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.

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

THE PROJECT FOR MASTER PLAN STUDY ON NATIONAL POWER SYSTEM DEVELOPMENT

Environmental and Social Considerations (ESC)

Feb. 13, 2017

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?

MASTER PLAN REVISION PROCEDURE

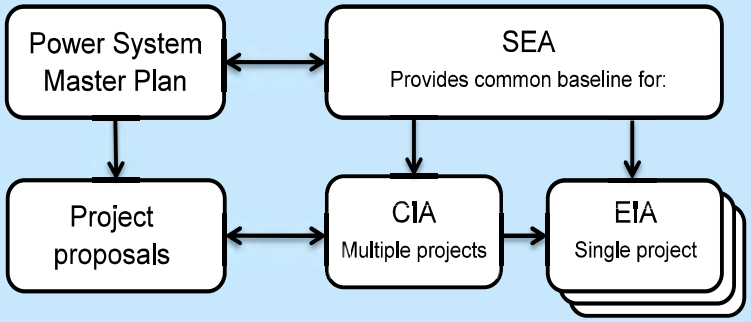
WHAT IS STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)?

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)

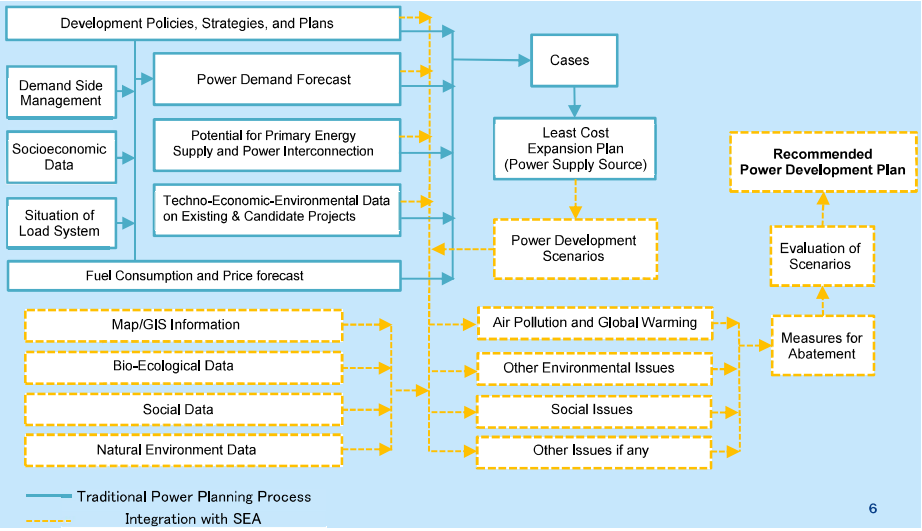
- Overall process for SEA:
  - ✓ Investigate multiple scenarios to be compared
  - ✓ Investigate relevant cumulative impacts
  - ✓ Scoping of environmental and social impacts
  - ✓ Stakeholder meetings (as needed)

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.

STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) IN POWER PLANNING



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

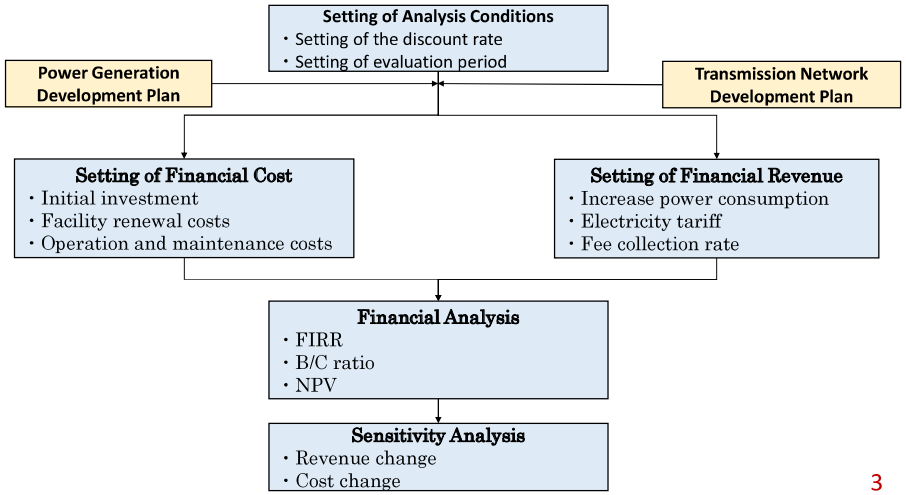
February 2017

1

Financial Analysis Manual

2

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**

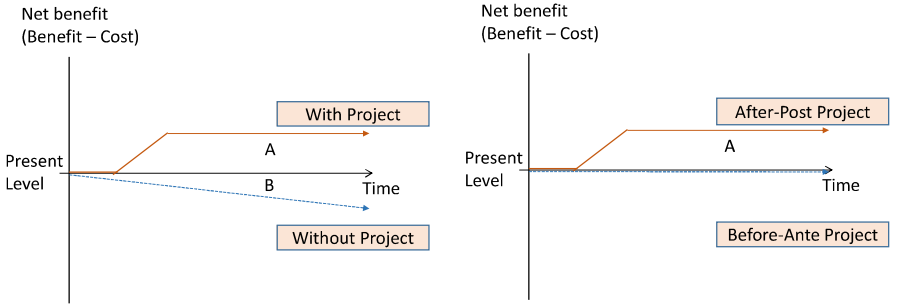


Figure 1 Image of Incremental Analysis (Left), and Pre-post Analysis (Right)

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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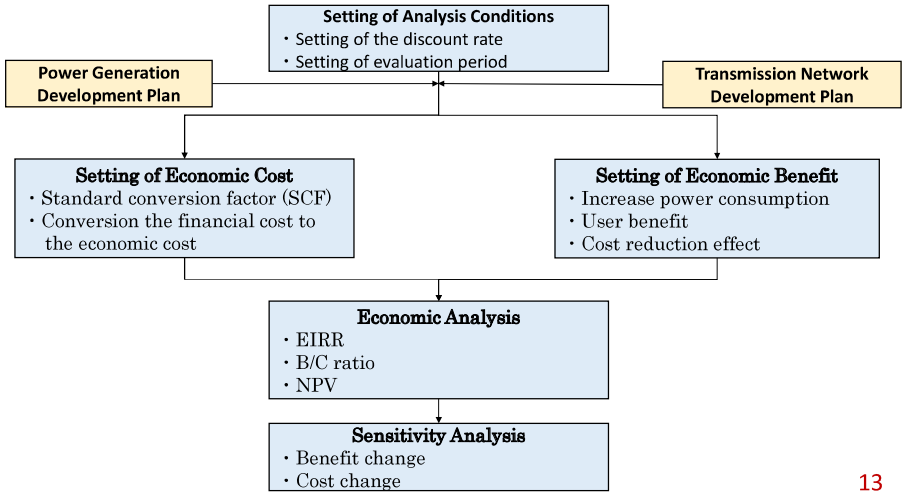
1. Economic Analysis Update Flow



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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**

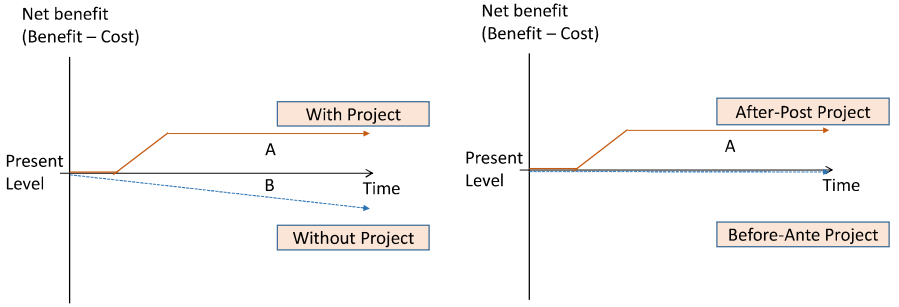

Figure 2 Image of Incremental Analysis (Left), and Pre-post Analysis (Right)

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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	ACEE (ERD)	—
9	Masaaki Shikano	Project Formulation Advisor	JICA Nigeria Office
10	Lawrence Etebe-Nkanu	Offr 1 (PSPD)	TCN
11	Engr. Alabi John O	OFF 1 (PSPD)	TCN
12	Ibrahim Chinda (Jnr)	OFFICER (PSPD)	TCN
13	Gabriel Agidani	JICA (Consultant)	JICA
14	Olufola Olukoyenbo	PSPD	TCN

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

No.	Name	Title	Organization
15	Engr. Shehu Abdu-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$D)	TCN - ISO
19	Emeka Onyeabor	SM MER	NERC
20	Engr Ifeakwe Emeka	offr 1 (SP$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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19	Emeka Onyeabor	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	Mgr (CAE)	TCN
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The Project for Master Plan Study on National Power System Development in Nigeria

No.	Name	Title	Organization
33	Engr. C.Y. Longfan	Senior Manager	REA
34	Ilem-Iyam Ugo	Officer II	TCN
35	Buni Bukar	PP (PPPC)	NBET
36	Engr P.A. Aribaba	Gm (Planning)	TCN - TSP
37	ENGR ABU KADIR	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	~~ETO~~	FMP
42	Hesbest Andy	~~EE II~~	FMPWH (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.P (PTO II)	FM.P
47	Joseph Esba	~~FMP (DSD)~~ EEI	FMoP (DSD)
48	ADAMU David To.	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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2	C. Chiatila	As. Mgr	TCN
3	Ifeakwe Emeka	Off. 1	TCN
4	Atiche Henry	Off I	TCN
5	Engr. Atabi Joseph	Offr. 1	TCN
6	Adamu I Umar	P.M. PSPD	TCN
7	John Peter O.	Offr II	TCN
8	OGUNFEYIMI G.	PTO (DSD)	FM.P
9	Onu Ogbonnaya M.	ME I	FMPWAH
10	Chimdi-Ejiogu N.	AD	~~REA~~
11	Christian Gekpe	AD	REA
12	Rhoda A. Mando	AD	REA
13	Enoh Ekpeyong	CEE	FMP
14	Dr Yusuf Yare	Head Trx	NDPHC

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

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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	~~ETO~~	FMP
42	Hesbest Andy	~~EE II~~	~~FMPWH(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.P (PTO II)	FM.P
47	Joseph Esba	~~FMP (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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5	Engr. Atabi Joseph	Offr. 1	TCN
6	Adamu I Umar	P.M. PSPD	TCN
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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

2018年 12 月 12 日
第二回 JCC（ドラフトファイナルレポート）

TIME TABLE FOR 2ND JOINT COORDINATION COMMITTEE (DRAFT FINAL REPORT) ON THE PROJECT FOR MASTER PLAN STUDY ON NATIONAL POWER SYSTEM DEVELOPMENT IN THE FEDERAL REPUBLIC OF NIGERIA

VENUE: MINISTER'S CONFERENCE ROOM
PLACE: 4TH FLOOR, FEDERAL MINISTRY OF POWER FEDERAL SECRETARIAT
DATE: *12TH DECEMBER, 2018.*

Time	*Event/Activity*	*Action by*
14:00-14:10	Opening Remarks from the Federal Ministry of Power	FMPWH
14:10-14:20	Introduction	All
14:20-14:30	Key note address	JICA Nigeria Office
14:30-14:40	Introduction	Mr. Makoto Abe
14:40-14:55	Organizations, Policies and Regulations	Mr. Naoki Hara
14:55-15:10	Power Demand Forecasts	Mr. Makoto Abe
15:10-15:30	Power Generation Development Plan	Mr. Kyoji Fujii
15:30-15:45	Tea Break ~	
15:50-16:10	Transmission network development plan	Mr. Karvelis Georgios
16:10-16:25	Environmental and Social Considerations	Mr. Kazuhiro Ishiura
16:25-16:40	Economic and Financial Analysis	Mr. Naoki Hara
16:40-16:55	Recommendations for Realizing the Master Plan	Mr. Masatsugu Komiya,
16:55-17:15	General discussion	All
17:15-17:20	Closing remarks from the Federal Ministry of Power	FMPWH

Note:
FMPWH- Federal Ministry of Power, Works and Housing,
TCN- Transmission Company of Nigeria

面談議事録	
業　務　名	ナイジェリア国電力マスタープラン策定プロジェクト（DFR 現地調査）
場　　所	FMPWH, MINISTER'S CONFERENCE ROOM
日　　時	2018 年 12 月 12 日（水）14:30～17:30
面談相手	Attendance List 参照 (FMPWH, TCN, NERC, ECN, WB, JICA)
コンサルタント側出席者	八千代エンジニヤリング㈱　　小宮、阿部、不二葦、原、浦部（記）

【議事概要】

第二回 JCC の開催。以下のプログラムの通り進行した。

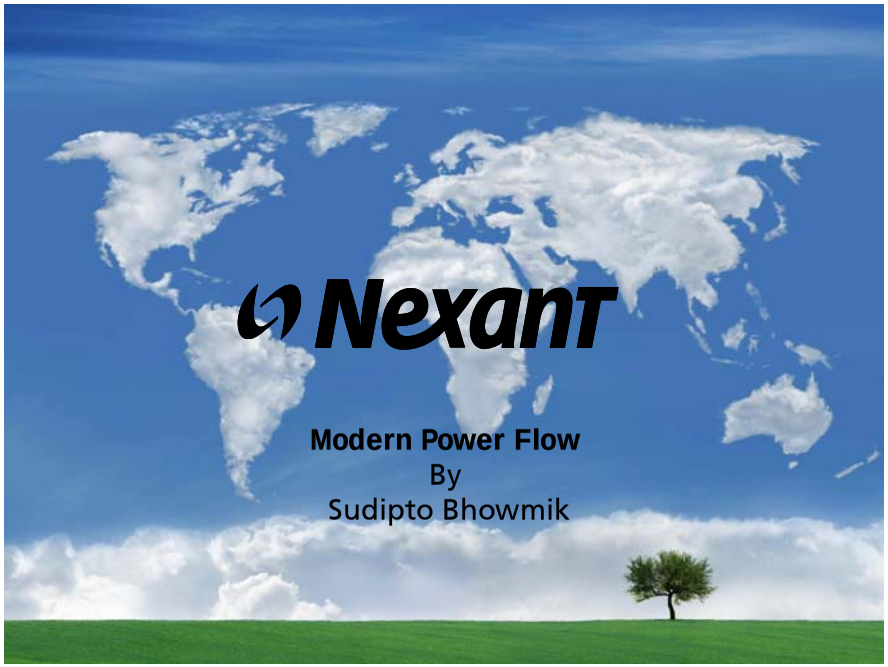
・Opening Remarks (FMPWH Mr. Ajayi)
・Introduction
・Key note address (JICA Mr. Komori)
・Presentation of DFR
- Introduction (Mr. Abe)
- Organizations, Policies and Regulations (Mr. Hara)
- Power Demand Forecasts (Mr. Abe)
- Power Generation Development Plan (Mr. Fujii)
- Transmission network development plan (Mr. Georgios)
- Environmental and Social Considerations (Mr. Ishiura)
- Economic and Financial Analysis (Mr. Hara)
- Recommendations for Realizing the Master Plan (Mr.Komiya, Mr.Hara)

途中会場変更が必要になったことなどから、進行が遅れディスカッションは翌日の Seminar に持ち越しとなった。

以　上

A-5　その他調査活動実績

2016 年 2 月 18 日
送電計画技術移転ワークショップ



Power Flow Analysis

Definition: Analysis concerned with describing the operating state of the entire Power System.

Power Flow Tool: Fundamental tool for most system operation and planning studies

Uses:

1. System Operation Studies
2. System Planning Studies (includes Generator Planning, Transmission planning)

Foundational tool for :

1. Optimal Power Flow
   - Economic Distpatch
   - Minimal Loss (Real and Reactive)
   - Reactive Device installation
   - Etc.

Power Flow Analysis - Uses

2. Stability Analysis
   - Transient stability Analysis
   - Small Signal stability analysis
   - Voltage stability analysis

Timelines of Studies:

1. Order of few cycles (1 cycle 1/50 s): *Transient stability*
2. Few seconds: *Small signal stability*,
3. Seconds to Minutes: *Voltage stability studies*
4. > Several Minutes : (**Also called steady state**), Power flow, Optimal power flow

State and its Meaning

State: Any varying set of quantities that provide a complete description of the system. Ex: SET 1: Voltage Magnitude and Angle at all buses in system *

SET 2: Real and Reactive Power injections at all buses

SET 3: Current magnitude and angle at all buses in system

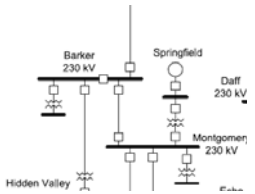
- In reality the known and unknown are:

Type of Bus	Variables Given (Knowns)	Variables Found (Unknowns)
Generator	Real power (P)	Voltage angle (Δ)
	Voltage magnitude (V)	Reactive power (Q)
Load or generator	Real power (P)	Voltage angle (Δ)
	Reactive power (Q)	Voltage magnitude (V)
Slack	Voltage angle (Δ)	Real power (P)
	Voltage magnitude (V)	Reactive power (Q)

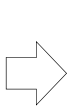
Network Representation

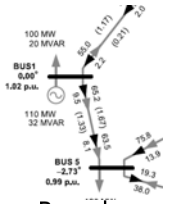
1. SCADA Data (assume Balanced 3 phase system ⇨ 1 Phase equivalent representation)
2. State Estimation (with Topology Processing). Assume correct parameters
3. Node-Breaker Model
4. Reduce into Bus-Branch model, used for input to Powerflow (*)

(*)Most modern tools also perform powerflow on node-breaker model



Node -Breaker





Bus - Branch

Powerflow tool

Given known quantities calculates unknown quantities using mathematical algorithm of successive approximation by iteration

- Newton Raphson (Full modelling, Robust and fast iteration if near solution)
- Modified Newton Raphson (simplifies slope, more iterations, works better for some cases)
- Decoupled power flow (Decouples Real and Reactive power, works well with flat start, but not if high resistance and conductance exists)

Powerflow intuition

- Highly Nonlinear equation (due to sine cosine terms)

$$P_i = \sum_{k=1}^{n} |V_i||V_k|[g_{ik}\cos(\theta_i - \theta_k) + b_{ik}\sin(\theta_i - \theta_k)]$$

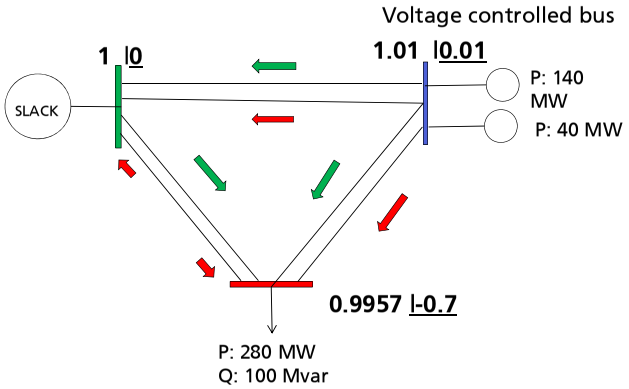
$$Q_i = \sum_{k=1}^{n} |V_i||V_k|[g_{ik}\sin(\theta_i - \theta_k) - b_{ik}\cos(\theta_i - \theta_k)]$$

- **Simplification for Branch flows:**

Real Power P_{ij} : proportional to B_{ij} (suseptance) * $(\theta_i - \theta_j)$

Reactive Power Qij : proportional to B_{ij} $|V_i|$ $|V_j|$

Power Flow Example – Flow Direction Branch analysis



Scenario- Effect of Increase in Load

If Real Load was to increase to 300 MW?

What Changed?

Only Real Power at load which by definition should be picked up by slack bus.

Slack bus/Generator: Should be chosen judiciously, usually a large generator with governor control and operating reserve

What Else Changed?

1. Due to increased flow the Real power loss of the system
2. Angle at Load bus

Scenario- Effect of Increase in Load -Reactive

If Reactive Load was to increase to 120 Mvar?

What Changed?

Only Reactive Power at load which by definition should be picked up by slack bus.

But!!
This would change the Voltage at Bus 2 and thus Generators at this bus picks up some of the reactive power increase

Hence by denoting **Voltage controlled bus** we are designating Generators have **automatic VAR** control on their field winding. Which leads to sharing of reactive Power by all such generators

Alternative: We fix the reactive power output of the Generator if we know this value and convert the bus to a load bus (P,Q bus)

Scenario- Effect of Line loss

If Line 1-2 Circuit 1 was to be outaged?

What Changed?

- Only parameter of line. Thus generators keep the same output (Except slack)
- Flows will change. Hence the load bus and Generator bus angles will change
- Load bus Voltage will change.
- Since the same power flows and the resistance of one path increases. Real power loss increases (picked up by slack)
- Reactive power "loss" may increase or decrease depending on Reactance , charging suseptance etc.

Slack Generator vs distributed generator

Slack Generator:

- Should be used for studies where small changes occur to already solved case
- Changes such as small generator rescheduling / Load allocation, single line loss, small transmission addition.
- Typically used for System operation studies

Distributed Generator:

- Assume we know the participation of the generators (have governor control/Reserve)
- Used for large changes in system such as large transmission buildout
- Large generator inclusion
- Large load changes
- Usually for long term planning

Transformers (2 winding)

Fixed tap Transformers :

- Similar to branches, use similar analysis

Load Tap Transformers:

- Taps can change automatically. PSS/E can simulate this.
- Harder to analyze introduces non-linearities if discrete tap steps is simulated
- Continuous tap steps make it more tractable but may not be practical

Other Exotic transformers (phase shifters, 3 winding)

Shunts

Fixed Shunts:

- Choose to include them in simulation or not

Switched Shunts:

- Similar to transformer tap, can change automatically.
- Harder to analyze introduces non-linearities if discrete shunt steps are simulated
- Continuous switch steps make it more tractable but may not be practical

Generator VAR control limits

To VAR control or Not?

- Practical to allow VAR controls to be enforced. Leads to control bus voltage to deviate
- VAR limits might make Voltage profile infeasible. Need to check for problems
- Once limit is reached within iteration it stays on its limit for further iterations, thus leading to unwanted solutions
- Can control this by only allowing limits at later point in iteration

Branch , Transformer, Interface limits, (QV, PV) curves

Power flow does NOT enforce these limits!!:

- Post Simulation: Need to check all these loading values, for infeasible solutions
- Sometimes these indicate problems in the parameters/ settings local to heavily loaded devices
- QV analysis at low/high voltage buses provide good understanding of reactive margins
- PV analysis at low/high angle buses, interfaces, provide good understanding of Real margins

What about Larger systems ?

1. Divide system into areas and analyze each area
2. Summarize total system generator and load
3. Concentrate on pockets of heavily loaded/lightly loaded systems
4. Lightly loaded/unconnected radial lines provide large charging currents. This leads to reactive problems as Generators start absorbing reactive power
5. May not converge, Check parameters and branch summary

Non Convergence

1. Check System summary, large differences in real reactive generation and load
2. May indicate voltage collapse situation. Check Generator VAR outputs
3. Fix taps to nominal values, Include shunts if needed as fixed, Fix switched shunts

Last resort:

- Increase tolerance values
- Decrease Simulation count and start with decoupled and then newton power flow
- Try including VAR control later in the iteration

RECAP

- Analysis of branch parameters/flows important
- Real power flow in a branch proportional to angle difference
- Reactive power proportional to voltages
- Judicious use of Slack bus/Distributed buses
- Check area summary for large systems (like losses, largest loading)
- Large angle/voltage difference between ends of a branch should be investigated
- For non-convergence check parameters, loading of line/Transformer, Generator outputs

Transmission Planning

- Transmission Planning aligned with System Operation
- 5 Year Planning Cycles
- Long Range Plans

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Transmission Planning

Generation Planning Criteria

- Loss Of Load Probability (LOLP) < 0.45% (40 hours per year)
- Planning Reserve Margin: 10% - 30% of total system peak load

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Transmission Planning

Category	Contingencies: Initiating Event(s) and Contingency Element(s)	System Limits or Impacts: System Stable and both Thermal and Voltage Limits within Applicable Rating[a]	System Limits or Impacts: Loss of Demand or Curtailed Firm Transfers	System Limits or Impacts: Cascading Outages
A No Contingencies	All Facilities in Service	Yes	No	No
B Event resulting in the loss of a single element	Single Line Ground (SLG) or 3-Phase (3Ø) Fault, with Normal Clearing: 1. Generator 2. Transmission Circuit 3. Transformer Loss of an Element without a Fault	Yes Yes Yes Yes	No [b] No [b] No [b] No [b]	No No No No
	Single Pole Block, Normal Clearing[a]: 4. Single Pole (dc) Line	Yes	No[b]	No
C Event(s) resulting in the loss of two or more (multiple) elements	SLG Fault, with Normal Clearing[a]: 1. Bus Section 2. Breaker (failure or internal Fault)	Yes Yes	Planned/ Controlled[c] Planned/ Controlled[c]	No No
	SLG or 3Ø Fault, with Normal Clearing[a], Manual System Adjustments, followed by another SLG or 3Ø Fault, with Normal Clearing[a]: 3. Category B (B1, B2, B3, or B4) contingency, manual system adjustments, followed by another Category B (B1, B2, B3, or B4) contingency	Yes	Planned/ Controlled[c]	No
	Bipolar Block, with Normal Clearing[a]: 4. Bipolar (dc) Line Fault (non 3Ø), with Normal Clearing[a]: 5. Any two circuits of a multiple circuit towerline[d]	Yes Yes	Planned/ Controlled[c] Planned/ Controlled[c]	No No
	SLG Fault, with Delayed Clearing[a] (stuck breaker or protection system failure): 6. Generator 7. Transformer 8. Transmission Circuit 9. Bus Section	Yes Yes Yes Yes	Planned/ Controlled[c] Planned/ Controlled[c] Planned/ Controlled[c] Planned/ Controlled[c]	No No No No

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Transmission Planning

Transmission Planning Criteria

- Steady State Period
  - Primary (n-1): Loading <= 100% of emergency rating
    No loss of stability
    No interruption of supply/service
    No generation dispatch out of merit order
  - Secondary (n-2): Consider loss of second element
    Propose prudent upgrades
  - Voltage: +/- 5% of nominal for normal operation +/- 5% of pre-disturbance for n-1
- Transient Period
  - Frequency: <= +/- .1% (normal)
    <= +/- 2.5% (system stress)

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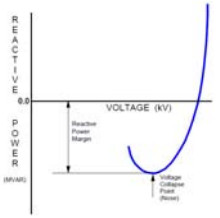
Transmission Planning

Voltage Stability Criteria

	MW Margin	MVAR (Reactive) Margin
Category B – Single Contingency	Area Load or path flow > 5%	Based on Worst Case Scenario
Category C – Double Contingencies or Bus outages	Area load or path flow > 2.5%	50% of Category B Requirement

- P-V (MW Margin) and Q-V (MVAR Margin) analyses are conducted with a Governor Power Flow*



* Simulates the period after the transient period but before manual adjustment.

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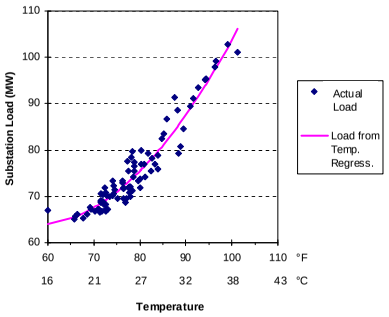
Transmission Planning

- Determine Temperature-Demand relationship
- Select the extreme temperature condition upon which generation and transmission expansion planning would be based.
  - 1-in-5, 1-in-10….
- Adjust historical peak demands to the selected extreme temperature
- Forecast demand



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Transmission Planning

Power Flow Analysis

- Determine if there are any normal (N-0) overloads
- Determine if there are any emergency overloads (N-1)
  - Run every contingency on peak, partial peak and peak condition
- Determine if there any problems with N-2 contingencies
- Develop solutions
  - Reconductor lines
  - Install new lines
  - Reconfigure lines

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Transmission Planning

- Develop series of Transmission Planning Base Cases thru 10 year period
- True up Year 1 Planning Base Cases with System Operations
  - Extremely important to have a Year 1 base case that represents stressed operating conditions
- Develop Peak, Partial Peak and Off-Peak Base Cases for Analysis
  - For relatively flat load profile it may only be necessary to run peak base case
  - Still important to run various sensitivities to test the load flow

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Transmission Planning

Transient and Voltage Stability Analysis

- Check N-1 and N-2 contingencies for voltage and stability problems
- Develop solutions
  - Shunt Capacitors
  - SVCs, Statcons
  - Synchronous Condensors
  - Series Capacitors
- Consider undervoltage load shedding and special protection scheme
  - Trip targeted load to prevent voltage collapse
  - Install out-of-step blocking and tripping protection
  - Islanding schemes for controlled separation

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Transmission Planning

Project Justification

- Reliability Projects
  - Grid code violation
  - Serious loss of load or cascading outages
- Develop Multiple Alternatives
  - Find least cost alternative
- Utilize Cost-Benefit Analysis for Transmission Projects
  - Consider using VOS/EUE to evaluate benefit of installing transmission upgrade versus solving the problem by using an SPS
  - Cost benefit ratio can be used to rank projects

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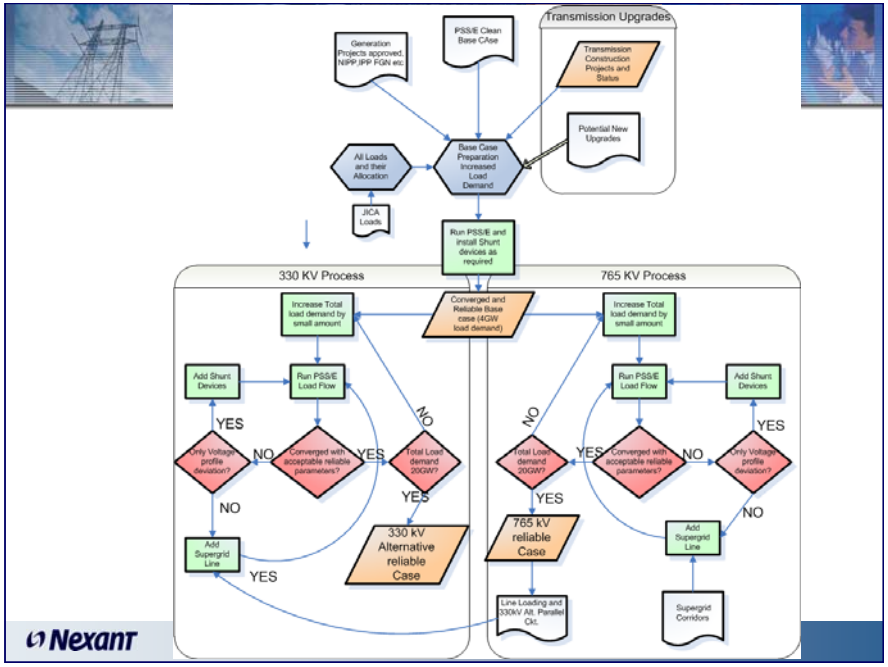


2016 年 5 月 3 日、4 日、5 日
電力需要予測技術移転ワークショップ

Power
Demand Forecasting Model

April 2016
JICA Study Team

Contents

Unit converters

1	ktoe	Kilo ton oil equivalent	Crude oil 1ton=1toe、1kg=10,000kcal
2	GWh	Giga Watt hour	1GWh=1,000,000kWh 1GWh=0.086ktoe（1kWh=860kcal）
3	mmBtu	Million British thermal unit	1toe=40mmBtu （1Btu = 0.25kcal）
4	1000cf	1000 cubic feet	1000cf＝28.5 m3 (1m3 = 35 cf)
5	TJ	Tera Joules	1TJ=24toe

8	Natural gas	1m3 = 8,000kcal ～9,500kcal
9	LNG	1 kg = 13,000kcal
10	Import Coal	1kg = 5,500kcal ～ 6,000kcal
11	Crude oil	1kg = 10000 kcal
12	LPG	1kg = 12,000 kcal
13	Fuel oil	1liter = 9,300kcal ～9,800kcal
14	Woods	1kg = 4,000kcal ～4,500kcal

1. Growth rate, Intensity and Elasticity

1-1 Growth rate

(1) Concept

Energy demand is proportion to GDP growth rate. Usually we use “Growth rate” for analyzing the relation between energy demand and GDP trend.

When GDP growth rate is 8% in a country,

Power demand growth rate is 8 ～10%.

When Population growth rate is 1% per year in a country

GDP basically increases with 3% per year.

(2) Two type of Growth rate

Average growth rates = ((f / a)^(1/5)-1)*100

			a	b	c	d	e	f	
			2015	2016	2017	2018	2019	2020	2020/15
Nominal GDP (MP)	Market price	Billion NGN	96,983	105,306	114,882	125,885	138,555	153,104	9.6
	Growth rate	G%	7.6	8.6	9.1	9.6	10.1	10.5	
Real GDP (FC)	Real at 2005 price	Billion NGN	26,178	27,217	28,442	29,864	31,506	33,396	5.0
	Growth rate	G%	3.0	4.0	4.5	5.0	5.5	6.0	
Deflator	2005=100	2005=100	369.0	386.0	403.8	422.2	441.5	461.4	4.6
	Growth rate	G%	4.6	4.6	4.6	4.6	4.6	4.5	
Sectoral GDP at 2005	Agriculture	Billion NGN	10,209	10,376	10,592	10,860	11,189	11,613	2.6
<Real GDP>	Industry	Billion NGN	5,236	5,393	5,597	5,853	6,171	6,591	4.7
	Services	Billion NGN	10,733	11,447	12,253	13,150	14,146	15,192	7.2
	GDP (FC)	Billion NGN	26,178	27,217	28,442	29,864	31,506	33,396	5.0

Annual growth rates = ((b / a)-1)*100

Data: Power demand forecasting model of PSMP 2015, Nigeria

(3) Exercise for Growth rate

Ex1-1 The table is the growth rate of GDP per capita of Nigeria

(1) How many years is in the period of each block ?

(2) What values are the GDP per capita each year ?

Years	Unit	2015	2016	2017	2022	2027	2032	2040
Growth rate per year	%		3.0	3.5	4.7	5.3	5.8	6.0
(1) The period	Year		1	1	5	5	5	8
(2) GDP per capita	US$/Capita	2,781	2,863	2,963	3,726	4,827	6,405	10,228

$A_t = A_{t-1} * (1 + r/100)^n$ r: growth rate n: period

Ex1-2 Nigerian population are 140 million in 2005 and 184 million in 2015, what is the percentage of the growth rate?

(1) How many years is the period? 10

(2) What percentage is the growth rate? 2.8

Definition: R= ((B/A)^(1/n)-1)*100

A in 2005, B in 2015, n : Years

(3) How many population does the country have in 2030?

Condition : Future growth rate is +2.6 % per year.

270

Ex1-3 Make the annual growth rate and the average growth rate for the following data.

	Unit	2010	2011	2012	2013	2014	2015	2015/2010
Nominal GDP of Nigeria	Billion NGN	55,469	63,713	72,600	81,010	90,137	96,983	11.8
Exchange rate	NGN/US$	150	154	157	157	159	190	
GDP of Nigeria	Billion US$	369	414	461	515	568	510	6.7
Annual growth rate of GDP(USD)	%		12.2	11.3	11.7	10.4	-10.2	
Population of Nigeria	1000 person	159,708	164,193	168,834	173,615	178,517	183,523	2.8
Annual growth rate	%		2.8	2.8	2.8	2.8	2.8	
GDP per Capita	US$/person	2,311	2,522	2,730	2,966	3,185	2,781	3.8
Annual growth rate	%		9.1	8.3	8.6	7.4	-12.7	

Average GR = ((510 / 369)^(1/5)-1)*100 = 6.7 %

Annual GR = (414 / 369 –1)*100 = 12.2 %

Ex1-4 Make annual growth rate and average growth rate for the following GDP by sector

Real GDP at 2005 price		2010	2011	2012	2013	2014	2015
Agriculture	Billion NGN	8,446	9,147	9,531	9,816	10,170	10,209
Industry	Billion NGN	5,119	5,444	5,446	5,267	5,339	5,236
Service	Billion NGN	7,117	7,187	7,715	8,858	9,916	10,733
Total	Billion NGN	20,682	21,778	22,693	23,941	25,425	26,178

Growth rate of GDP at 2001		2011/2010	2012/2011	2013/2012	2014/2013	2015/2014	2015/2010
Agriculture	%	8.3	4.2	3.0	3.6	0.4	3.9
Industry	%	6.4	0.0	-3.3	1.4	-1.9	0.5
Service	%	1.0	7.4	14.8	11.9	8.2	8.6
Total	%	5.3	4.2	5.5	6.2	3.0	4.8

1-2 Intensity

(1) Concept

- It is used a ratio between energy consumption and economic data. We call it “Intensity”.
- Intensity to GDP, Population and Industrial output are used for energy demand forecast models.

Ex1: Energy Intensity to population
= Primary energy supply / Population

Ex2: Energy Intensity to GDP
= Primary energy supply / GDP

Ex3: Energy Intensity to industrial output
= Primary energy supply / industrial output

(2) Energy consumption / GDP or Population

Intensity calculation in 2011

	Nigeria	Tanzania	South Africa	Ghana	Japan	USA
Power consumption (TWh)	33	5	237	9	1,003	4,127
GDP (Billion at 2005 USD)	166	21	300	17	4,622	13,847
Population (Millions)	164	44	52	25	128	312
Power consumption/GDP (kWh per USD)	0.20	0.24	0.79	0.50	0.22	0.30
Power consumption per capita (kWh / person)	202	116	4,604	344	7,848	13,246

GDP at 2005 price
Source : World bank database 2014

(3) Energy consumption / Industrial production index

	Japan	USA	UK	Germany
Iron	100	118	112	103
Chemical	100	118		127
Paper	100	161		
Cement	100	180		110

Source :The data in 1998, Published by Comprehensive energy committee in METI

Since 1973, Japan has been made an effort for energy conservation in industrial sectors.

In the current years, energy consumption intensity in Japan is the most excellent in the developed countries.

(4) Comparison of Energy Consumption to GDP by Country

Japan has a low intensity of energy consumption per GDP compared to other industrialized counties in the year of 2000.

Source: Natural Resources and Energy Agency in Japan

* The values are Final energy consumption (toe) / Real GDP (1995 prices) when Japan is set by 1.00.

(5) Denominator for Intensity calculation

Sector	Denominator	Example
Country wide	US$ base GDP US$ PPP base GDP	Toe / US$ Toe / US$ (PPP)
Industry	Production ton Value added	Toe/ ton Toe / US$
Buildings	Floor area Number of person	Toe / m2 Toe / person

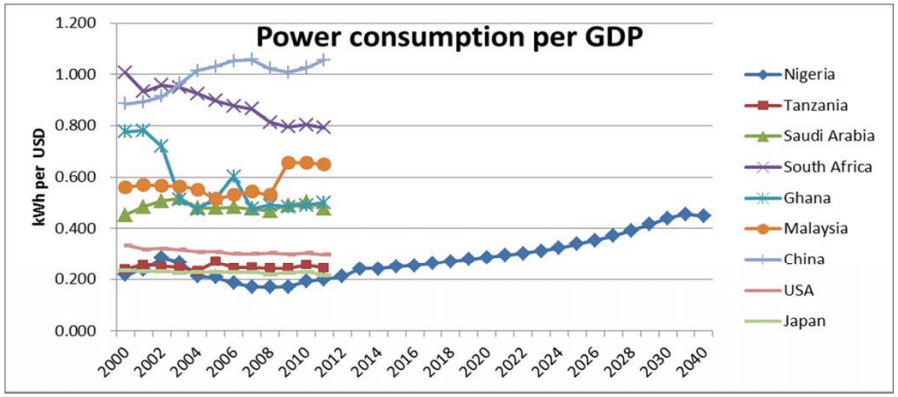
US$ base GDP & PPP GDP in Nigeria

		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
GDP (Current NGN)	Billion NGN	14,735	18,710	20,941	24,665	25,236	55,469	63,713	72,600	81,010	90,137
GR	%		27.0	11.9	17.8	2.3	119.8	14.9	13.9	11.6	11.3
GDP (Current US$)	Billion US$	112	145	166	208	169	369	412	461	515	569
GR	%		29.6	14.5	25.0	-18.5	117.8	11.6	12.0	11.7	10.4
GDP (Constant NGN at 2010)	Billion NGN	39,155	42,370	45,263	48,101	51,437	55,469	58,180	60,670	63,943	67,977
GR	%		8.2	6.8	6.3	6.9	7.8	4.9	4.3	5.4	6.3
GDP (Constant US$ at 2005)	Billion US$	112	121	130	138	147	159	167	174	183	195
GR	%		8.2	6.8	6.3	6.9	7.8	4.9	4.3	5.4	6.3
GDP, PPP (Current US$)	Billion US$	513	573	628	680	733	800	857	909	973	1,049
GR	%		11.5	9.7	8.4	7.7	9.2	7.1	6.2	7.0	7.9
GDP, PPP (Constant US$ at 2011)	Billion US$	576	624	666	708	757	817	857	893	941	1,001
GR	%		8.2	6.8	6.3	6.9	7.8	4.9	4.3	5.4	6.3

PPP: Purchasing Power Parity

(6) Power intensity to GDP

Definition : Power consumption / GDP



GDP : Real GDP at 2005, the intensity after 2015 is estimation.

(7) Exercise for Intensity

EX1-5 Can you make Power intensity to population in Nigeria and Japan?

	Nigeria				Japan		
	Pupulation	Power Generation	Intensity to Population		Pupulation	Power Generation	Intensity to Population
	Million	GWh	kWh/ person		Million	TWh	kWh/ person
2005	139.6	24,042	172.2	2000	126.9	1,012	7,974
2006	143.3	23,276	162.4	2001	127.1	995	7,823
2007	147.2	22,883	155.5	2002	127.4	1,009	7,916
2008	151.2	24,095	159.4	2003	127.7	998	7,815
2009	155.4	26,032	167.5	2004	127.8	1,029	8,051
2010	159.7	30,081	188.3	2005	127.8	1,049	8,213
2011	164.2	32,989	200.9	2006	127.8	1,054	8,253
2012	168.8	36,031	213.4	2007	127.8	1,085	8,490
2013	173.6	43,183	248.7	2008	127.7	1,031	8,075
2014	178.5	45,728	256.2	2009	127.6	1,000	7,838
2015	183.5	48,740	265.6	2010	127.5	1,068	8,378

EX1-6 Could you make energy consumption intensity to GDP in Nigeria and Japan?

Nigeria				Japan			
Year	Primary energy consumption (IEA data)	GDP constant price at 2005	TPEC / GDP US$	Year	Primary energy consumption	GDP constant price at 2005	TPEC / GDP US$
	KTOE	Billion USD	TOE /US$1000		KTOE	Billion USD	TOE /US$1000
2000	86,043	68	1.27	2000	519,000	4,308	0.12
2001	90,337	71	1.28	2001	510,800	4,323	0.12
2002	93,227	73	1.27	2002	510,400	4,336	0.12
2003	98,523	81	1.22	2003	506,200	4,409	0.11
2004	101,310	108	0.94	2004	522,500	4,513	0.12
2005	105,303	112	0.94	2005	520,500	4,572	0.11
2006	106,182	121	0.88	2006	519,800	4,649	0.11
2007	109,938	129	0.85	2007	515,200	4,751	0.11
2008	113,219	138	0.82	2008	495,400	4,702	0.11
2009	111,447	147	0.76	2009	472,200	4,442	0.11
2010	119,970	158	0.76	2010	499,100	4,649	0.11
2011	126,929	166	0.77	2011	461,500	4,622	0.10
2011/2000	3.60	8.49	-4.51	2011/2000	-1.06	0.64	-1.69

1-3 Elasticity

(1) Concept

When we want to know the relation between economic growth and power consumption, Elasticity is useful to analyze it.

Power consumption elasticity to GDP

= Power consumption growth rate / GDP growth rate

<Example>

a. Power consumption of Nigeria

14.8 TWh in 2000 49.8 TWh in 2015 Growth rate 8.4 %

b. Real GDP (2005 constant)

68 bill US$ in 2000 200 bill US$ in 2015 Growth rate 7.5 %

c. Elasticity

Elasticity to GDP = 8.4 % / 7.5% = 1.12

(2) TPEC elasticity to GDP in the countries

	Growth rate of TPEC (2000 – 2010)	Growth rate of GDP (2000 – 2010)	Elasticity
Nigeria	3.37%	8.80%	0.38
Tanzania	3.89%	7.01%	0.55
Japan	-1.01%	0.67%	-1.51
USA	-0.18%	1.73%	-0.10
Malaysia	4.42%	5.08%	0.87
Saudi Arabia	5.78%	6.17%	0.94
South Africa	2.32%	3.61%	0.64

(3) Elasticity to GDP of Japan

	Energy Consumption Growth rate	Real GDP growth rate	Elasticity	Comments
1930-1940	6.7%	4.4%	1.54	Great depression
1940-1950	-2.8%	-2.4%	1.18	WWII
1950-1960	7.8%	9.3%	0.83	
1960-1970	12.2%	10.1%	1.21	GDP high growth
1970-1975	2.8%	2.6%	1.08	GDP high growth
1975-1980	1.6%	6.3%	0.26	After first oil crisis
1980-1985	0.4%	3.5%	0.12	After Second oil crisis
1985-1990	3.7%	4.8%	0.77	Economic Bubble
1990-1995	2.3%	1.5%	1.48	Collapse the Bubble
1995-1998	0.04%	0.6%	0.07	Restructure age
2000- 2010	-1.01%	0.7%	-1.51	Senior Society

In GDP high growth ages, Elasticity > 1 After oil crisis, Elasticity < 1

(4) Exercise for Elasticity

EX1-7 Can you make energy consumption elasticity to GDP of Nigeria

	Annual data		Annual growth rate & Elasticity			Five year avergae & Elasticity		
	Power consumption	GDP PPP US$ at 2011	Power growth rate	GDP growth rate	Annual Elasticity	Power growth rate	GDP growth rate	GDP Elasticity
	GWh	Billon $	%	%				
1990	13,463	115						
1991	14,075	118	4.55	3.34	1.36			
1992	14,742	124	4.74	5.04	0.94			
1993	14,401	130	-2.31	4.57	-0.51			
1994	15,393	135	6.89	4.08	1.69			
1995	15,857	142	3.01	4.93	0.61	3.33	4.39	0.76
1996	16,243	149	2.43	4.62	0.53			
1997	16,117	157	-0.78	5.39	-0.14			
1998	15,111	165	-6.24	5.23	-1.19			
1999	16,089	173	6.47	4.87	1.33			
2000	14,727	183	-8.47	5.94	-1.42	-1.47	5.21	-0.28
2001	15,462	193	4.99	5.27	0.95			
2002	21,545	201	39.34	4.42	8.91			
2003	20,184	212	-6.32	5.26	-1.20			
2004	24,275	225	20.27	6.27	3.23			
2005	23,539	239	-3.03	5.96	-0.51	9.83	5.43	1.81
2006	23,110	254	-1.82	6.63	-0.27			
2007	22,978	271	-0.57	6.43	-0.09			
2008	21,110	288	-8.13	6.19	-1.31			
2009	19,777	304	-6.31	5.74	-1.10			
2010	26,121	323	32.08	6.07	5.29	2.10	6.21	0.34
2011	27,034	344	3.50	6.71	0.52			
2011/1990			3.38	5.38	0.63			

EX1-8 When future GDP growth rate (7.0%) for Nigeria are given by the table, how much is power peak demand and GDP in future? Assume the elasticity in 2014 from 2015 to 2025.

	Power peak	Growth rate of NG	GDP PPP US$ at 2011	Growth rate of GDP	Elasticity
	MW	%	Billion $	%	
2005	3,652		239		
2006	3,583	-1.9	254	6.6	(0.28)
2007	3,475	-3.0	271	6.4	(0.47)
2008	3,659	5.3	288	6.2	0.86
2009	3,958	8.2	304	5.7	1.42
2010	4,560	15.2	323	6.1	2.51
2011	4,944	8.4	344	6.7	1.25
2012	5,329	7.8	366	6.3	1.23
2013	6,302	18.3	386	5.5	3.32
2014	6,674	5.9	410	6.2	0.95
2015	7,118	6.7	439	7.0	0.95
2016	7,591	6.7	469	7.0	0.95
2017	8,097	6.7	502	7.0	0.95
2018	8,635	6.7	538	7.0	0.95
2019	9,210	6.7	575	7.0	0.95
2020	9,823	6.7	615	7.0	0.95
2021	10,477	6.7	658	7.0	0.95
2022	11,174	6.7	705	7.0	0.95
2023	11,917	6.7	754	7.0	0.95
2024	12,710	6.7	807	7.0	0.95
2025	13,556	6.7	863	7.0	0.95

2. Methodology of Power Demand Forecasting

2-1 Procedures of power demand forecasting

Study social economic strategies

Social & economic forecasting

Sector activity forecasting

Power demand forecasting

Peak demand forecasting

The details are as follows;

2-2 Study social economic strategies

(1) Data collection

Documents	Organizations	GDP growth rates	Periods
Vision 20 2020	Nigerian Government	13 % per year	2015 - 2020
GDP outlook from 2015 to 2020	FMBNP	5 % ～ 6 % /year	2015 - 2020
Nigeria economic outlook 2015	AfDB	7 % per year excluding oil sector	2015 - 2020
Economic outlook April 2015	IMF	6 % per year excluding oil sector	2015 - 2020

From	Information and Data
TCN	Multi Year Tariff Order (Excel sheet of Financial model 31122014)
TCN	Energy Generated and Energy Consumption From 2005-2014
TCN	Energy Consumption (Sales and D-loss) by region from 2005 to 2014
TCN	PHCN Annual report 2011 and 2012
TCN	National Load Demand Study & National Energy Development project
NERC	MYTO Distribution by Company from 2015 to 2018

(2) Social and economic indicators are forecasted

Indicators	Forecast
Population	Population growth rates are given.
Population by area	Urban and Rural area
Number of Household	Population / Person per household.
Nominal GDP	Real GDP * GDP deflator
Real GDP	GDP growth rates are given.
GDP by sector	Agriculture, Industry, Commercial service, Public service Transportation sectors
Deflator	Inflation rates are given
Exchange rate (to US$)	Estimated by the equation of 'Deflator - USA inflation rate'
Crude oil price	Refer to well known persons' opinion
Income per capita	GDP / population
GDP per capita	Nominal GDP (USD) / population

Blue are Exogenous variables

(3) Organizations for International data collection

Organization	Uniform Resource Locator (URL)
World bank country Database	http://data.worldbank.org/country **Economy, Energy and Electricity Supply and demand data**
IMF economic data	http://elibrary-data.imf.org/FindDataReports.aspx?d=33061&e=169393 **GDP, Exchange rate, Price index, Export/Import and Interest rate**
IEA country database	http://www.iea.org/countries/ **Energy supply and demand balances for many years**
UN Energy yearbook	https://unstats.un.org/unsd/energy/default.htm **Statistic division**
OPEC Home page	http://www.opec.org/opec_web/en/index.htm **Oil price outlook**
Energy Information Agency USA	http://www.eia.gov/ **Country database**

(4) Collected data from world wide database

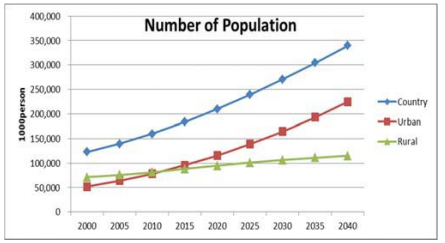
	From	Information and Data
1	WB	Power consumption per capita and GDP per capita of the selected countries
2	WB	Exchange rate and GDP of Nigeria
3	BP	Crude oil price of WTI and Brent
4	IEA	Actual power demand by sector of Nigeria (As recorded data)
5	UN	Population forecast of Nigeria by UN, Population Division
6	AfDB	Nigeria Economic outlook 2015
7	AfDB	Global Value Chain Development and Structural Transformation in Nigeria

2-3 Social & Economic data forecasting

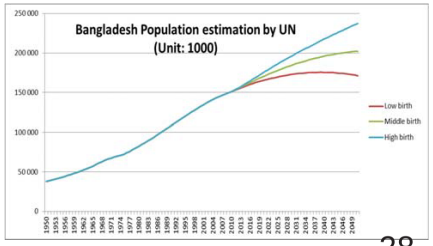
(1) Population forecasts

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045
Country	122,900	139,600	159,700	183,500	210,100	239,300	270,900	304,400	339,500	376,000
Urban	52,000	63,900	78,300	95,600	115,600	138,600	164,700	193,500	225,000	268,000
Rural	70,800	75,700	81,400	87,900	94,500	100,700	106,200	110,900	114,500	108,000
Urban share	42	46	49	52	55	58	61	64	66	71
Rural share	58	54	51	48	45	42	39	36	34	29

Source : UN population study, Original : Nigeria population commission



Nigeria



Bangladesh

(2) GDP and GDE

GDP (Gross Domestic Product)
GDE (Gross Domestic Expenditure)

GDP items		GDE items	
Agriculture	AG	Private consumption	PC
Industry	IN	Government consumption	GC
(Manufacturing)	MF	Capital Formation	CF
(Oil & Gas)	OG	Export	EX
Services	SV	Import	IM
GDP = AG + IN + SV		Stock increase	SK
(IN = MF +OG)		GDE=PC+GC+CF+EX-IM+SK	

GDP = GDE

(3) Nominal GDP and Real GDP

The following data are real and nominal GDP of Nigeria

Billion NGN

	2003	2004	2005	2006	2007	2008	2009	2010
N-GDP	8,700	11,700	14,700	18,700	20,900	24,700	25,200	55,500
R-GDP	10,600	14,200	14,700	15,900	17,000	18,100	19,300	20,700
Deflation	82	82	100	117	123	136	131	268

Nominal data

2005	2006	2007	2008	2009	2010
$V_{05}*P_{05}$,	$V_{06}*P_{06}$,	$V_{07}*P_{07}$,	$V_{08}*P_{08}$	$V_{09}*P_{09}$,	$V_{10}*P_{10}$

Real data

2005	2006	2007	2008	2009	2010
$V_{05}*P_{05}$,	$V_{06}*P_{05}$,	$V_{07}*P_{05}$,	$V_{08}*P_{05}$	$V_{09}*P_{05}$,	$V_{10}*P_{05}$

2-4 Sector activity forecasting

(1) Elasticity approach

Sector growth rate = Elasticity * GDP growth rate

			2010	2015	2020	2025	2030	2035	2040
Real GDP	Real at 2005price	Billion NGN	20,682	26,178	33,396	44,692	61,232	83,893	114,941
	Growth rate	G%	7.0	3.0	6.0	6.0	6.5	6.5	6.5
Real GDP	Agriculture	Billion NGN	8,446	10,209	11,613	13,995	17,076	20,720	25,015
	Industry	Billion NGN	5,119	5,236	6,591	9,161	13,039	18,455	25,990
	Services	Billion NGN	7,117	10,733	15,192	21,535	31,118	44,718	63,936
	GDP	Billion NGN	20,682	26,178	33,396	44,692	61,232	83,893	114,941
Growth rate	Agriculture	%	4.79	0.4	3.6	3.6	3.9	3.9	3.9
	Industry	%	9.03	(1.9)	6.6	6.6	7.2	7.2	7.2
	Services	%	8.26	8.2	7.2	6.9	7.5	7.5	7.5
	GDP	%	7.00	3.0	6.0	6.0	6.5	6.5	6.5
Agriculture	Elasticity to GDP	a.n.	0.85	0.48	**0.60**	**0.60**	**0.60**	**0.60**	**0.60**
Industry	Elasticity to GDP	a.n.	0.70	2.00	**1.10**	**1.10**	**1.10**	**1.10**	**1.10**
Services	Elasticity to GDP	a.n.	1.42	2.38	**1.20**	**1.15**	**1.15**	**1.15**	**1.15**
GDP (FC)	Elasticity to GDP	a.n.	1.00	1.00	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**

(2) Regression analysis for sectoral GDP

Economic equations by economic theory

Agriculture. Forestry.& Fishery = f(GDP, GDP/Pop)

Manufacturing & Construction = f(Investment, Export)

Transportation = f(GDP, urban population)

Commercial. Banking, Service = f(GDP)

Public service = f(GDP)

(3) Foreign exchange rate

NGN per US dollar is calculated from 2016 to 2040. NGN is moved in proportion with the difference between US inflation and Nigeria inflation.

Nt = Nt-$_1$ ＊1+ (Nigeria inflation rate － US inflation rate))

Foreign exchange definition factors

a. Inflation rate between Nigeria and USA
b. Trade balance (Export – Import) of Nigeria
c. Interest rate between Nigeria and USA
d. Economic basic factors (Age of Labor force, Infrastructure, Market potential and Political stability)

(4) Power ratio in final energy consumption

Power ratio = Power (toe) / final consumption (toe)

%

	1980	1990	2000	2009	2012
Nigeria	0.9	1.1	1.0	1.5	2.0
USA	13.3	17.5	19.5	21.4	
Japan	19.0	21.5	23.5	25.6	
Africa (Average)	14.9	17.7	19.9	20.8	
Asia (Average)	11.7	14.0	18.4	21.7	

Source : IEA data

Nigeria power and final energy ktoe

Power energy	405	677	743	1540	2,164
Final energy	45,900	59,000	78,000	100,000	116,000

Note: Include Woods & Charcoal, 1kWh = 860 kcal

(5) Energy price forecasting

Energy	Formula (As of April 2016)
Crude oil price	West Texas Intermediate ($/ bbl) WTI (t) = WTI (t-1) * (1+ USA Inflation rate) Inflation rate = 1.5% ～2.0% Brent price is nearly equal to WTI price.
Natural gas	On shore production cost 1~2 $/mmBtu Off shore production cost 5~7 $/mmBtu (shallow) Off shore production cost 8~10 $/mmBtu (deep) Pipeline cost = 1~5 $/mmBtu
LNG	LNG price ($/ mmBtu) ＝ WTI ($/bbl) / 6 Ex: WTI = 60 $/bbl → LNG = 60 / 6= 10 mmBtu
Coal	Import coal (5800 – 6000kcal /kg from Australia) = Set value of WTI ($/bbl) Ex: WTI = 60 $/bbl → Import coal = 60 $/ton

Note : The above formula is rough guideline expressions.
LNG price formula is called as “J-curve” or “S- curve”.

< Organizations for Crude oil price forecasts >

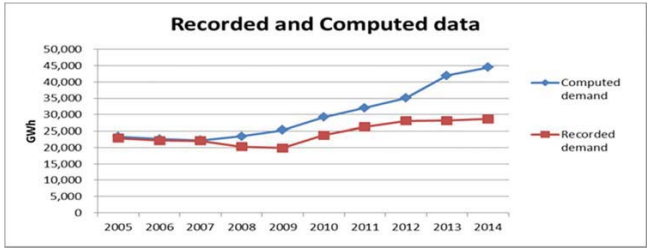
Organization	Publication	Latest version
International Energy Agency (IEA)	World Energy Outlook（WEO)	2015 version
Organization of the Petroleum Exporting Countries(OPEC)	World Oil Outlook	2014 version
Energy Information Agency (EIA, USA)	International Energy Outlook	2014 version
The Institute of Energy Economics, Japan(IEEJ)	Asia/ World Energy Outlook	2015 version

(6) Without constrain demand (Potential demand)

The expression for calculating the without constrain power demand is defined as follows;

Without constrain power demand
= Statistical power consumption + Power shedding and peak cut
= Statistical power consumption * (1+ α%)

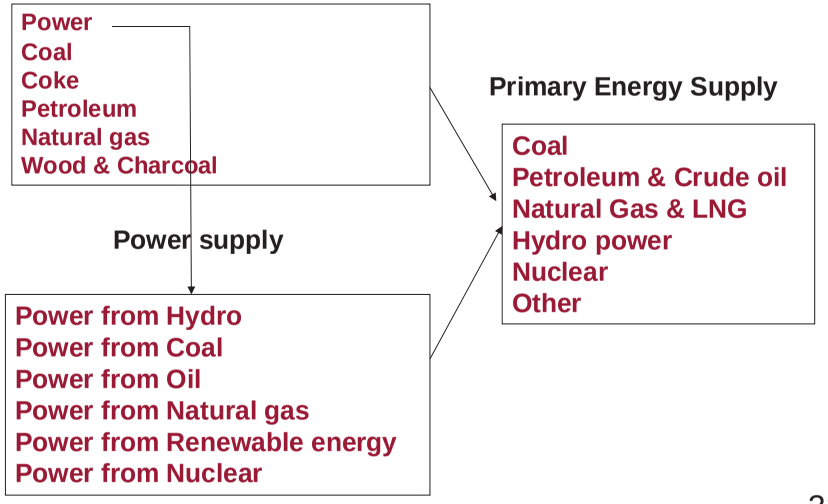
α% : Potential factor : Power shedding and peak cut are targeted.



Recorded data: Statistical power consumption Computed data : Without constrain

(7) Final energy and Primary energy balance

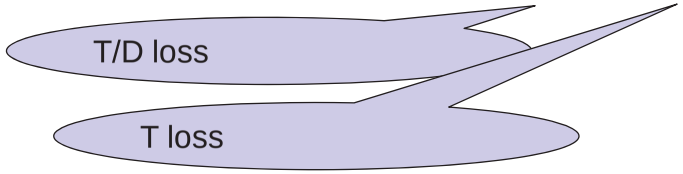
Final energy consumption in all sectors



(8) Exercise sectoral power consumption shares

EX2-1 Can you fill the following table. You are expected to enter the power consumption by sector and calculate the shares.

	Power Consumption		Shares	
	2005	2014	2005	2014
	GWh	GWh	%	%
Residential	10,302	14,821	45.0	51.8
Industry	2,119	4,058	9.3	14.2
Commercial	4,754	6,751	20.8	23.6
LNG	111	244	0.5	0.9
Public use	673	934	2.9	3.3
T/D loss	4,914	1,814	21.5	6.3
Supply total	22,873	28,622	100.0	100.0



(9) Exercise power demand forecast

EX2-2 Can you fill the following table. You are expected to enter the actual data and suitable expressions in the table. (Refer to Nigeria EX2-2 in EXCEL sheet)

	Unit	Actual value		Forecast							
		2004	2014	2015	2016	2017	2018	2019	2020	2021	2022
GDP forecasting (real at 2005)	Billion NGN	14,215	25,425	27,205	29,109	31,147	33,327	35,660	38,156	40,827	43,685
Future growth rate	%		6.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Power generation (Without constrain)	GWh	23,630	45,728	49,377	53,317	57,572	62,166	67,127	72,483	78,267	84,512
Future growth rate	%		6.8	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Elasticity to GDP			1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14

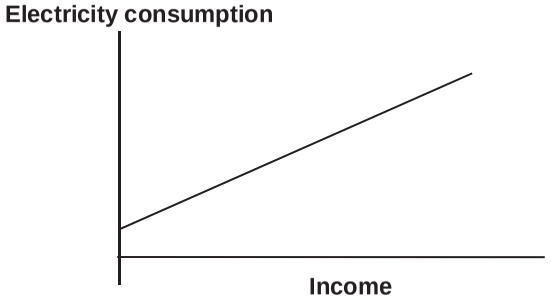
3. Economic Equations for Demand Forecasting

3-1 Typical equations for energy demand forecasting

(1) Linear function

Economic activities are shown by several kinds of equations. The following are typical equations

Y=a*X +b a : marginal ratio



(2) Powered function

$Y=b*X^a$ is the same equation to log Y= a*log X + log b.

In the above equation, “a” is “Y’s elasticity to X”.

<Proof>

Definition of Elasticity :$Q=(dY / Y) / (dX / X)$

$Q^* (dX / X) =(dY / Y)$

$\int Q \ 1/X \ dX= \int 1/Y \ dY$

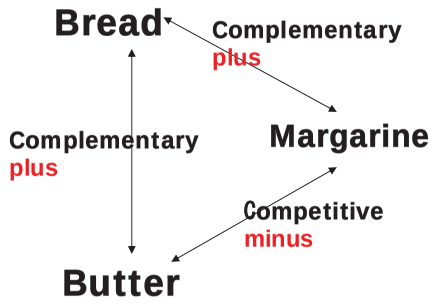
$Q^*\log X = \log Y + b$

$\longrightarrow \log Y = Q^*\log X + b$

Therefore Q=a : a is elasticity

<Sign of Elasticity>

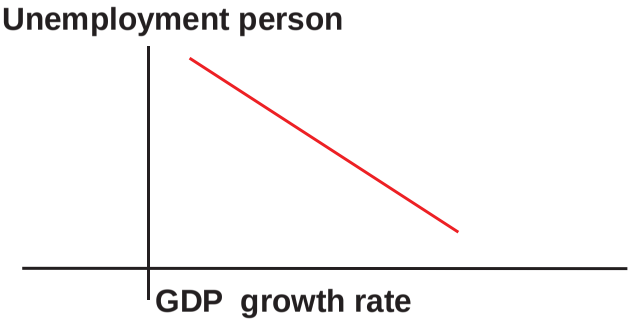
Complementary goods	Competitive goods
Butter = a*(Bread)^r	Butter = a*(Margarine)$^{-r}$
Ink bottle = b*(Pen)^r	Ink bottle = b*(Ball pen)$^{-r}$



(3) Reverse proportion type

Y=a / X + b 1/X → Z

Y=a*Z + b a: marginal ratio



3-2 Approach for energy demand forecasting

(1) Intensity approach

Intensity approach is frequently used for energy demand forecasting for all kind of sectors.

Energy demand = intensity * Denominator

Denominators of Energy intensity by sector

Sector	Denominator selected
Agriculture sector	GDP of Agriculture sector
Industry sector	GDP of Industry sector
Transportation sector	Freight transportation (ton km) Passenger transport (person km) GDP of the country
Commercial & Ser. sector	GDP of Commercial & Service Floor area of Buildings
Residential sector	Number of population Number of Households

45

(2) Stock approach

Stock approach is frequently used for transportation sector and residential sector.

Energy demand = technical coefficient * operation load
* Number of equipment

Gasoline demand = Gas efficiency * Travel distance
* Number of Vehicles

Kerosene demand = Kerosene efficiency per stove
* Number of Households

Energy demand = a* Number of equipment +b

46

(3) Elasticity approach

It is popular approach in energy demand model. Energy demand is depended on Income and energy price. Elasticity of energy price usually takes minus sign.

Log(Energy demand)=a*log(Income)+b* log(energy price) +c

$Log(E)=a*log(Y) + b*log(P) + c*log(E_{-1}) + d$

a: short elasticity to income

b: short elasticity to energy price

Log(E)= a/(1-c)*log(Y)+b/(1-c)*log(P) + d

a/(1-c): long range elasticity to income

b/(1-c): long range elasticity to price

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3-3 Regression Analysis

(1) Regression equation

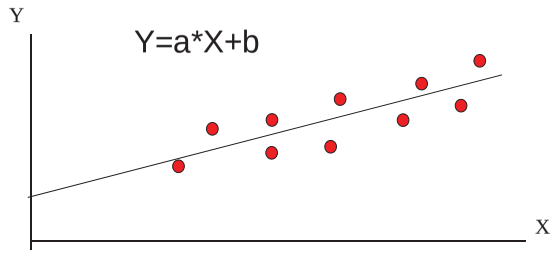
★ Concept

"a": Coefficient of X

"a" is one of statistics generated by variable (X,Y)

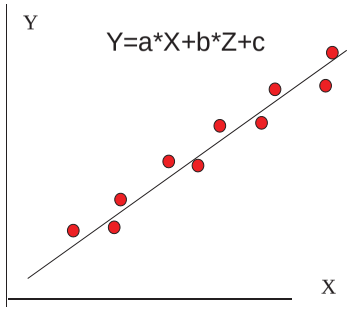
"a" is one of mean with t-distribution.

"a" has a standard deviation.



48

(2) Regression coefficient test



t_a= a / SD(a), t_b= b / SD(b)

Null hypothesis =0

ABS(t_a)> 2 Degree of freedom(n-x-1)

ABS(t_b)> 2 Degree of freedom(n-x-1)

a not=0, b not=0

a and b are means of each t- distribution.

If b=0, we can rewrite Y=a*X+b*Z+c to Y=a*X+c.

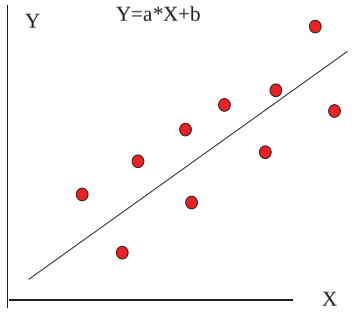
It means that variable Z has no relation to Y.

But if a=0, we can rewrite Y=a*X+b*Z+c to Y=b*Z+c.

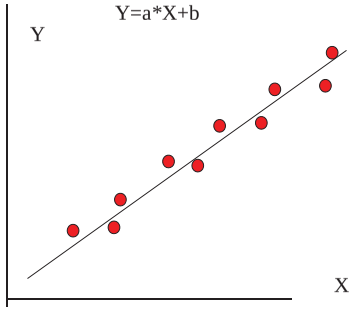
It means that variable X has no relation to Y.

Then we have to test regression coefficient by the t-value of coefficients.

(3) Determination coefficient (Correlation coefficient)



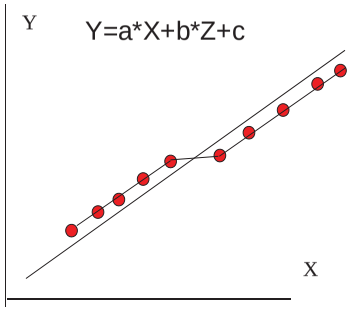
Determination coefficient
= 0.6-0.7
Not fitting



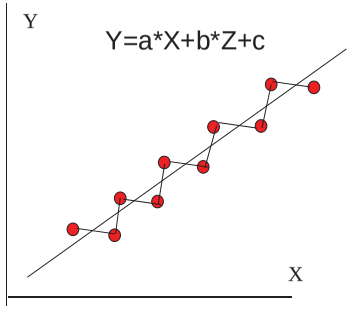
Determination coefficient
= 0.8-0.9
Fitting

Determination coefficient = (Correlation coefficient) ^{2}

(4) Durbin Watson ratio



DW <1



DW > 3

$$DW=\Sigma(e_t-e_{t-1})^2/\Sigma e_t^2 = \Sigma(e^2_t-2e_te_{t-1}+e^2_{t-1})/\Sigma e_t^2$$

DW ratio should be in the range of 0<DW <4 (1<DW<3 better).

The function with DW=2 is the best fitting to the actual data.

(5) Statistical Test

LS: R.953; AR.944; DW3.16; F101.9; DF5(p5%R.54/F5.79/t2.57); RSS8806.8

INEL= 204.12(4.65) +.6859(10.1)*(INTO*(LAG1.INEL/LAG1.INTO)*(1+GRELRT/100)/(1+LAG1.GRELRT/100))

R: R-Square (0<R^2<1). Better close to 1

AR: Adjusted R. (0<R^2<1) Better close to 1 if the samples are small.

DW: Durbin Watson Stat. (0<DW<4). Good condition 1<DW＜3

DF: Deg. of Freedom (>1).

t-value ABS(t-value) > 2

(6) **Sign test**

Sign test is not statistical test. It has to be tested by the relation between dependent variable and independent variable.

Consumption = a* income +b a >0

Gasoline consumption = a* number of car +b a>0

Gasoline consumption = a* Gas price / WPI + b a<0

Kerosene demand = a*log(Wage)
+ b*log(Kerosene price/ CPI)
+ c*log(Kerosene demand $_{-1}$) + d
a > 0, b < 0, c >0

4. How to use Simple E

4-1 Installation

(1) Installation of Simple E

Step1 Copy *Simple_E.xla* in External device to your favorite hard disk directory.
Desktop
C:¥Program Files¥Microsoft Office¥Office¥Library

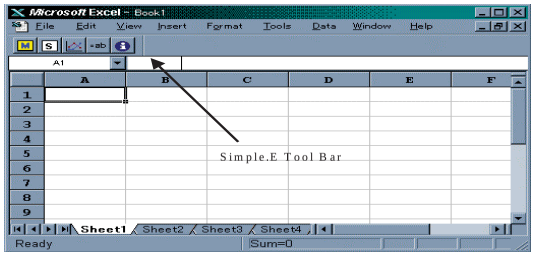
Step2 Open MS-EXCEL

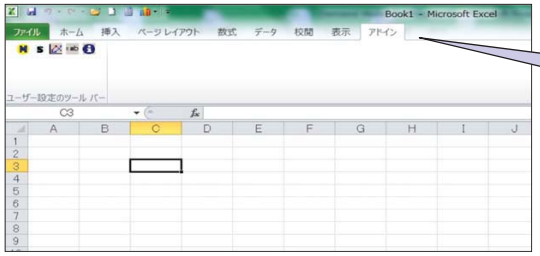
Step3 "Quick Access" ⇨ "Other command". ⇨ Addin

Step4 " Setting" ⇨ "Browse" to select *Simple_E.*

Step5 Check the box of *Simple_E.* in "Add-In" menu

(2) Simple.E tool bar
The program *Simple E.* will be loaded and the five buttons of *Simple E.* toolbar will be displayed on the upper-left corner as follows;

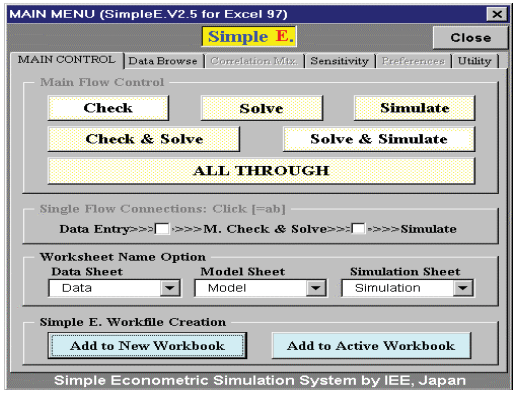




4-2. Create Simple E. worksheets

(1) To create new worksheets into a new workbook, click "Add to New Workbook".

(2) To create new worksheets in the same active workbook, click "Add to Active Workbook."



(3) Relation among Data sheet, Model sheet and Sim sheet

Data sheet

	TREND	1	2	3	4	5	6	7	8	9	10	11
H I	TIME	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
(1) Agriculture,	RGPRM	61	64	65	69	72	76	80	84	88	93	98
(2) Industry	RGIND	88	97	107	117	128	139					
(3) Services	RGSER	107	113	120	127	133	141					
(4) GDP	RGGDP	257	274	292	312	333	356					

Model sheet

			Internal	Option					
H	I	J	Y	Type	X1	X2	X3	X4	X5
(1) Agriculture, Fishery, For			RGPRM	=	RGPRM				
(2) Industry			RGIND	=	Lag1.RGIND*1.05				
(3) Services			RGSER	=	Lag1.RGSER*1.04				
(4) GDP			RGGDP	=	RGPRM+RGIND+RGSER				

Simulation sheet

			TREND	1	2	3	4	5	6	7	8	9	10	11
H	I	J	TIME	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
(1) Agriculture, Fishery, Fore			RGPRM	61	64	65	69	72	76	80	84	88	93	98
(2) Industry			RGIND	88	97	107	117	128	139	146	154	161	170	178
(3) Services			RGSER	107	113	120	127	133	141	146	152	158	164	171
(4) GDP			RGGDP	257	274	292	312	333	356	373	390	408	427	447

4-3. Data sheet

(1) FREE AREA

The columns A~J are free area. This area will be useful to set data categories, data source, variable name, unit, and other comments.

(2) Trend Constant

"TREND" is the default code name for the serial number from 1 to 245. The code name "TREND" can be used as a variable of series "1, 2, 3, … , 245".

(3) CODE Area

The column "K" is for code name of the variable. Code name should be unique for each variable, and the characters are limited to from "A" to "Z", from "0" to "9", ".", "_".

(4) TIME LABEL

If the actual data is prepared from 2005 to 2015 and if the TIME is set from 2005 to 2025. Simple.E automatically takes the range between 2016 and 2025 for forecast.

(5) DATA

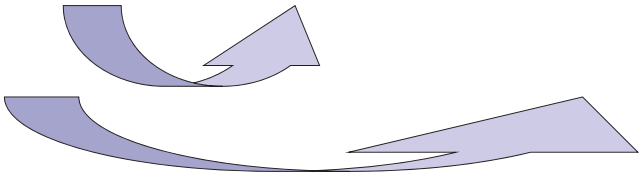
The area is for the data of each variable, the data should be prepared for all time interval.

If a variable is available from 2005 to 2015, all cells must be filled with actual values. Missing data or non-numeric values are not allowed.

	TREND	1	2	3	4	5	6	7	8	9	10	11
H I	TIME	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
(1) Agriculture,	RGPRM	61	64	65	69	72	76	80	84	88	93	98
(2) Industry	RGIND	88	97	107	117	128	139					
(3) Services	RGSER	107	113	120	127	133	141					
(4) GDP	RGGDP	257	274	292	312	333	356					

(6) Copy Comments from Data sheet to Other sheets

Data	Model	Simulation
F1 Agriculture	=Data!F1	=Data!F1
F2 Industry	=Data!F2	=Data!F2
F3 Services	=Data!F3	=Data!F3



(7) Exercise for Data sheet

Ex3-1 Can you try to set the following data in Data sheet ?

Data sheet

		TREND	1	2	3	4	5	6	7	8	9	10	11
H	I	TIME	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
(1) Agriculture,		RGPRM	61	64	65	69	72	76	80	84	88	93	98
(2) Industry		RGIND	88	97	107	117	128	139					
(3) Services		RGSER	107	113	120	127	133	141					
(4) GDP		RGGDP	257	274	292	312	333	356					

★ Set the years from 2005 to 2010 in the TIME line of the Data sheet.

★ Set the comments in the Comment Columns

★ Set the variable names

★ Set the time series data

★ Calculate GDP

Ex3-2 Can you set the forecasting years and the exogenous values for Agriculture sector

		TREND	1	2	3	4	5	6	7	8	9	10	11
H	I	TIME	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
(1) Agriculture,		RGPRM	61	64	65	69	72	76	80	84	88	93	98
(2) Industry		RGIND	88	97	107	117	128	139					
(3) Services		RGSER	107	113	120	127	133	141					
(4) GDP		RGGDP	257	274	292	312	333	356					

★ Set the forecasting years from 2011 to 2015 in the TIME line of the Data sheet.

★ Set the exogenous values for Agriculture sector

4-4 Model sheet

(1) Formats of Model sheet

★ The first ten columns A:J are free area.

★ The model equations are specified in the col K to col AB.

★ The column K is the code for the internal variable.

★ The column L is for options of model.

★ The columns M to col AB are for independent variables.

(2)Option Type (Useful)

"$LS" or Blank cell -- Simple E. executes regression based on Ordinary Least Square (Regression Analysis).

Y	Type	X1
YY	$LS	XX

$$YY = a * XX + b$$

	H	I	J	K	L	M	N	O
				Internal	Option			
	H	I	J	Y	Type	X1	X2	X3
				YY	$LS	XX		
				YY		XX		

"=" or "$EQ"-- Direct Equation: The variable in "Y" is defined directly by the formula in "X." "

Y	Type	X1
YY	=	XX

YY = XX

H	I	J	K	L	M	N	O
			Internal	Option			
H	I	J	Y	Type	X1	X2	X3
			YY	=	XX		

65

"$DL" – Double Log: Simple E. executes regression after transforming the variables of both sides to log format.

Y	Type	X1
YY	$DL	XX

Log(YY) = a * log(XX) + b

H	I	J	K	L	M	N	O
			Internal	Option			
H	I	J	Y	Type	X1	X2	X3
			YY	$DL	XX		

66

"$SL" – Semi Log: Simple E. executes regression after transforming the variable of "Y" side to log format.

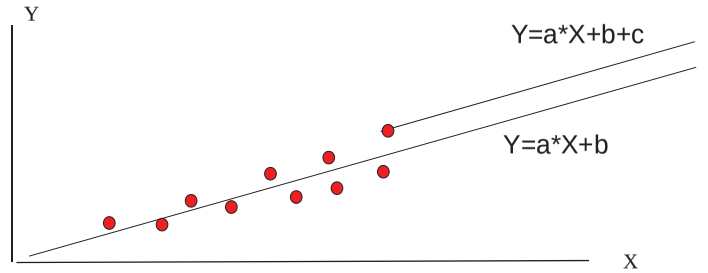
Y	Type	X1
YY	$SL	XX

Log(YY) = a * XX + b

H	I	J	K	L	M	N	O
			Internal	Option			
H	I	J	Y	Type	X1	X2	X3
			YY	$SL	XX		

67

$CA—Constant Adjustment: Simple E adjust between regression equation and the latest actual value.



H	I	J	K	L	M	N	O
			Internal	Option			
H	I	J	Y	Type	X1	X2	X3
			YY	$CA	XX		

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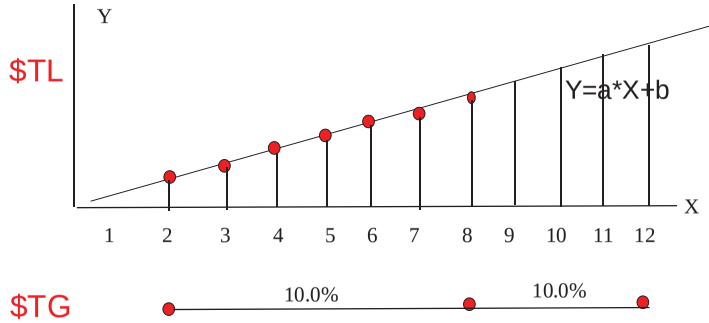
$TL—Linear Trend, estimated by serial number

$TG—Growth Trend, estimated by average actual growth rate



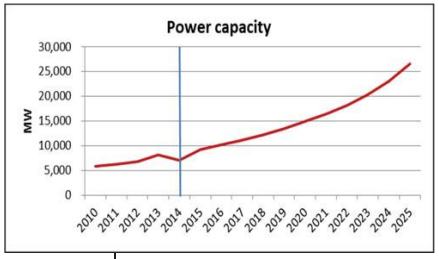
(3) Arithmetic operators in Model sheet

I	J	Internal Y	Option Type	X1	X2	X3	X4	X5
Market exchange rate	NGN/US$	EXCHNG	=	Lag1.EXCHNG*(1+EXCGR/100)				
Growth rate	G%	EXCGR	=	EXCGR				
Country number	1000 persons	POPNUM	=	Lag1.POPNUM*(1+POPNGR/100)				

Arithmetic Operators	Operators in Model sheet
+	+
-	-
=	X1 variable is moved to Y variable
×	*
÷	/
X^n	X^n
X_{t-1}	Lag1.X
Set Dummy var in 2007	DUM.2007

(4) Dummy variable

When the special points can not be explained by any variables, we can set dummy variables in regression equations



	2005	2006	2007	2008	2009	2010
Dum.2007	0	0	1	0	0	0
Dum.2007..	0	0	1	1	1	1
Dum.2007.2009	0	0	1	0	1	0
Dum.2007..2009	0	0	1	1	1	0
Dum.2007.2009..	0	0	1	0	1	1

(5) Exercise for Model sheet

Ex3-3 Can you describe the expressions in the Model sheet ?

Model sheet

H	I	J	Y	Type	X1
=Data!H3			RGPRM	=	RGPRM
=Data!H4			RGIND	=	Lag1.RGIND*1.05
=Data!H5			RGSER	=	Lag1.RGSER*1.04
=Data!H6			RGGDP	=	RGPRM+RGIND+RGSER

★ Set Special paste and Link paste in H col to L col of Model sheet for copying the Comment, Variable names and Types from Data sheet.

★ Set the expressions for the variables.

4-5 Simulation sheet

(1) Free columns

The first columns “A:J” are the free area.

(2) Code names

The column K shows the same code name as that in model sheet except for the variable in functional form with operators.

(3) Actual values

Actual value in Simulation sheet are copied from Data sheet.

(4) Simulated Forecasts

The simulation forecasts or the cells with formulas are shown with the red color font.

The cells of forecasts contain estimated or defined equations. If the forecasts are linear trends calculated by SimpleE., the font color is set to pink.

These cells of the pink color cells doesn’t contain equations.

(5) Exercise for simulation sheet

Ex3-4 Can you describe only the comments in the Simulation sheet ?

Simulation sheet

H	I	J	TIME	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
(1) Agriculture, Fishery, Fore			RGPRM	61	64	65	69	72	76	80	84	88	93	98
(2) Industry			RGIND	88	97	107	117	128	139	146	154	161	170	178
(3) Services			RGSER	107	113	120	127	133	141	146	152	158	164	171
(4) GDP			RGGDP	257	274	292	312	333	356	373	390	408	427	447

★ Set Special paste and Link paste in H col to K col of Simulation sheet for copying the Comments and Variable names from Data sheet.

★ The data area from K col are filled by the calculation values after SimpleE run.

4-6 Important Simple E Menu

(1) Main Menu

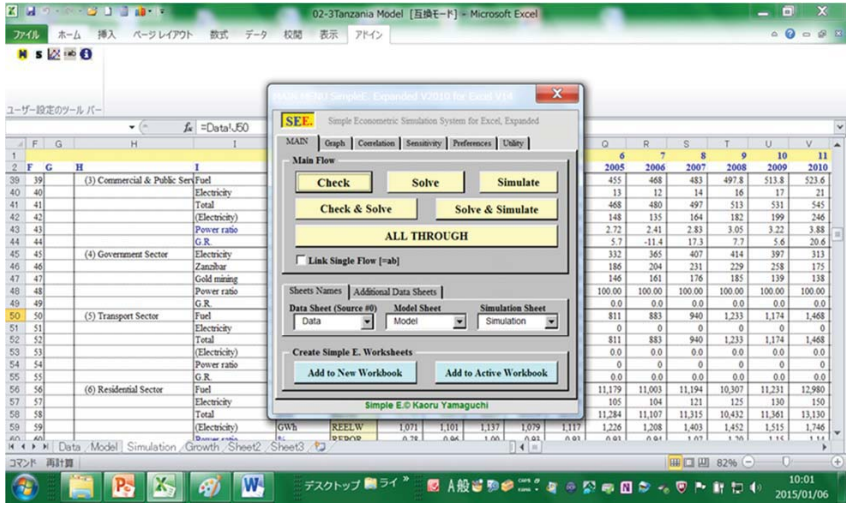
Simple E. Main-Menu

Synchronize: Synchronize the variable of the row for all windows

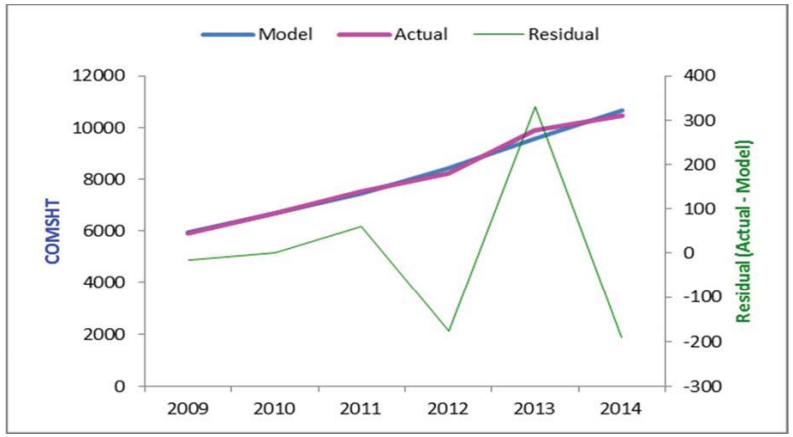
Graph: Create graph(s) of the variable(s) on the selected row(s)

Re-Calculate Row(s): Reset and Re-calculate the equation(s) of the variable(s) of the selected row(s)

< Main Menu >



(3) Graph



(2) Synchronize

Model sheet

F	G	H	I	J	Internal Y	Option Type	X1	X2	X3
3	1								
4	1.1	Exchange rate	Market exchange rate	NGN/US$	EXCHNG	=	Lag1.EXCHNG*(1+EXCGR/100)		
5			Growth rate	G%	EXCGR	=	EXCGR		
6									
7	1.2	Population	Country number	1000 persons	POPNUM	=	Lag1.POPNUM*(1+POPNGR/100)		
8			Growth rate	G%	POPNGR	=	POPNGR		
9									
10	1.3	Nominal GDP	MP	Billion NGN	NGDP	=	Lag1.NGDP*(1+(GDPGR+DGPGR)/100)		
11			Growth rate	G%	NGPGR	=	(NGDP/Lag1.NGDP-1)*100		
12		Real GDP (FC)	Real at 2005price	Billion NGN	RGDP	=	Lag1.RGDP*(1+GDPGR/100)		
13			Growth rate	G%	GDPGR	=	GDPGR		
14		Deflator	2005 = 100	2005=100	DGDP	=	Lag1.DGDP*(1+(DGPGR)/100)		
15			Growth rate	G%	DGPGR	=	DGPGR		

Data sheet

F	G	H	I	J	TREND TIME	1 2000	2 2001	3 2002	4 2003	5 2004
3	1									
4	1.1	Exchange rate	Market exchange rate	NGN/US$	EXCHNG	102	111	121	129	133
5			Growth rate	G%	EXCGR		9.37	8.40	7.17	2.84
6										
7	1.2	Population	Country number	1000 persons	POPNUM	122,877	126,005	129,225	132,550	135,999
8			Growth rate	G%	POPNGR		2.55	2.56	2.57	2.60
9										
10	1.3	Nominal GDP	MP	Billion NGN	NGDP	4,717	4,910	7,128	8,743	11,674
11			Growth rate	G%	NGPGR		4.1	45.2	22.6	33.5
12		Real GDP (FC)	Real at 2005price	Billion NGN	RGDP	8,888	9,281	9,632	10,629	14,215
13			Growth rate	G%	GDPGR		4.4	3.8	10.4	33.7
14		Deflator	2005 = 100	2005=100	DGDP	53.0	52.8	73.9	82.2	82.0
15			Growth rate	G%	DGPGR		-0.3	39.9	11.1	-0.2

(4) Re-Calculate

F	G	H	I	J	K	L	M	N	O	P	Q
92			Regression (Short)	GWh	INDSHT	$DL	RGDMAN	TAIND	Dum.2010	Dum.2011	
93			Regression (Long)	GWh	INDLON	$DL	RGDMAN	TAIND	Dum.2010	Dum.2011	
94			Elasticity to industry GDP	a.n.	INDELG	=	INDELG				
95			Elsaticity to Industry tarif	a.n.	INDELT	=	INDELT				
96			EE&C factor	2012=100	INDEFC	=	Lag1.INDEFC*(1-INDERT/100)				
97			EE&C rate	%	INDERT	=	INDERT				
98											
99	2.3	(3) Commercial Sector	Commerce (Recorded)	GWh	COMSUP	=	COMTOT*RECCHP/100				
100			Commerce(shedding)	GWh	COMSHD	=	COMTOT-COMSUP				
101			Commerce (Computed)	GWh	COMTOT	=	Lag1.COMTOT*(1+COMELG*GRCOM/100)*((1+COMELT*GTACOI				
102			Regression (Short)	GWh	COMSHT	$DL	RGDCOM	TACOM	Dum.2010		
103			Regression (Long)	GWh	COMLON	$DL	RGDMAN	TACOM			
104			Elasticity to commercial G	a.n.	COMELG	=	COMELG				
105			Elsaticity to Commercial t	a.n.	COMELT	=	COMELT				
106			EE&C factor	2012=100	COMEFC	=	Lag1.COMEFC*(1-COMERT/100)				
107			EE&C rate	%	COMERT	=	COMERT				
108											
109	2.4	(4) LNG	LNG (Recorded)	GWh	LNGSUP	=	LNGTOT*RECCHP/100				
110			LNG(shedding)	GWh	LNGSHD	=	LNGTOT-LNGSUP				

5. Model building of Power Demand Forecasts

5-1 Model image

The purpose of the model is to forecast the power demand by 2040 under the Population, GDP, Oil price, Tariff growth rates and so on.

< Exogenous and Power Demand Forecast blocks>

Exogenous variable	Power Demand Forecast
(1) Population	(1) Agriculture
(2) GDP	(2) Industry
Agriculture	(3) Commercial & Service Sector
Industry	(4) Public
Services	(5) Residential Sector
(3) Crude oil	(6) Power demand
(4) Power tariff	Peak demand
(5) EE&C	(1) Own use
	(2) Net peak demand
	(3) Gross peak demand (Generation)

< Forecasting equations in the model >

Residential_power_demand = Residential_power_demand(t-1)
(1+GDP_Elasticity(GDP_GR – Population_GR)
*(1 - Tariff_Elasticity * Tariff_GR)
*(EE&C_factor / EE&C_factor (t-1)
*(1+ (Electrification_rate - Electrification_rate(t-1))

Industry_power_demand = Industry_power_demand(t-1)
(1+GDP_Elasticity(GDP_GR)
*(1 - Tariff_Elasticity * Tariff_GR)
*(EE&C_factor / EE&C_factor (t-1))

< Training items by sheet >

Sheets	Contents
Data sheet	The formation and data already are set in the sheet. The actual data are from 2000 to 2014. You should understand the structure.
Model sheet	The formation and variable names are copied from the data sheet. You are expected to input the expressions.
Simulation sheet	The formations are copied from data sheet. You should rearrange the decimal points.
Growth rate	The formations are copied from data sheet. You should input the expressions for calculating the growth rate.

5-2 Data input into Data sheet

EX4-1 Expect you to understand the model structure in Data sheet .

(1) Actual data from 2000 to 2014

(2) Blue color values are exogenous variables up to 2040.

(3) Precondition sheets (Original source sheet, Population sheet) are deleted.

(4) You shall understand the model flow in Data sheet

5-3 Modelling into Model sheet

EX4-2 Expect you to input expressions in Model sheet .

Set expressions in Model sheet (1)

3	1						
4	1.1	Exchange rate	Market exchange rate	NGN/US$	EXCHNG	=	Lag1.EXCHNG*(1+EXCGR/100)
5			Growth rate	G%	EXCGR	=	EXCGR
6							
7	1.2	Population	Country number	1000 persons	POPNUM	=	Lag1.POPNUM*(1+POPNGR/100)
8			Growth rate	G%	POPNGR	=	POPNGR
9							
10	1.3	Nominal GDP	MP	Billion NGN	NGDP	=	Lag1.NGDP*(1+(GDPGR+DGPGR)/100)
11			Growth rate	G%	NGPGR	=	(NGDP/Lag1.NGDP-1)*100
12		Real GDP (FC)	Real at 2005price	Billion NGN	RGDP	=	Lag1.RGDP*(1+GDPGR/100)
13			Growth rate	G%	GDPGR	=	GDPGR
14		Deflator	2005＝100	2005=100	DGDP	=	Lag1.DGDP*(1+(DGPGR)/100)
15			Growth rate	G%	DGPGR	=	DGPGR

Set expressions in Model sheet (2)

16	1.4	**Gross Domestic Product (real at 2005-06 price)**					
17		**<Real GDP>**	Agriculture	Billion NGN	RGDAGR	=	WGDAGR/WGGDP*RGDP
18			Industry	Billion NGN	RGDIND	=	WGDIND/WGGDP*RGDP
19			(Manufacturing)	Billion NGN	RGDMAN	=	WGDMAN/WGGDP*RGDP
20			(Oil & Gas)	Billion NGN	RGDOIL	=	WGDOIL/WGGDP*RGDP
21			Services	Billion NGN	RGDCOM	=	WGDCOM/WGGDP*RGDP
22			GDP (FC)	Billion NGN	RGGDP	=	RGDAGR+RGDIND+RGDCOM
23		**<Growth rate of Real GDP>**					
24			Agriculture	%	GRAGR	=	ESAGR*GDPGR
25			Industry	%	GRIND	=	ESIND*GDPGR
26			(Manufacturing)	%	GRMAN	=	ESMAN*GDPGR
27			(Oil & Gas)	%	GROIL	=	ESOIL*GDPGR
28			Services	%	GRCOM	=	ESCOM*GDPGR
29			GDP (FC)	%	GRGDP	=	GDPGR
30		**<W-Growth rate of Real GDP>**					
31			Agriculture	Billion NGN	WGDAGR	=	Lag1.WGDAGR*(1+GRAGR/100)
32			Industry	Billion NGN	WGDIND	=	Lag1.WGDIND*(1+GRIND/100)
33			(Manufacturing)	Billion NGN	WGDMAN	=	Lag1.WGDMAN*(1+GRMAN/100)
34			(Oil & Gas)	Billion NGN	WGDOIL	=	Lag1.WGDOIL*(1+GROIL/100)
35			Services	Billion NGN	WGDCOM	=	Lag1.WGDCOM*(1+GRCOM/100)
36			GDP (FC)	Billion NGN	WGGDP	=	WGDAGR+WGDIND+WGDCOM

Set expressions in Model sheet (3)

37		**<Elasticity to rGDP>**					
38			Elasticity to GDP	a.n.	ESAGR	=	ESAGR
39			Elasticity to GDP	a.n.	ESIND	=	ESIND
40			Elasticity to GDP	a.n.	ESMAN	=	ESMAN
41			Elasticity to GDP	a.n.	ESOIL	=	ESOIL
42			Elasticity to GDP	a.n.	ESCOM	=	ESCOM
43			Elasticity to GDP	a.n.	ESGDP	=	ESGDP
44		**<rGDP per capita>**					
45			Agriculture	NGN/person	PCAGR	=	RGDAGR*1000000/POPNUM
46			Industry	NGN/person	PCIND	=	RGDIND*1000000/POPNUM
47			(Manufacturing)	NGN/person	PCMAN	=	RGDMAN*1000000/POPNUM
48			(Oil & Gas)	NGN/person	PCOIL	=	RGDOIL*1000000/POPNUM
49			Services	NGN/person	PCCOM	=	RGDCOM*1000000/POPNUM
50			GDP (FC)	NGN/person	PCGDP	=	RGGDP*1000000/POPNUM
51							

Set expressions in Model sheet (4)

52	1.5	Tariff of Country (Nominal)	Country average	NGN/kWh	TCAVE	=	(TCRES+TCCOM+TCIND)*0.7/3
53		(Source: NECR & TCN)	Domestic(R2)	NGN/kWh	TCRES	=	Lag1.TCRES*(1+(GTARES+0.2*GDPGR)/100)
54		Abuja tariff	Commercial(C2)	NGN/kWh	TCCOM	=	Lag1.TCCOM*(1+(GTACOM+0.2*GDPGR)/100)
55			Industry(D2)	NGN/kWh	TCIND	=	Lag1.TCIND*(1+(GTAIND+0.2*GDPGR)/100)
56			Special (A2)	NGN/kWh	TCLNG	=	Lag1.TCLNG*(1+(GTALNG+0.2*GDPGR)/100)
57			Streel light(S1)	NGN/kWh	TCSLT	=	Lag1.TCSLT*(1+(GTASLT+0.2*GDPGR)/100)
58		Tariff of Country (at 2015 p)	Country average	NGN/kWh	TAAVE	=	(TARES+TACOM+TAIND)*0.7/3
59			Domestic	NGN/kWh	TARES	=	Lag1.TARES*(1+GTARES/100)
60			Commercial	NGN/kWh	TACOM	=	Lag1.TACOM*(1+GTACOM/100)
61			Industry	NGN/kWh	TAIND	=	Lag1.TAIND*(1+GTAIND/100)
62			LNG	NGN/kWh	TALNG	=	Lag1.TALNG*(1+GTALNG/100)
63			Streel light	NGN/kWh	TASLT	=	Lag1.TASLT*(1+GTASLT/100)
64		Growth rate of Country tariff	Country average	%	GTAAVE	=	GTAAVE
65			Domestic	%	GTARES	=	GTARES
66			Commercial	%	GTACOM	=	GTACOM
67			Indusrry	%	GTAIND	=	GTAIND
68			LNG	%	GTALNG	=	GTALNG
69			Streel light	%	GTASLT	=	GTASLT
70		Crude oil price	WTI forecastd (Nominal	US$/bbl	CRDPRC	=	CRDPRC
71			Excalation factor	G%	CRDESC	=	CRDESC
72			WTI adjusted by US infla	US$/bbl	CRDDOB	=	CRDDOB
73			Growth rate	%	CRDDGR	=	CRDDGR
74			USA inflation	2015=100	USAIFL	=	USAIFL
75			Growth rate	G%	USAIGR	=	USAIGR
76							

Set expressions in Model sheet (5)

77	2	Electric Energy Demand - computed demand (grid + auto generation			YEAR6	=	YEAR6			
78	2.1	(1) Residential use	Resdential (Recorded)	GWh	RESSUP	=	RESTOT*RECCHP/100			
79			Residential (shedding)	GWh	RESSHD	=	RESTOT-RESSUP			
80			Residentail (Computed)	GWh	RESTOT	=	(Lag1.RESTOT*(1+RESELG*(GDPGR-POPNGR)/100)			
81			Regression (Short)	GWh	RESSHT	$DL	RGDP/POPN	TARES	RESELR	
82			Regression (Long)	GWh	RESLON	$DL	RGDP/POPN	TARES	RESELR	DUM.2006
83			Elasticity to GDP per cap	a.n.	RESELG	=	RESELG			
84			Elsaticity to Domestic tari	a.n.	RESELT	=	RESELT			
85			Electrification rate (World	%	RESELR	=	RESELR			
86			EE&C factor	2012=100	RESEFC	=	Lag1.RESEFC*(1-RESERT/100)			
87			EE&C rate	%	RESERT	=	RESERT			
88										
89	2.2	(2) Industry Sector	Industry (Recorded)	GWh	INDSUP	=	INDTOT*RECCHP/100			
90			Industry (shedding)	GWh	INDSHD	=	INDTOT-INDSUP			
91			Industry (Computed)	GWh	INDTOT	=	Lag1.INDTOT*(1+INDELG*GRMAN/100)*((1+INDEL			
92			Regression (Short)	GWh	INDSHT	$DL	RGDMAN	TAIND	Dum.2010	Dum.2011
93			Regression (Long)	GWh	INDLON	$DL	RGDMAN	TAIND	Dum.2010	Dum.2011
94			Elasticity to industry GDP	a.n.	INDELG	=	INDELG			
95			Elsaticity to Industry tariff	a.n.	INDELT	=	INDELT			
96			EE&C factor	2012=100	INDEFC	=	Lag1.INDEFC*(1-INDERT/100)			
97			EE&C rate	%	INDERT	=	INDERT			
98										

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Set expressions in Model sheet (6)

99	2.3	(3) Commercial Sector	Commerce (Recorded)	GWh	COMSUP	=	COMTOT*RECCHP/100				
100			Commerce(shedding)	GWh	COMSHD	=	COMTOT-COMSUP				
101			Commerce (Computed)	GWh	COMTOT	=	Lag1.COMTOT*(1+COMELG*GRCOM/100)*((1+COMELT*GTAC				
102			Regression (Short)	GWh	COMSHT	$DL	RGDCOM	TACOM	Dum.2010		
103			Regression (Long)	GWh	COMLON	$DL	RGDMAN	TACOM			
104			Elasticity to commercial G	a.n.	COMELG	=	COMELG				
105			Elsaticity to Commercial t	a.n.	COMELT	=	COMELT				
106			EE&C factor	2012=100	COMEFC	=	Lag1.COMEFC*(1-COMERT/100)				
107			EE&C rate	%	COMERT	=	COMERT				
108											
109	2.4	(4) LNG	LNG (Recorded)	GWh	LNGSUP	=	LNGTOT*RECCHP/100				
110			LNG(shedding)	GWh	LNGSHD	=	LNGTOT-LNGSUP				
111			LNG (Computed)	GWh	LNGTOT	=	Lag1.LNGTOT*(1+LNGELG*GROIL/100)*((1+LNGELT*GTALNG				
112			Regression (Short)	GWh	LNGSHT	$DL	RGDOIL	TALNG	Dum.2013	Dum.2014	
113			Regression (Long)	GWh	LNGLON	$DL	RGDOIL	TALNG	Dum.2010	Dum.2012..2014	
114			Elasticity to Oil & Gas GI	a.n.	LNGELG	=	LNGELG				
115			Elsaticity to OIL & Gas ta	a.n.	LNGELT	=	LNGELT				
116			EE&C factor	2012=100	LNGEFC	=	Lag1.LNGEFC*(1-LNGERT/100)				
117			EE&C rate	%	LNGERT	=	LNGERT				
118											

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Set expressions in Model sheet (7)

119	2.5	(5) Public use	St-light & Power use(Rec	GWh	PUBSUP	=	PUBTOT*RECCHP/100
120			St light & Power use(She	GWh	PUBSHD	=	PUBTOT-PUBSUP
121			St light & power use(Com	GWh	PUBTOT	=	Lag1.PUBTOT*(1+PUBELG*GDPGR/100)
122			Regression (Short)	GWh	PUBSHT	=	PUBSHT
123			Regression (Long)	GWh	PUBLON	=	PUBLON
124			Elasticity to country GDP	a.n.	PUBELG	=	PUBELG
125			Elsaticity to Average tariff	a.n.	PUBELT	=	PUBELT
126			EE&C factor	2012=100	PUBEFC	=	Lag1.PUBEFC*(1-PUBERT/100)
127			EE&C rate	%	PUBERT	=	PUBERT
128							
129	2.6	(6) T loss	T- loss (Recorded)	GWh	TDLSUP	=	CTYSUP*TDLRAT/100
130			T- loss (Shedding)	GWh	TDLSHD	=	CTYSHD*TDLRAT/100
131			T- loss (Computed)	GWh	TDLTOT	=	TDLSUP+TDLSHD
132			T- loss rate (T-loss 8%)	%	TDLRAT	=	TDLRAT
133							
134	2.7	(7) Electric energy dema	Residential	GWh	ENGRES	=	RESSUP
135		(Recorded)	Industry	GWh	ENGIND	=	INDSUP
136			Commercial	GWh	ENGCOM	=	COMSUP
137			LNG	GWh	ENGLNG	=	LNGSUP
138			Public use	GWh	ENGPUB	=	PUBSUP
139			T/D loss	GWh	ENGTDL	=	TDLSUP
140			Supply total	GWh	CTYSUP	=	RESSUP+INDSUP+COMSUP+LNGSUP+PUBSUP+TDLSUP

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Set expressions in Model sheet (8)

141		(Shedding)	Residential	GWh	SHDRES	=	RESSHD
142			Industry	GWh	SHDIND	=	INDSHD
143			Commercial	GWh	SHDCOM	=	COMSHD
144			LNG	GWh	SHDLNG	=	LNGSHD
145			Public use	GWh	SHDPUB	=	PUBSHD
146			T/D loss	GWh	SHDTDL	=	TDLSHD
147			Shedding total	GWh	CTYSHD	=	RESSHD+INDSHD+COMSHD+LNGSHD+PUBSHD+TDLSHD
148		(Computed)	Residential	GWh	COPRES	=	RESTOT
149			Industry	GWh	COPIND	=	INDTOT
150			Commercial	GWh	COPCOM	=	COMTOT
151			LNG	GWh	COPLNG	=	LNGTOT
152			Public use	GWh	COPPUB	=	PUBTOT
153			T- loss	GWh	COPTDL	=	TDLTOT
154			Computed total	GWh	CTYTOT	=	RESTOT+INDTOT+COMTOT+LNGTOT+PUBTOT+TDLTOT
155	2.8	(8) Power sector use	Own use (Recorded)	GWh	POWSUP	=	POWTOT*RECCHP/100
156			Own use (Shedding)	GWh	POWSHD	=	POWTOT-POWSUP
157			Own use (Computed)	GWh	POWTOT	=	GROTOT*POWOWN/100
158			Own use rate	a.n.	POWOWN	=	POWOWN
159							
160		(9) Gross Generation	Country (Recorded)	GWh	GROSUP	=	CTYSUP+POWSUP
161			Country (Shedding)	GWh	GROSHD	=	CTYSHD+POWSHD
162			Country (Computed)	GWh	GROTOT	=	CTYTOT+POWTOT
163							

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Set expressions in Model sheet (9)

164	3	**Power demand**			YEAR7	=	YEAR7
165	3.1	Computed demand	Gross generation	GWh	CDMGRO	=	GROTOT
166			Load factor	%	CDMLOA	=	CDMLOA
167			Gross peak demand	MW	CDMPKD	=	CDMGRO*1000/24/365/(CDMLOA/100)
168			Reserve margin	%	CDMRESV	=	CDMRESV
169			Required capacity	MW	CDRCAP	=	CDMPKD*(1+CDMRESV/100)
170			Net demand(Energy)	GWh	CDMNEG	=	CTYTOT
171			Net peak demand(Power	MW	CDMNPW	=	CTYTOT*1000/24/365/(CDMLOA/100)
172							
173			Shedding	GWh	CDMSHE	=	CTYSHD
174			Shedding at peak demand	MW	CDMSHP	=	CDMSHE*1000/24/365/(CDMLOA/100)
175			Shedding rate at peak den	%	CDMSHR	=	CDMSHR
176							
177			TCN demand	GWh	CDMPHC	=	CDMNEG*(1-CDMASH/100)
178			Auto producer's demand	GWh	CDMAUT	=	CDMNEG*CDMASH/100
179			Auto producer share	%	CDMASH	=	CDMASH
180			TCN peak demand	MW	CDPPHC	=	CDMPHC*1000/24/365/(CDMLOA/100)
181			Auto producer's peak den	MW	CDPAUT	=	CDMAUT*1000/24/365/(CDMLOA/100)
182							

Set expressions in Model sheet (10)

183	3.2	Recorded demand	Recorded energy demand	GWh	RECEG	=	CDMNEG-CDMSHE
184		(Including Auto producers)	Recorded peak demand	MW	RECPW	=	RECEG*1000/24/365/(CDMLOA/100)
185			Catch up	%	RECCHP	=	100-CDMSHR
186			Requred capacity	MW	RECRCAP	=	CDRCAP*RECPW/CDMNPW
187			TCN demand	GWh	RECGPH	=	RECEG-CDMAUT
188			Auto producer's demand	GWh	RECGAU	=	CDMAUT
189			TCN peak demand	MW	RECMPH	=	RECPW-CDPAUT
190			Auto producer's peak den	MW	RECMAU	=	CDPAUT
191							
192	3.3	Off grid power demand	Energy demand (Off grid)	GWh	OFFGWH	=	OFFGWH
193			Power demand (Off grid)	MW	OFFMW	=	OFFMW
194			Capacity (Off grid)	MW	OFFCAP	=	OFFINST-OFFRET
195			Installed capacity	MW	OFFINST	=	OFFINST
196			Retired capacity	MW	OFFRET	=	OFFRET
197							
198	3.4	Computed domestic power de	Energy demand	GWh	DOPOPOW	=	CDMNEG+OFFGWH
199			Peak demand	MW	DOPOPEK	=	CDMNPW+OFFMW
200			Capacity	MW	DOPOCAP	=	CDRCAP+OFFCAP
201							
202	3.5	Recorded domestic power den	Energy demand	GWh	DOREPOW	=	RECEG+OFFGWH
203			Peak demand	MW	DOREPEK	=	RECPW+OFFMW
204			Capacity	MW	DORECAP	=	RECRCAP+OFFCAP
205							

Set expressions in Model sheet (11)

206	3.6	Export	Energy demand	GWh	EXPGWH	=	Lag1.EXPGWH*(1+0.7*(CDMPHC/Lag1.CDMPHC-1))
207			Power demand	MW	EXPMW	=	EXPGWH*1000/24/365
208			Capacity required	MW	EXPCAP	=	EXPMW*1.1
209							
210	3.7	Computed country power dem	Energy demand	GWh	CNPOPOW	=	DOPOPOW+EXPGWH
211		On + Off + Export	Peak demand	MW	CNPOPEK	=	DOPOPEK+EXPMW
212			Capacity	MW	CNPOCAP	=	DOPOCAP+EXPCAP
213						=	
214	3.8	Recorded country power dema	Energy demand	GWh	CNREPOW	=	DOREPOW+EXPGWH
215		On + Off + Export	Peak demand	MW	CNREPEK	=	DOREPEK+EXPMW
216			Capacity	MW	CNRECAP	=	DORECAP+EXPCAP
217							
218	3.9	Computed country power dem	Energy demand	GWh	TCNPOW	=	CDMNEG+EXPGWH
219		On + Export	Peak demand	MW	TCNPOPEK	=	CDMNPW+EXPMW
220			Capacity	MW	TCNPOCAP	=	CDRCAP+EXPCAP
221							

5-4 Simulation sheet

EX4-3 Expect you to rearrange decimal points and the formats as you like in Simulation sheet .

a. Select the range with “L3 : AZ221” in Data sheet

b. Copy the range

c. Open the simulation sheet

d. Past the rang to the same range in Simulation sheet

5-5 Growth rate sheet

EX4-4 Expect you to input the expressions for the average growth rate.

2015/2010	=	IF(Simulation!V4>0, ((Simulation!AA4/Simulation!V4)^(1/5)-1)*100,0)
2020/2015	=	IF(Simulation!AA4>0, ((Simulation!AF4/Simulation!AA4)^(1/5)-1)*100,0)
2025/2020	=	IF(Simulation!AF4>0, ((Simulation!AK4/Simulation!AF4)^(1/5)-1)*100,0)
2030/2025	=	IF(Simulation!AK4>0, ((Simulation!AP4/Simulation!AK4)^(1/5)-1)*100,0)
2035/2030	=	IF(Simulation!AP4>0, ((Simulation!AU4/Simulation!AP4)^(1/5)-1)*100,0)
2040/2035	=	IF(Simulation!AU4>0, ((Simulation!AZ4/Simulation!AU4)^(1/5)-1)*100,0)
2040/2015	=	IF(Simulation!AA4>0, ((Simulation!AZ4/Simulation!AA4)^(1/25)-1)*100,0)

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Thank you

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A-6　本邦招聘プログラム

A-6　本邦招聘プログラム

1. 目的

本プロジェクトで策定された「ナイジェリア国電力マスタープラン」の内容を電力業界の本邦関連企業（プラント、電気機器メーカー、総合商社等)、政府関係者（外務省、在京ナイジェリア大使館）等に広く周知し、情報・意見交換を行うための本邦セミナーを開催する。また、同関係者等に対し、日本の電力政策・制度の紹介を行う機会等を設ける。

2. 参加者

#	Name		Ministry or Company	Title (English)	職位
1	Mr.	Ojo Stephen Olajide	FMPWH	Director, Finance & Accounts	財務会計局 局長
2	Mr.	Ayodele Ademola	FMPWH	Asst Director, Planning & Research	調査企画局 局長補佐
3	Mr.	(Dr.) S.A. Owolabi	FMPWH	Chief Engineer, Energy Resources	エネルギー資源局 主幹
4	Mr.	(Engr.) Eneh Kingsley	FMPWH	Chief Engineer, Energy Resources	エネルギー資源局 主幹
5	Mr.	(Engr.) P.E. Okpanefe	FMPWH	Chief Engineer, Transmission Dept.	送電局 主幹
6	Mr.	(Engr.) Ogunfeyimi G.J.	FMPWH	PTO, Distribution Dept.	配電局 専門家
7	Mr.	(Engr.) S.B. Ayangeaor	FMPWH	Asst Chief Engineer, Renewable & Rural	再生可能エネルギー・地方電化局 主幹補佐
8	Mr.	(Engr.) Shehu Abba Aliyu	TCN	General Manager, System Planning & Development	系統計画部 部長
9	Mr.	(Engr.) Sunday Obi	NERC	Chief Engineer	主幹
10	Mr.	(Engr.) Olayande J. Sunday	ECN	Director, Energy planning	エネルギー計画部 部長
-	Mr.	Gabriel Agidani	JICA Nigeria office	Consultant, Infrastructure Development	インフラ担当　コンサルタント

3. 日程及び内容

下表に、本邦招聘プログラムを示す。2019 年 1 月 13 日から 1 月 25 日にかけて実施した。

日数	内容	時間	活動	訪問先	宿泊地
1/13 （日）	移動	13：25～	ナイジェリア出国（アブジャ-アディスアベバ ET0910、 アディスアベバ-成田　ET0672）		―
1/14 （月）	移動	19:20～21:00	東京着（成田着 19:20　ET0672）		**東京**
1/15 （火）	表敬訪問	08:45～09:30 10:00～11:00 13:00～14:00 14:00～15:00	滞在ガイダンス（JICE, YEC） 大使館表敬（港区虎ノ門） JICA 表敬（資源・エネルギーグループ） JICA 面談（アフリカ部、民間連携事業部）	在京大使館 JICA 市ヶ谷	同上

日数	内容	時間	活動	訪問先	宿泊地
		15:00～18:00	MD 協議		
1/16 （水）	視察	07:30～09:30 10:00～12:30 13:30～15:30 16:00～17:30	移動 電線メーカー工場見学、講義・質疑応答 移動 MD 協議	電線メーカー	同上
1/17 （木）	セミナー 意見 交換会	09:30～11:00 13:00～15:30 15:30～20:00	MD 協議・締結 ナイジェリア電力マスタープランのプレゼン、 質疑応答、業界関係者等との意見交換 移動（東京-姫路）	東京グリーンパレス（ふじ）	**姫路**
1/18 （金）	講義 視察	08:10～10:00 10:00～14:00 14:00～15:30 15:30～17:00	発電用ガスタービン工場視察 移動（姫路-福岡） 九州電力概要説明 中央給電指令所視察	ガスタービンメーカー 九州電力本店	**福岡市**
1/19 （土） 1/20 （日）	視察		福岡市周辺インフラ整備状況等視察	－	同上
1/21 （月）	視察	08:30～10:00 10:00～12:00 12:00～14:30 14:30～16:00 16:00～18:30	唐津市へ移動 天山発電所(揚水)視察【所在】佐賀県唐津市 神埼市へ移動(途中昼食：コンビニ等) 広滝第一発電所視察(一般水力)【所在】佐賀県神埼市 別府市へ移動(宿へ)	天山発電所、 広滝第一発電所	**大分県 別府市**
1/22 （火）	視察	09:30～10:30 10:30～12:00 12:00～14:30 14:30～16:00 16:00～17:30	大分市へ移動 新大分発電所(LNG 火力)視察【所在】大分県大分市 臼杵市へ移動(途中昼食：コンビニ等) 東九州変電所(50 万 V)視察【所在】大分県臼杵市 別府へ移動(宿へ)	新大分発電所、 東九州変電所	同上
1/23 （水）	視察	09:00～10:30 10:30～12:00 12:00～15:30	豊前市へ移動 豊前蓄電池変電所視察【所在】福岡県豊前市 福岡空港へ移動(途中昼食：コンビニ等) 移動（福岡-羽田）	豊前蓄電池変電所	**東京**
1/24 （木）	報告会 講義	11:00～12:00 14:00～15:00 (13:45 別館下に到着) 22：00～	本邦招聘プログラムの報告会 資源エネルギー庁講義　@経済産業省別館 日本の電力政策・制度の紹介（ガイダンス） エネルギーの安定供給政策（講義・質疑応答） 省エネルギー、新エネルギー政策（講義・質疑応答） 東京発（成田 22：00 発－ドバイ EK0319）	八千代エンジニヤリング（株）、資源エネルギー庁（経済産業省別館）	－
1/25 （金）	移動	～15：15	ナイジェリア帰国（ドバイ－アブジャ EK0785）	－	－

TIME TABLE FOR SEMINAR ON POWER SECTOR IN THE FEDERAL REPUBLIC OF NIGERIA

VENUE: CONFERENCE ROOM "FUJI", TOKYO GREEN PALACE
DATE: 17TH JANUARY, 2019 at 13:00 PM

Time	*Event/Activity*	*Action by*
13:00-13:15	Opening Remarks by Organizer Introduction of the Representatives from Nigeria	JICA YEC
13:15-13:20	Key Note Address by the Representative from Nigeria	FMPWH
13:20-13:25	Address by Embassy of the Federal Republic of Nigeria in Japan	EOFRN
13:25-14:35	Introduction of Development Plan in the Power Sector in Nigeria	FMPWH,TCN
13:25-13:50	◆ Power Generation Development Plan	FMPWH
13:50-14:10	◆ Transmission Network Development Plan	TCN
14:10-14:35	◆ Encouraging Private Investment in the Power Sector in Nigeria	FMPWH
14:35-14:55	Question and Answer	All
14:55-15:00	Closing Remarks by the Representative from Nigeria	FMPWH/ECN
15:00-15:30	General discussion through one to one interaction	Voluntary Participation

Note: Seminar is conducted in English. An interpreter will be supplied for question and answer session.
YEC: Yachiyo Engineering Co., Ltd.
EOFRN: Embassy of the Federal Republic of Nigeria in Japan
FMPWH: Federal Ministry of Power, Works and Housing
TCN: Transmission Company of Nigeria
ECN: Energy Commission of Nigeria

議事録	
業　務　名	ナイジェリア国電力マスタープラン策定プロジェクト 本邦招聘セミナー
場　　所	東京グリーンパレス
日　　時	2019 年 1 月 17 日（木）13:00～15:30
出　席　者	別添の参加者リスト参照

【議事概要】

ナイジェリア国電力マスタープラン策定プロジェクトにおける本邦招聘プログロムの一環として、本プロジェクトにて策定された 25 年間の電力マスタープランの本邦企業・関連機関への報告および意見交換を目的に、セミナーを開催した。
以下、ナイジェリア側による電力マスタープランに関するプレゼン後の質疑応答の内容のみ記載する。

Q1 In Nigeria, generation capacity is 7,600MW and I assume transmission capacity is about 5,100MW. When Transmission capacity become same value as Generation? And how about distribution?

A1 Before the end of next year, several on-going transmission projects would that additional capacity which are at the various stages of completion would have been completed to make the transmission wheeling capacity be the same with generation.

Presently with the support of world bank, federal government of Nigeria have developed a project scheme call distribution expansion projects to strengthen and expand the distribution networks at 33kV and 11kV levels across the 11 discos regions, this is done to enable the distribution capacity match up with the available generation and also to utilize the stranded generation capacity. The procurement process have already started since last year with completion period 6 months. These projects when completed by end of last quarter of this year will provide the additional capacity to match up with the generation capacity.

Q2 How the MP study will be implement?
To show the seriousness of government to implement the MP this involves various stages of implementation these are;

i) When the draft MP was submitted, the Minister of power works and housing has directed that the document be first review by all the stake holders in the Nigeria electricity supply industry (NESI) and come up with their comments. Thereafter, the comments of the stakeholders will make the ministry present a memo to the federal executive council for the MP document to form a potential policy document for the sector.

ii) The ministry is in process of acquiring an office for master plan engineers and will be provided with equipment and necessary facility to periodically measure the level of implementation and review of the

【議事概要】

documents as may be required in line with other government policy for the sector.

Q3-1 In the slide 42 of the presentation, what would be the sources of the budget of USD 1,381million for 330kV to be able to achieve level of grid expansion proposed in the master plan TCN grid configuration, thus this include JICA, AfDB and world bank funding have been taking into consideration?

Q3-2 If the transmission losses is high, is there any penalty for this?

A3-1 The budget estimation is what required to complete all on-going projects that are required to achieve n-1 criteria and grid expansion to the year 2020. This included federal government fund and all development partners like JICA, AfDB and World Bank.

A3-2 In the MYTO regime, there is penalty for contravene the market rules, most especially the losses on the transmission lines which specified loss of 8.05%, if the losses is above this, the system operator will fine for transmitting above this limit. In another way round, if the system operator can minimize the losses below the 8.05%, the operator will be incentivize and rewarded accordingly.
Whenever a violation of the Commission's Codes, regulations etc is established, the Commissioners determines the amount of fine to be meted out to the relevant licensee. In some cases Nice is issued to the affected licensee asking for explanation and reasons why the licensee should not be fine,

Q4 What is the relation between TCN and DISCO?
TCN is transmission company of Nigeria and DISCO is distribution company. TCN operate 330kV, 132kV and transformers above 132/33kV.

以　上