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

Methodology and procedure of updating Generation Expansion Plan

February 2017

Technical Working Group

1. Introduction

- This manual covers the process and methodology of updating the generation expansion plan of National Power System Development (Master Plan).
- The least cost generation expansion plans will be formulated through simulation using WASP software. For details of WASP software, its manual can be referred and the description of how to use WASP is not included in this manual.
- Federal Ministry of Power, Works and Housing (FMPWH) is responsible for updating the generation expansion plan in cooperation with related agencies such as Nigerian Electricity Regulatory Commission (NERC), Transmission Company of Nigeria (TCN), Energy Commission of Nigeria (ECN), Nigeria Bulk Electricity Trading Plc (NBET), Gas Aggregation Company of Nigeria (GACN), Nigeria Gas Company (NGC), etc.

2. Flow of updating generation expansion plan

STEP-1: Data collection and update
(1) Power demand forecast
(2) Characteristics of existing power plants
(3) Ongoing and planned generation expansion (Fixed expansion)
(4) Variable expansion candidates (thermal and hydro)
(5) Fuel price, availability and reserve
(6) Power development policy

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STEP-2: WASP simulation using updated data and generation expansion scenarios, if any change is required

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STEP-3: Evaluation of generation expansion scenarios from the aspects of (1) total generation cost, (2) energy balance/sustainability and (3) environment

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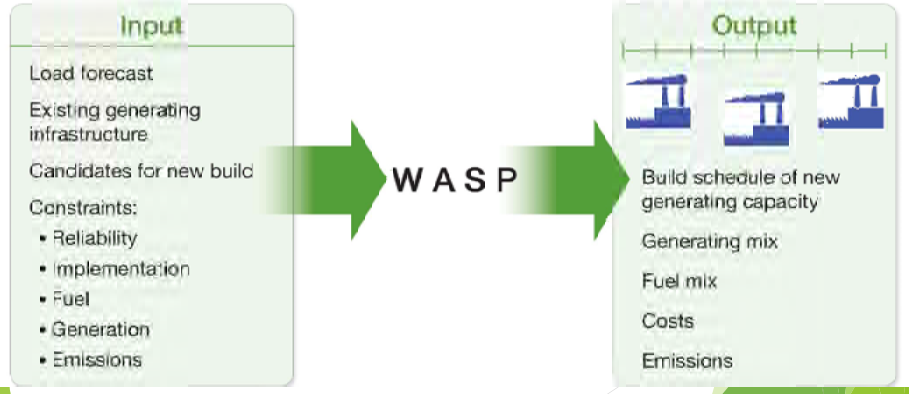
STEP-4: Formulation of revised generation expansion plan

[Reference] What is WASP?

WASP
Wien Automatic System Planning Package



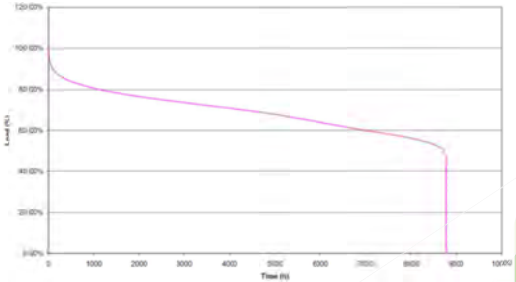
Source: IAEA (Aug.2009) "Tools and Methodologies for Energy System Planning and Nuclear Energy System Assessments"

2. Data collection and update

Type of data and information	Responsible organization						
	FMPWH	TCN	NERC	GENCOs	NBET	GACN	NGC
Power demand forecast		Update power demand forecast and load duration curve					
Characteristics of existing power plants				Update the characteristics of existing power plants			
Ongoing and planned generation expansion	Update the status of ongoing and planned generation expansion	Update the status of ongoing and planned generation expansion	Update the status of ongoing and planned generation expansion (IPP)		Update the status of ongoing and planned generation expansion (IPP)		
Variable expansion candidates	Update the variable expansion candidates						
Fuel price, availability and reserve						Update the fuel price, availability and reserve	Update the fuel price, availability and reserve
Power development policy	Update power development policy						

2.1 Power demand forecast

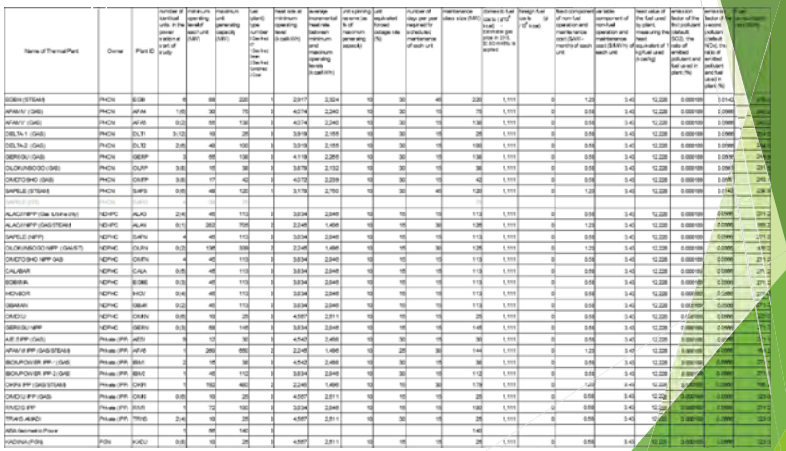
- Power demand forecast for nation-wide, grid connected customers shall be updated by TCN. Peak demand (MW) and energy demand (GWh) for each year of the planning period as well as monthly variation of the highest peak demand from January to December are necessary as the input data for WASP.
- Load duration curve which is represented the following figure is also an input of Loadsy (load system description) module of WASP and needs to be updated using the hourly load of the latest year.



Load duration curve

2.2 Characteristics of existing power plants

- Characteristics of existing thermal and hydro power plants, as shown in the following table needs to be updated. The information shall be collected by questionnaires to generation companies.



2.3 Ongoing and planned generation expansion

- Progress status of ongoing and planned generation projects need to be updated in order to evaluate how sure and when they will be online. Committed projects are treated as “fixed expansion” in WASP while projects in initial planning stages are deemed as “variable expansion” which commissioning year and required capacity are determined by WASP.

2.4 Variable expansion candidates
(1) Thermal power plants

- Variable expansion candidates for thermal power plants as shown in the following table will be updated if any other or different type of plants are applicable.

Plant type	Capacity	Efficiency	Cost	Plant life
Simple cycle gas turbine	100MW class	30.8%	$980/kW	30 years
	200MW class	34.7%	$680/kW	30 years
Combined cycle	300MW class	51.4%	$980/kW	30 years
	500MW class	54.0%	$941/kW	30 years
	1,000MW class	55.1%	$842/kW	30 years
Coal fired conventional	300MW class	40.7%	$2,500/kW	40 years
	700MW class	42.1%	$2,000/kW	40 years
	1,000MW class	43.0%	$2,000/kW	40 years

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2.4 Variable expansion candidates
(2) Hydro power plants

- Potential hydro sites which are identified through a study named “Screening for Hydropower Options with Associated Water Resources Development in the Niger Basin” assisted by the World Bank and conducted by Tractebel Engineering was used for the Project. Out of 64 sites identified by the WB study, 20 to 30 sites which have high ranking scores and large capacity were selected for hydro candidates for the Project.

No.		Hydropower Station	Plant ID	Type	Installed Capacity (MW)	Operation Records: Monthly output(MWh) Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Output (MWh)
1	Prospecting sites(Large Scale)	NIG03	NIG3	R.Dam	190	65,793	39,530	22,839	17,543	38,672	74,962	96,750	96,750	93,629	96,750	93,629	96,750	833,600
2		NIG02	NIG2	R.Dam	266	92,275	59,588	31,550	13,240	19,722	38,792	84,230	195,535	189,227	195,535	133,365	110,640	1,163,700
4		BEN05-85	BEN5	Dam	239	36,322	16,173	12,335	22,506	62,456	129,354	135,563	138,867	134,387	138,867	134,387	86,586	1,047,800
3		BEN06-85	BEN6	Dam	265	39,031	17,379	13,255	24,184	67,114	139,001	155,667	155,667	150,646	155,667	150,646	93,043	1,161,300
5		BEN07	BEN7	RoR	196	34,113	16,605	12,068	18,771	50,277	100,298	111,305	111,305	107,714	111,305	107,714	75,227	856,700
6		DON05	DON5	Dam	198	26,869	11,067	20,615	52,814	97,617	94,468	97,617	97,617	94,468	97,617	94,468	80,062	865,300
7		BEN01-185	BEN1	Dam	203	28,449	13,270	6,159	5,458	21,445	56,600	140,525	140,525	135,992	140,525	135,992	63,458	888,400
8		NIG01	NIG1	Dam	134	60,764	54,884	33,164	13,916	20,730	40,776	60,764	60,764	58,804	60,764	58,804	60,764	584,900
9		BEN03	BEN3	Dam	101	20,387	9,179	548	6,370	20,800	52,102	57,937	57,937	56,068	57,937	56,068	45,667	441,000
1	Prospecting sites(Middle Scale)	BEN04-85	BEN4	RoR	88	17,754	7,994	4,235	5,547	18,113	4,550	61,516	61,516	59,532	61,516	42,060	39,769	384,188
2		KAT04	KAT4	RoR	36	4,590	1,761	2,630	6,664	16,753	18,221	18,829	18,829	18,221	18,829	18,221	13,552	157,100
3		KAT07	KAT7	Dam	52	6,648	2,550	3,810	9,653	24,268	26,695	27,585	27,585	26,695	27,585	26,695	19,631	229,400
4		BEN02	BEN2	RoR	35	15,524	8,705	4,043	3,498	13,764	15,023	15,524	15,524	15,023	15,524	15,023	15,524	152,700
5		KAT02	KAT2	Dam	67	8,357	3,206	4,790	12,135	30,506	34,611	35,765	35,765	34,611	35,765	34,611	24,677	294,800
6		TAR12	TR12	Dam	77	3,008	849	513	2,796	8,974	21,422	57,065	57,065	55,224	57,065	36,226	10,324	336,000
7		DON09	DON9	Dam	33	6,024	2,772	2,044	3,798	8,643	17,279	18,395	18,395	17,801	18,395	17,801	13,155	144,500
8		ANK13	AK13	RoR	20	5,084	3,239	2,063	12,208	2,576	3,081	8,387	11,425	11,057	11,425	11,057	7,899	89,500
9		TAR08	TAR8	Dam	38	9,538	4,388	3,235	6,013	13,683	17,894	18,490	18,490	17,894	18,490	17,894	18,490	164,500
10		TAR10	TR10	Dam	58	1,438	394	131	379	3,050	7,969	24,138	32,800	41,544	29,069	17,330	4,924	251,800
11		TAR06	TAR6	Dam	31	1,218	344	208	1,132	3,634	8,675	22,692	22,692	21,960	22,692	14,671	4,181	133,400
12		GON10-300	GN10	Dam	24	1,258	1,014	487	217	412	4,347	17,146	18,154	17,568	14,202	9,238	4,380	106,800
13		DON12	DN12	Dam	45	1,388	392	237	1,290	4,140	9,882	29,609	33,331	32,256	33,331	16,712	4,763	196,300
14		MAD05-360	MAD5	Dam	29	9,436	6,012	3,828	2,675	4,781	5,719	15,568	16,242	15,718	16,242	15,718	14,662	126,600
13		DON04	DON4	Dam	56	2,443	690	416	2,270	7,288	17,397	41,441	41,441	40,104	41,441	29,421	5,496	240,911
14		DON11	DN11	RoR	21	898	251	152	827	2,655	6,338	15,252	15,252	14,760	15,252	10,718	3,055	89,900

No.	Hydropower Station	Monthly Availability(MW) Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	O&M Cost ($/kW.month) as of 2015	Construction Features as of 2016: Project Cost (M USD)	Construction Period (Year)	COD	Plant Life (Year)
1	NIG03	129	86	45	36	76	152	190	190	190	190	190	190		231	5 (+5)	2026	50
2	NIG02	125	90	43	19	27	54	114	266	266	266	187	150		323	5 (+5)	2026	50
4	BEN05-85	63	31	21	40	108	230	234	239	239	239	239	149		458	5 (+5)	2026	50
3	BEN06-85	66	33	23	43	114	245	265	265	265	265	265	158		520	4 (+5)	2025	50
5	BEN07	60	32	21	34	88	182	196	196	196	196	196	132		396	5 (+5)	2026	50
6	DON05	54	25	42	110	198	198	198	198	198	198	198	162		414	4 (+5)	2025	50
7	BEN01-185	41	21	9	8	31	84	203	203	203	203	203	92		474	5 (+5)	2026	50
8	NIG01	134	134	73	32	46	93	134	134	134	134	134	134		448	4 (+5)	2025	50
9	BEN03	35	18	1	11	36	94	101	101	101	101	101	79		850	6 (+5)	2027	50
1	BEN04-85	25.31	12.62	6.04	8.17	25.82	6.70	87.70	87.70	87.70	87.70	61.96	56.70		146	3 (+3)	2022	50
2	KAT04	8.75	3.72	5.02	13.13	31.94	35.90	35.90	35.90	35.90	35.90	35.90	25.84		100	3 (+3)	2022	50
3	KAT07	12.63	5.36	7.24	18.95	46.10	52.40	52.40	52.40	52.40	52.40	52.40	37.29		147	3 (+3)	2022	50
4	BEN02	34.90	21.67	9.09	8.13	30.94	34.90	34.90	34.90	34.90	34.90	34.90	34.90		100	4 (+3)	2023	50
5	KAT02	15.73	6.68	9.01	23.60	57.40	67.30	67.30	67.30	67.30	67.30	67.30	46.44		347	3 (+3)	2022	50
6	TAR12	3.63	1.14	0.62	3.49	10.84	26.74	76.70	76.70	76.70	76.70	45.23	12.47		444	3 (+3)	2022	50
7	DON09	10.81	5.50	3.67	7.04	15.51	32.03	33.00	33.00	33.00	33.00	33.00	23.60		308	3 (+3)	2022	50
8	ANK13	9.08	6.40	3.68	20.40	4.60	5.68	14.98	20.40	20.40	20.40	20.40	14.10		255	3 (+3)	2022	50
9	TAR08	19.39	9.88	6.58	12.63	27.82	37.60	37.60	37.60	37.60	37.60	37.60	37.60		670	4 (+3)	2023	50
10	TAR10	1.04	0.32	0.09	0.28	2.21	5.96	17.47	44.09	57.70	39.07	12.96	3.56		2,006	7 (+3)	2026	50
11	TAR06	1.48	0.46	0.25	1.43	4.43	10.92	30.50	30.50	30.50	30.50	18.47	5.09		1,083	5 (+3)	2024	50
12	GON10-300	2.13	1.90	0.83	0.38	0.70	7.62	16.84	24.40	24.40	[illegible]	16.19	7.43		2,983	7 (+3)	2026	50
13	DON12	1.44	0.45	0.25	1.39	4.30	10.62	30.78	44.80	44.80	44.80	17.95	4.95		1,634	7 (+3)	2026	50
14	MAD05-360	16.79	11.84	6.81	4.92	8.51	10.51	27.70	28.90	28.90	28.90	28.90	26.09		3,592	7 (+3)	2026	50
13	DON04	3.08	0.96	0.52	2.95	9.18	22.64	55.70	55.70	55.70	55.70	38.29	10.56		2,430	5 (+3)	2024	50
14	DON11	1.11	0.35	0.19	1.06	3.29	8.13	20.33	20.33	20.33	20.33	13.74	3.79		2,010	5 (+3)	2024	50

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2.5 Fuel price, availability and reserve
2.6 Power development policy

- Gas price, gas allocation to power generation and natural gas reserve will be updated by GACN and NGC.
- Any change in power development policy such as the promotion of renewable energy, coal fired power and nuclear power shall be incorporated into the revision of power development plan.

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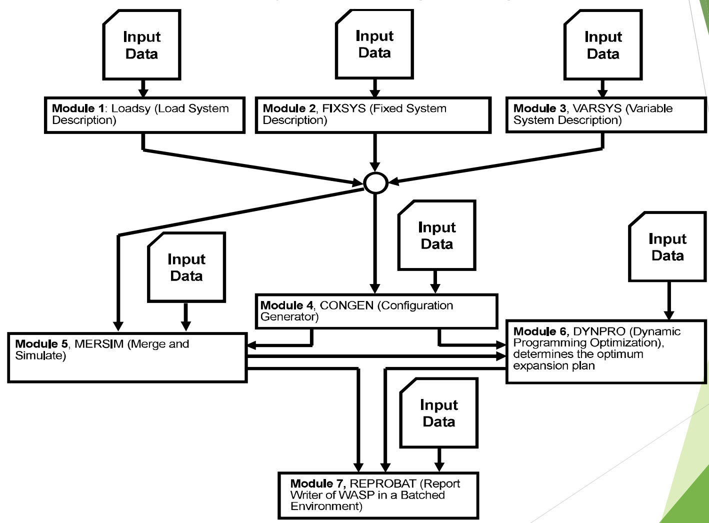
3. WASP simulation

- Updated data will be used for WASP simulation to obtain the revised least cost generation expansion plan.



Source: WASP IV User's Manual

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Function of WASP modules

- Module 1: Loadsy (Load System Description), processes information describing period peak loads and load duration curves for the power system over the study period.
- Module 2, FIXSYS (Fixed System Description), processes information describing the existing generation system and any predetermined additions or retirements, as well as information on any constraints imposed by the user on environmental emissions, fuel availability or electricity generation by some plants.
- Module 3, VARSYS (Variable System Description), processes information describing the various generating plants which are to be considered as candidates for expanding the generation system.
- Module 4, CONGEN (Configuration Generator), calculates all possible year-to-year combinations of expansion candidate additions which satisfy certain input constraints and which in combination with the fixed system can satisfy the loads. CONGEN also calculates the basic economic loading order of the combined list of FIXSYS and VARSYS plants.
- Module 5, MERSIM (Merge and Simulate), considers all configurations put forward by CONGEN and uses probabilistic simulation of system operation to calculate the associated production costs, energy-not-served and system reliability for each configuration. In the process, any limitations imposed on some groups of plants for their environmental emissions, fuel availability or electricity generation are also taken into account. The dispatching of plants is determined in such a way that plant availability, maintenance requirement, spinning reserve requirements and all the group-limitations are satisfied with minimum cost. MERSIM can also be used to simulate the system operation for the best solution provided by the current DYNPRO run and in this mode of operation is called REMERSIM.
- Module 6, DYNPRO (Dynamic Programming Optimization), determines the optimum expansion plan based on previously derived operating costs along with input information on capital costs, energy-not-served cost and economic parameters and reliability criteria.
- Module 7, REPROBAT (Report Writer of WASP in a Batched Environment), writes a report summarizing the total or partial results for the optimum or near optimum power system expansion plan and for fixed expansion schedules.

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4. Update of generation expansion plan
4.1 Evaluation of generation expansion scenarios

- Generation expansion scenarios as shown in the following table will be compared and evaluated from the aspects of cost (total generation cost), energy balance (sustainability and security of energy resources) and environment (amount of emission). If necessary, generation expansion scenarios will be modified or added.

	Capacity Share			Evaluation		
	Gas	Coal	Hydro and Renewable	Cost	Energy Balance	Environment
Scenario-1 (Conservative)	70%	10%	20%			
Scenario-2 (More coal)	60%	20%	20%			
Scenario-3 (No coal)	75%	0%	25%			

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4.2 Formulation of revised generation expansion plan

- The revised WASP simulation results indicate the updated least cost generation expansion plan. However, variable expansion candidates for thermal power plants do not have the information on their location and connection points to the grid.
- Therefore, they need to be allocated to specific projects which are included in IPP queue lists so that all the sites for expansion candidates are identified. This is necessary for power system analysis which follows the generation expansion plan.

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

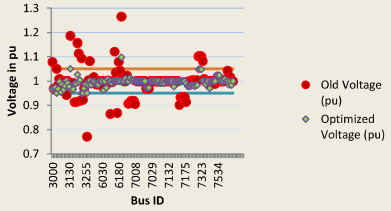
TWG on Transmission System Analysis

Feb 2017

By Engr. Nazif Abdulkadir
Sudipto Bhowmik

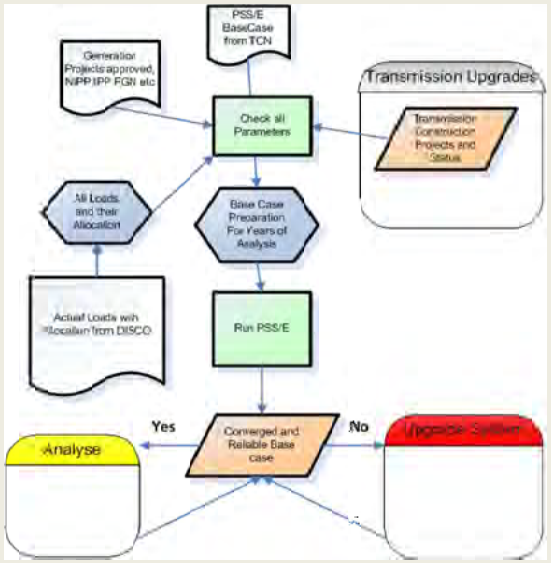
Overview

- Long term planning study
- Analysis consists of Steady state analysis
  - i. Powerflow
  - ii. Contingency analysis
  - iii. Reactive Study



- Cost based analysis and alternative Voltage Levels

Overall Process flowchart



Transmission System update procedure

Creation of starting year Base case

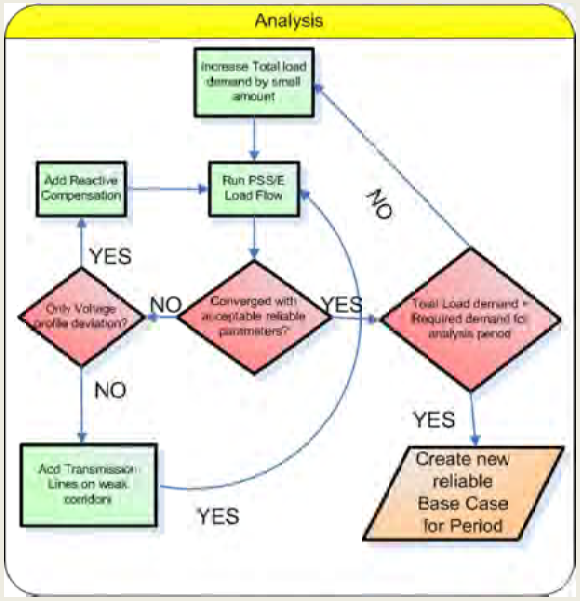
- Run preliminary power flow
- Check values and parameters

– **Transmission Upgrades**
  - Include the transmission upgrades scheduled by TCN and NIPP till year end for the year of analysis
  - Take into account risks such as legal or financial for calculating actual date of completion
  - Include the locations and type of conductor or transformers in the base case

– **Generation Upgrades**
  - Amount and location of new Generation for the year of analysis
  - Include all technical and financial constraints as risks for compleation of the final online status of the generation
  - Include the assumption that generation will participate in regulation by 10% of available capacity

– **Load Upgrades**
  - Amount and location of new Load for the year of analysis
  - Use the actual data collected from the DISCOS and their estimated load increase
  - Proportional load allocation to be included at all load buses

Analysis Process



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Technical Analysis procedure:

- **Incremental increase in Load at all buses**
  - Run power flow for convergence
  - Check results for indication of voltage or convergence failure
- **Voltage profile analysis**
  - Check values of voltages at all buses and ensure they fall within limits
  - Adjust by adding reactive compensation
- **Steady state convergence analysis**
  - Check flows and whether they fall within limits of lines and transformer ratings
  - Adjust by adding transmission lines and or upgrading transformers

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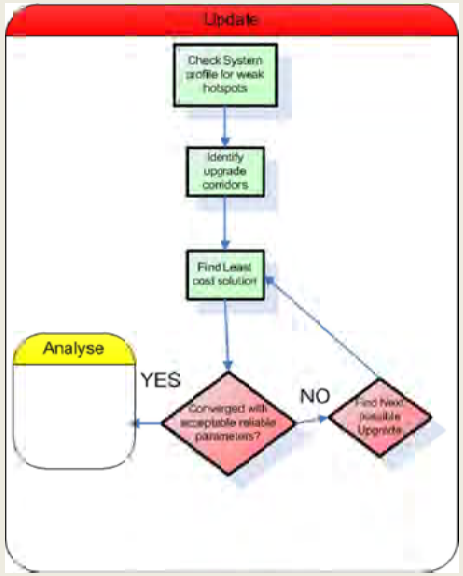
Upgrading of System



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Upgrade system procedure:

- **Include scheduled system upgrades**
  - Include transmission upgrades
  - Include transformer upgrades
  - Include substation upgrades
- **Incremental system upgrades**
  - For convergence create set of transmission upgrades based on weak corridors
  - Create viable sets based on incremental mitigation by including the upgrades
- **Cost analysis**
  - Perform cost based analysis of all set of viable transmission upgrades
  - Check viability of different technology such has higher voltages

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Working Group: Division of Labour

For updating the Transmission master plan the positioning and relationship with other organizations with the Transmission Analysis Working Group (hereinafter referred to as TAWG) are shown below.

Generation upgrades
Generation working group along with their associated representative. To be verified by TCN as well as NERC

Transmission Upgrades
TAWG along with TCN.

Load Upgrades
Load working group and DISCOs. TCN's data collection of load profile at all DISCO's will be used as reference as well as the future projected load along with its allocation.

System Analysis
Mostly performed by TAWG along with verification from TCN as well as NCC. NERC system criteria will be used as the reference limits

System Upgrades
TAWG ,with verification from TCN. The Substation WG will be used as reference. Costing, Right of Way impacts will require the Financial and Environmental WG respectively.

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Matrix of Organizations involved

Item	Related Agencies	Data Collection	Analysis method	Reference
Generation upgrades	TCN, FMPWH, Generation WG	IPP Generation Queue, New unscheduled projects	Determined by Generation WG	NBET generation applications, NERC generation applications
Transmission Upgrades	TCN, FMPWH,NDPHC	NIPP projects, NDPHC projects, TCN projects	Determined by TCN	NERC codes
Load Upgrades	TCN, FMPWH, Load WG	DISCO measured load, DISCO projected load	Determined by Load WG	DISCO published data, TCN data collection, LWG report
System Analysis	TCN, FMPWH	NERC codes and TCN system planning /operating criteria	Analysis performed and directed via PSS/E and system operating criteria	NERC criteria, JICA master plan criteria, TCN criteria
System Upgrades	TCN, FMPWH,Sub. WG, Env WG. Fin. WG	NERC codes and TCN system planning /operating criteria.	PSS/E and Least Cost method	NERC criteria, JICA master plan criteria, TCN Criteria

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THE PROJECT FOR MASTER PLAN STUDY ON NATIONAL POWER SYSTEM DEVELOPMENT

Environmental and Social Considerations (ESC)

Feb. 13, 2017

1

OUTLINE

Master Plan Revision Procedure:

1. What is Strategic Environmental Assessment (SEA) ?
2. SEA in power planning
3. SEA Process
4. How can be the Master Plan updated?

2

MASTER PLAN REVISION PROCEDURE

3

WHAT IS STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)?

Analytical and participatory approach that aims to integrate environmental considerations into policies, plans, and programs, and evaluate the inter linkages with economic and social considerations."

OECD/DAC, "Applying Strategic Environmental Assessment: good practice guidance for development cooperation" (2006)

- Overall process for SEA:
  - ✓ Investigate multiple scenarios to be compared
  - ✓ Investigate relevant cumulative impacts
  - ✓ Scoping of environmental and social impacts
  - ✓ Stakeholder meetings (as needed)

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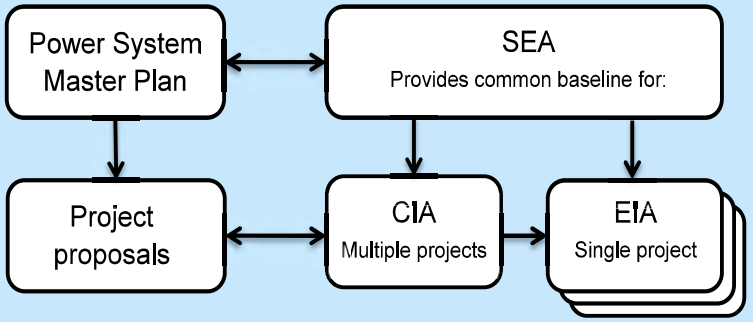
WHAT IS STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)?



Cumulative impact assessment (CIA) focuses on the combined impacts caused by one or more projects acting with existing or planned developments. SEA also considers cumulative impacts, but from a strategic policy or plan perspective.

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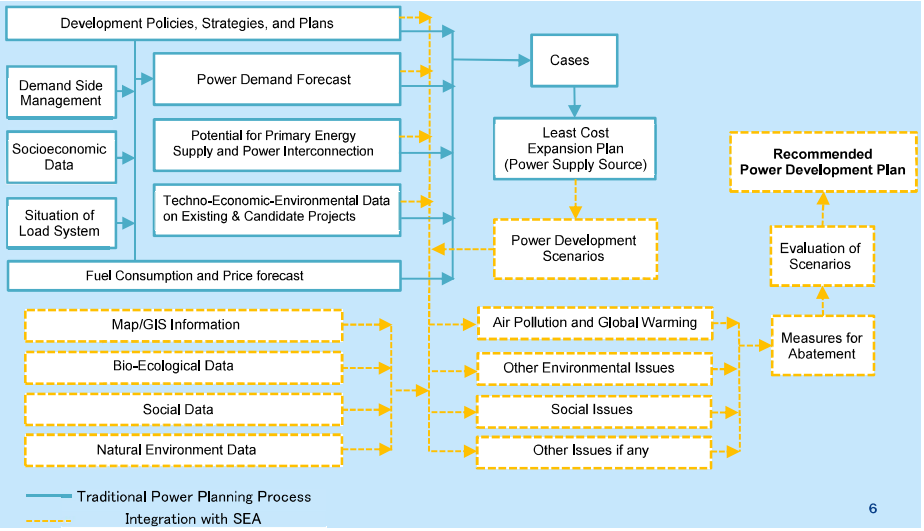
STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) IN POWER PLANNING



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HOW CAN BE THE MASTER PLAN UPDATED?

- Basic steps
  - ✓ In each stage of the process of SEA, TWG(ESC) (Technical Working Group for Environmental and Social Consideration) is to be formed with FMP, TCN and other relevant organizations for discussion, work assignment, and making consensus
  - ✓ Data review and interview with related organizations to update information
  - ✓ Stakeholder meetings as needed

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WE WOULD APPRECIATE YOUR COOPERATION

THANK YOU!

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

Economic and Financial Analysis Manual

February 2017

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Financial Analysis Manual

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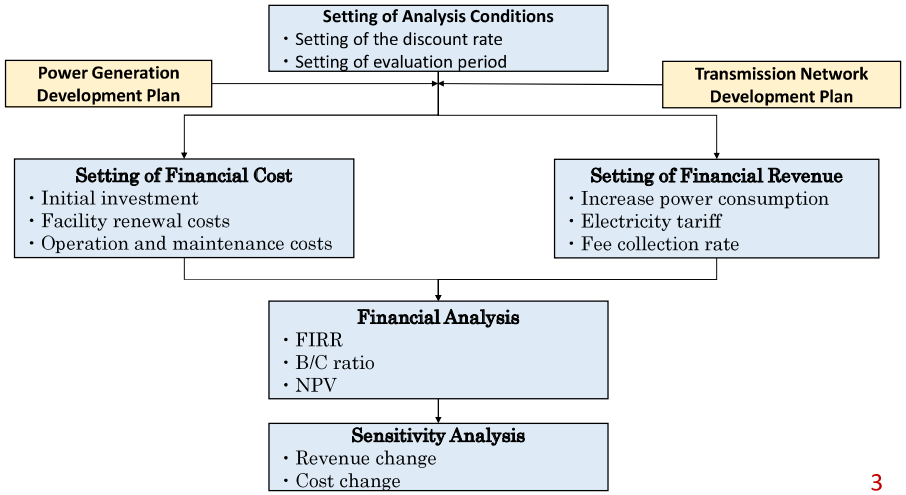
1. Financial Analysis Update Flow



2. Methods and Evaluation Index of Financial Evaluation

Financial analysis is carried out in order to verify financially sustainability of the project.
Financial analysis is to evaluate the profitability of the project by using evaluation index.

Table 1 Evaluation Index and Evaluation Conditions of Financial Analysis

Evaluation Index	Definition and Calculation Formula	Feasible conditions
Net Present Value (NPV)	NPV = (sum of the present value of benefits) - (sum of the present value of costs)	NPV＞0
Benefit-Cost ratio (B / C Ratio)	B/C = (sum of the present value of benefits) / (sum of the present value of costs)	B/C＞1.0
Financial Internal Rate of Return (FIRR)	NPV = 0 become discount rate. In other words, the discount rate, such as the present value of benefits and costs become equal	FIRR＞r r=Disscount rate

3. Setting of Analysis Conditions

(1) The Evaluation Period

Taking into consideration the useful life of the facility, it is set to 30 **years**.

→ From the first year spending cost, up to 30 years from the start of services of facilities.

(2) Discount Rate to be used in The Financial Analysis

Set in the real interest rate base.

→ The policy rate (by Central Bank of Nigeria) – Inflation rate

4. Setting Financial Cost

(1) Set in The Present Price

To set the financial cost be converted to present price basis.

(2) Calculate The Cost of Each Year

The cost during the evaluation period to account for each year.

(3) Cost Items to be Calculated

1) Initial construction costs
2) Facility renewal costs
3) Operation and maintenance costs

(4) Directed to The Project Proposed by The Master Plan

(3) Calculation of Residual Value

The end annual evaluation period, account for the residual value of the facility.

5. Setting Financial Revenues

(1) Increase The Consumption Amount of Power

Compared to in the case of Without Case (case of not implement the project) and With Case (case of implement the project), to measure the increase in power consumption.
Measurement of the difference between the With Case and Without Case, in accordance with the principle of incremental analysis. ⇒ **Incremental consumption = A + B**

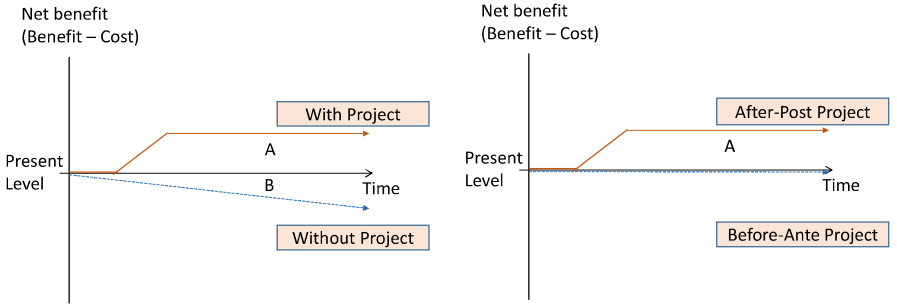


Figure 1 Image of Incremental Analysis (Left), and Pre-post Analysis (Right)

5. Setting Financial Revenues

(1) Increase The Consumption Amount of Power

- **With Case**

For power generation development plan and transmission network development plan will be formulated in a way that corresponds to the demand forecast, With Case consumption amount is corresponding to the demand forecast.

- **Without Case**

Because remains of the supply system of the present time, power consumption is limited to the power that can be supplied by the current supply system.

In addition, due to facility of deterioration, case of decrease the power supply than the current situation, to measure the decrease. In other words, the part A plus part B of Figure 1.

(2) Electricity Charges
Electricity rate is set at present value based on the latest charges NERC has set in MYTO.

(3) Fee Collection Rate
Fee collection rate, based on the track record of recent years of fee collection rate, sets the target of each year.

6. Financial Analysis

- The evaluation index to be used in the financial analysis, to calculate the "Net Present Value (NPV)," "Benefit-Cost Ratio (B / C Ratio)", "Financial Internal Rate of Return (FIRR)".
- In the financial analysis, to set a certain project implementation period, as the target of the additional revenue and costs that are brought about by the implementation of the project within the period, the calculation in terms of present value is carried out.
- To create a cash flow table that was predicted each year unit for revenue and cost, financial analysis is carried out.

Table 2. Image of the Cash Flow Statement

Year	Construction/ Renual costs	Operation and Maintenance costs	Total cost	Revenue	Net revenue
1	4.3		4.3		-4.3
2	8.5		8.5		-8.5
3	12.8		12.8		-12.8
4	12.8		12.8		-12.8
5	4.3		4.3		-4.3
6		1.3	1.3	10.4	9.1
7		1.3	1.3	10.4	9.1
8		1.3	1.3	10.4	9.1
9		1.3	1.3	10.4	9.1
10		1.3	1.3	10.4	9.1
11-35	5.0	1.3	6.3	10.4	4.1
Total	42.7	45.5	238.2	364	100.8

6. Financial Analysis

Table 3. Image of the Financial Analysis Result

[Output]

F-IRR (Project F-IRR)	6.56%
NPV (4.0% Discount)	127.4
B/C (4.0% Discount)	1.20
NPV	817.5
B/C	1.61

7. Sensitivity Analysis

- The sensitivity analysis, is to simulate the impact on the results of the financial analysis by a change in primary variable.

Table 4. Image of the Sensitivity Analysis Result

Sensitivity Analysis		Change in Investment Cost				
		20% decrease	10% decrease	Base case	10% increase	20% increase
Change in Revenue	20% increase	10.97%	9.01%	8.12%	7.65%	6.43%
	10% increase	9.75%	8.92%	7.32%	6.82%	5.98%
	Base case	8.45%	7.30%	6.56%	5.82%	4.90%
	10% decrease	7.40%	6.10%	5.23%	4.21%	3.40%
	20% decrease	6.48%	5.78%	4.42%	3.21%	2.23%

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Economic Analysis Manual

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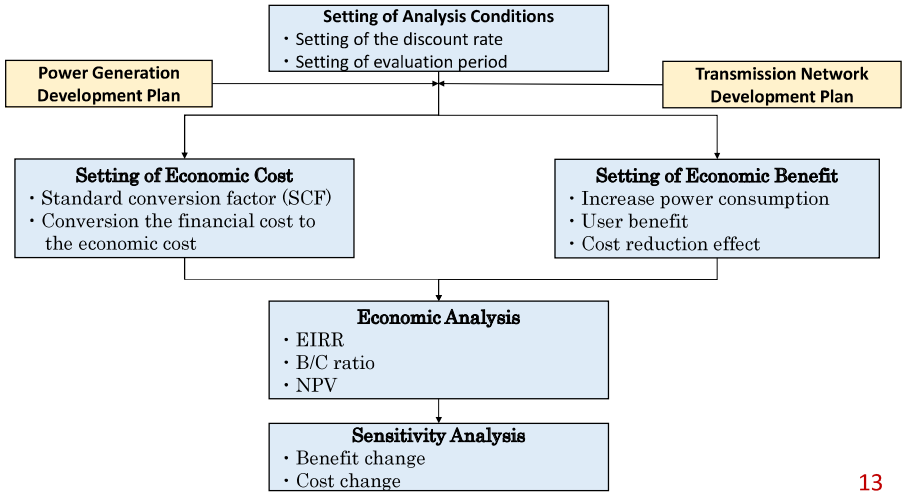
1. Economic Analysis Update Flow



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2. Methods and Evaluation Index of Economic Evaluation

Economic analysis is carried out to verify the appropriateness of investing in the project for the whole society. Evaluation of the economic analysis is to evaluate the profitability of a national economy of the project using each evaluation index.

Table 5 Evaluation Index and Evaluation Conditions of Financial Analysis

Evaluation Index	Definition and Calculation Formula	Feasible conditions
Net Present Value (NPV)	NPV = (sum of the present value of benefits) - (sum of the present value of costs)	NPV＞0
Benefit-Cost ratio (B / C Ratio)	B/C = (sum of the present value of benefits) / (sum of the present value of costs)	B/C＞1.0
Economic Internal Rate of Return (EIRR)	NPV = 0 become discount rate. In other words, the discount rate, such as the present value of benefits and costs become equal	EIRR＞r r=Disscount rate

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3. Setting of Analysis Conditions

(1) The Evaluation Period

Taking into consideration the useful life of the facility, it is set to **40 years**.

→ From the first year spending cost, up to 40 years from the start of services of facilities.

(2) Discount Rate to be used in The Economic Analysis

EIRR which is calculated as the result of the economic analysis will be compared to the social discount rate. Social discount rate of 10-12 percent is considered as a standard discount rate by International Development Bank.

→From the view point of more conservative evaluation, **12%** is adopted.

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4. Setting Economic Cost

(2)Calculation of the Economic Costs

Cost in EIRR calculation, not the actual expenditure used in FIRR calculations, economic costs are used. Calculation method of this economic cost is carried out in the following procedure.

General calculation procedure of the economic costs

1) Classification of tangible expenditures and intangible expenditures
2) Content classification of tangible expenditures (extraction of transfer items)
3) Actual expenditures content classification (classification of tradable goods and non-tradable goods)
4) Conversion to the economic price of each goods

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5. Setting Economic Benefit

(1) Increase The Consumption Amount of Power

Compared to in the case of Without Case (case of not implement the project) and With Case (case of implement the project), to measure the increase in power consumption.
Measurement of the difference between the With Case and Without Case, in accordance with the principle of incremental analysis. ⇒ **Incremental consumption = A + B**

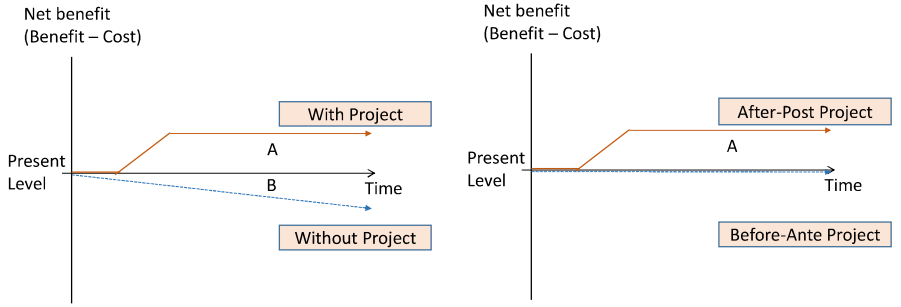

Figure 2 Image of Incremental Analysis (Left), and Pre-post Analysis (Right)

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5. Setting Economic Benefit

(2) Benefit Item

Comparing two cases, if this project is implemented (with case), and if the demand for electricity supply is not met due to not implementing this project (without case), aims to quantify **1) user benefit**, **2) cost reduction effect**, to be recorded as benefits.

1) Benefit of Users

The user benefit of electricity, to calculate the benefit to measure the willingness to pay of the service user.
However, there is no survey of measuring the willingness to pay for electricity in Nigeria.
For this reason, it looks conservative to set the electricity rates that are paid present, or, set in reference to the measurement result of the willingness to pay of African other countries.

2) Cost Reduction Effect

Cost reduction effect measures the difference of cost related to electricity for both (Without Case) and (With Case). Without Case calculates the cost of securing the electricity through alternative means such as in-house self-powered generation.
To adopt the estimates of private power generation costs, such as the World Bank and the African Development Bank.

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6. Economic Analysis

- The evaluation index to be used in the economic analysis, to calculate the "Net Present Value (NPV)," "Benefit-Cost Ratio (B / C Ratio)", “Economic Internal Rate of Return (EIRR)".
- In the economic analysis, to set a certain project implementation period, as the target of the additional benefit and costs that are brought about by the implementation of the project within the period, the calculation in terms of present value is carried out.
- To create a cash flow table that was predicted each year unit for benefit and cost, economic analysis is carried out.

Table 6. Image of the Cash Flow Statement

Year	Construction/ Renewal costs	Operation and Maintenance costs	Total cost	Benefit	Net benefit
1	4.3		4.3		-4.3
2	8.5		8.5		-8.5
3	12.8		12.8		-12.8
4	12.8		12.8		-12.8
5	4.3		4.3		-4.3
6		1.3	1.3	10.4	9.1
7		1.3	1.3	10.4	9.1
8		1.3	1.3	10.4	9.1
9		1.3	1.3	10.4	9.1
10		1.3	1.3	10.4	9.1
11-35	5.0	1.3	6.3	10.4	4.1
Total	42.7	45.5	238.2	364	100.8

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6. Economic Analysis

Table 7. Image of the Economic Analysis Result

[Output]

E-IRR (Project E-IRR)	15.08%
NPV (12.0% Discount)	52.3
B/C(12.0% Discount)	1.20
NPV	2286.9
B/C	2.77

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7. Sensitivity Analysis

- The sensitivity analysis, is to simulate the impact on the results of the economic analysis by a change in primary variable.

Table 8. Image of the Sensitivity Analysis Result

Sensitivity Analysis		Change in Investment Cost				
		20% decrease	10% decrease	Base case	10% increase	20% increase
Change in Benefit	20% increase	20.35%	19.03%	17.45%	16.34%	15.10%
	10% increase	18.68%	17.45%	16.36%	15.21%	14.02%
	Base case	17.87%	16.23%	15.08%	14.79%	13.52%
	10% decrease	16.36%	15.01%	13.89%	12.75%	11.21%
	20% decrease	14.51%	13.44%	12.35%	11.25%	10.05%

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The Project for Master Plan Study on National Power System Development in Nigeria

Attendance List

Date: 13th February, 2017　　Location:

Purpose: Technical Working Group Workshop on Update National Power System Development (Master Plan)

No.	Name	Title	Organization
1	POPOOLA SOLOMON	Prin Tech Officer	FED MIN of Power
2	IGBA MATHEAS	HIGHER TECH. OFF.	〃
3	Onu, Ogbonnaya M.	Mechanical Engineer I	FMP W&H
4	Engr. Effiong Ekanem	Principal Engineer	FMPIN$H
5	Engr. N.D Nulgu	Asst Director	FMPH&A
6	Engr. K.J. Anikpe	Asst Chief Engineer	FMPW$H
7	Engr. O.T. OWOEYE	AD (ERD)	—
8	Dr. Owolabi Sulu	A CEE (ERD)	—
9	Masaaki Shikano	Project Formulation Advisor	JICA Nigeria Office
10	Lawrence Etobe-Mbam	Offr 1 (PSPD)	TCN
11	Engr. Alabi John O	OFF 1 (PSPD)	TCN
12	Ibrahim Chinda (Dr)	OFF (I) (PSPD)	TCN
13	Gabriel Agidani	JICA (Consultant)	JICA
14	Olufola Olukoya	PSPD	TCN

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15	Engr. Shehu Abba-Aliyu	Ag. GM(SP&D)	ISO, TCN
16	Engr. M.A. Ajibade	Ag. AGM (PSP)	TSP, TCN
17	Oyekanmi A.D (Engr.)	SEE (ERD)	FMP
18	L.B. Igbinoba	Offr II (SP$D)	TCN - ISO
19	Emeka Onyeabule	SM MER	NERC
20	Engr Ifeakwe Emeka	offr 1 (SP$D)	ISO, TCN
21	Engr. Bendo Saka	offr 1 (SP$D)	TCN - ISO
22	Engr. Effiong Effiong	SM (Gen - NERC)	NERC
23	EKWA REBECCA	I.T	TCN-ISO
24	Adeleke Lanre	Corper	TCN-ISO
25	Amaka Ume	Corper	TCN/ISO
26	Engr M.K. Abdullahi	Sm (CAE)	TCN
27	Engr. IKELI-H	MSr (CAE)	TCN
28	JOHN PETER O.	OFF II (CAE)	TCN
29	A. NAZIF	PM (Data & Studies)	TCN
30	Alicia Henry	off II (CAE)	TCN
31	Onwuana Victor	S.E.E.	FMP
32	AHMED YAHAYA ALHASSANI	R.E.A (PM)	REA

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5	Engr. N.D Nulgu	Asst Director	FMPHQA
6	Engr. K.J. Anikpe	Asst Chief Engineer	FMPWSH
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36	Engr P.A. Aribaba	Gm (Planning)	TCN - TSP
37	ENGR ABU KADIRI	ES&S	NERC
38	Sunday Obi	ES&S	NERC
39	O.T. Abdulkarim	EEI	DSD (FMP)
40	ABUTU EMMANUEL	f (GM (CAE + RSI))	TCN - TSP
41	David Joshua	~~TTO~~	FMP
42	Hesbest Andy	~~EE II~~	~~FMPW&H(P)~~
43	Maimunah Ogunsiji	Offr 1	TCN - ISO
44	Adamu I Umar	P.M. PSPD	TCN - TSP
45	Adeyi Ibrahim	Offr I	TCN - ISO
46	OGUNFEYIMI G.	FM o P (PTO II)	FM o P
47	Joseph Esba	~~FMoP (DSD)~~ EEI	FMoP (DSD)
48	ADAMU David Te.	EEI (ERD)	FMP
49	Muntari Ibrahim	Assist. Director	R. E. A
50	Christian Gekpe	A D	REA
51	CHIMDI-EJIOGU N	AD	REA
52	MANDO A. RHODA	AD	REA

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3	Ifeakwe Emeka	Off. 1	TCN
4	Atiche Henry	Off I	TCN
5	Engr. Atabi John.	Offr. 1	TCN
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9	Onu Ogbonnaya M.	ME 1	FMPWH
10	Chimdi-Ejiogu N.	AD	REA.
11	Christian Gekpe	AD	REA
12	Rhoda A. Mando	AD	REA
13	Enoh Ikpeme	CEE	FMP
14	Dr Yusuf Yare	Head Trx	NDPHC

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