecessary in future, because sufficient power will be supplied from TCN by 2033. If the above assumption does not exist, Auto producers (private generators) will increase in line with Nigerian economic growth and the power supply from Auto producers and TCN will be as shown in the following figure:



Source: JICA Study Team

Note: The above figure assumes Auto producers will not receive the power from TCN in future.

Figure 4-4.7 Power supply from Auto producers and TCN

4-4-5 Power Demand of Off-grid Systems

The purposes of the power demand forecast in the Master Plan are to predict the future power demands to be actualized and the total supply covering Nigerian total power demand includes not only the power grid supply from TCN but also the Off-grid supply. However, the power development and transmission plans are located after power demand forecasts are established for TCN as the main power supplier in Nigeria. The power demand forecasts are targeted at TCN demand (Domestic and Export) and Auto producers that may become TCN users in future, which means that the Off-grid power supply in Nigeria is excluded from the TCN supply. With this in mind, the following Off-grid demand forecasts are established and most Off-grid users live in rural areas.

Regarding power supply forecasts from the Off-grid system after referring to the "National Renewable Energy and Energy Efficiency Policy" (NREEE), it is assumed that power is supplied from Small Hydro Power (SHP), Solar panels (PV), Solar thermal, Wind power and Bio generator. According to the above plan, it is predicted that renewable energy capacities can be introduced with 317 MW as the short-term plan (in and around 2015), 3,638 MW for the medium term (in and around 2020) and 18,508 MW for the long term (in and around 2030).

Table 4-4.8 Introduction plan for Renewable energy sources (Large-scale hydel)

			Short	Middle	Long
Renewable	Unit	2013 actual	Around 2015	Around 2020	Around 2030
Small Hydro	MW		140	1,607	8,174
Solar & Solar Thermal	MW	75	117	1,343	6,831
Wind	MW		55	631	3,211
Bio	MW		5	57	292
Total (Ex large Hydro)	MW	75	317	3,638	18,508
(Large Hydro)	MW		2,121	4,549	4,627

Source: National Renewable Energy and Energy Efficiency Policy (NREEE) PP. 35-36
Note: The GDP Growth Rate in NREEE is assumed to be 7% per year.

In INDC (Intended Nationally Determined Contributions), there is a plan for "Work towards Off-grid solar PV of 13GW", which means some parts of the Off-grid power are supplied by PV.

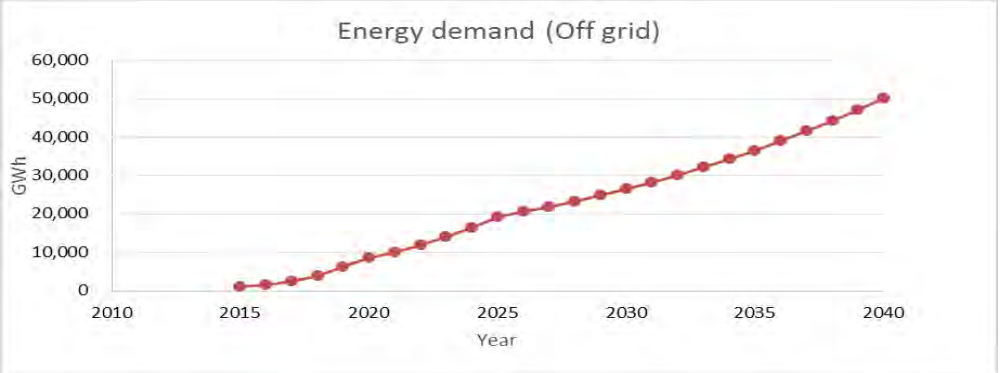
Off-grid power demand is estimated under the above conditions by 2040. It is said that the capacity factor of renewable energy sources is around 30% per unit, however, it is estimated that the capacity factor as country average is around 20%.

Table 4-4.9 Power demand forecasts for Off-grid

	Energy demand (Off-grid)	Power demand (Off-grid)	Capacity (Off-grid)
	GWh	MW	MW
2015	961	157	224
2016	1,535	250	358
2017	2,454	400	572
2018	3,923	640	914
2019	6,272	1,023	1,461
2020	8,585	1,400	2,000
2021	10,087	1,645	2,350
2022	11,847	1,932	2,760
2023	13,950	2,275	3,250
2024	16,397	2,674	3,820
2025	19,316	3,150	4,500
2026	20,604	3,360	4,800
2027	21,891	3,570	5,100
2028	23,179	3,780	5,400
2029	24,896	4,060	5,800
2030	26,613	4,340	6,200
2031	28,330	4,620	6,600
2032	30,047	4,900	7,000
2033	32,193	5,250	7,500
2034	34,339	5,600	8,000
2035	36,485	5,950	8,500
2036	39,061	6,370	9,100

	Energy demand (Off-grid)	Power demand (Off-grid)	Capacity (Off-grid)
	GWh	MW	MW
2037	41,636	6,790	9,700
2038	44,212	7,210	10,300
2039	47,216	7,700	11,000
2040	50,221	8,190	11,700
2040/15	17.1%	17.1%	17.1%

Source: National Renewable Energy and Energy Efficiency Policy and Study Team
Note: "2040/15" means the average growth rate from 2015 to 2040 and the unit is %.



Source: JICA Study Team

Figure 4-4.8 Power energy demand of Off-grid systems

4-4-6 Nationwide Power Demand

The summation demand of TCN and Auto producers, Off-grid systems and Export becomes the nationwide power demand of Nigeria. The power demand, peak demand and the required capacities for total domestic power demand and exports are as shown in the following table:

Table 4-4.10 Nationwide power demand (Total power demand)

	Domestic demand		Export		On-grid total		Off-grid		On + Off-grid	
	(A)		(B)		(C)=(A)+(B)		(D)		(E)=(C)+(D)	
	Energy demand	Peak demand	Energy demand	Power demand	Energy demand	Power demand	Energy demand	power demand	Energy demand	power demand
	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW
2015	61,494	9,237	2,293	262	63,787	9,498	961	157	64,748	9,655
2016	60,787	9,571	2,274	260	63,062	9,831	1,535	250	64,597	10,081
2017	63,678	10,096	2,350	268	66,028	10,364	2,454	400	68,482	10,765
2018	69,715	11,131	2,506	286	72,222	11,417	3,923	640	76,145	12,057
2019	77,639	12,483	2,706	309	80,345	12,792	6,272	1,023	86,616	13,815
2020	86,270	14,069	2,916	333	89,186	14,402	8,585	1,400	97,771	15,802
2021	95,240	15,532	3,173	362	98,413	15,894	10,087	1,645	108,500	17,539
2022	105,031	17,128	3,445	393	108,476	17,522	11,847	1,932	120,323	19,454
2023	115,699	18,868	3,731	426	119,430	19,294	13,950	2,275	133,381	21,569
2024	127,304	20,761	4,033	460	131,336	21,221	16,397	2,674	147,733	23,895
2025	139,898	22,814	4,350	497	144,248	23,311	19,316	3,150	163,564	26,461
2026	153,434	25,022	4,717	538	158,151	25,560	20,604	3,360	178,754	28,920
2027	167,964	27,391	5,091	581	173,056	27,973	21,891	3,570	194,947	31,543
2028	183,517	29,928	5,474	625	188,991	30,553	23,179	3,780	212,170	34,333
2029	200,113	32,634	5,864	669	205,977	33,304	24,896	4,060	230,873	37,364
2030	216,522	35,310	6,238	712	222,760	36,022	26,613	4,340	249,373	40,362
2031	230,548	37,598	6,552	748	237,100	38,346	28,330	4,620	265,430	42,966

	Domestic demand (A)		Export (B)		On-grid total (C)=(A)+(B)		Off-grid (D)		On + Off-grid (E)=(C)+(D)	
	Energy demand	Peak demand	Energy demand	Power demand	Energy demand	Power demand	Energy demand	power demand	Energy demand	power demand
2032	244,877	39,934	6,863	783	251,740	40,718	30,047	4,900	281,786	45,618
2033	259,450	42,311	7,170	819	266,620	43,129	32,193	5,250	298,813	48,379
2034	274,207	44,717	7,544	861	281,752	45,579	34,339	5,600	316,091	51,179
2035	289,083	47,143	7,831	894	296,914	48,037	36,485	5,950	333,399	53,987
2036	304,051	49,584	8,115	926	312,166	50,511	39,061	6,370	351,227	56,881
2037	319,052	52,031	8,395	958	327,447	52,989	41,636	6,790	369,083	59,779
2038	334,732	54,588	8,684	991	343,416	55,579	44,212	7,210	387,628	62,789
2039	351,104	57,258	8,981	1,025	360,085	58,283	47,216	7,700	407,302	65,983
2040	368,179	60,042	9,287	1,060	377,466	61,102	50,221	8,190	427,687	69,292
40/15	7.4%	7.8%	5.8%	5.8%	7.4%	7.7%	17.1%	17.1%	7.8%	8.2%

Source: JICA Study Team

Note: "2040/15" means the average growth rate from 2015 to 2040 and the unit is %.

Note: Export is forecast by the expression of "0.7* TCN demand growth rate" after referring to "MYTO II"

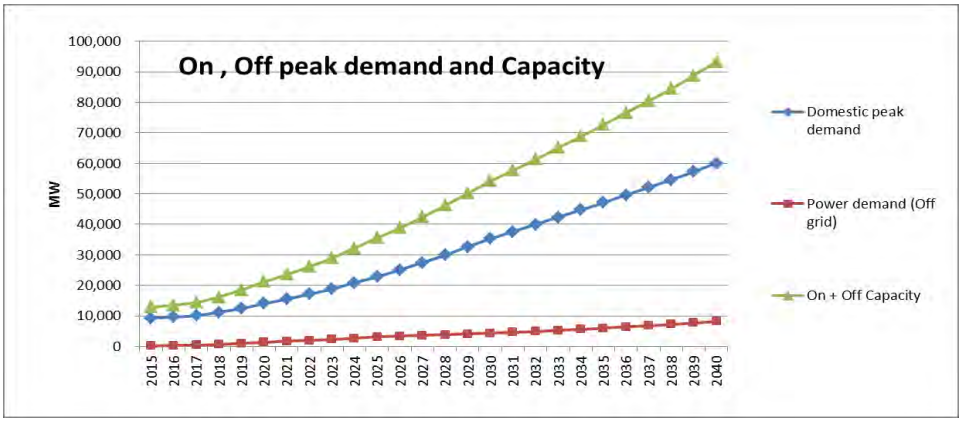
Table 4-4.11 Growth rate in nationwide power demand

Unit: %

		2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2040/15
Computed power demand	Energy demand	8.4	7.0	11.9	10.7	6.6	5.0	8.2
Export	Peak demand	18.9	4.9	8.3	7.5	4.7	3.5	5.8
On-grid demand	Energy demand	7.7	8.7	10.1	9.1	5.9	4.9	7.7
Off-grid demand	Peak demand	35.0	55.0	17.6	6.6	6.5	6.6	17.1
On + Off demand + Export	Capacity	5.9	16.2	18.4	9.8	6.0	5.1	11.0

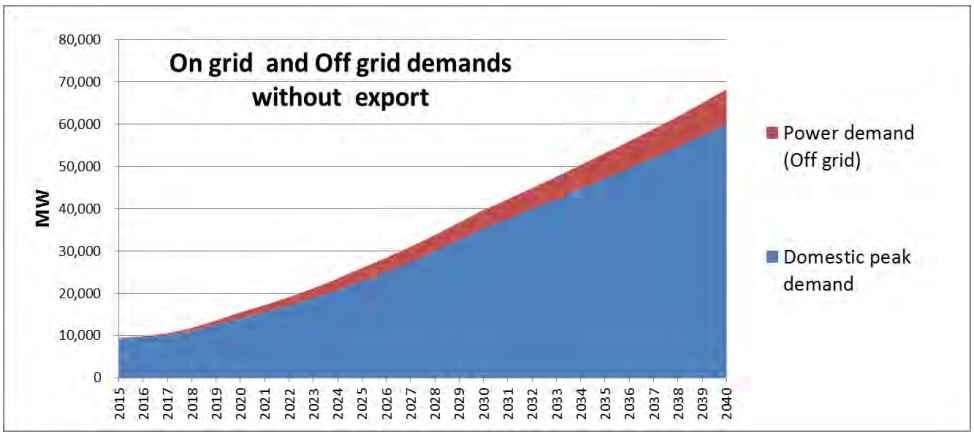
Source: JICA Study Team

The trends in terms of On-grid, Off-grid and estimated capacity are as shown in the following figure and significant capacities are required to introduce large-scale renewable energy sources in future.



Source: JICA Study Team

Figure 4-4.9 Nationwide peak demand and capacity



Source: JICA Study Team

Figure 4-4.10 Nationwide power energy demand

4-4-7 Power Demand under the GDP Scenario

The power demands under the GDP scenario are as shown in the following table: The average growth rates of GDP in the High case are 7.3% / year from 2015 to 2040 (8.0% per year after 2020), with a base case of 6.1% from 2015 to 2040 (6.5% per year after 2020) and a Low case of 4.8% (5.0% per year after 2020). Moreover, the average peak demand growth rates of cases are 9.9% / year for the High case from 2015 to 2040, 7.8% / year in base case during the same period and 5.6% / year in the Low case during the same period.

Table 4-4.12 Power demand by case (GDP scenario)

	Power Demand (GWh)			Peak Demand (MW)		
Year	High Case	Base Case	Low Case	High Case	Base Case	Low Case
2015	61,494	61,494	61,494	9,237	9,237	9,237
2016	60,792	60,787	60,777	9,572	9,571	9,570
2017	63,706	63,678	63,613	10,100	10,096	10,086
2018	69,800	69,715	69,518	11,144	11,131	11,099
2019	77,816	77,639	75,638	12,511	12,483	12,161
2020	89,045	86,270	81,462	14,521	14,069	13,285
2021	101,194	95,240	87,230	16,503	15,532	14,225
2022	114,828	105,031	93,374	18,726	17,128	15,227
2023	130,089	115,699	99,915	21,215	18,868	16,294
2024	147,127	127,304	106,873	23,993	20,761	17,429
2025	166,091	139,898	114,267	27,086	22,814	18,634
2026	186,992	153,434	122,023	30,494	25,022	19,899
2027	209,977	167,964	130,163	34,243	27,391	21,227
2028	235,151	183,517	138,690	38,348	29,928	22,617
2029	262,609	200,113	147,605	42,826	32,634	24,071
2030	290,705	216,522	156,044	47,408	35,310	25,447
2031	316,265	230,548	162,561	51,576	37,598	26,510
2032	342,928	244,877	169,078	55,924	39,934	27,573
2033	370,603	259,450	175,569	60,437	42,311	28,632
2034	399,183	274,207	182,007	65,098	44,717	29,682
2035	428,554	289,083	188,365	69,888	47,143	30,718
2036	458,674	304,051	194,635	74,800	49,584	31,741

Year	Power Demand (GWh)			Peak Demand (MW)		
	High Case	Base Case	Low Case	High Case	Base Case	Low Case
2037	489,436	319,052	200,790	79,817	52,031	32,745
2038	522,240	334,732	207,086	85,166	54,588	33,771
2039	557,194	351,104	213,517	90,867	57,258	34,820
2040	594,408	368,179	220,076	96,935	60,042	35,890
2040/15	9.5%	7.4%	5.2%	9.9%	7.8%	5.6%

Source: JICA Study Team

Note: "2040/15" means the average growth rate from 2015 to 2040 and the unit is %.

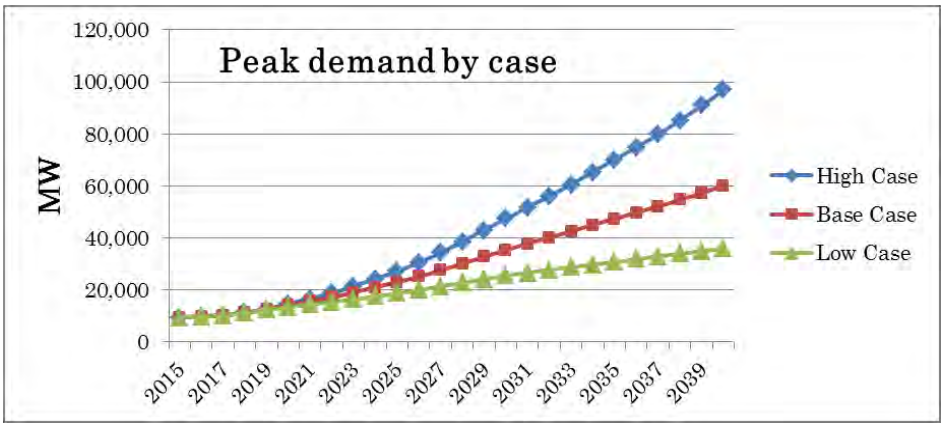
Note: The demands of the cases are only On-grid and exports are excluded.

Table 4-4.13 Power demand growth rates and elasticity for the cases

Case	Items	Unit	2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2040/15
High	GDP	%	4.8	4.6	8.0	8.0	8.0	8.0	7.3
	Net demand	%	8.4	7.7	13.3	11.8	8.1	6.8	9.5
	Net peak demand	%	7.6	9.5	13.3	11.8	8.1	6.8	9.9
	Elasticity		1.58	2.07	1.66	1.48	1.01	0.85	1.36
Base	GDP	%	4.8	4.3	6.5	6.5	6.5	6.5	6.1
	Net demand	%	8.4	7.0	10.2	9.1	6.0	5.0	7.4
	Net peak demand	%	7.6	8.8	10.2	9.1	6.0	5.0	7.8
	Elasticity		1.58	2.05	1.57	1.40	0.92	0.771	1.28
Low	GDP	%	4.8	3.8	5.0	5.0	5.0	5.0	4.8
	Net demand	%	8.4	5.8	7.0	6.4	3.8	3.2	5.2
	Net peak demand	%	7.6	7.5	7.0	6.4	3.8	3.2	5.6
	Elasticity		1.58	1.97	1.40	1.28	0.86	0.64	1.17

Note: Elasticity are calculated by "Peak demand growth rate / GDP growth rate"

Source: JICA Study Team



Source: JICA Study Team

Figure 4-4.11 Peak demand by case (MW)

The nationwide power demand including TCN, Auto producers, Off-grid and Export is shown in the following table:

Table 4-4.14 Power demand by case (On + Auto producers + Off + Export)

	Power Demand (GWh)			Peak Demand (MW)		
	High Case	Base Case	Low Case	High Case	Base Case	Low Case
2015	64,748	64,748	64,748	9,655	9,655	9,655
2016	64,602	64,597	64,587	10,082	10,081	10,080
2017	68,511	68,482	68,416	10,769	10,765	10,754
2018	76,232	76,145	75,942	12,070	12,057	12,024
2019	86,797	86,616	84,565	13,844	13,815	13,487
2020	100,614	97,771	92,845	16,262	15,802	15,004
2021	114,597	108,500	100,296	18,526	17,539	16,210
2022	130,350	120,323	108,386	21,077	19,454	17,521
2023	148,102	133,381	117,222	23,954	21,569	18,952
2024	168,003	147,733	126,825	27,179	23,895	20,509
2025	190,333	163,564	137,343	30,798	26,461	22,214
2026	213,470	178,754	146,197	34,546	28,920	23,646
2027	238,713	194,947	155,434	38,636	31,543	25,141
2028	266,170	212,170	165,056	43,086	34,333	26,698
2029	296,363	230,873	175,066	47,981	37,364	28,319
2030	327,187	249,373	185,439	52,979	40,362	30,000
2031	355,408	265,430	193,412	57,557	42,966	31,292
2032	385,165	281,786	201,380	62,384	45,618	32,583
2033	415,938	298,813	209,316	67,377	48,379	33,870
2034	448,141	316,091	217,247	72,598	51,179	35,153
2035	481,026	333,399	225,030	77,936	53,987	36,416
2036	515,092	351,227	233,150	83,467	56,881	37,734
2037	549,800	369,083	241,153	89,102	59,779	39,032
2038	587,004	387,628	249,298	95,142	62,789	40,354
2039	626,811	407,302	257,580	101,607	65,983	41,698
2040	669,333	427,687	265,992	108,513	69,292	43,063
2040/15	9.8%	7.8%	5.8%	10.2%	8.2%	6.2%

Source: JICA Study Team

Note: "2040/15" means the average growth rate from 2015 to 2040 and the unit is %.

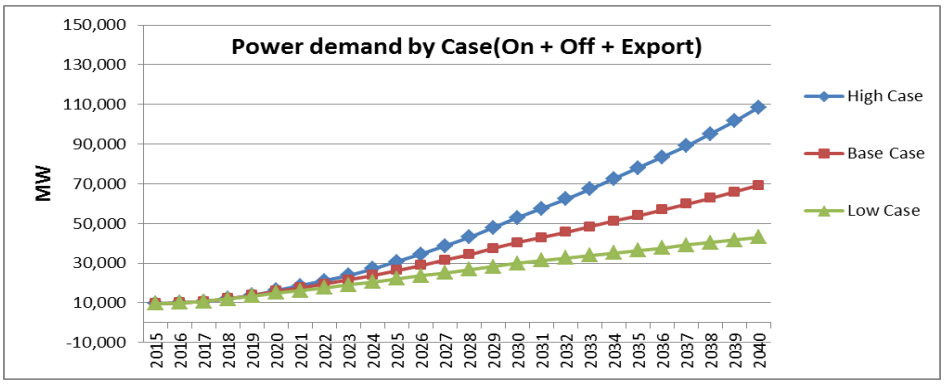
Note: The above demands include On-grid, Off-grid and Export

Table 4-4.15 Growth rate of power demand (On + Auto producers + Off+ Export)

Case	Items	Unit	2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2040/15
High	GDP	%	4.8	4.6	8.0	8.0	8.0	8.0	7.3
	Total demand	%	8.9	9.2	13.6	11.4	8.0	6.8	9.8
	Peak demand	%	8.0	11.0	13.6	11.5	8.0	6.8	10.2
	Elasticity		1.67	2.39	1.70	1.44	1.00	0.85	1.40
Base	GDP	%	4.8	4.3	6.5	6.5	6.5	6.5	6.1
	Total demand	%	8.9	8.6	10.8	8.8	6.0	5.1	7.8
	Peak demand	%	8.0	10.4	10.9	8.8	6.0	5.1	8.2
	Elasticity		1.67	2.42	1.68	1.35	0.92	0.78	1.34
Low	GDP	%	4.8	3.8	5.0	5.0	5.0	5.0	4.8
	Total demand	%	8.9	7.5	8.1	6.2	3.9	3.4	5.8
	Peak demand	%	8.0	9.2	8.2	6.2	4.0	3.4	6.2
	Elasticity		1.67	2.42	1.64	1.24	0.80	0.68	1.29

Source: JICA Study Team

Note: Elasticities are calculated by "Peak demand growth rate / GDP growth rate"

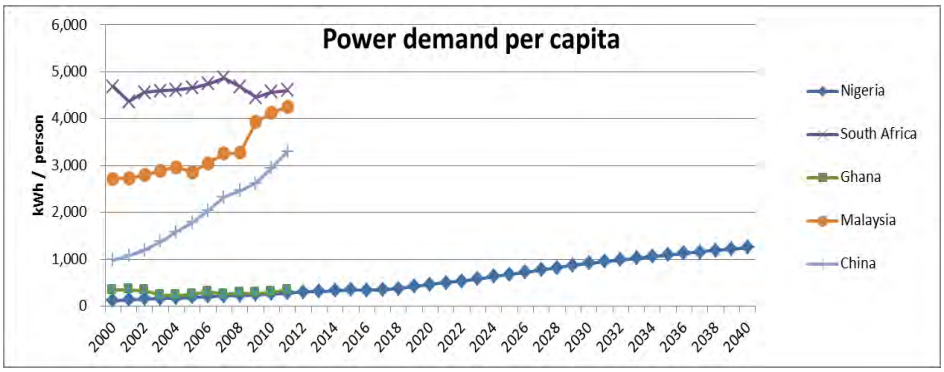


Source: JICA Study Team

Figure 4-4.12 Power demand by case (On + Auto producers + Off+ Export)

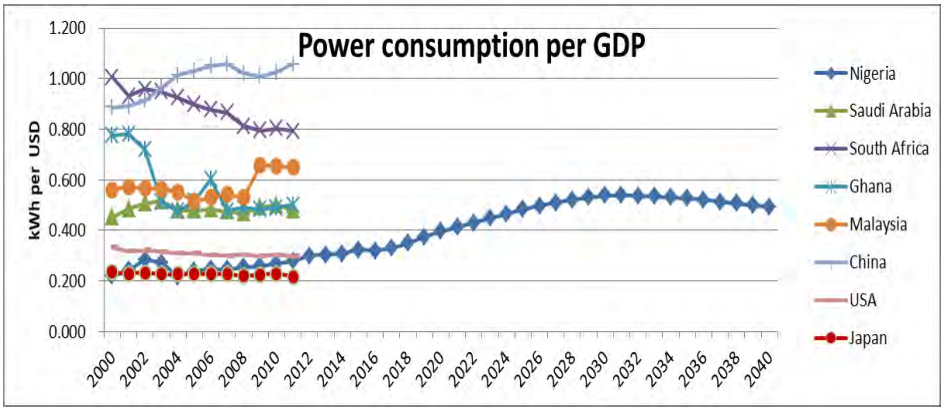
4-4-8 International Comparison

When comparing Nigerian power demand of the base case to other countries, the results are as shown in the following. Indicators for the comparison are "Power consumption per capita" and "Power consumption per GDP".



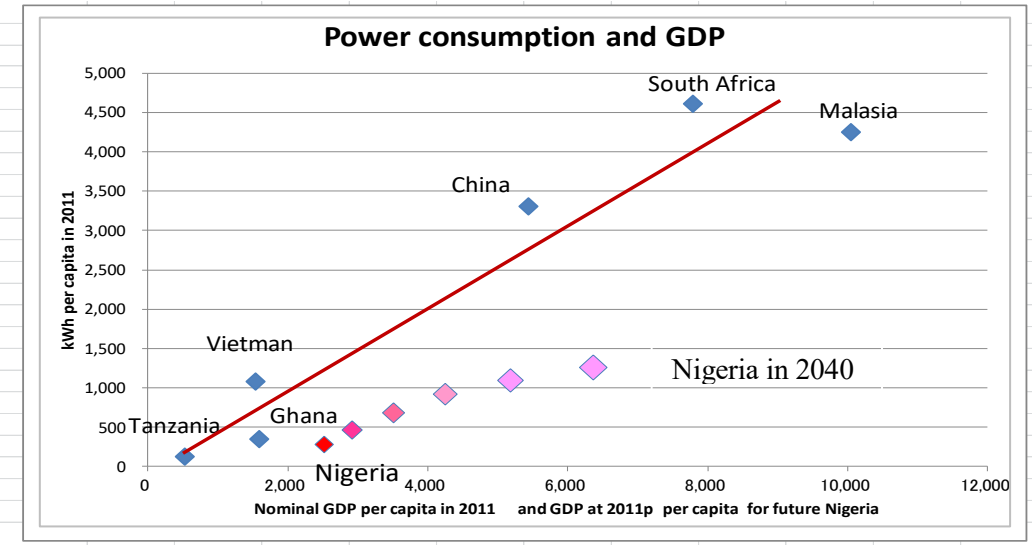
Source: selected country data from World Bank database and Nigeria data from JICA Study Team

Figure 4-4.13 Power consumption per capita



Source: The World Bank database for the countries and JICA Study Team
Note: Real GDP is 2005 price

Figure 4-4.14 Power consumption per GDP



Source: JICA Study Team

Figure 4-4.15 Power consumption per GDP and power consumption per capita

4-5 DisCo-wise Power Demand Forecasts

4-5-1 Methodologies of DisCo-wise Power Demand Forecasts

The DisCo-wise power demands are forecast by an approach to distribute the TCN and Auto producer demand to DisCos, with details of the methodologies as follows:

a. Forecast regional population.
b. Sum up the regional population to DisCo-wise.
c. Forecast DisCo-wise electrification rates.
d. Forecast DisCo-wise customers.
e. Calculate power consumption per customer (actual values in 2014 are used as initial values.)
f. Future power consumption per customer.
   = Previous power consumption per customer * (1 + Elasticity * (Income per-capita growth rate))
g. DisCo-wise power demand after 2015
   = Power consumption per customer * number of customers
h. Adjust the elasticity to meet the total of DisCo-wise power demand for Post-2015 TCN demand.

Table 4-5.1 Calculation equations for DisCo customers

Sector	Equation
Customer by DisCo	=a* (DisCo population* DisCo electrified rate) + b a, b Constants
Residential consumption per customer	=a*Log (Customer by DisCo) + b a, b Constants
Commercial consumption per customer	= a* Commercial GDP + b a, b Constants
Industry consumption per customer	= a* Industry GDP + b a, b Constants
Street light consumption per customer	= a* GDP + b a, b Constants

Source: JICA Study Team
Note: The equations of the above sectors are created for each DisCo, so the constants differ among DisCos

Table 4-5.2 DisCo-wise Load Factor

DisCo	2012	2013	2014	2015	2016	2017	2018	2019	2020
Abuja	75	76	76	73	73	72	72	71	70
Benin	75	76	76	73	73	72	72	71	70
Enugu	75	76	76	73	73	72	72	71	70
Ibadan	75	76	76	73	73	72	72	71	70
Ikeja + EKO	75	76	76	73	73	72	72	71	70
Jos	75	76	76	73	73	72	72	71	70
Kaduna	75	76	76	73	73	72	72	71	70
Kano	75	76	76	73	73	72	72	71	70
Port Harcourt	75	76	76	73	73	72	72	71	70
Yola	75	76	76	73	73	72	72	71	70
Total	75	76	76	73	73	72	72	71	70

Source: JICA Study Team (after referring to the "MYTO II Model"
Note: The load factors from 2012 to 2014 are around 76% and decline progressively. After 2021, the load factors are 70%.

4-5-2 Number of Customers by DisCo

The populations by DisCo are calculated from the populations of 38 regions. The regional locations by DisCo are as shown in the following table:

Table 4-5.3 The location between regions and DisCos

DisCo names	State names distributed power				
Abuja	FCT(Abuja)	Nasarawa	Niger	Kogi	
Benin	Delta	Edo	Ekiti	Ondo	
Enugu	Abia	Anambra	Ebonyi	Enugu	Imo
Ibadan	Kwara	Ogun	Osun	Oyo	
IKEJA+EKO	Lagos				
Jos	Bauchi	Benue	Gombe	Plateau	
Kaduna	Kaduna	Kebbi	Sokoto	Zamfara	
Kano	Jigawa	Kano	Katsina		
P/H	Akwa Ibom	Bayelsa	Cross River	Rivers	
Yola	Adamawa	Borno	Taraba	Yobe	

Source: JICA Study Team (after referring to NBS documents)

Note: Benue State belongs to Jos DisCo
Source: TCN

Figure 4-5.1 Locations of Distribution companies (As of Jan. 2016)

DisCo-wise populations to sum up the regional population are as follows:

Table 4-5.4 DisCo-wise population forecasts

Unit: 1000 persons

DisCo	2014	2015	2020	2025	2030	2035	2040
Abuja	9,309	9,585	11,022	12,617	14,341	16,192	18,120
Benin	17,073	17,582	20,356	23,425	26,770	30,349	34,095
Enugu	20,030	20,480	22,795	25,287	27,903	30,558	33,299
Ibadan	19,600	20,193	23,361	26,848	30,646	34,710	39,036
Ikeja + EKO	11,631	11,971	13,811	15,844	18,061	20,417	22,894
Jos	22,495	23,122	26,418	30,065	33,992	38,184	42,595
Kaduna	20,551	21,105	24,030	27,200	30,594	34,220	38,010
Kano	25,114	25,846	29,783	34,140	38,877	43,902	49,190
Port Harcourt	17,779	18,320	21,190	24,377	27,809	31,486	35,361
Yola	14,935	15,319	17,330	19,526	21,907	24,382	26,945
Total	178,517	183,523	210,096	239,329	270,901	304,401	339,543

Source: JICA Study Team

The following table shows DisCo-wise electrification rates. The following electrification rates are estimated in line with the government target. Most of the targets for 100% electrification will be achieved by 2025.

Table 4-5.5 DisCo-wise electrification (Connection base)

Unit: %

DisCo	2006	2014	2015	2020	2025	2030	2035	2040
Abuja	45	54	57	76	100	100	100	100
Benin	59	80	82	90	100	100	100	100
Enugu	62	71	73	86	100	100	100	100
Ibadan	64	80	81	90	100	100	100	100
Ikeja + EKO	95	99	99	100	100	100	100	100
Jos	39	40	42	56	75	100	100	100
Kaduna	43	41	44	58	76	100	100	100
Kano	34	36	38	49	62	79	100	100
Port Harcourt	44	61	64	80	100	100	100	100
Yola	29	30	32	42	56	75	100	100
Total	50	57	59	71	85	95	100	100

Source: JICA Study Team

Using DisCo-wise population and the DisCo-wise electrification rate, DisCo-wise customers are calculated as shown in the following table:

Table 4-5.6 DisCo-wise customers

Unit: number of customers

		2014	2015	2020	2025	2030	2035	2040
Abuja customers	Residential	**667,537**	**728,276**	1,125,643	1,729,448	1,932,215	2,132,877	2,317,751
	Commercial	**84,029**	**90,822**	130,771	171,943	227,672	303,900	406,564
	Industry	**2,299**	**2,507**	3,717	4,793	6,282	8,355	11,195
	Special	**837**	**913**	1,354	1,747	2,292	3,050	4,089
	Light	**573**	**625**	924	1,147	1,406	1,715	2,077
	Total	**755,275**	**823,143**	1,262,408	1,909,077	2,169,867	2,449,897	2,741,676
Benin customers	Residential	**975,930**	**1,057,222**	1,528,726	1,945,739	2,183,292	2,415,711	2,628,996
	Commercial	**112,554**	**121,165**	170,878	220,054	289,468	384,114	511,104
	Industry	**5,551**	**5,998**	8,527	10,703	13,854	18,226	24,193
	Special	**2,217**	**2,396**	3,406	4,274	5,530	7,272	9,652
	Light	**170**	**183**	260	319	391	476	575
	Total	**1,096,422**	**1,186,964**	1,711,797	2,181,088	2,492,534	2,825,799	3,174,521
Enugu customers	Residential	**650,453**	**709,254**	1,057,040	1,367,664	1,462,964	1,538,165	1,591,283
	Commercial	**89,956**	**98,088**	146,336	192,508	254,610	337,085	444,313
	Industry	**9,327**	**10,170**	15,039	19,140	24,771	32,387	42,475
	Special	**827**	**903**	1,336	1,700	2,201	2,878	3,774
	Light	**164**	**179**	263	322	390	468	555
	Total	**750,727**	**818,594**	1,220,014	1,581,335	1,744,936	1,910,983	2,082,399
Ibadan customers	Residential	**1,222,429**	**1,339,782**	2,029,049	2,563,518	2,792,027	2,980,761	3,117,605
	Commercial	**357,901**	**391,830**	594,030	779,731	1,019,300	1,329,015	1,719,809
	Industry	**14,218**	**15,582**	23,512	29,876	38,255	49,304	63,530
	Special	**2,250**	**2,466**	3,722	4,730	6,056	7,805	10,057
	Light	**452**	**496**	744	905	1,079	1,270	1,475
	Total	**1,597,250**	**1,750,156**	2,651,056	3,378,760	3,856,716	4,368,154	4,912,476
Ikeja + Eko customers	Residential	**1,201,075**	**1,318,788**	1,961,521	2,182,382	2,376,290	2,526,137	2,625,939
	Commercial	**348,509**	**380,635**	568,330	725,047	942,911	1,222,532	1,572,781
	Industry	**3,035**	**3,326**	4,995	6,188	7,903	10,149	13,020
	Special	**5,558**	**6,089**	9,140	11,321	14,455	18,559	23,806
	Light	**185**	**204**	302	359	426	500	578
	Total	**1,558,362**	**1,709,042**	2,544,288	2,925,296	3,341,985	3,777,877	4,236,124
Jos customers	Residential	**369,105**	**406,759**	654,161	1,006,379	1,530,109	1,669,418	1,794,746
	Commercial	**48,575**	**54,685**	93,888	131,024	187,117	256,476	349,202
	Industry	**2,398**	**2,653**	4,201	5,574	7,691	10,320	13,897
	Special	**1,959**	**2,170**	3,433	4,560	6,298	8,456	11,393
	Light	**133**	**147**	231	291	370	451	544
	Total	**422,170**	**466,414**	755,914	1,147,828	1,731,585	1,945,121	2,169,782
Kaduna customers	Residential	**354,579**	**380,354**	549,069	839,008	1,262,462	1,376,424	1,478,643
	Commercial	**63,614**	**68,028**	93,701	122,160	164,106	215,669	284,668
	Industry	**4,562**	**4,855**	6,491	8,135	10,603	13,648	17,795
	Special	**3,484**	**3,707**	4,958	6,213	8,096	10,418	13,582
	Light	**1,716**	**1,825**	2,450	3,075	3,888	4,730	5,709
	Total	**427,955**	**458,769**	656,668	978,590	1,449,155	1,620,888	1,800,397
Kano customers	Residential	**510,659**	**559,529**	871,511	1,277,621	1,855,661	2,669,740	2,953,131
	Commercial	**33,883**	**37,129**	56,661	75,606	104,049	144,373	198,492
	Industry	**591**	**648**	979	1,263	1,700	2,330	3,188
	Special	**867**	**949**	1,436	1,850	2,489	3,409	4,662
	Light	**88**	**97**	145	179	225	281	347
	Total	**546,088**	**598,352**	930,732	1,356,519	1,964,124	2,820,133	3,159,819
P/H customers	Residential	**452,838**	**496,129**	770,991	1,122,502	1,255,488	1,385,451	1,505,561
	Commercial	**50,864**	**55,737**	85,120	113,948	153,266	206,855	278,750
	Industry	**838**	**919**	1,396	1,810	2,386	3,185	4,276
	Special	**3,919**	**4,298**	6,528	8,455	11,135	14,851	19,924
	Light	**9**	**10**	16	19	24	29	35
	Total	**508,468**	**557,093**	864,050	1,246,734	1,422,299	1,610,372	1,808,545
Yola customers	Residential	**287,999**	**314,236**	484,228	734,017	1,103,495	1,642,733	1,785,575
	Commercial	**24,943**	**27,195**	40,656	54,140	74,341	102,992	140,624
	Industry	**1,948**	**2,125**	3,152	4,062	5,460	7,473	10,155
	Special	**1,181**	**1,288**	1,913	2,464	3,310	4,527	6,150
	Light	**22**	**24**	36	44	55	70	85
	Total	**316,093**	**344,868**	529,984	794,726	1,186,662	1,757,795	1,942,589
Total	Residential	6,692,604	7,310,329	11,031,937	14,768,279	17,754,002	20,337,417	21,799,231
	Commercial	1,214,828	1,325,314	1,980,371	2,586,160	3,416,840	4,503,011	5,906,305
	Industry	44,767	48,783	72,006	91,542	118,906	155,376	203,725
	Special	23,099	25,179	37,225	47,313	61,861	81,226	107,087
	Light	3,512	3,790	5,371	6,660	8,255	9,988	11,980
	Total	7,978,810	8,713,395	13,126,910	17,499,954	21,359,864	25,087,018	28,028,328

Source: JICA Study Team, the estimated number of customers in 2014 and 2015 are quoted from the "MYTO II Model"

When the previous table is rearranged by sector, the sector- and DisCo-wise customers are as follows:

Table 4-5.7 Sector-wise customer forecasts

Unit: number of customers

			2015	2020	2025	2030	2035	2040
Residential customers	1	Abuja	728,276	1,113,329	1,715,371	1,920,287	2,122,221	2,306,178
	2	Benin	1,057,222	1,512,649	1,927,943	2,168,153	2,402,067	2,614,005
	3	Enugu	709,254	1,042,045	1,351,017	1,449,035	1,525,814	1,577,986
	4	Ibadan	1,339,782	1,977,686	2,507,476	2,747,172	2,943,501	3,080,485
	5	Ikeja + EKO	1,318,788	1,913,515	2,132,688	2,336,851	2,493,902	2,594,490
	6	Jos	406,759	643,552	994,135	1,519,015	1,659,520	1,783,973
	7	Kaduna	380,354	540,990	829,469	1,253,595	1,368,179	1,469,308
	8	Kano	559,529	865,395	1,270,757	1,849,612	2,664,080	2,946,790
	9	P /H	496,129	761,884	1,112,184	1,246,706	1,377,502	1,496,762
	10	Yola	314,236	479,768	728,937	1,098,900	1,638,249	1,780,364
		Total	7,310,329	10,850,811	14,569,977	17,589,327	20,195,033	21,650,340
Commercial customers	1	Abuja	90,822	142,646	185,438	238,934	313,662	416,754
	2	Benin	121,165	185,966	236,659	303,294	396,035	523,434
	3	Enugu	98,088	159,948	207,484	266,730	347,098	454,067
	4	Ibadan	391,830	643,364	833,300	1,061,435	1,362,696	1,751,494
	5	Ikeja + EKO	380,635	615,269	773,510	980,995	1,252,984	1,601,525
	6	Jos	54,685	103,814	142,400	197,190	265,040	357,920
	7	Kaduna	68,028	101,050	130,656	171,656	222,120	291,240
	8	Kano	37,129	62,549	82,187	109,776	149,597	204,150
	9	P /H	55,737	93,510	123,390	161,094	213,563	285,634
	10	Yola	27,195	44,660	58,660	78,300	106,617	144,499
		Total	1,325,314	2,152,775	2,773,685	3,569,405	4,629,412	6,030,718
Industry customers	1	Abuja	2,507	4,046	5,197	6,723	8,930	12,083
	2	Benin	5,998	9,235	11,549	14,780	19,436	26,063
	3	Enugu	10,170	16,313	20,668	26,418	34,509	45,690
	4	Ibadan	15,582	25,279	32,002	40,570	52,332	68,127
	5	Ikeja + EKO	3,326	5,375	6,622	8,377	10,769	13,961
	6	Jos	2,653	4,578	6,048	8,244	11,039	15,003
	7	Kaduna	4,855	6,925	8,688	11,252	14,496	19,102
	8	Kano	648	1,072	1,375	1,827	2,499	3,453
	9	P /H	919	1,522	1,965	2,555	3,405	4,614
	10	Yola	2,125	3,436	4,410	5,855	8,005	10,983
		Total	48,783	77,782	98,523	126,601	165,420	219,079
Special customers	1	Abuja	913	1,474	1,895	2,453	3,260	4,414
	2	Benin	2,396	3,688	4,611	5,899	7,755	10,396
	3	Enugu	903	1,449	1,836	2,347	3,065	4,058
	4	Ibadan	2,466	4,002	5,066	6,423	8,285	10,786
	5	Ikeja + EKO	6,089	9,835	12,114	15,321	19,693	25,526
	6	Jos	2,170	3,743	4,949	6,750	9,044	12,298
	7	Kaduna	3,707	5,290	6,634	8,591	11,066	14,580
	8	Kano	949	1,572	2,015	2,674	3,657	5,050
	9	P /H	4,298	7,118	9,175	11,919	15,872	21,497
	10	Yola	1,288	2,085	2,674	3,549	4,850	6,651
		Total	25,179	40,255	50,969	65,926	86,547	115,257
Light customers	1	Abuja	625	913	1,176	1,469	1,824	2,247
	2	Benin	183	258	327	408	506	622
	3	Enugu	179	259	329	406	496	598
	4	Ibadan	496	725	916	1,116	1,341	1,584
	5	Ikeja + EKO	204	295	363	441	528	621
	6	Jos	147	228	297	387	479	588
	7	Kaduna	1,825	2,414	3,143	4,060	5,027	6,167
	8	Kano	97	144	184	235	300	376
	9	P /H	10	15	20	25	31	38
	10	Yola	24	35	45	58	74	93
		Total	3,790	5,286	6,800	8,605	10,605	12,934
Total customers	1	Abuja	823,143	1,262,408	1,909,077	2,169,867	2,449,897	2,741,676
	2	Benin	1,186,964	1,711,797	2,181,088	2,492,534	2,825,799	3,174,521
	3	Enugu	818,594	1,220,014	1,581,335	1,744,936	1,910,983	2,082,399
	4	Ibadan	1,750,156	2,651,056	3,378,760	3,856,716	4,368,154	4,912,476
	5	Ikeja + EKO	1,709,042	2,544,288	2,925,296	3,341,985	3,777,877	4,236,124
	6	Jos	466,414	755,914	1,147,828	1,731,585	1,945,121	2,169,782
	7	Kaduna	458,769	656,668	978,590	1,449,155	1,620,888	1,800,397
	8	Kano	598,352	930,732	1,356,519	1,964,124	2,820,133	3,159,819
	9	P /H	557,093	864,050	1,246,734	1,422,299	1,610,372	1,808,545
	10	Yola	344,868	529,984	794,726	1,186,662	1,757,795	1,942,589
		Total	8,713,395	13,126,910	17,499,954	21,359,864	25,087,018	28,028,328

Source: Customer numbers in 2014 and 2015 are quoted from MYTO, others are estimated by the JICA Study Team.

4-5-3 Regional Survey on Power Demand

The regional survey was implemented by TCN and DisCos in 2016 and collects not only the actual power supply but also desirable power supply and Off-grid demand in future. The results are as follows:

Table 4-5.8 The results of the regional survey in 2016

	C	D	E	F	G	H
NAME OF DisCo	DisCo LOAD DEMAND FROM 2016 FIELD MEASURENT	HISTORIC 33kVPEAK LOAD COLLECTED IN 2016	DisCo ESTIMATE ON-GRID SUPPRESSED LOAD	DisCo ESTIMATED Off-grid SUPPRESSED (POTENTIAL) LOAD	Potential demand On-grid in 2016	Potential demand On + Off in Future
AEDC	762	577	270	381	1,033	1,414
BEDC	1,223	777	163	221	1,386	1,607
EEDC	1,027	803	380	287	1,406	1,694
IBEDC	1,286	1,119	184	280	1,470	1,749
IKEDC+EKEDC	2,566	1,834	683	716	3,249	3,965
JEDC	399	416	44	143	443	586
KAEDCO	602	632	93	342	695	1,037
KEDCO	708	514	187	224	895	1,119
PHEDC	948	885	130	230	1,078	1,308
YOLA	280	305	35	365	315	679
TOTAL	9,801	7,861	2,169	3,188	11,969	15,157
Demand with Coincidence factor 90%	8,821	7,075	1,952	2,869	10,772	13,641

Source: TCN

Note: Coincidence factor is the probability of the peak demands of DisCos coinciding.

< Explanation of column titles >

C: DisCo-wise estimated power demand (Computed data).

D: DisCo-wise estimated power demand at 33kV.

E: DisCo-wise On-grid estimated power shortage.

F: DisCo-wise power estimated potential by Off-grid.

G: = C + E

H: = C + E + F

< Ratio between actual supply and potential demand in 2016>

(A) Actual peak supply in 2016 : 5,074 MW

(B) Estimated potential demand : 10,772 MW

(C) The ratio of (A) / (B) : 47%

4-5-4 Power Demand Forecasts by DisCo

Sectoral and DisCo-wise power demand in the base case are calculated by dividing the sectoral country power demand by the DisCo-wise sector power demand using their number of customers as the denominator. The results are as follows:

Table 4-5.9 Power demand forecasts by DisCo

			2015	2020	2025	2030	2035	2040
On-grid	1	Abuja	5,305	8,892	19,901	34,697	53,067	79,075
Power demand	2	Benin	7,123	9,457	14,272	20,022	24,608	29,457
Computed data	3	Enugu	7,224	9,160	12,856	15,921	17,281	18,345
GWh	4	Ibadan	7,550	10,945	17,606	26,287	34,391	43,915
	5	Ikeja + EKO	16,692	22,344	30,017	41,529	50,205	59,177
	6	Jos	2,274	3,065	4,978	8,326	9,157	9,830
	7	Kaduna	3,573	5,001	9,402	18,206	23,514	29,644
	8	Kano	4,598	7,248	13,190	24,761	40,804	55,426
	9	P/H	5,539	7,873	13,579	19,192	23,773	28,712
	10	Yola	1,616	2,286	4,097	7,580	12,284	14,599
		Total	61,494	86,270	139,898	216,522	289,083	368,179
On-grid + Off-grid	1	Abuja	885	1,611	3,606	6,287	9,616	14,328
Peak demand	2	Benin	1,189	1,714	2,586	3,628	4,459	5,338
Computed data	3	Enugu	1,206	1,660	2,330	2,885	3,131	3,324
MW	4	Ibadan	1,260	1,983	3,190	4,763	6,232	7,957
	5	Ikeja + EKO	2,786	4,049	5,439	7,525	9,097	10,723
	6	Jos	380	555	902	1,509	1,659	1,781
	7	Kaduna	596	906	1,704	3,299	4,261	5,371
	8	Kano	767	1,313	2,390	4,487	7,394	10,043
	9	P/H	924	1,427	2,460	3,477	4,308	5,203
	10	Yola	270	414	742	1,373	2,226	2,645
		Total	10,263	15,632	25,349	39,234	52,381	66,714
Country peak	Coincident 90%		9,237	14,069	22,814	35,310	47,143	60,042

Source: JICA Study Team

Note: The total in the table meets the country power demand of base case demand (TCN + Auto producers).

Table 4-5.10 Sectoral power demand by DisCo

Unit: %

		2020/15	2025/20	2030/25	2035/30	2040/35	2040/15
1	Abuja	12.7	17.5	11.8	8.9	8.3	11.8
2	Benin	7.6	8.6	7.0	4.2	3.7	6.2
3	Enugu	6.6	7.0	4.4	1.7	1.2	4.1
4	Ibadan	9.5	10.0	8.3	5.5	5.0	7.7
5	Ikeja + EKO	7.8	6.1	6.7	3.9	3.3	5.5
6	Jos	7.9	10.2	10.8	1.9	1.4	6.4
7	Kaduna	8.7	13.5	14.1	5.2	4.7	9.2
8	Kano	11.3	12.7	13.4	10.5	6.3	10.8
9	P/H	9.1	11.5	7.2	4.4	3.8	7.2
10	Yola	9.0	12.4	13.1	10.1	3.5	9.6
	Total	8.8	10.2	9.1	6.0	5.0	7.8
	Country	8.8	10.2	9.1	6.0	5.0	7.8

Source: JICA Study Team

The DisCo power demands including the above demand (TCN + Auto producers) and Off-grid are follows:

Table 4-5.11 DisCo-wise power demand (On + Off-grid)

			2015	2020	2025	2030	2035	2040
On-grid + Off-grid	1	Abuja	5,305	9,407	21,120	36,115	54,861	81,555
Power demand	2	Benin	7,123	9,993	15,341	21,272	26,195	31,660
Computed data	3	Enugu	7,224	9,990	14,539	17,822	19,613	21,484
GWh	4	Ibadan	7,550	11,568	18,848	27,738	36,232	46,472
	5	Ikeja + EKO	16,692	22,358	30,043	41,560	50,244	59,232
	6	Jos	2,274	4,496	8,378	13,575	15,764	18,932
	7	Kaduna	3,573	6,296	12,424	22,785	29,253	37,518
	8	Kano	4,598	8,757	16,632	29,862	49,011	66,783
	9	P/H	5,539	8,857	15,802	21,787	27,066	33,280
	10	Yola	1,616	3,133	6,086	10,619	17,329	21,485
		Total	61,494	94,855	159,214	243,135	325,568	418,400
On-grid + Off-grid	1	Abuja	885	1,779	3,987	6,806	10,327	15,308
Peak demand	2	Benin	1,189	1,811	2,807	3,928	4,871	5,904
Computed data	3	Enugu	1,206	1,786	2,617	3,276	3,668	4,062
MW	4	Ibadan	1,260	2,106	3,470	5,144	6,754	8,676
	5	Ikeja + EKO	2,786	4,363	6,155	8,500	10,433	12,562
	6	Jos	380	618	1,045	1,703	1,926	2,149
	7	Kaduna	596	1,056	2,045	3,764	4,898	6,249
	8	Kano	767	1,412	2,614	4,792	7,813	10,620
	9	P/H	924	1,527	2,690	3,790	4,736	5,792
	10	Yola	270	574	1,107	1,870	2,906	3,582
		Total	10,263	17,032	28,537	43,574	58,331	74,904
Country peak	Coincident 90%		9,393	15,469	25,964	39,650	53,093	68,232

Source: JICA Study Team

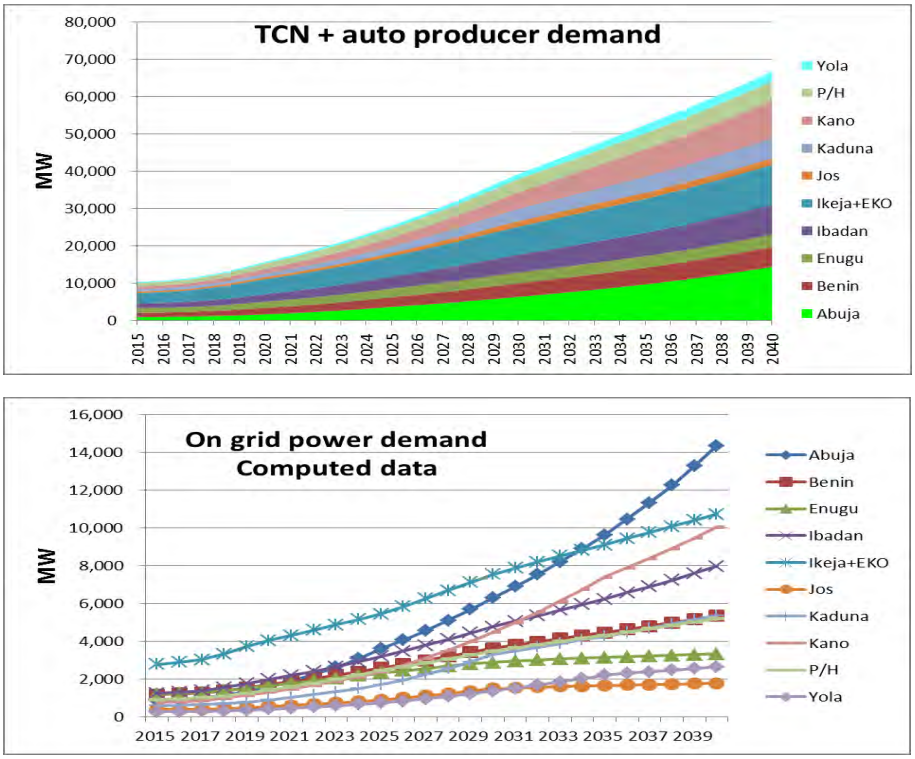
Note: The total is the base case domestic demand including "TCN+ Auto producers + Off-grid"

Table 4-5.12 Growth rate of DisCo-wise power demand (On + Off-grid)

Unit: %

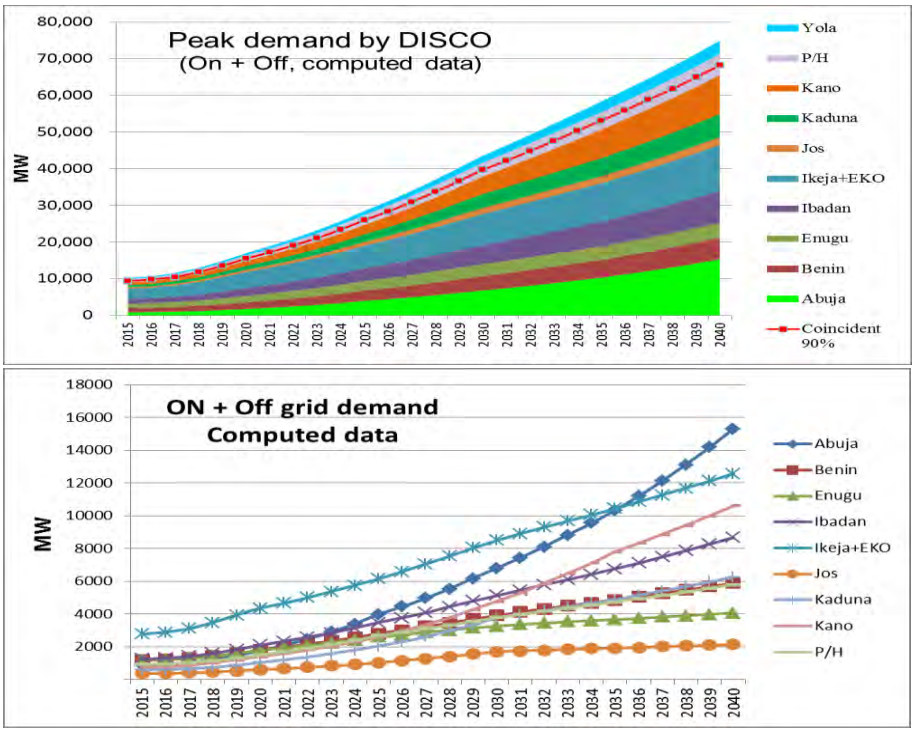
		2020/15	2025/20	2030/25	2035/30	2040/35	2040/15
1	Abuja	15.0	17.5	11.3	8.7	8.2	12.1
2	Benin	8.8	9.2	7.0	4.4	3.9	6.6
3	Enugu	8.2	7.9	4.6	2.3	2.1	5.0
4	Ibadan	10.8	10.5	8.2	5.6	5.1	8.0
5	Ikeja + EKO	9.4	7.1	6.7	4.2	3.8	6.2
6	Jos	10.2	11.1	10.3	2.5	2.2	7.2
7	Kaduna	12.1	14.1	13.0	5.4	5.0	9.9
8	Kano	13.0	13.1	12.9	10.3	6.3	11.1
9	P/H	10.6	12.0	7.1	4.6	4.1	7.6
10	Yola	16.3	14.0	11.1	9.2	4.3	10.9
	Total	10.7	10.9	8.8	6.0	5.1	8.3
	Country	10.5	10.9	8.8	6.0	5.1	8.3

Source: JICA Study Team



Source: JICA Study Team

Figure 4-5.2 DisCo-wise power demand (TCN + Auto producers)



Source: JICA Study Team

Figure 4-5.3 DisCo-wise power demand (TCN + Auto producers + Off-grid)

Power consumption per capita is as shown in the following table: The top table shows (TCN + Auto producer demand) / Population and the lower table shows (On + Off-grid demand) / Population) by DisCo

Table 4-5.13 Power consumption per capita by DisCo

Unit: kWh / person

			2015	2020	2025	2030	2035	2040
TCN+Auto producer	1	Abuja	553	807	1,577	2,419	3,277	4,364
kWh/ person	2	Benin	405	465	609	748	811	864
Computed data	3	Enugu	353	402	508	571	566	551
	4	Ibadan	374	469	656	858	991	1,125
	5	Ikeja + EKO	1,394	1,618	1,895	2,299	2,459	2,585
	6	Jos	98	116	166	245	240	231
	7	Kaduna	169	208	346	595	687	780
	8	Kano	178	243	386	637	929	1,127
	9	P/H	302	372	557	690	755	812
	10	Yola	106	132	210	346	504	542
	Country average		335	411	585	799	950	1,084
			2015	2020	2025	2030	2035	2040
On-grid + Off-grid	1	Abuja	550	850	1,670	2,520	3,390	4,500
kWh/ person	2	Benin	410	490	650	790	860	930
Computed data	3	Enugu	350	440	570	640	640	650
	4	Ibadan	370	500	700	910	1,040	1,190
	5	Ikeja + EKO	1,390	1,620	1,900	2,300	2,460	2,590
	6	Jos	100	170	280	400	410	440
	7	Kaduna	170	260	460	740	850	990
	8	Kano	180	290	490	770	1,120	1,360
	9	P/H	300	420	650	780	860	940
	10	Yola	110	180	310	480	710	800
	Country average		340	450	670	900	1,070	1,230

Source: JICA Study Team

Table 4-5.14 Growth rate of power demand per capita (On + Off)

Unit: %

		2020/15	2025/20	2030/25	2035/30	2040/35	2040/15
1	Abuja	9.1	14.5	8.6	6.1	5.8	8.8
2	Benin	3.6	5.8	4.0	1.7	1.6	3.3
3	Enugu	4.7	5.3	2.3	0.0	0.3	2.5
4	Ibadan	6.2	7.0	5.4	2.7	2.7	4.8
5	Ikeja + EKO	3.1	3.2	3.9	1.4	1.0	2.5
6	Jos	11.2	10.5	7.4	0.5	1.4	6.1
7	Kaduna	8.9	12.1	10.0	2.8	3.1	7.3
8	Kano	10.0	11.1	9.5	7.8	4.0	8.4
9	P/H	7.0	9.1	3.7	2.0	1.8	4.7
10	Yola	10.4	11.5	9.1	8.1	2.4	8.3
	Country average	5.8	8.3	6.1	3.5	2.8	5.3

Source: JICA Study Team

< Further note: Difference between Country total and DisCo total >

The nationwide power demand for the base case in 2040 is 60,042MW (TCN+ Auto producers) as Table 4-4.12. Otherwise, the total power demand of all DisCos is 66,714MW in Table 4-5.9. Since the individual peak demands of DisCos do not coincide, there is scope to use the coincidence factor to calculate from the total DisCo peak to the country peak. The value at 90% is suitable for the coincidence factor, because the coincidence factor with 90% is used in the TCN demand survey implemented in 2016. The DisCo total calculated by the 90% coincidence factor is 60,043MW (= 66,714MW*0.9), which is nearly equivalent to the peak nationwide demand (TCN + Auto producers).

4-6 Power Demand Forecasts for Power System Design

4-6-1 Constraints on Plant Designs

The Study Team met with Nigerian counterparts to discuss how to set the future power load as part of planning for facilities to realize the Master Plan. During the meeting, the following concerns were pointed out by TCN who own and maintain the existing facilities:

- Given that the current TCN has limited fund resources, transmission capacity will be not caught to power generation, even though the generation capacity is built up as much as the future power demand in the base case.
- Some DisCos have load rejection policies (meaning some DisCos reject receiving the power from TCN). Under current circumstances, whereby DisCo activities in the power supply chains are subject to a bottleneck, some portions of the supplied power may not be consumed by final customers due to previous rejection policies. This will not be so easy to solve, despite investments made in generation and transmission.
- Although DisCos have been already privatized in Nigeria, the tariff collection rate remains comparatively low amid difficulty in obtaining capital procurements for current DisCos. Accordingly, efforts to enhance distribution networks appear challenging.

To implement the scenario in line with the “base case”, TCN should clarify the above agendas, including investment funds and the abovementioned difficulties in the power sector.

When considering a future decentralized-type power supply system based on prevailing renewable energy sources in Nigeria, the Nigerian domestic power demand for meeting the “base case” should be totalized by two supply systems; one of which TCN supply and another the decentralized power supply.

Given the numerous agendas and difficulties as above mentioned, it is preferable to select the “Low case” demand for the future power load of the Master Plan, with the remaining differences between the base case and Low case attributable to decentralized power systems in Nigeria in future. The working group has discussed the above alternatives and ultimately agreed to select the power demands of the Low case.