

**Japan International Cooperation Agency**

**Philippines  
Department of Energy**

**The Study on Institutional Capacity Building  
for the DOE under a Restructured Philippine  
Electric Power Industry  
in the Republic of the Philippines**

**Manual for PDP Preparation**

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# Abbreviations

DDP	Distribution Development Plan
DU	Distribution Utility
DOE	Department of Energy
EC	Electric Cooperative
EPIRA	Electric Power Industry Restructuring Act
ERC	Energy Regulatory Commission
GDP	Gross Domestic Product
GRDP	Gross Regional Domestic Product
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IOU	Investor-Owned distribution Utilities
IRR	Implementing Rules and Regulations
JICA	Japan International Cooperation Agency
LOLP	Loss of Load Probability
MEDP	Missionary Electrification Development Plan
MEP	Missionary Electrification Plan
NEA	National Electrification Administration
NECDDP	National Electric Cooperatives Distribution Development Plan
NEDA	National Economic Development Authority
NPC	National Power Corporation
PDP	Power Development Program
PEP	Philippine Energy Plan
PPA	Power Purchase Agreement or Adjustment
QTP	Qualified Third Party
SPUG	Small Power Utilities Group
TRANSCO	National Transmission Company
TDP	Transmission Development Program
UC	Universal Charge
WASP	Wein Automatic System Planning Package
WESM	Wholesale Electricity Spot Market
WB	World Bank

# Contents

Section 1 Overview.....	2
1. Outline of the Manual.....	2
1.1 Objective of the PDP Manual.....	2
1.2 Contents.....	2
1.3 Keeping the PDP manual.....	2
2. Common Issues.....	3
2.1 The objective of PDP.....	3
2.2 Integration with subordinate programs.....	3
2.2.1 Integration Policy in PDP (2004-2013).....	3
2.2.2 Integration of TDP.....	4
2.2.3 Integration of DDP.....	4
2.2.4 Integration of MEDP.....	5
2.3 Responsible organizations and their responsibility.....	6
3. Workflow / Overall Schedule.....	6
3.1 Workflow / Overall Schedule.....	6
4 Checklists.....	8
Section2 Demand Forecasting.....	10
1. Outline of Manual.....	10
2. Data collection.....	12
2.1 Population data.....	13
2.2 GDP, GRDP.....	18
2.3 Sales data.....	22
2.4 The data from TRANSCO.....	24
3. The method of demand forecasting.....	25
3.1 Forecasting method of sales data.....	25
3.2 Conversion method to peak demand.....	30
3.3 Rearrangement of Energy Sales.....	32
4. The file system of Demand Forecasting.....	35
5. Verification of forecasting results.....	40
6. Remarks.....	44
7. Reference.....	48
7.1 Data Source.....	48
8. STATISTICA.....	49
8.1 Single regression.....	49
8.2 Multiple regression by STATISTICA.....	54

Section 3 Power Supply Plan.....	60
1. Outline of this Section.....	60
1.1 Scope.....	60
1.2 Contents .....	60
1.3 Simulation Software.....	60
1.4 Overall Workflow.....	61
2 Data gathering.....	64
2.1 Necessary Data.....	64
2.3 Data Gathering.....	65
2.3.1 Generation facility data.....	65
2.3.2 System-Related Data .....	66
2.3.3 Data for Indicative Plants .....	66
2.3.4 Common Data .....	67
3. Preparation of the Power Supply Plan.....	68
3.1.Preparation Flow .....	68
3.2 WASP-IV calculation.....	69
3.2.1 Folder Structure of the WASP-IV .....	69
3.2.2 Data folder of WASP-IV .....	69
3.2.3 TIPS for operation.....	70
3.2.4 Tips for Sensitivity Analysis.....	74
3.3 Preparation of the Regional Supply Plan .....	76
3.3.1 Basic Approach for Preparation of the Regional Supply Plan.....	76
3.4 Optimal Location / Interconnection Issues .....	80
3.4.1 outline of GTMax.....	80
3.4.2 Determining the Optimal Location.....	80
3.4.3 GTMax data preparation.....	81
3.4.5 Interconnection Issues.....	86
4. Checklist.....	87
5 Technical Documents .....	88
5.1 Manuals.....	88
5.2 Technical Report submitted by JICA .....	88
5.3 General Publication .....	89
Section 4 Transmission Development Plan .....	91
1. Purpose of Evaluation.....	91
1.1 Purpose of Evaluation .....	91
1.2 Responsibilities of DOE and TRANSCO.....	91
2. Scope of Evaluation.....	92

2.1 Evaluation Period.....	92
2.2 Facilities for Evaluation.....	92
2.2.1 Scope of TDP and DDP .....	92
2.2.2 Distinction between Transmission Assets and Subtransmission Assets .....	93
3. Work Flow .....	94
3.1 TDP Preparation and Evaluation .....	94
3.1.1 Work Flow .....	94
3.1.2 Contents of TDP .....	96
3.1.3 Materials for Submission.....	97
3.2 Planning of Interconnection.....	98
3.2.1 Work Flow .....	98
3.2.2 Methodology for Planning Interconnection .....	101
4. Schedule .....	104
5. Methodology for Evaluation.....	105
5.1 Reliability .....	105
5.1.1 Reliability Criteria .....	105
5.1.2 Performance Indicators .....	107
5.1.3 Power Quality.....	109
5.2 Technical Check Points .....	110
5.2.1 Grid Code.....	110
5.2.2 Planning Criteria of TRANSCO.....	111
5.3 Consistency with other Programs.....	113
5.3.1 PDP .....	113
5.3.2 DDP .....	113
5.3.3 Transmission Plan of Generation Companies.....	113
5.4 Other Check Points .....	114
5.4.1 Economics.....	114
5.4.2 Long-term Planning.....	114
5.4.3 Unit Capacity of Generators .....	115
5.4.4 Interconnection between Islands .....	115
5.4.5 Transmission Charge.....	116
6. Checklist.....	117
6.1 Reliability .....	117
6.2 Technical Check Points .....	117
6.3 Consistency with other Programs.....	118
6.4 Other.....	118
Section 5    Rural Electrification .....	120

1. General process flow of the rural electrification project.....	121
2. Concept of the manual.....	124
3. Workflow and organization concerned .....	125
3.1 Workflow of preparation of the rural electrification plan.....	125
3.2 Confirmation of contents of the submitted document from the subordinate organization by NEA/DOE .....	126
3.3 Investigation of electrification method of unenergized area by NEA .....	126
3.4 Consolidation of each electrification plan by DOE .....	126
3.5 Appraisal and approval of the universal charge by ERC .....	127
3.6 Responsibilities of the organizations concerned.....	127
4. Preparation schedule of rural electrification plan.....	128
5. Key points in preparing the rural electrification plan.....	129
5. Key points in preparing the rural electrification plan.....	129
5.1 Data collection.....	129
5.2 Evaluation of subordinate programs .....	129
5.3 Consolidation with PDP .....	129
5.4 Petition for the universal charge .....	130
5.5 Promotion of practical electrification.....	130
6. Basic Data Collection and database .....	131
6.1 Basic data collection .....	131
6.2 Database .....	137
7. Selection of optimum electrification procedure .....	148
8 Training .....	158
9 Establishment of the Operation and Management System .....	159
Section 6 Distribution Development Plan .....	163
1.Introduction.....	163
2.Framework .....	163
3.Existing Facilities .....	166
4.Long-term Vision .....	168
4.1 Expansions.....	168
4.2 Rehabilitation.....	171
4.3 Demand Forecast .....	174
4.4 Supply Forecast .....	175
4.5 Critical Conditions .....	176
5.Investment Requirement.....	177
6. Attachments.....	178

## List of Figures

### Section 2

Fig. 1-1 Flow diagram of demand forecasting .....	11
Fig. 1-2 Recommended timetable of demand forecasting tasks .....	12
Fig. 2-1 Linearity of actual and projected population in the entire Philippines .....	14
Fig. 2-2 Population growth estimation by area .....	15
Fig. 2-3 % share of regional population obtained using a practical forecasting process .....	16
Fig. 2-4 Results of regional population .....	17
Fig. 2-5 GDP scenarios adopted in the forecasting process in PDP2004-2013.....	19
Fig. 2-6 % share of GRDP against total GDP in the Philippines.....	21
Fig. 2-7 GDP scenario broken down to regional GDP scenarios .....	21
Fig. 2-8 Database of sales data .....	23
Fig. 3-1 Outline of the process of demand forecasting.....	25
Fig. 3-2 Outline of Process I .....	26
Fig. 3-3 Outline of Process II.....	26
Fig. 3-4 Relationship between GDP/Capita and Population .....	27
Fig. 3-5 Adjustment methods for peak demand to pass through the Year 2003.....	32
Fig. 4-1 File system for forecasting .....	35
Fig. 4-2 Input sheet and figures in the file share GDP%-1 .....	36
Fig. 4-3 Creating actual and estimated demand by sector.....	37
Fig. 4-4 Applying regression results to forecasting sales energy in distribution.....	37
Fig. 4-5 Some results in the Sales1 file.....	38
Fig. 4-6 Creating variation on the file “RESULT_ADJUSTED “ .....	39
Fig. 5-1 Comparison among growth curves.....	40
Fig. 5-2 Comparison with the historical growth curve.....	41
Fig. 5-3 Example of a graph showing growth rate trends .....	42
Fig. 5-4 Example of a graph showing elasticity trends .....	43
Fig. 6-1 Structure of facilities in the power system .....	44
Fig. 6-2 Real power flow among entities before restructuring.....	45
Fig. 6-3 Real power flow among entities after restructuring .....	45
Fig. 6-4 Data flows among entities.....	47
Fig. 8-1 Data input on the spreadsheet.....	49
Fig. 8-2 Pull down menu of “Statistics” and the position of the “Multiple regression” menu .....	50
Fig. 8-3 “Multiple Linear Regression Spreadsheet2” Menu.....	50

Fig 8-4 Selection of variables .....	51
Fig 8-5 “Multiple Regression Results: Spreadsheet1” .....	52
Fig 8-6 “Regression Summary for Dependent Variables” spreadsheet .....	53
Fig 8-7 Data input on the spreadsheet.....	54
Fig 8-8 Pull down the “Statistics” menu and position the “Multiple regression” menu .....	55
Fig 8-9 “Multiple Linear Regression Spreadsheet2” Menu.....	55
Fig 8-10 Selection of variables.....	56
Fig 8-11 “Multiple Regression Results: Spreadsheet1” .....	57
Fig 8-12 “Regression Summary for Dependent Variables” spreadsheet .....	58

### Section 3

Fig. 1.1 Workflow of PDP .....	61
Fig. 2.3.1 Data Gathering system.....	65
Fig. 3.1 Workflow for Simulation .....	68
Fig. 3.4.1 Outline of the GTMax .....	80
Fig. 3.4.2 Methodology of the study.....	86

### Section 4

Fig 3.1: Work Flow .....	95
Fig 3.2: Work Flow (Interconnection) .....	100
Fig 4.1: Schedule for TDP preparation and evaluation.....	104

### Section 5

Fig. 3.1 Workflow of preparation of the rural electrification plan .....	125
Fig 6.1 Social baseline data collection format by NEA (No.1) .....	134
Fig 6.2 Social baseline data collection format by NEA (No.2).....	135
Fig. 6.3 Map for the management of electrification rate by ECs and municipalities	138
Fig. 6.4 Map for management of electrification rate by barangay.....	139
Fig. 6.5(a) Map for management of electrification rate by barangay with grid line...	140
Fig. 6.5(b) Map for management of electrification rate by barangay with grid line ..	140
Fig. 6.6 Average Wind Energy .....	143
Fig. 6.7 Average Wind Energy .....	143
Fig. 6.8 Annual average of Isolation .....	143
Fig. 6.9 Difference between dry and rainy season .....	144
Fig.6.10 Annual rainfall .....	144
Fig.6.11 Micro-Hydro Resource Potential.....	144



Fig. 7.1 Assumption of daily power usage pattern .....	150
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## List of Tables

### Section 1

Table 2.2.1 Items to be arranged for TDP integration .....	4
Table 2.2.2 Data that can be collected by DDP .....	5
Table 2.2.3 Organizations and their responsibilities .....	6
Table 3.1 Overall Workflow of PDP .....	7

### Section 2

Table 2-1 Population according to the national census data .....	13
Table 2-2 Population projections on “The State of the Philippine Population Report 2000” .....	13
Table 2-3 Results of a single regression between year and % share of population.....	16
Table 2-4 Coefficients of the formulation .....	20
Table 3-1 Load factors in each grid and sub-grid .....	31
Table 3-2 % share of demand in the Visayas .....	33
Table 3-3 AF in each sub-grid .....	34

### Section 3

Table 1.1 Overall Schedule for PDP .....	62
Table 2.1 necessary data for the PDP simulation.....	64
Table 3.3.1 Initial run of the WASP-IV for VISAYAS .....	76
Table 3.3.2 Initial Distribution of Candidates to Islands.....	77
Table 3.3.3 Power Development Plan (Second Draft) .....	79
Table 4.1 Checklist for preparing PDP .....	87

### Section 4

Table 2.1: Scope of TDP and DDP.....	92
Table 2.2: Distinction between Transmission and Subtransmission Assets.....	93
Table 3.1: Information Provision by DOE to TRANSCO .....	94
Table 3.2: Information regarding Power Development Plan .....	94
Table 3.3: Contents of the List of Individual Existing Facilities.....	97
Table 3.4: Classification of Interconnection.....	98
Table 3.5: Responsibilities of DOE and TRANSCO .....	99
Table 3.6: Items to be considered for planning interconnections .....	101
Table 3.7: Economical Effects of Interconnection .....	101
Table 3.8: Example of Economic Analysis for Interconnection (M\$) .....	102

Table 5.1: Planning Criteria of TRANSCO.....	112
Table5.2: Example of Economic Comparison (MP).....	114
Table 5.3: Largest Current Unit Capacities .....	115
Table 5.4: Example of Incremental Transmission Charge .....	116

## Section 5

Table 3.1 Related organizations .....	127
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## Section 6

Table3-1. Summary of Existing Facilities (Lines).....	166
Table3-2. Summary of Existing Facilities (Transformers).....	167
Table4-1. Summary of Expansions (2003-2007) (Ckt-kms) .....	169
Table4-2. Summary of Substation Capacity (Transformers, 2003-2007) (MVA).....	170
Table4-3. Summary of Rehabilitation (2003-2007) (Ckt-kms) .....	172
Table4-4. Summary of Decommissioning (Transformers, 2003-2007) (MVA).....	173
Table4-5. Summary of Demand Forecast (2003-2007) (MWH).....	174
Table4-6. Summary of Demand Forecast (2008-2012) (MWH).....	174
Table4-7. Summary of Total Supply Forecast (2003-2012) (KW, MWH).....	175
Table4-8. Summary of Supply-Demand Surplus Forecast (2003-2012) (KW, %, MWH) .....	175
Table4-9. Summary of Critical Conditions (2003-2007) .....	176
Table4-10. Summary of Critical Conditions (2008-2012) .....	176
Table5-1. Summary of Investment Requirement (2003-2007) (Million PHP) .....	178



**Manual  
for  
the Power Development Plan  
Preparation  
(Overview)**

## Section 1 Overview

### 1. Outline of the Manual

#### 1.1 Objective of the PDP Manual

This manual clarifies the work schedule and its flow for the smooth preparation of the Power Development Program (hereinafter referred to as PDP) through collaboration between DOE and related organizations under EPIRA. Related subordinate plans such as TDP (Transmission Development Plan) and the MEDP (Missionary Electrification Development Plan) are referred to in the PDP manuals for integration with PDP pursuant to EPIRA. Therefore, the work flow diagram of these programs is clarified considering the PDP preparation schedule.

#### 1.2 Contents

The PDP manual consists of the following six sections:

- (1) Common Issues
- (2) Demand Forecasting
- (3) Power Supply Plan
- (4) Transmission Development Plan
- (5) Missionary Electrification Plan
- (6) Distribution Development Plan

The work flow diagram in the preparation of the PDP is clarified in the manuals. The necessary items and their timeframes are also given. The roles and responsibilities of the related organizations for the preparation evaluation and approval of the subordinate program are also explained. Engineering documents to understand technical and policy issues are attached at the end of the manual, if necessary.

#### 1.3 Keeping the PDP manual

Manuals and their electronic files are kept in the power bureau of DOE. Revision should be made every October as soon as the plan is submitted to Congress.

## 2. Common Issues

### 2.1 The objective of PDP

Contestable policy enters the power sector through EPIRA. The role of DOE is to lead the power industry, which is divided into three sectors, i.e., the generation, the transmission and the distribution sector, through their policy to realize stable, high quality, low price electricity. To achieve this, PDP is the most important tool in indicating the ideal picture of the future power sector. In addition, the encouragement of private investors is the most important policy in supporting the realization of PDP.

### 2.2 Integration with subordinate programs

#### 2.2.1 Integration Policy in PDP (2004-2013)

Pursuant to EPIRA, PDP should integrate subordinate programs. Here, subordinate programs mean the following:

- a. Transmission Development Plan (TDP)
- b. Distribution Development Plan (DDP)
- c. Missionary Electrification Plan (MEDP)

Considering the contents and schedule of PDP, the following policy is applied to the subordinate programs:

- TDP: Integration and coordination of all projects

All power development projects and transmission projects newly planned should be integrated.

- DDP: Data integration

DDP may be used as a data-gathering tool. The necessary data for preparing PDP, such as demand in each franchise data and facility data item is collected as a part of DDP and reflected in PDP.

- MEDP: Integration of document

PDP, which is the national grid plan, differs from MEDP, which is the energized plan, for the un-energized plan too greatly to integrate both data and contents.

Therefore, the integration may be conducted only on documentation. In future, an effective grid extension methodology may be integrated.

### 2.2.2 Integration of TDP

As described, the integration of TDP with PDP should be conducted in all power development projects and transmission development projects. Table 2.2.1 shows the necessary items to be arranged in related organizations.

**Table 2.2.1 Items to be arranged for TDP integration**

Items	Contents	Dataflow
<b><u>a. Demand</u></b> - Actual Peak Demand - Demand Forecasting	- Data Submission - Demand forecast Results	- TRANSCO to DOE - DOE to TRANSCO
<b><u>b. Power Development Projects</u></b> - Ongoing Projects - Committed Projects - Retirement Projects - Indicative Projects	- Project List - Project List - Project List - Necessary Capacity Addition by Fuel Type and Area	- DOE to TRANSCO
<b><u>c. Transmission Development Projects</u></b> - First Draft Plan - Evaluation Results	- First Draft Plan - Evaluation Results (Project List to be considered)	- TRANSCO to DOE - DOE to TRANSCO

### 2.2.3 Integration of DDP

Pursuant to EPIRA, all distribution utilities must submit DDP to DOE by March 15<sup>th</sup> every year. The contents of DDP are (1) the Distribution System Development Plan and (2) the Power Demand and Supply Plan. However, the former is not directly related to PDP. Meanwhile, the latter includes the demand forecast and supply plan that can be utilized for PDP. Therefore, the necessary data for their franchise area can be collected by using DDP as data-gathering tool.

Table 2.2.2 shows the data that can be collected as a part of DDP. In future, island grids or independent grids may be connected to the national grid. In this case, integration of DDP will be an important portion of PDP.

**Table 2.2.2 Data that can be collected by DDP**

Items	Integration with the PDP
<p><b>a. Demand for Franchise Area</b></p> <ul style="list-style-type: none"> <li>- Actual Peak Demand</li> <li>- Demand Forecasting</li> </ul> <p><b>b. Power Supply Plan</b></p> <ul style="list-style-type: none"> <li>- By supply contract with NPC</li> <li>- By own Facilities</li> <li>- By supply contract with IPP</li> <li>- Data of Embedded Generator</li> </ul>	<ul style="list-style-type: none"> <li>- Reference Data for Demand Forecast</li>   <li>- Basic Data for the Power Development Plan</li> </ul>

#### 2.2.4 Integration of MEDP

PDP is the national grid plan, while MEDP is the energized plan for the un-energized plan. Therefore, integration does not have to be conducted even for the data as DDP.

Since MEDP covers the most important and sensitive issues, MEDP itself should be a part of PEP / PDP. Therefore, MEDP may as well be integrated with PDP as an independent part.

In future, the grid extension may become more important not only for supplying power to all of the Philippines, but also to save OPEX. Therefore, the present status is to observe the electrification situation and to arrange databases for future PDP that integrates the unenergized areas with the national grid-by-grid extension.



## 2.3 Responsible organizations and their responsibility

Table 2.2.3 shows organizations and their responsibilities in preparing PDP. PDP and MEDP are prepared by DOE from this year.

**Table 2.2.3 Organizations and their responsibilities**

Organization	PDP	TDP	MEDP	DDP
DOE	Preparation	Evaluation /Approval	Preparation	Integration / Preparation
NEA	Arrangement of EC data		Arrangement of EC data / Submission of draft energized plan	Integration of EC's plan
ERC	Approval of projects	Approval of projects	Approval of Universal Charge	Approval of Charge
TRANSCO	Coordination of the projects	Preparation		
Generation Companies	Data submission			
PIOUs	Data submission		Submission of the list of barangays	Preparation for franchise area
ECs	Data submission		Submission of the list of barangays	Preparation for franchise area
NPC-SPUG	-		Submission of draft energized Plan	

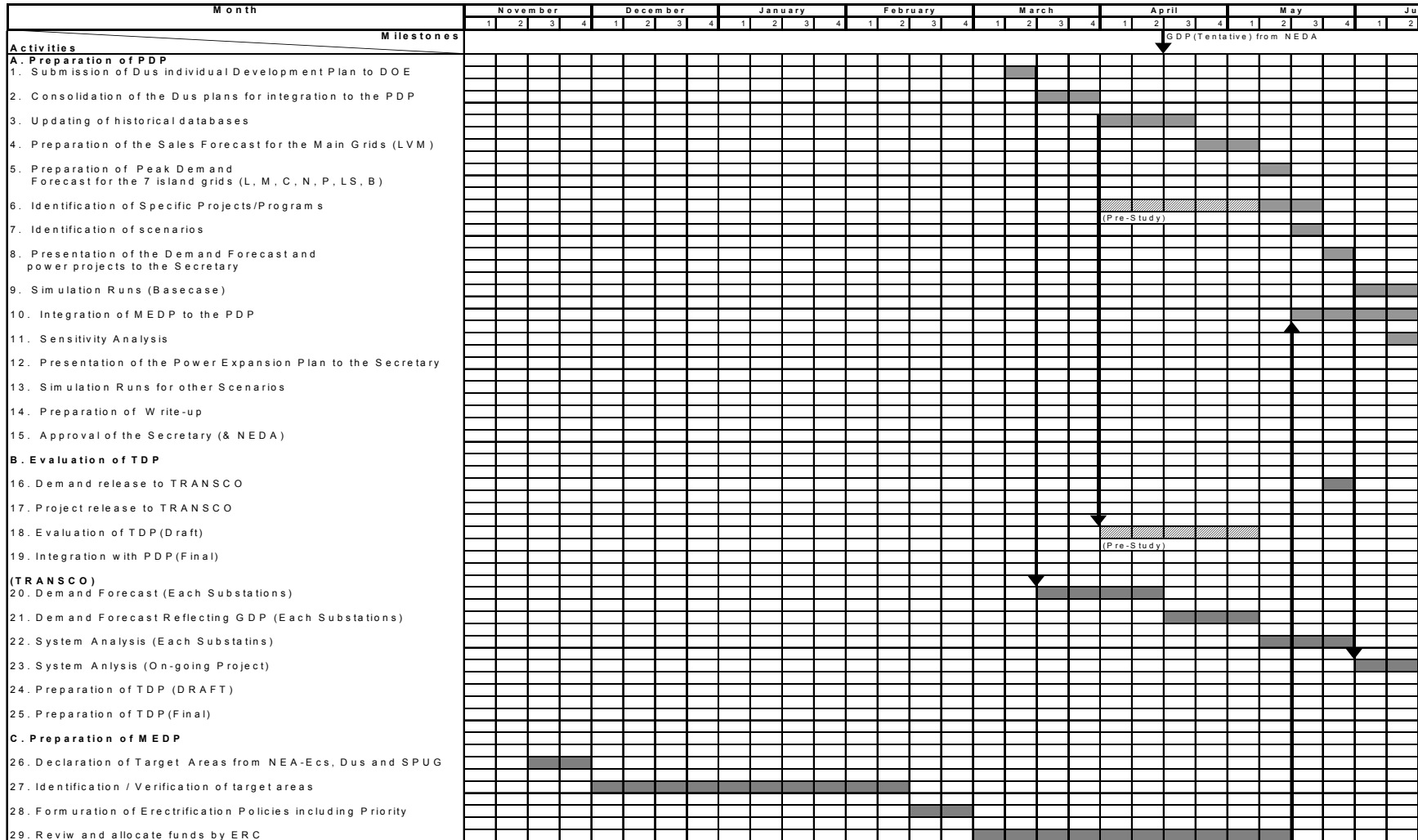
## 3. Workflow / Overall Schedule

### 3.1 Workflow / Overall Schedule

Table 3.1 shows the overall schedule for preparing PDP. As described, PDP has to be prepared by integrating the other subordinate plans. Therefore, the overall schedule should include the schedule of these plans as well as PDP itself.

Each workflow of PDP, TDP and MEDP is described in the technical volumes.

**Table 3.1 Overall Workflow of PDP**



## 4 Checklists

Workflow, checklists are attached at the end of each section. Therefore, the work should be conducted using these lists.



**Manual**  
**for**  
**the Power Development Plan**  
**Preparation**  
**(Demand Forecasting)**

## Section2 Demand Forecasting

The manual for demand forecasting consists of the following. Detailed explanations are provided in each chapter.

- 1: Outline of the demand forecasting part of this manual
- 2: Method of data collection and preparation process
- 3: Methodology and process of demand forecasting
- 4: File system of demand forecasting
- 5: Verification of forecasting results
- 6: Remarks
- 7: References

### 1. Outline of Manual

The following outlines are the process of demand forecasting.

#### <Data collection and checking>

**STEP 1:** Collecting an estimation of future population and estimation of future regional population.

**STEP 2:** Collecting GDP and GRDP actual and forecasted GDP data from NEDA. Breaking down the forecasted data into regional GDP data.

**STEP 3:** Collecting sales data from utilities including PIOUs and ECs.

**STEP 4:** Collecting actual data of TRANSCO peak demand in the previous year and load factor from TRANSCO.

#### <Demand forecasting>

**STEP 1:** Demand forecasting by cross-referencing sectors and regions.

**STEP 2:** Rearrangement of the results as island peak demand. Separation of forecasted demand between the main grid (On-Grid) and the isolated grid (Off-Grid).

**STEP 3:** Modifying the TRANSCO peak to the SYSTEM peak by adding demand supplied by embedded generators.

**STEP 4:** Creating variations in forecasting results.

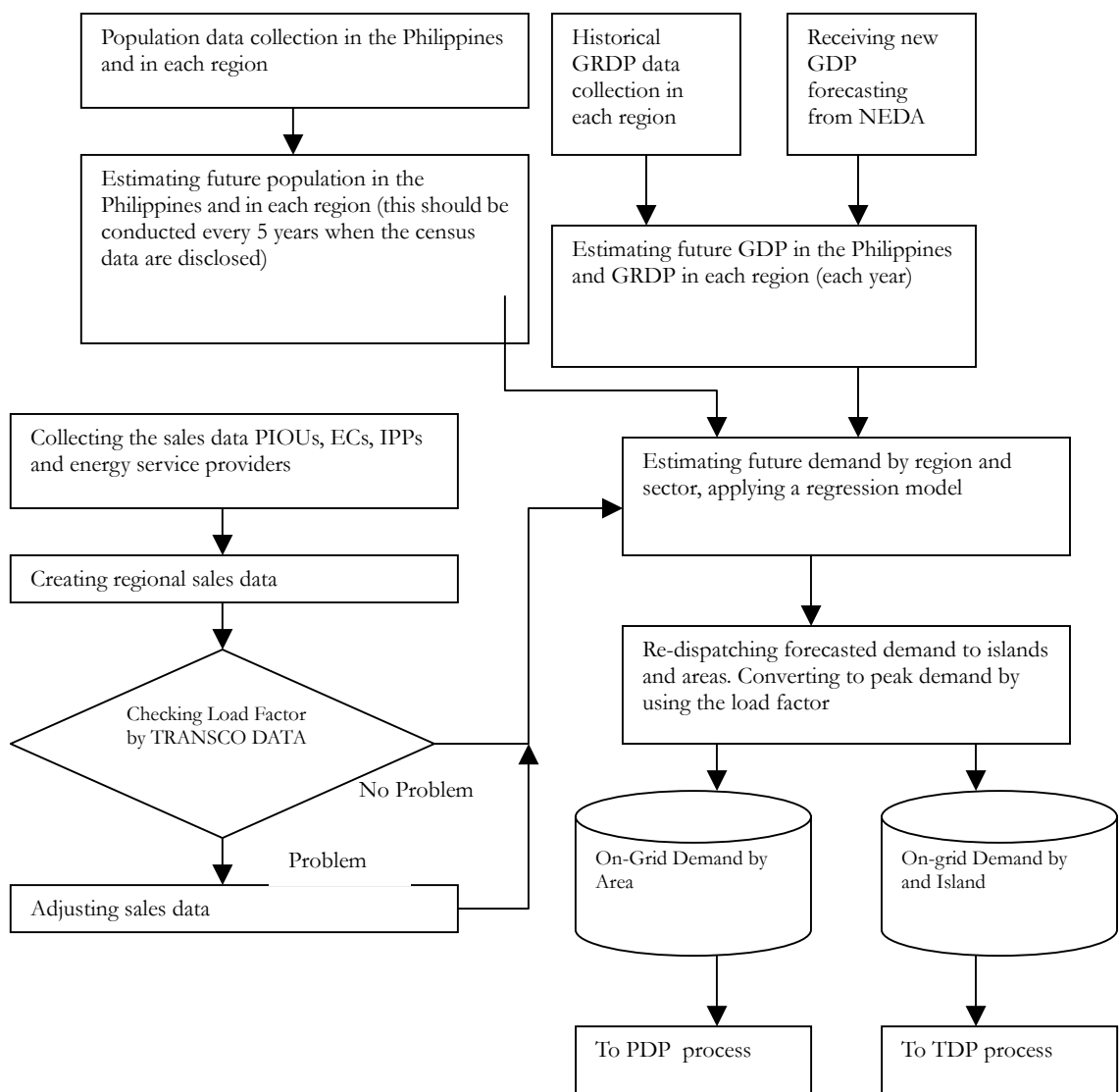
**STEP 5:** Verifying the results by checking the growth rate and elasticity

A workflow diagram is shown in the following figure as well as the recommended

timetable for demand forecasting tasks. The most critical point in this workflow is the collection of GDP-related data from NEDA that usually takes place in the middle of April. This point cannot be changed. Therefore, to construct a safety schedule for the remaining part of the planning, it is important that the remaining data collection and treatment be completed before the GDP data is disclosed.

Details of the tasks are given in following diagram.

**Fig. 1-1 Flow diagram of demand forecasting**



Month	February				March				April				May			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
<b>Milestones</b>	Sales data from NEA and PIOUs Peak and Load Factor Data from TRANSCO								GDP(Tentative) from NEDA							
<b>Activities</b>	transfer the result to PDP,TDP,MED															
<b>A. Demand forecasting Schedule</b>	Any time Census data are disclosed															
1.Forecasting Future Population	█				█				█				█			
2. Data collection from Distribution utilities					█				█				█			
3. Check Sales Data comparison with TRANSCO Data									█				█			
4. Updating of historical databases of sales data									█				█			
5. Creating GDP and GRDP Scenarios									█				█			
6. Forecasting Sales Data by Regions													█			
7. Preparation of Peak Demand													█			
Forecast for the 7 island grids (L, M, C, N, P, LS, B)																

**Fig. 1-2 Recommended timetable of demand forecasting tasks**

## 2. Data collection

This chapter discusses contents in the manual on data collection. Figure 2.3 shows the data flow for data collection of DOE and several organizations. **Collected data items**<sup>1</sup> are the following.

- Population
- GDP, GRDP
- Sales Data
- Actual Peak Demand

<sup>1</sup> See “7.1 Data Source” for data sources referenced in the demand forecasting for PDP 2004.

## 2.1 Population data

### (1) Data collection

#### Outline:

Population data depends on the data disclosed by NSO. Necessary data are the following:

Total population in the Philippines disclosed every five years

Regional population data in the Philippines disclosed every five years

Official future population forecasting results in the Philippines

#### Practical Process adopted in PDP2004-2013:

Actual available population data collected as national census data by area are shown in following table.

**Table 2-1 Population according to the national census data**

Date	Luzon	Visayas	Mindanao
05/01/1975	22,790,274	10,133,392	9,146,994
05/01/1980	26,080,694	11,112,523	10,905,243
05/01/1990	33,357,887	13,041,947	14,298,160
09/01/1995	38,249,776	14,158,443	16,205,487
05/01/2000	42,810,872	15,520,152	18,133,864

The following table shows population projections, which is available on the website of “The State of the Philippine Population Report 2000.” These projections were adopted in the demand forecasting in PDP2004-2013.

**Table 2-2 Population projections on “The State of the Philippine Population Report 2000”**

POPULATION PROJECTIONS		2005*	2010*	2015*	2020*	2025*	2030*	2035*	2040*
Total (in millions)		84.2	91.9	99	105.6	111.5	117.1	122	126.2
By sex	Male	42.4	46.2	49.8	53	55.9	58.6	61	62.9
	Female	41.8	45.6	49.2	52.5	55.6	58.4	61	62.9
By Age group (% of total)	0 - 14 yrs	33.80%	31.10%	28.60%	26.20%	24.10%	22.40%	21.10%	19.90%
	15 - 64 yrs	61.80%	63.90%	65.60%	67.00%	68.00%	68.30%	68.10%	67.70%
	65 and over	4.40%	5.00%	5.80%	6.80%	8.00%	9.30%	10.80%	12.40%
Average annual growth rate		1.87	1.66	1.45	1.23	1.07	0.95	0.81	0.66
Population Density (persons per square kilometer)		281	306	330	352	372	390	407	421
Crude birth rate		25.1	22.3	20	18	16.6	15.6	14.5	13.3
Crude death rate		5.9	5.6	5.5	5.5	5.7	6	6.3	6.8

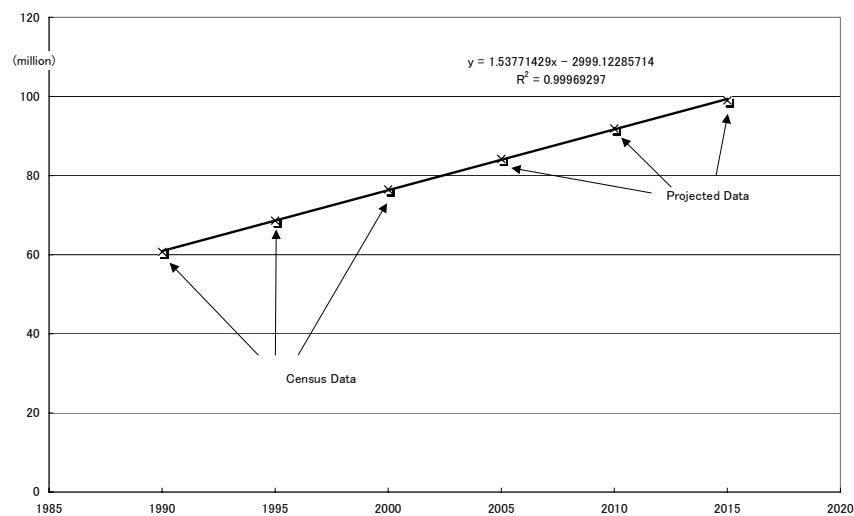
It is possible to refer to the estimated future population of the cities to check estimated regional population. These data can be referenced from the National Statistic Book, and are easily collected. However, for regional population, which is not shown in this book, DOE should evaluate and estimate this itself.



## (2) Data preparation

### Outline:

By selecting the period from 1990 – 2015, and then connecting actual data of 1990, 1995 and 2000 and projected data of 2005, 2010 and 2015, it is found that these data series are almost linear. Using this characteristic, we can determine population by region and by year through following steps.



**Fig. 2-1 Linearity of actual and projected population in the entire Philippines**

- STEP 1: Estimating the functions of the future population explained by year
- STEP 2: Estimating the functions of the population share by region and adjusting total percentage as 100%
- STEP 3: Multiplying the estimated population by area to population share by region

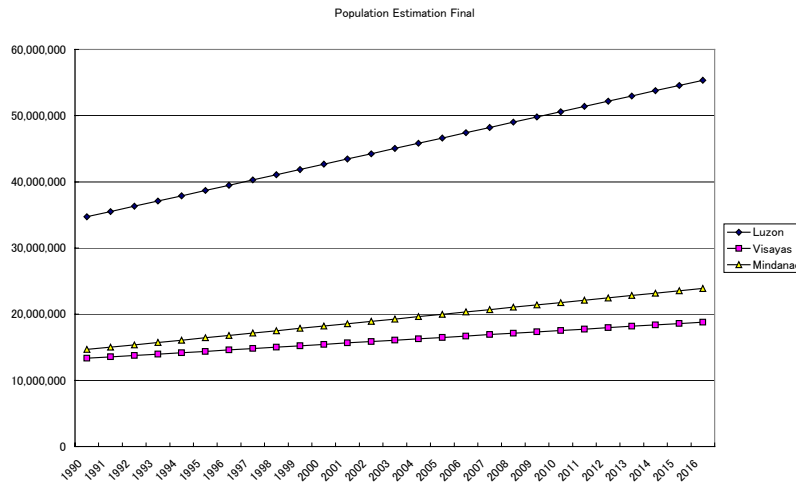
### **Practical Process adopted in PDP 2004-2013:**

The following explanations provide more detail of the above process.

#### **i) Estimation of population by area (STEP 1)**

Looking at actual population by area from 1990 to 2000, population growth in each area is almost linear. In addition, projected population in the entire Philippines is also almost linear until 2015. Therefore, it is reasonable to estimate future population growth by area as linear. The following figure shows this linear growth of population estimated using past growth

trends and projection.



**Fig. 2-2 Population growth estimation by area**

**ii) Estimation of population share by region (STEP2)**

To estimate population share by region against area, a **single regression process**<sup>2</sup> using “STATISTICA” is required. These regressions are done between the percentages of the share of the regional population against the area population. The results can be obtained as the functions shown in the table below, where X means the year number (such as 2002) and Y means the percentage share.

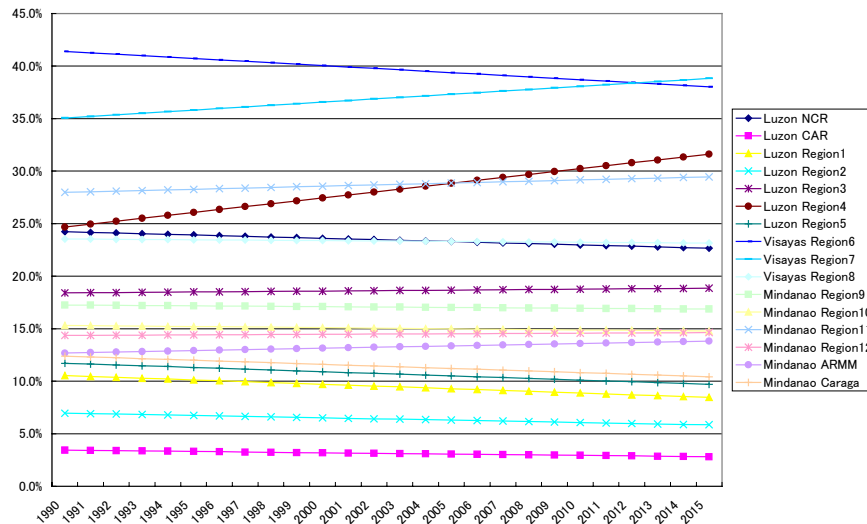
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<sup>2</sup> See “7.2 Single regression by STATISTICA” for explanation of how to run single regression using STATISTICA

**Table 2-3 Results of a single regression between year and % share of population**

Region Name		Formulation
NCR	National Capital Region	$Y = -0.0006266X + 1.4892217$
CAR	CAR	$Y = -0.000247X + 0.525955$
Region1	Ilocos Region	$Y = -0.0008324X + 1.7619274$
Region2	Cagayan Valley	$Y = -0.0004453X + 0.9558348$
Region3	Central Luzon	$Y = 0.0001758X - 0.1657567$
Region4	Southern Tagalog	$Y = 0.002777X - 5.279507$
Region5	Bicol Region	$Y = -0.0008016X + 1.7123248$
Region6	Western Visayas	$Y = -0.001349X + 3.099273$
Region7	Central Visayas	$Y = 0.001508X - 2.649635$
Region8	Eastern Visayas	$Y = -0.000158X + 0.550361$
Region9	Western Mindanao	$Y = -0.000156X + 0.483345$
Region10	Northern Mindanao	$Y = -0.000218X + 0.587344$
Region11	Southern Mindanao	$Y = 0.000594X - 0.901758$
Region12	Central Mindanao	$Y = 0.000110X - 0.075010$
ARMM	ARMM	$Y = 0.000455X - 0.778276$
Caraga	Caraga <sup>1/</sup>	$Y = -0.000784X + 1.684354$

Finally, the future percentage share is calculated by inserting the year number (such as 2002, 2003, etc). The results, which can be obtained through the forecasting process in 2003, are shown in the following figure. In this process, adjustment for setting the total of percentage share of regions in the same area to be 100% is required.



**Fig. 2-3 % share of regional population obtained using a practical forecasting process**

### iii) Calculation of regional population (STEP3)

Finally, the regional population projection is obtained by multiplying the percentage share of the regional population and the area population. The results are shown in the following figure.

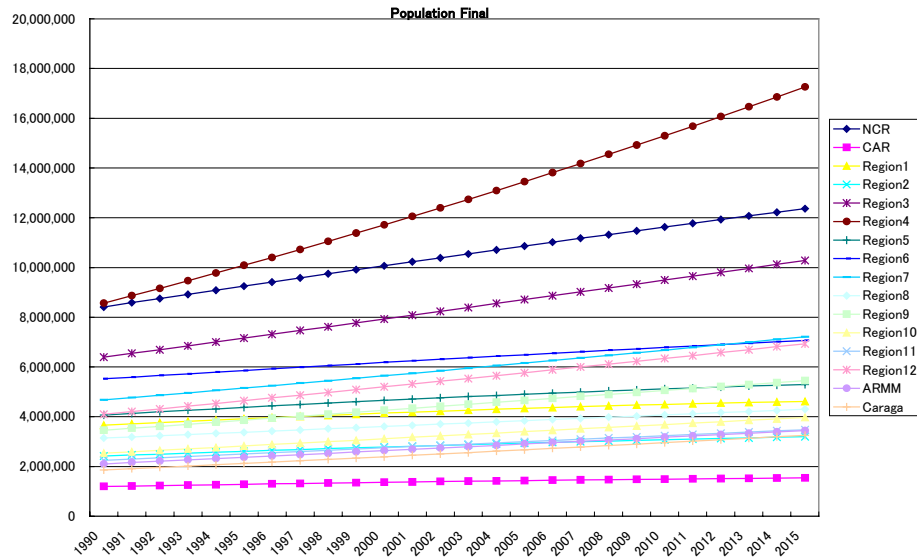


Fig. 2-4 Results of regional population

## 2.2 GDP, GRDP

### (1) Data Collection

#### Outline:

Actual data on GDP and GRDP (regional GDP) should be collected from NEDA. The data to be collected are as follows:

Actual GDP in the previous year disclosed by NEDA

Actual GRDP in the previous year disclosed by NEDA

Forecasted rate of GDP increase for more than the next 10 years

The NEA tentatively discloses the actual GDP from the previous fiscal year, and GDP is forecast in the middle of April or early May. Because this schedule will not change, it is not necessary to change the data collection scheme for GDP-related data from the previous planning. Officially, the GDP forecast is disclosed for the next five years based on economical activity study results for the next few years, using the economical forecasting model in NEDA. In addition, in this process, NEDA refers to several forecasts on the Philippines' economic situation compiled by external organizations. However, looking at the results of estimation longer than five years, the estimation model has less reality, so on some points, the results are often an overestimation. Therefore, when DOE applies these results to demand forecasting, adjustment of the GDP estimation results is required.

#### **Practical process adopted in PDP 2004-2013:**

In the forecasting process of PDP2004-2013, the modification shown below was adopted.

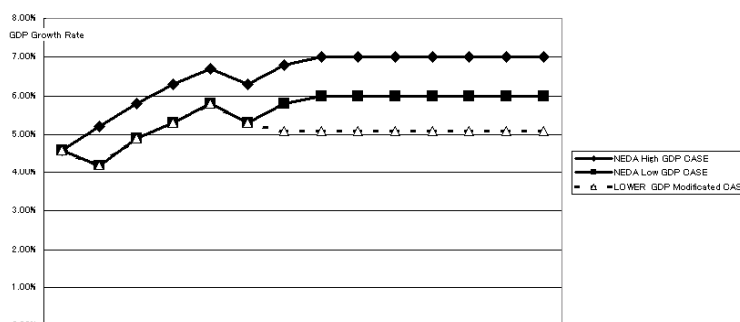
**STEP 1:** Obtaining two GDP scenarios established by NEDA in PDP2004-2013 (High GDP growth case and Low GDP growth case). A case in which the growth rate after 2008 is the same as the average low cases in NEDA data between 2003 and 2007 is assumed.

**STEP 2:** Finding future regional GDP share by region

**STEP 3:** Calculating future regional GDP by region

Therefore, we adopted three GDP growth scenarios as shown below.

	NEDA High GDP CASE	NEDA Low GDP CASE	LOWER GDP Modified CASE
2002	4.60%	4.60%	4.60%
2003	5.20%	4.20%	4.20%
2004	5.80%	4.90%	4.90%
2005	6.30%	5.30%	5.30%
2006	6.70%	5.80%	5.80%
2007	6.30%	5.30%	5.30%
2008	6.80%	5.80%	5.10%
2009	7.00%	6.00%	5.10%
2010	7.00%	6.00%	5.10%
2011	7.00%	6.00%	5.10%
2012	7.00%	6.00%	5.10%
2013	7.00%	6.00%	5.10%
2014	7.00%	6.00%	5.10%
2015	7.00%	6.00%	5.10%



**Fig. 2-5 GDP scenarios adopted in the forecasting process in PDP2004-2013**

NEDA’s forecasting GDP data are actually national targets, and they are usually very optimistic. Thus, DOE should assume a more pessimistic scenario than NEDA’s targets to evaluate investors’ risk regarding delaying the demand growth of a worse economical condition.

**Remarks:**

In addition, looking at published data in the National Statistic Book, GRDP data on the electricity, gas and water sector data are lacking for the previous fiscal year. Disclosure of these data seems to be later than for other sectors. For example, in the 2002 Year Book, GRDP data on the electricity, gas and water sector in 2001 are not available. Therefore, DOE may have to collect this missing data directly from NSO.

**(2) Preparation**

**Outline:**

DOE must estimate future GRDP itself because NEDA does not estimate it. In addition, detailed GRDP data from the last year seem to be disclosed after the disclosure of the final actual GDP data in July. Therefore, the actual GRDP data in past years excluding those of the previous year are only available for an estimation of the future GRDP share in the forecasting process. As shown in the later part of the manual, the non-residential part of demand is calculated as one sector. Therefore, the breakdown of GDP to sectors is not necessary.

## Practical process adopted in PDP2004-2013:

### i) Obtaining a GDP forecast and calculating a new assumption GDP Value (STEP 1)

Because future GDP target by NEDA is given as the growth rate, calculation of future GDP value is first required. This process is necessary for the three GDP scenarios mentioned above.

### ii) Finding future regional GDP share by region (STEP 2)

Using actual regional GDP (GRDP), it is possible to find the future share of each region's GDP against the total GDP in the Philippines. This percentage share can be obtained by **single regression**<sup>3</sup> between the actual GRDP share and the year. Regression results shown as coefficients of the formulation are shown in the following table, and the percentage share results are shown in the following figure.

**Table 2-4 Coefficients of the formulation**

	NCR	CAR	Region I	Region II	Region III	Region IV	Region V	Luzon
a	-0.854376	-1.00627	-0.204431	-0.183504	0.496082	-0.718777	0.424836	-2.04644
b	0.000581	0.00052	0.000118	0.000103	-0.000201	0.000438	-0.000198	0.00135
	Region VI	Region VII	Region VIII	Visayas				
a	0.377003	-0.792831	0.390829	-0.024999				
b	-0.000153	0.000431	-0.000184	0.000094				
	Region IX	Region X	Region XI	Region XII	caraga	ARMM	Mindanao	
a	0.396985	2.566797	2.135228	1.895235	-1.04643	-2.87638	3.071439	
b	-0.000185	-0.001263	-0.001037	-0.000935	0.00053	0.00144	-0.001449	

% share of GRDP = a \* Number of Year + b

<sup>3</sup> See "7.2 Single regression by STATISTICA" for information on how to run STATISTICA.

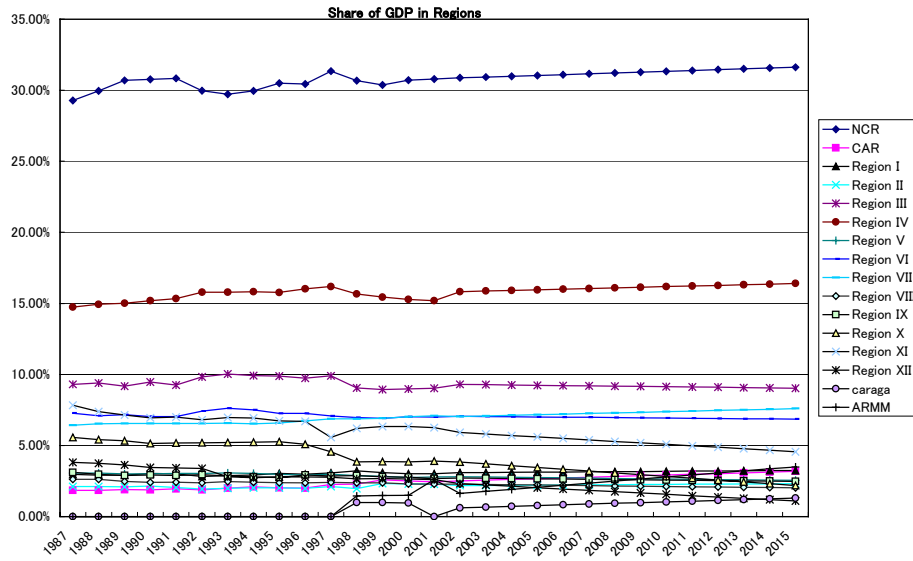


Fig. 2-6 % share of GRDP against total GDP in the Philippines

### iii) Calculating future regional GRDP (STEP 3)

Multiplying the percentage share of GRDP and the GDP scenario of the entire Philippines, the future GRDP values are obtained. This process is necessary for each of the three GDP scenarios mentioned above.

Year	National GDP	Growth Rate	GDP
1990			720,691
1991	-0.58%		716,523
1992	0.34%		718,942
1993	2.12%		734,156
1994	4.40%		769,451
1995	4.67%		802,224
1996	5.85%		849,122
1997	5.17%		893,017
1998	-0.57%		887,905
1999	3.41%		918,161
2000	4.01%		954,962
2001	3.60%		989,300
2002	4.60%		1,034,900
2003	4.2%		1,078,282
2004	4.9%		1,131,574
2005	5.3%		1,181,046
2006	5.8%		1,240,128
2007	5.3%		1,326,812
2008	5.8%		1,403,873
2009	6.0%		1,488,105
2010	6.0%		1,577,391
2011	6.0%		1,672,036
2012	6.0%		1,772,357
2013	6.0%		1,878,698
2014	6.0%		1,991,420
2015	6.0%		2,110,905

Year	Region I	Region II	Region III	Region IV	Region V	Region VI	Region VII	Region VIII	Region IX	Region X	Region XI	Region XII	Caraga	ARMM	Percentage			
1990	13,848	21,169	13,848	48,950	102,929	21,003	472,106	46,741	47,193	13,329	119,203	31,211	37,099	30,214	24,999	0	132,244	
1991	20,272	18,482	21,579	14,714	66,209	109,844	21,734	469,105	80,493	46,973	13,399	114,819	20,773	37,104	40,156	24,477	0	132,500
1992	218,695	13,951	20,344	19,874	76,206	133,623	21,201	499,963	33,321	43,664	13,788	113,505	41,761	33,161	48,861	24,999	0	132,589
1993	218,200	14,779	31,091	14,592	53,648	118,877	22,008	490,897	56,814	48,418	18,021	122,045	41,562	30,699	0	0	0	132,584
1994	222,656	16,088	32,816	16,581	78,116	121,243	23,318	504,401	67,814	63,164	18,862	126,208	21,379	49,119	63,090	21,021	0	142,758
1995	244,642	16,299	24,478	16,307	79,209	129,929	23,797	619,208	69,186	62,861	19,161	129,218	22,986	42,294	64,648	22,401	0	146,758
1996	258,412	17,024	25,395	16,871	82,292	138,100	24,960	567,254	61,681	67,195	20,191	139,027	24,939	45,160	65,829	23,715	0	148,441
1997	278,814	20,143	21,499	18,200	88,271	145,607	26,318	606,413	61,127	61,487	21,501	146,156	25,823	46,161	69,771	24,760	0	150,214
1998	279,287	20,801	20,844	17,604	88,076	159,129	26,264	603,716	61,958	61,188	20,995	144,191	26,401	34,188	65,131	25,051	8,774	150,982
1999	278,817	22,020	20,261	21,426	82,173	141,818	26,072	602,468	63,455	63,455	21,777	148,087	26,686	36,618	68,294	24,591	5,224	152,027
2000	292,294	23,967	23,842	21,920	85,810	149,920	26,388	629,210	67,190	67,190	22,000	156,208	28,897	38,860	69,997	25,774	8,146	152,846
2001	304,472	24,171	23,801	23,951	89,209	159,224	27,960	648,189	69,399	70,178	22,573	162,147	29,597	39,785	61,959	25,844	0	155,844
2002	319,279	26,826	21,869	22,812	96,299	169,892	28,981	689,199	72,689	72,689	23,691	169,489	30,181	39,208	63,299	29,979	6,399	158,299
2003	334,413	27,676	28,464	29,874	100,706	175,154	30,660	719,912	76,929	76,901	24,921	179,616	30,386	40,086	62,482	29,971	2,229	160,284
2004	360,487	29,612	36,296	24,960	104,762	189,898	31,396	796,366	79,479	80,999	26,385	185,377	30,689	44,581	24,995	6,172	27,648	169,419
2005	389,338	31,797	37,244	28,294	110,664	199,188	32,729	797,968	89,918	86,378	28,427	196,314	31,726	41,162	66,788	24,998	9,291	171,252
2006	391,843	34,290	39,882	29,854	116,194	201,678	34,778	845,989	88,169	90,872	27,728	206,361	33,387	41,979	69,334	24,486	10,429	172,738
2007	413,282	36,791	41,884	26,771	122,885	212,444	36,812	902,624	92,639	96,262	28,959	217,845	34,971	45,928	71,693	24,643	11,686	174,440
2008	438,170	39,448	44,394	31,541	129,880	226,914	37,140	946,208	97,297	102,469	30,195	229,812	36,877	49,022	74,599	24,664	13,095	176,962
2009	466,298	42,794	47,293	39,388	136,316	246,121	39,713	1,005,892	103,427	109,299	31,923	244,689	38,692	49,998	77,248	24,742	14,663	180,424
2010	494,144	46,174	50,267	38,765	144,178	268,219	41,389	1,087,598	109,391	116,473	33,549	259,473	40,627	44,880	80,248	24,751	16,272	182,443
2011	524,786	49,886	53,464	38,889	162,492	271,269	43,969	1,193,862	116,698	124,188	35,254	276,195	42,766	45,143	83,329	24,672	18,254	185,847
2012	562,282	53,787	58,889	40,849	181,284	298,371	46,645	1,288,095	122,289	129,299	37,844	291,811	44,994	46,612	86,498	24,698	20,299	188,291
2013	601,892	57,896	63,912	43,176	199,680	328,429	49,447	1,379,887	129,424	141,192	39,991	309,496	47,407	48,972	89,292	24,909	22,460	190,113
2014	649,499	62,987	64,728	45,869	188,417	356,699	51,171	1,468,531	139,884	150,479	40,889	328,254	49,829	46,220	92,688	24,988	24,688	191,436
2015	672,229	68,489	69,944	190,811	346,189	50,023	1,442,302	144,721	160,418	42,961	340,146	52,419	46,229	95,444	25,283	27,469	25,891	193,891

Fig. 2-7 GDP scenario broken down to regional GDP scenarios



**Remarks:**

These processes for breaking down to regional GDP scenarios should be updated when new scenario for GDP targets and actual GDP data from the previous year are disclosed. In this case, a GDP spreadsheet related should be extended throughout the year.

## 2.3 Sales data

### (1) Data Collection

**Outline:**

Due to restructuring NPC, it will soon be difficult to collect sectional sales data from NPC. Therefore, a demand forecasting scheme based on sales data by distribution utilities has been adopted for the new demand forecasting scheme.

**Practical process adopted in PDP 2004-2013:**

Sales data from PIOUs and municipal utilities are collected by ERC directly for rate regulation. Copies of these data are also sent to DOE. Sales data before Year 2001 can be collected from this information. However, some data were lacking in the historical data stock, and these data were recorded in paper format. The creation of a digital database and interpolation of lacking data were necessary.

NEA and NPC-SPUG collected data from ECs independently, and these data were collected on digital media. The data collection route through NEA should be the main route, and "The Chronicle," which is published by NEA every three years is the best reference for collection of past data. In addition, NEA may disclose the data of the previous year before starting the demand forecasting process. By referring to these data, a sales database for ECs can be prepared and updated.

However, ideally, DOE should collect copies of these sales data directly from ECs and PIOUs using the data collection scheme for DDP. This will contribute to efficient and accurate data collection.

The data that have been collected are as follows:

- Annual sales data by sector (residential, commercial and industrial) in utilities
- Amount of contract (connection) data by sector ( residential, commercial and industrial) in utilities

- Annual purchased energy in utilities
- Annual energy loss in utilities
- Annual consumption in utilities

		LUZON							
		1. Angeles Electric Corporation	2. Bataan Electric Lights System	3. Cabanatuan Electric Corp.	4. Dagupan Elec. Corp.	5. Ibaan Elec. & Eng'g. Corp.	6. La Union Electric Company, Inc.	7. Manaoag Utility Inc.	8. Manila Company
Bulk Power	1990								
	1991								
	1992								
	1993								
	1994								
	1995								
	1996								
	1997								
	1998								
	1999								
	2000								
	2001								
Comm/ Gen. Ser.	1990	61,075,585	933,192	11,393,855	18,645,264	732,328		211,347	3,776,4
	1991	48,782,105		12,822,561	18,926,538	698,509		263,951	3,750,8
	1992	44,727,633		12,331,686	19,625,902	789,790		206,555	3,815,8
	1993	47,341,346		12,545,533	22,670,121	852,636		263,013	3,784,4
	1994	59,436,282		17,538,927	25,714,339	1,130,448	17,787,284	299,327	4,747,0
	1995	72,909,463	2,112,505	18,883,190	28,758,558	1,337,667	23,383,749	346,022	5,140,3
	1996	103,076,333	2,292,637	33,510,579	30,534,208	808,809	33,983,813	297,509	5,805,0
	1997	134,621,550	2,168,124	36,559,883	32,549,463	1,752,386	25,602,520	248,996	6,313,5
	1998	140,664,488	2,335,587	45,287,412	34,317,132	1,938,085	28,997,134	354,428	6,870,4
	1999	146,748,171		48,703,909	35,142,420	2,035,591	30,688,272		7,038,1
	2000	167,664,443		51,611,050	39,188,330	1,911,348	32,379,409		7,507,2
	2001	165,890,417		51,914,496	41,792,645	2,375,011	34,070,547		7,905,7
Ind'l/ Gen. Pow.	1990	4,715,992		8,006,939	14,859,640	1,918,456		410,273	3,980,2
	1991	3,843,828		9,070,265	15,242,933	2,368,430		324,910	4,335,0
	1992	4,102,481		8,746,803	16,665,402	1,927,930		388,721	4,430,4
	1993	4,574,133		8,716,876	20,347,261	1,697,273		367,719	4,333,0
	1994	4,817,387		10,953,051	24,023,120	2,653,609	2,846,334	467,559	5,048,2
	1995	4,612,800	0	10,734,797	27,701,979	2,027,510	2,096,660	469,125	5,327,1
	1996	5,294,361	0	8,636,607	31,520,431	1,222,608	3,533,555	519,689	5,909,1
	1997	5,345,277		6,455,525	35,487,736	2,681,436	3,173,138	570,253	6,213,4
	1998	5,486,154		7,175,166	40,466,033	2,493,280	4,165,777	814,834	5,952,6
	1999	4,876,949		5,487,417	44,497,618	2,557,186	5,004,614		5,974,4
	2000	8,171,269		5,305,238	47,228,609	2,267,076	5,843,451		6,359,8
	2001	12,399,915		5,136,094	55,423,661	1,554,967	6,682,288		6,503,2
Others	1990	3,751,075	427,389	5,589,106	1,395,708	150,144		71,456	89,9
	1991	3,028,811		5,770,274	1,400,000	82,700		65,755	81,0

Fig. 2-8 Database of sales data

**Remarks:**

In this year's process, sales data are collected from these sources.

**1) Sales Data of PIOUs and Municipals**

Summary data on the sales of private owned utilities and municipal utilities by sector and on the energy balance (such as purchase, self consumption or generated) were collected as approved summary sheets recorded on the ERB or the ERC form. These data are available at the monitoring division in DOE. In addition, we used back numbers of annual reports stocked in ERC.

## **2) Sales Data of ECs**

Principally, the historical sales data of each EC were collected by referencing the chronicles.

## **3) Sales Data in Transmission**

To check trends in direct sales in transmission level, we collected historical direct sales data of NPC from TRANSCO. These data, after WESM started, can be collected as settled traded energy generated for costumers connected to transmission system.

## **2.4 The data from TRANSCO**

### **(1) Data collection**

#### **Out line:**

Historically, peak energy in PDP means the system peak, which equals the TRANSCO peak plus demand capacity supplied by an embedded capacity. To determine this system peak, the following data are necessary.

The annual TRANSCO system peak demand and the TRANSCO peak in Luzon, the Visayas and Mindanao grids.

Annual load factor in the Luzon, Visayas and Mindanao grids.

Annual loss factor in the Luzon, Visayas and Mindanao grids.

These data in sub-grids in the Visayas

### **Practical process adopted in PDP2004-2013:**

In the process of PDP2004-2013, historical peak data were collected from TRANSCO. These data are supplied via Ms. Dina Dezon. Both the TRANSCO peak and the system peak include embedded supplied capacity supplied by TRANSCO. However, there is no guaranty that this system peak can be collected from TRANSCO in future.

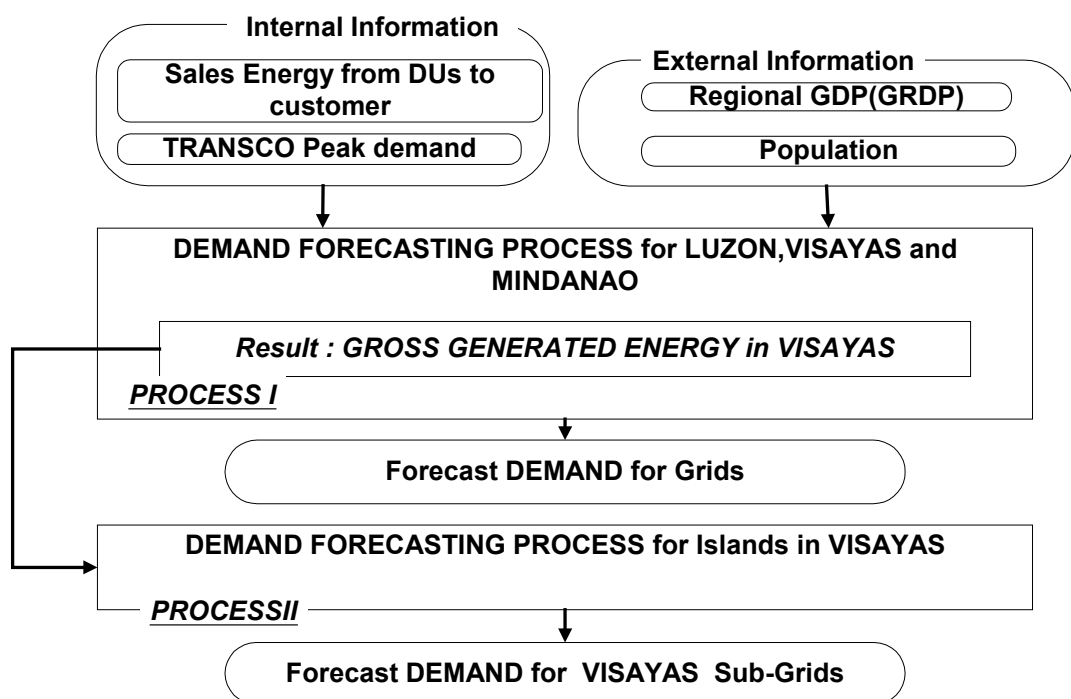
### **Remarks:**

In future, DOE must collect embedded capacity in the grid by itself. Because the DDP data collection scheme requires this data, DOE must estimate this embedded capacity using collected data in the DDP scheme.

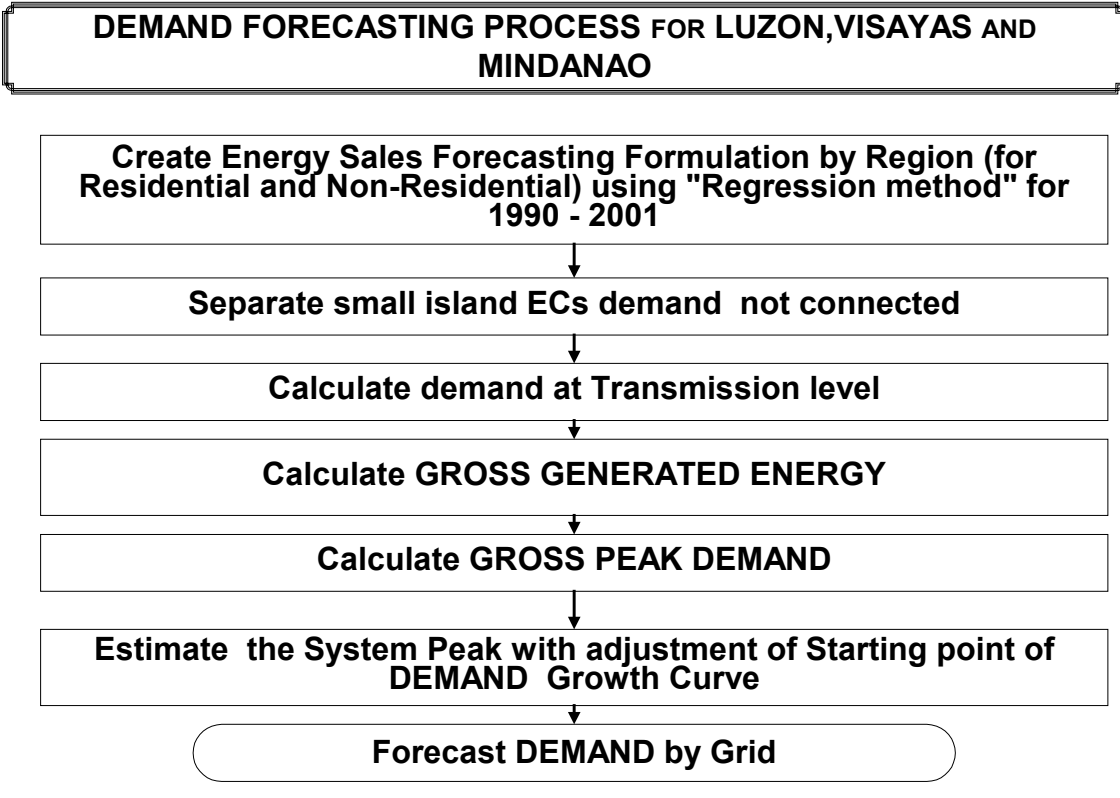
### 3. The method of demand forecasting

#### 3.1 Forecasting method of sales data

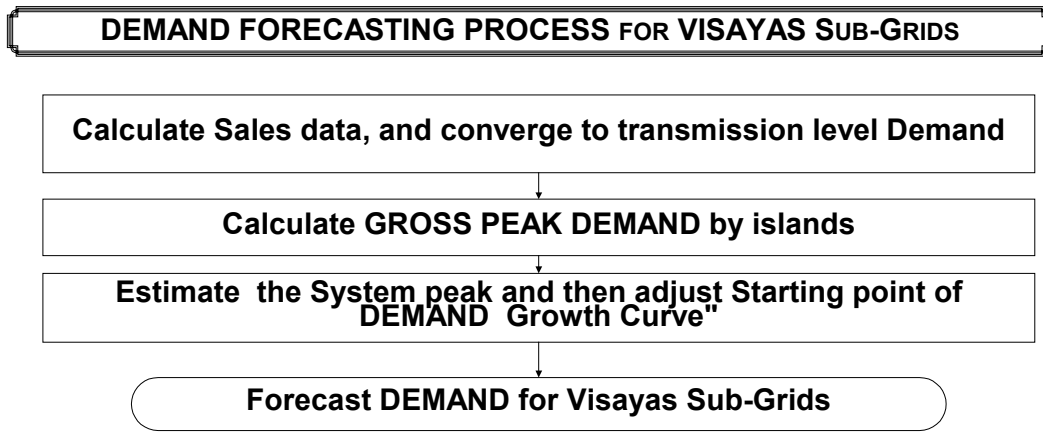
The following flowcharts are an outline of the demand forecasting process. There are two parts in these charts. The first (Process I) is for demand forecasting of the main grid in Luzon, the Visayas and Mindanao. The second process is for demand forecasting of the sub-grid in the Visayas.



**Fig. 3-1 Outline of the process of demand forecasting**



**Fig. 3-2 Outline of Process I**



**Fig. 3-3 Outline of Process II**

## STEP1: Regression model for forecasting sales in distribution

As the first step in demand forecasting, sales data in each region are forecasted using the regression model. In this case, “STATISTICA” can be applied to find **multi and single regression** results<sup>4</sup>.

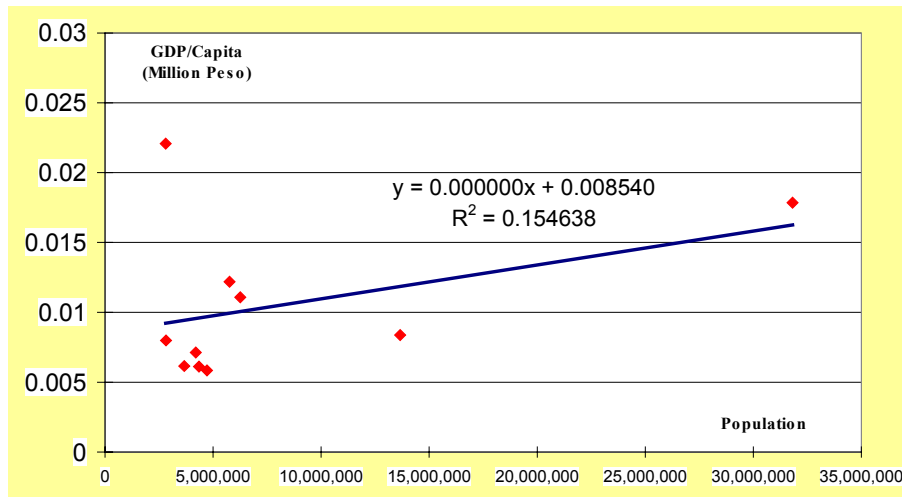
Forecasted demand in distribution is categorized into two sectors, residential and non-residential. Looking at historical data, it seems that separating the non-residential sector into individual sectors such as industrial, commercial and others is very difficult because sales are sometimes categorized as industry and at other times categorized as bulk. In addition, this energy cannot be separated. Therefore, we decided to merge non-residential demand into one category.

Therefore, the formulations for forecasting are as follows.

$$\text{Residential Sales (GWh)} = a + b * \text{Regional Population} \\ + c * \text{Regional GDP/Capita}$$

$$\text{Non-Residential (GWh)} = a + b * \text{Regional GDP}$$

Here, GDP/Capita and Population are thought do not strongly correlate (no multi-collinearity) based on the analysis shown in the following figure.



**Fig. 3-4 Relationship between GDP/Capita and Population**

<sup>4</sup> See “7.3 Multiple regression by STATISTICA” for information on how to run multiple regression using STATISTICA.

The functions used for forecasting, derived from the regression process, are shown below.

In these regressions, NCR, CAR, Reg3 and Reg4 are treated as one region because the MERALCO franchise is included. In addition, Reg10, Reg12, ARMM and Carga are merged into one region because these historical data were merged previously.

NCR-CAR-Reg3-Reg4:

$$\text{Residential Demand (MWh)} = -17665930000 + 630.5035 * \text{Regional Population} + 358197000000 * \text{GDP/Capita}$$

$$\text{Non-Residential Demand (MWh)} = 45108.56 * \text{Regional GDP} - 10191280000$$

Region 1:

$$\text{Residential Demand (MWh)} = -1905928000 + 485.7272 * \text{Regional Population} + 53182860000 * \text{GDP/Capita}$$

$$\text{Non-Residential Demand (MWh)} = 22470.17 * \text{Regional GDP} - 361413900$$

Region 2:

$$\text{Residential Demand (MWh)} = -702201700 + 287.3052 * \text{Regional Population} + 13626840000 * \text{GDP/Capita}$$

$$\text{Non-Residential Demand (MWh)} = 9539.046 * \text{Regional GDP} - 72201850$$

Region 5:

$$\text{Residential Demand (MWh)} = -1006732000 + 219.4846 * \text{Regional Population} + 37921890000 * \text{GDP/Capita}$$

$$\text{Non-Residential Demand (MWh)} = 15397.67 * \text{Regional GDP} - 217450400$$

Region 6:

$$\text{Residential Demand (MWh)} = 484.3776 * \text{Regional Population} - 2435031000$$

(In this case, the GDP/Capita effect negative, so we apply single regression)

$$\text{Non-Residential Demand (MWh)} = 15593.48 * \text{Regional GDP} - 523328400$$

Region 7:

$$\text{Residential Demand (MWh)} = -1827906000 + 362.4048 * \text{Regional Population} + 37408070000 * \text{GDP/Capita}$$

$$\text{Non-Residential Demand (MWh)} = 27696.38 * \text{Regional GDP} - 730708500$$

Region 8:

$$\begin{aligned} \text{Residential Demand (MWh)} &= -918689800 + 263.6572 * \text{Regional} \\ &\quad \text{Population} + 26744410000 * \text{GDP/Capita} \\ \text{Non-Residential Demand (MWh)} &= 14779.78 * \text{Regional GDP} - 194985000 \end{aligned}$$

Region9:

$$\begin{aligned} \text{Residential Demand (MWh)} &= -631487000 + 158.0149 * \text{Regional} \\ &\quad \text{Population} + 25567390000 * \text{GDP/Capita} \\ \text{Non-Residential Demand (MWh)} &= 21730.26 * \text{Regional GDP} - 301956500 \end{aligned}$$

Reg10+Reg12+ARMM+Carga:

$$\begin{aligned} \text{Residential Demand (MWh)} &= -688597800 + 65.60195 * \text{Regional} \\ &\quad \text{Population} + 17870210000 * \text{GDP/Capita} \\ \text{Non-Residential Demand (MWh)} &= 3893.83 \text{ Regional GDP} - 186815800 \end{aligned}$$

Region 11:

$$\begin{aligned} \text{Residential Demand (MWh)} &= -1562909000 + 761.9512 * \text{Regional} \\ &\quad \text{Population} + 3483093000 * \text{GDP/Capita} \\ \text{Non-Residential Demand (MWh)} &= 46282.68 \text{ Regional GDP} - 1735566000 \end{aligned}$$



## 3.2 Conversion method to peak demand

### **STEP 1: Estimation of Area Gross Generated Energy**

Gross generated energy was calculated using the following formula in each grid by using the “Adjustment Factor (% Value difference of gross generation and sales in distribution against sales in distribution companies).” These AF values are calculated by using the actual sales data and the actual gross generated energy from generation between 1999 and 2001.

$$\begin{aligned} \text{Gross Generation (GWh) by Grid} \\ = \text{Energy Sales in Distribution} * (1 + \text{AF}) \end{aligned}$$

#### **1) Luzon**

$$\begin{aligned} \text{Luzon Gross Generated Energy(MWh)} = \\ \text{Sale Energy in Distribution (“NCR-CAR-Reg3-Reg4”+Region1+Region2+Region5)} * \\ (1+34.2\%) \end{aligned}$$

#### **2) Visayas**

$$\begin{aligned} \text{Visayas Gross Generated Energy(MWh)} = \\ \text{Sale Energy in Distribution (Region9+ “Reg10+Reg12+ARMM+Carga” +Region11)} \\ * (1+65.6\%) \end{aligned}$$

#### **3) Mindanao**

$$\begin{aligned} \text{Mindanao Gross Generated Energy(MWh)} = \\ \text{Sale Energy in Distribution (Region6+Region7+Region8)} * (1+38.8\%) \end{aligned}$$

### **STEP 2: Conversion to Peak Demand**

Peak demand (MW) is calculated as the following formula.

$$\text{Peak Demand (MW)} = \text{Gross Generated Energy(MWh)} / 8760 \text{Hours} / \text{Load Factor}$$

With the last forecast, the following load factors were applied to the calculation of peak demand.

**Table 3-1 Load factors in each grid and sub-grid**

<b>Grid</b>	<b>Load Factor (%)</b>
<b>Phils</b>	<b>59.0</b>
<b>Luzon</b>	<b>71.2</b>
<b>Visayas</b>	<b>70.0</b>
Leyte-Samar	66.0
Cebu	64.0
Negros	52.0
Panay	59.0
<b>Mindanao</b>	<b>70.0</b>

### 3.3 Rearrangement of Energy Sales

#### STEP 1: Creating variation

Original forecasted demands are characterized by declining elasticity between growth rate and GDP growth rate. In the last forecast, we created variation as a constant elasticity case, in which the elasticity is kept the same as the Year 2003 value even after 2003. Treatment of creating variation is very easy as shown in the following steps.

- Set the 2003 demand the same as the original.
- Calculate the growth rate maintaining the same elasticity from the GDP growth rate in the area
- Calculate new peak demand using the calculated demand growth rate

#### STEP 2: Adjustment Peak

Peak demand calculated using the process in 3.4 does not pass through actual peak demand in 2002 because this MW growth is calculated based on data from 1990 to 2001. Thus, the growth curve is adjusted to pass through the actual peak value in 2002. In this process, the growth rates are kept the same as the original as shown in the following figure.

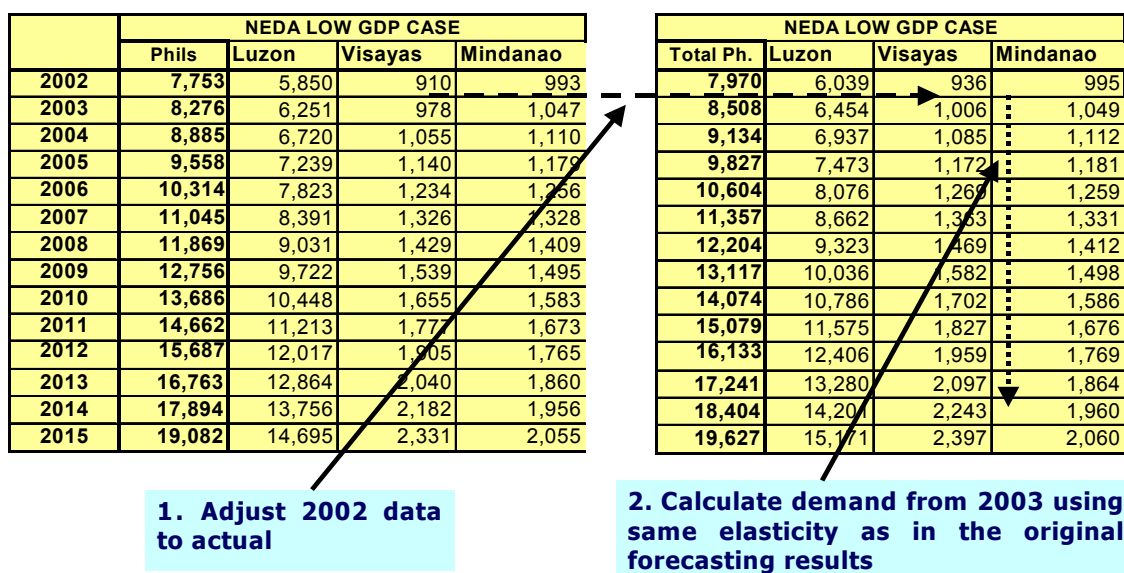


Fig. 3-5 Adjustment methods for peak demand to pass through the Year 2003

### STEP 3: Peak in an island's sub-grid

Peak demand in each island in the Visayas is found using the following steps. First, the sales data of each DISCO in Regions 6-8 were re-allocated among the islands when these DISCOs are located on large islands of the Visayas. Next, the future share of sales is estimated using the trend in the percentage share of sales in the Visayas.

**Table 3-2 % share of demand in the Visayas**

	CEBU	PANAI	NEGROS	BOHOL	LEYTE-SAMAR
1990	46.0%	16.2%	19.6%	2.3%	16.0%
1991	45.9%	17.0%	19.7%	2.3%	15.1%
1992	47.5%	16.6%	19.0%	2.2%	14.6%
1993	48.7%	16.3%	18.5%	2.2%	14.3%
1994	49.3%	15.8%	18.2%	2.3%	14.4%
1995	49.9%	15.6%	17.8%	2.5%	14.2%
1996	48.8%	15.6%	17.4%	2.5%	15.6%
1997	47.7%	15.5%	17.4%	2.6%	16.8%
1998	46.2%	16.0%	17.4%	2.5%	17.8%
1999	46.2%	16.4%	16.8%	3.2%	17.5%
2000	46.3%	16.4%	16.6%	3.0%	17.8%
2001	45.8%	16.2%	17.0%	3.1%	17.9%
2002	46.4%	15.9%	16.2%	3.3%	18.3%
2003	46.3%	15.8%	15.9%	3.3%	18.6%
2004	46.2%	15.8%	15.6%	3.4%	19.0%
2005	46.1%	15.8%	15.4%	3.5%	19.3%
2006	46.0%	15.7%	15.1%	3.6%	19.6%
2007	45.9%	15.7%	14.8%	3.7%	19.9%
2008	45.8%	15.7%	14.5%	3.8%	20.3%
2009	45.7%	15.6%	14.2%	3.9%	20.6%
2010	45.6%	15.6%	13.9%	4.0%	20.9%
2011	45.5%	15.6%	13.7%	4.1%	21.2%
2012	45.4%	15.5%	13.4%	4.2%	21.6%
2013	45.3%	15.5%	13.1%	4.2%	21.9%
2014	45.2%	15.5%	12.8%	4.3%	22.2%
2015	45.1%	15.4%	12.5%	4.4%	22.5%

### STEP 4: Gross generated energy in an island's sub-grid

Using these future share data, we found the future sales energy of an island, and then they are converged generated energy and peak using percentage value, which means the adjustment factor (AF) between generation and sales and load factor.

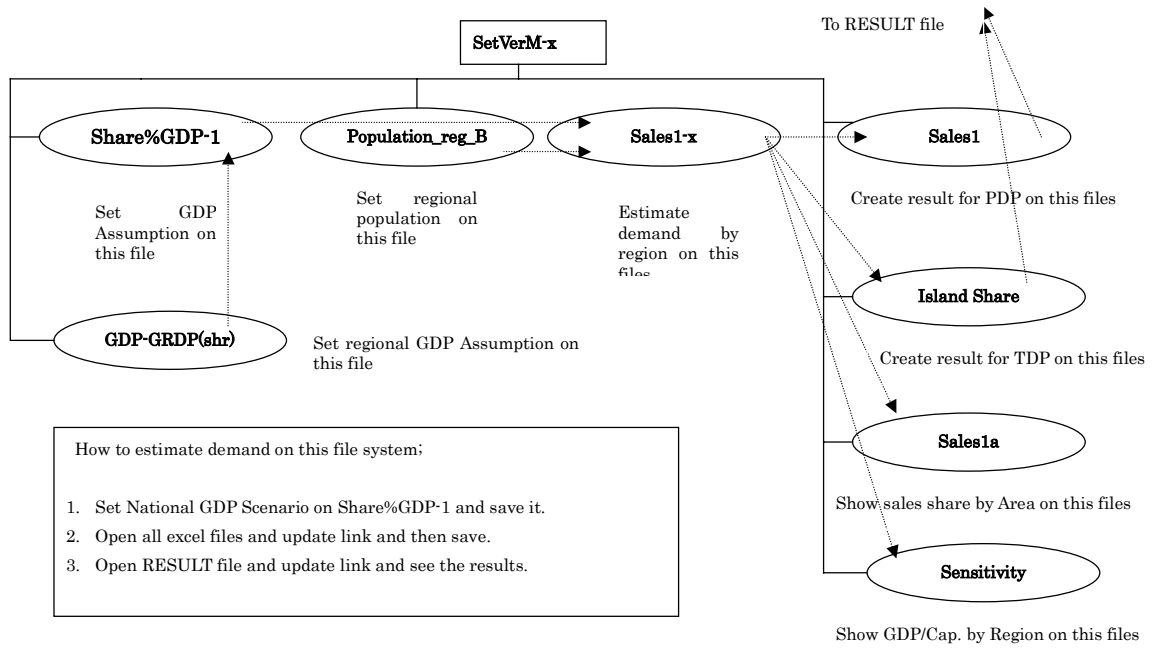
Gross Generated Energy(MWh)= Sale energy in DISCOs \* (1+AF (%value))

**Table 3-3 AF in each sub-grid**

<b>Panay</b>	<b>Negros</b>	<b>Cebu</b>	<b>Bohol</b>	<b>Leyte-Samar</b>
<b>3.9%</b>	<b>41.0%</b>	<b>34.4%</b>	<b>5.5%</b>	<b>136.9%</b>

## 4. The file system of Demand Forecasting

For demand forecasting, file systems of Excel that are linked to each other are created to easily handle forecasting. The structure of this file system is shown in the following figure.

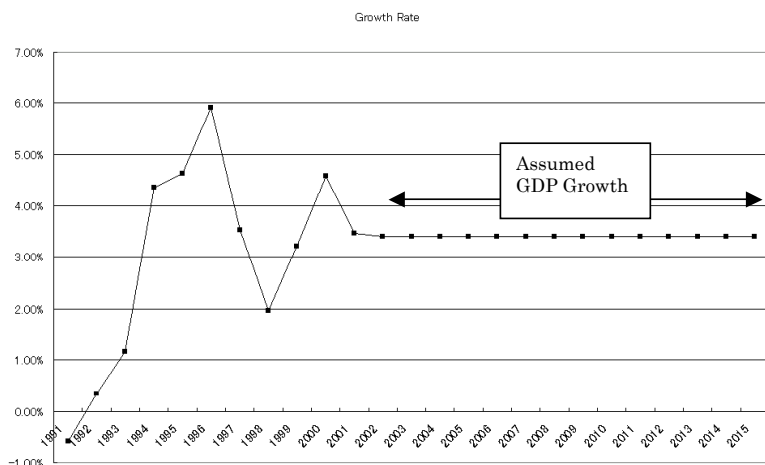


**Fig. 4-1 File system for forecasting**

**(1) shareGDP%-1 file**

In this file, the GDP assumption is input. These data are input on the sheet named “Total Phil. Assump.”

National GDP		
Year	Growth Rate	GDP
1990		720,691
1991	-0.58%	716,522
1992	0.34%	718,942
1993	1.16%	727,249
1994	4.36%	758,948
1995	4.63%	794,108
1996	5.92%	841,099
1997	3.54%	870,838
1998	1.97%	888,000
1999	3.21%	916,510
2000	4.58%	958,529
2001	3.46%	991,679
2002	3.4%	1,025,396
2003	3.4%	1,060,260
	Assumed GDP Growth	1,096,308
	%	1,133,583
	%	1,172,125
2007	3.4%	1,211,977
2008	3.4%	1,253,184
2009	3.4%	1,295,792
2010	3.4%	1,339,849
2011	3.4%	Calculated GDP
2012	3.4%	
2013	3.4%	
2014	3.4%	
2015	3.4%	



**Fig. 4-2 Input sheet and figures in the file share GDP%-1**

**(2) Sales1-x files**

On the Sales1-x (X=1,10) files, future sales in the distribution system are calculated using the above regression results. This process is conducted when these files are open. In these files, the historical sales data of each region are calculated as residential and non-residential, then the future sales volume is forecast in the table shown in Fig.4-3.

Year	EC-CAR		EC-Region1		EC-Region2		Marikina		Angeles		Tarlac		Mansions		Orangayo		San Fernando		Mun of Bataan		Ibaan		Cabanatuan		Bataan Exclt	
	Resid	Non-Resid	Resid	Non-Resid	Resid	Non-Resid	Resid	Non-Resid	Resid	Non-Resid	Resid	Non-Resid	Resid	Non-Resid	Resid	Non-Resid	Resid	Non-Resid	Resid	Non-Resid	Resid	Non-Resid	Resid	Non-Resid	Resid	Non-Resid
1990	49,151	40,885	214,236	163,306	155,497	110,749	3,583,069,656	7,645,745,608	78,312,498	69,542,853	18,878,796	17,892,016	3,664,596	6,585,859	0	0	0	0	5,913,277	1,260,591	2,153,821	2,800,929	15,970,236	24,869,900	0	0
1991	49,851	41,490	285,921	182,177	159,897	153,719	3,263,614,987	8,177,897,858	69,218,176	66,162,817	21,466,616	20,112,008	8,810,088	8,710,888	31,152,867	3,623,206	30,869,802	61,189,498	1,892,062	3,149,738	17,611,716	27,666,167	0	0	0	0
1992	52,136	48,321	232,964	179,391	193,891	89,011	3,840,959,917	9,339,359,931	55,921,081	52,280,020	24,143,954	28,629,789	41,454,028	6,263,959	35,099,001	26,491,024	31,037,711	59,627,504	3,324,058	2,814,229	18,437,953	28,879,942	0	0	0	0
1993	54,751	49,670	250,134	173,447	190,894	150,623	4,089,050,071	9,241,059,733	57,540,243	55,889,825	25,292,571	47,504,880	4,407,040	5,447,105	20,817,051	11,809,783	28,811,130	55,771,573	4,820,521	6,695,445	49,495,271	39,893,694	0	0	0	0
1994	62,374	58,217	308,024	213,009	184,149	188,587	4,652,442,698	9,902,621,498	65,206,391	61,022,225	29,894,335	60,887,081	5,209,965	2,538,203	34,118,000	25,891,464	34,195,548	52,975,629	2,873,899	3,815,639	46,321,113	39,219,579	6,324,388	0	0	0
1995	69,133	64,665	346,594	232,494	239,323	199,295	5,239,796,514	12,293,734,714	73,233,897	61,659,893	33,241,834	64,824,971	5,999,614	2,899,921	37,119,000	30,849,834	39,469,923	50,959,729	3,411,831	3,498,104	50,704,471	37,669,834	7,049,911	2,113,255	0	0
1996	79,906	69,871	393,490	252,325	215,186	214,062	5,875,788,174	11,834,690,119	82,700,241	112,498,788	39,652,788	79,453,885	6,626,411	3,311,488	34,927,283	36,254,755	46,023,814	60,862,221	2,118,654	2,118,238	39,605,904	45,397,336	9,568,113	2,292,637	0	0
1997	87,769	74,948	449,941	287,951	288,038	239,034	6,290,203,044	12,892,249,184	89,030,036	143,249,141	45,039,091	106,709,871	7,890,414	3,489,912	37,998,086	31,426,213	33,449,949	106,089,269	3,183,851	4,928,891	40,309,991	52,329,911	17,489,268	2,198,124	0	0
1998	95,297	76,458	522,241	319,870	387,753	286,532	7,349,379,000	15,267,721,000	108,338,163	150,399,445	50,889,041	79,830,699	7,843,026	3,586,636	40,604,755	39,588,438	60,866,556	152,714,496	6,046,824	4,706,459	47,382,426	64,375,874	13,244,114	2,835,587	0	0
1999	109,951	76,750	545,172	322,819	397,394	311,412	7,884,266,000	13,149,192,000	102,703,541	155,810,020	52,789,700	79,179,246	8,326,898	3,628,136	43,201,448	41,695,501	64,157,891	151,362,000	6,436,367	4,811,253	48,010,701	65,077,070	0	0	0	0
2000	115,293	82,338	599,029	399,551	433,321	344,759	7,893,431,000	14,000,039,000	109,010,781	169,334,713	57,070,241	83,766,271	9,444,961	3,932,239	43,067,596	45,945,414	70,411,225	193,074,083	6,285,293	4,463,899	52,643,529	70,004,711	0	0	0	0
2001	121,825	86,089	652,586	360,593	479,921	379,659	8,139,362,780	14,550,964,533	119,030,024	183,189,831	61,822,978	90,868,380	11,024,516	3,656,684	47,304,170	49,491,837	76,066,151	185,613,596	7,887,531	4,289,106	53,923,863	69,841,318	0	0	0	0

Year	NCR-CAR-Reg3-Reg4		GDP
	Resid	Non-Resid	
1990	3,767,854,554	8,010,771,600	413,061
1991	3,971,408,555	8,431,702,167	411,167
1992	4,164,959,678	8,602,361,323	413,337
1993	4,258,134,229	8,485,250,875	418,528
1994	4,920,874,364	10,211,577,513	436,802
1995	5,584,705,712	10,921,543,281	461,977
1996	6,311,244,854	12,246,218,444	489,657
1997	6,903,126,455	13,170,285,469	519,724
1998	7,774,744,891	13,532,335,836	512,102
1999	7,718,792,501	13,731,858,136	525,659
2000	8,342,604,833	14,634,853,600	551,056
2001	8,636,876,382	15,236,748,506	569,541
2002	9,297,058,827	16,991,236,454	599,949
2003	9,811,482,065	17,977,402,777	621,760
2004	10,328,420,753	18,999,271,198	644,361
2005	10,847,874,891	20,058,129,450	667,781
2006	11,369,844,461	21,155,311,563	692,047
2007	11,894,329,522	22,292,199,518	717,192
2008	12,421,330,017	23,470,224,972	743,247
2009	12,950,845,965	24,690,871,030	770,245
2010	13,482,877,367	25,955,674,096	798,219
2011	14,017,424,224	27,266,225,781	827,205
2012	14,554,486,537	28,624,174,878	857,239
2013	15,094,064,306	30,091,229,413	888,360
2014	15,636,157,533	31,489,158,767	920,605
2015	16,180,766,218	32,999,795,873	954,017
	390.4	34,590.4	KWh/GDP

Fig. 4-3 Creating actual and estimated demand by sector

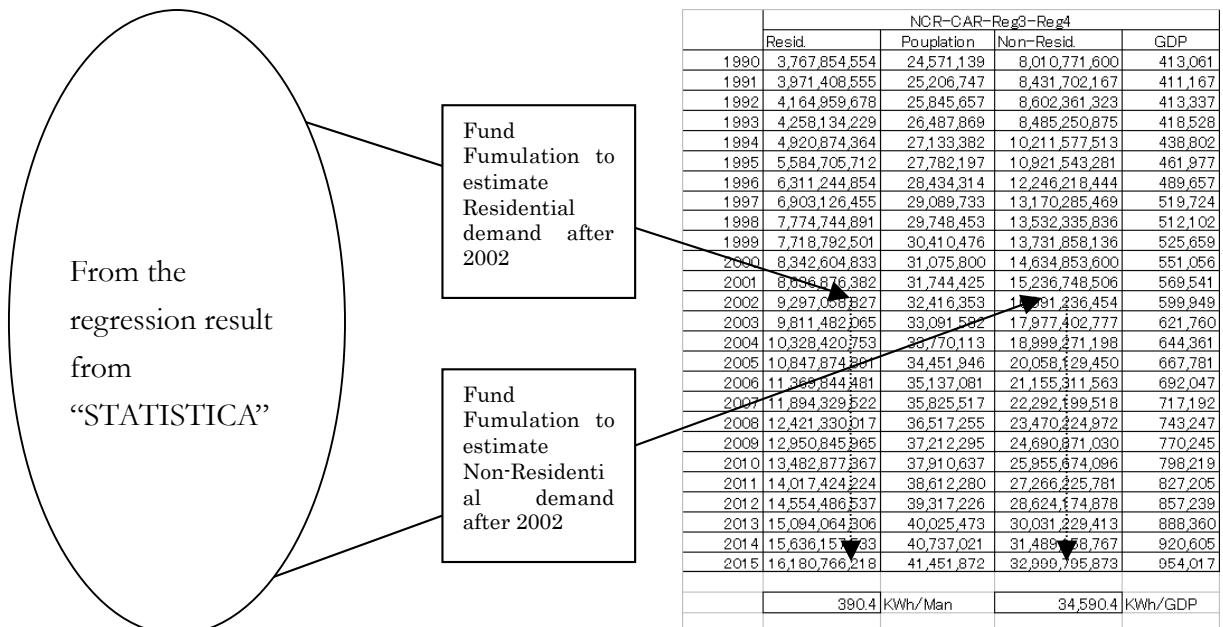


Fig. 4-4 Applying regression results to forecasting sales energy in distribution



### (3) Sales1 file

In this file, all sales estimated in the file of “sales1-x” are calculated for the grid. In addition, the separation of isolated ECs, the treatment of AF and load factor to convert sales in the distribution system to gross generated energy and peak demand.

Year	NCR-CAR-Diag-Reg4		Reg4		Reg5		Reg6		Reg7		Reg8		Reg9		Reg10		Reg11		
	Residential	Non-Res	Residential	Non-Res	Residential	Non-Res	Residential	Non-Res	Residential	Non-Res	Residential	Non-Res	Residential	Non-Res	Residential	Non-Res	Residential	Non-Res	
1980	3,767,854,254	8,010,771,600	169,089,242	1,021,163,688	69,378,000	57,895,000	1,008,897,000	1,333,444,000	145,219,000	185,696,000	216,850,250	453,727,431	53,427,000	62,580,000	108,006,000	1,564,429,000	1,728,395,461	58,712,736	228,373,374
1981	3,971,498,956	8,431,702,161	159,871,230	1,094,791,291	76,214,000	68,759,000	1,094,496,000	1,430,744,000	162,447,000	220,491,000	296,081,720	495,815,962	57,292,000	63,654,000	107,060,000	1,688,270,340	1,905,981,959	239,681,548	431,546,696
1982	4,184,859,618	8,602,981,823	183,304,544	1,111,169,175	82,339,000	65,261,000	1,236,660,000	1,313,954,000	191,419,000	228,458,000	271,895,625	562,263,981	66,743,000	64,501,000	104,789,000	1,891,389,000	1,911,283,931	502,835,098	255,555,523
1983	4,258,134,229	8,485,250,775	200,114,836	1,118,282,734	77,796,000	66,263,000	1,161,000,000	1,193,953,000	211,389,000	245,830,000	313,851,887	649,959,371	75,065,000	68,533,000	130,669,000	1,936,418,000	1,844,171,500	572,521,620	265,389,056
1984	4,500,074,984	10,011,677,513	250,049,091	1,170,919,000	100,114,000	73,000,000	1,274,000,000	1,444,490,000	300,410,000	284,920,000	309,811,115	731,807,413	60,643,000	75,449,000	143,290,000	2,070,000,000	2,030,603,768	540,603,000	300,246,697
1985	5,584,706,712	10,821,543,281	288,019,374	1,185,511,042	120,868,000	86,387,000	1,171,777,000	1,785,005,000	266,160,000	270,869,000	360,185,870	827,884,765	93,948,000	82,104,000	178,274,000	2,121,063,000	2,344,474,713	657,016,156	358,461,105
1986	6,311,244,654	12,246,219,444	337,052,907	1,182,225,441	137,812,000	99,771,000	1,185,209,000	1,61,068,000	312,443,000	283,257,000	443,420,287	889,056,428	113,741,000	86,897,000	212,154,000	2,255,229,000	2,626,200,830	595,348,452	401,346,960
1987	6,933,29,051	13,170,985,489	369,929,788	1,200,003,031	156,290,000	110,161,000	1,229,146,000	2,020,550,000	347,639,000	307,000,000	507,641,314	958,243,889	145,331,000	114,709,000	247,105,000	2,382,589,000	2,844,895,040	593,098,969	472,295,377
1988	7,774,744,881	15,832,335,836	419,469,788	1,258,307,269	180,800,000	121,170,000	1,253,771,000	2,268,071,000	402,476,000	327,503,000	558,811,677	882,644,080	178,688,000	126,540,000	273,274,000	2,500,000,000	3,202,772,612	618,296,060	527,143,468
1989	7,718,792,501	15,731,899,139	447,797,717	1,266,588,608	186,421,000	122,208,000	1,262,056,000	1,865,507,000	422,202,000	328,829,000	610,804,889	1,049,336,687	187,274,000	123,851,000	284,105,000	2,509,910,000	3,211,200,207	699,293,540	541,380,696
1990	8,342,604,633	14,834,893,858	491,108,121	1,286,624,885	206,162,000	134,321,000	1,286,656,000	1,813,494,000	485,233,000	354,159,000	678,411,791	1,077,542,316	206,803,000	169,606,000	305,877,000	2,605,000,000	3,335,234,464	644,873,521	538,349,984
1991	8,636,976,382	15,236,748,506	539,252,623	1,303,072,191	218,029,000	143,574,000	1,314,278,000	2,085,611,000	480,851,000	370,015,000	710,464,071	1,141,302,053	215,978,000	142,234,000	342,134,000	2,719,000,000	3,582,372,842	689,072,934	611,497,470
1992	9,297,058,827	16,981,230,454	540,300,408	1,349,882,318	225,769,725	141,682,000	1,317,962,228	2,073,926,228	509,979,889	401,732,085	757,882,991	1,270,082,491	230,666,327	151,640,113	355,419,000	2,804,916,683	3,800,606,668	648,784,043	660,435,121
1993	9,811,482,061	17,877,462,777	539,819,231	1,370,158,889	238,407,991	153,072,668	1,328,407,388	2,131,988,125	540,769,107	423,697,285	802,219,340	1,349,638,013	246,987,407	160,071,331	378,009,211	2,934,009,211	3,947,073,814	702,731,427	689,701,854
1994	10,538,420,763	18,999,271,198	599,539,485	1,405,628,969	250,876,862	186,102,549	1,351,350,683	2,266,406,639	570,886,663	444,244,302	857,766,252	1,432,314,834	265,305,201	169,707,004	401,759,870	3,065,965,014	4,200,880,670	666,026,000	738,845,395
1995	10,847,874,891	20,059,129,450	623,178,171	1,432,129,509	269,996,337	198,887,664	1,367,786,113	2,301,733,403	600,941,339	469,514,019	908,323,226	1,518,240,789	279,589,710	179,051,005	424,888,868	3,127,955,186	4,411,095,144	674,800,819	777,866,744
1996	11,399,844,681	21,155,211,563	648,826,287	1,461,089,026	274,820,410	212,344,508	1,383,773,671	2,418,300,633	630,744,753	469,485,187	959,191,793	1,607,542,316	295,803,000	189,606,889	447,973,546	3,203,545,097	4,611,260,601	853,812,460	816,736,921
1997	11,884,328,522	22,282,199,518	679,458,835	1,482,376,449	286,367,103	226,190,577	1,399,313,575	2,501,198,249	660,198,249	513,189,807	1,000,349,621	1,700,349,621	311,088,870	198,378,106	471,031,563	3,265,353,374	4,811,677,400	855,536,868	978,638,750
1998	12,421,330,017	23,470,224,972	697,160,813	1,524,204,175	297,816,393	240,543,829	1,414,005,208	2,617,671,318	689,382,098	537,628,746	1,061,859,506	1,796,797,896	328,303,522	206,368,416	494,057,032	3,368,396,508	5,062,044,460	701,400,401	884,187,644
1999	12,950,945,985	24,980,871,003	719,841,221	1,557,224,211	308,560,281	255,423,013	1,428,049,174	2,693,930,824	719,616,214	562,844,466	1,113,659,211	1,887,027,249	344,448,688	219,581,362	517,000,895	3,494,092,844	5,225,462,363	710,383,526	832,713,521
2000	13,482,277,287	25,985,674,096	741,546,058	1,591,480,777	319,252,785	270,844,883	1,443,245,275	2,805,583,369	746,860,229	589,860,100	1,165,799,483	2,001,183,701	360,662,989	229,020,336	540,010,931	3,610,260,884	5,452,922,247	719,383,315	871,116,627
2001	14,017,424,224	27,000,225,781	762,227,326	1,627,620,707	329,635,888	286,838,329	1,456,885,508	2,917,636,447	775,325,532	615,646,880	1,218,190,307	2,109,418,083	376,807,765	239,689,217	562,838,160	3,707,815,811	5,652,452,613	729,291,714	1,009,400,834
2002	14,554,880,837	28,024,174,878	781,981,023	1,663,889,611	338,720,596	304,644,598	1,470,929,877	3,031,066,663	813,410,866	643,216,823	1,270,021,691	2,221,887,296	392,929,276	250,581,862	585,630,444	3,845,284,336	5,844,033,961	717,440,328	1,047,558,852
2003	15,084,054,306	30,001,229,413	800,711,439	1,704,386,794	345,533,801	300,933,081	1,483,485,378	3,152,939,296	851,216,119	671,851,045	1,323,959,811	2,338,164,485	409,027,501	261,721,169	608,699,177	4,044,773,891	6,044,349,280	748,500,087	1,052,553,681
2004	15,636,167,839	31,450,150,787	810,465,700	1,741,610,700	360,049,823	309,209,861	1,495,655,041	3,261,044,246	880,744,000	700,286,440	1,377,211,401	2,460,190,420	495,102,442	273,110,781	631,626,266	4,244,019,820	6,262,212,800	785,881,271	1,120,656,302
2005	16,180,796,218	32,989,785,673	826,229,681	1,785,982,095	369,274,841	310,507,781	1,509,292,967	3,368,009,000	908,009,000	717,047,141	1,410,970,141	2,588,964,621	481,114,007	284,734,281	654,334,000	4,464,043,889	6,460,943,889	784,619,615	1,141,769,211

Year	Phil Total TWh	Luzon Total	Visayas Total	Mindanao Total	Luzon			Visayas			Mindanao		
					Residential	Non-Res	Residential	Non-Res	Residential	Non-Res	Residential	Non-Res	
1980	15	12.41	1.12	1.72	4,104,222,796	8,304,734,298	415,502,256	702,002,431	508,175,235	1,207,513,375			
1981	16.0	13.09	1.24	1.68	4,337,801,785	8,752,714,293	455,736,720	779,850,862	515,089,894	1,163,550,768			
1982	16.5	13.47	1.39	1.65	4,554,493,222	9,111,646,098	536,127,655	856,272,881	521,825,114	1,132,806,024			
1983	16.9	13.43	1.56	1.78	4,652,143,164	9,779,849,138	600,335,987	964,442,371	580,229,558	1,386,606,979			
1984	18.7	16.02	2.01	1.98	5,425,826,384	10,589,138,522	654,475,115	1,001,546,413	653,854,642	1,310,819,337			
1985	21.8	17.55	1.93	2.32	6,175,362,686	11,371,846,323	750,293,870	1,180,967,765	771,208,818	1,550,906,335			
1986	24.3	19.69	2.14	2.43	6,871,319,761	12,722,387,885	875,587,287	1,268,180,428	875,708,798	1,558,373,787			
1987	26.5	21.39	2.39	2.73	7,652,485,163	13,731,574,506	1,000,591,316	1,379,851,688	1,014,165,423	1,720,242,685			
1988	29.3	22.76	2.61	2.94	8,623,390,669	14,137,894,195	1,154,776,677	1,446,687,361	1,121,190,681	1,918,475,849			
1989	28.6	22.82	2.72	2.93	8,615,067,218	14,307,221,744	1,220,280,889	1,489,116,687	1,146,605,813	1,780,291,755			
1990	30.7	24.62	2.96	3.15	9,334,339,824	15,281,103,495	1,344,606,195	1,611,537,293	1,231,099,448	1,922,528,497			
1991	32.1	25.69	3.06	3.42	9,708,436,005	15,949,005,699	1,407,284,071	1,653,251,553	1,338,494,476	2,081,169,219			
1992	34.9	28.14	3.29	3.38	10,380,285,189	17,160,537,506	1,495,252,198	1,824,484,889	1,394,455,795	1,985,290,810			
19													

MW	NEDA High GDP CASE				NEDA LOW GDP CASE				LOWER GDP Modified CASE				PEP2003-2012 LOW GDP Case Result				PEP200
	Total Ph.	Luzon	Visayas	Mindanao	Total Ph.	Luzon	Visayas	Mindanao	Total Ph.	Luzon	Visayas	Mindanao	Total Ph.	Luzon	Visayas	Mindanao	Total Ph.
2002	7,970	6,039	936	995	7,970	6,039	936	995	7,970	6,039	936	995	8,249	6,308	941	1,000	8,390
2003	8,605	6,530	1,013	1,061	8,508	6,454	1,006	1,049	8,505	6,454	1,003	1,049	8,833	6,752	1,007	1,074	9,131
2004	9,326	7,090	1,100	1,136	9,134	6,937	1,085	1,112	9,129	6,937	1,079	1,112	9,518	7,275	1,084	1,159	9,983
2005	10,135	7,718	1,197	1,220	9,827	7,473	1,172	1,181	9,818	7,473	1,163	1,181	10,257	7,835	1,168	1,254	10,951
2006	11,030	8,416	1,302	1,312	10,604	8,076	1,269	1,259	10,591	8,076	1,256	1,259	11,139	8,503	1,276	1,360	12,036
2007	11,925	9,115	1,409	1,401	11,357	8,662	1,363	1,331	11,340	8,662	1,346	1,331	11,997	9,161	1,377	1,459	13,228
2008	12,930	9,903	1,527	1,500	12,204	9,323	1,469	1,412	12,094	9,255	1,438	1,402	12,870	9,830	1,477	1,563	14,540
2009	14,019	10,759	1,655	1,605	13,117	10,036	1,582	1,498	12,879	9,872	1,532	1,474	13,813	10,548	1,592	1,673	16,009
2010	15,172	11,667	1,790	1,715	14,074	10,786	1,702	1,586	13,694	10,517	1,631	1,547	14,815	11,319	1,707	1,789	17,606
2011	16,393	12,632	1,933	1,828	15,079	11,575	1,827	1,676	14,543	11,189	1,733	1,621	15,890	12,149	1,829	1,912	19,325
2012	17,686	13,657	2,085	1,945	16,133	12,406	1,959	1,769	15,426	11,890	1,840	1,696	17,033	13,034	1,958	2,041	0
2013	19,058	14,746	2,245	2,066	17,241	13,280	2,097	1,864	16,345	12,622	1,950	1,773	0	0	0	0	0
2014	20,512	15,905	2,415	2,192	18,404	14,201	2,243	1,960	17,303	13,387	2,066	1,850	0	0	0	0	0
2015	22,055	17,137	2,596	2,321	19,627	15,171	2,397	2,060	18,300	14,186	2,186	1,929	0	0	0	0	0

**Constant Elasticity Case**

MW	NEDA High GDP CASE				NEDA LOW GDP CASE				LOWER GDP Modified CASE				PEP2003-2012 LOW GDP Case Result				PEP200
	Total Ph.	Luzon	Visayas	Mindanao	Total Ph.	Luzon	Visayas	Mindanao	Total Ph.	Luzon	Visayas	Mindanao	Total Ph.	Luzon	Visayas	Mindanao	Total Ph.
2002	7,970	6,039	936	995	7,970	6,039	936	995	7,970	6,039	936	995	8,249	6,308	941	1,000	8,390
2003	8,605	6,530	1,013	1,061	8,508	6,454	1,006	1,049	8,505	6,454	1,003	1,049	8,833	6,752	1,007	1,074	9,131
2004	9,368	7,120	1,107	1,142	9,177	6,967	1,093	1,117	9,170	6,967	1,086	1,117	9,518	7,275	1,084	1,159	9,983
2005	10,270	7,817	1,218	1,236	9,957	7,564	1,196	1,197	9,946	7,564	1,184	1,197	10,257	7,835	1,168	1,254	10,951
2006	11,322	8,628	1,347	1,347	10,883	8,272	1,319	1,292	10,865	8,272	1,301	1,292	11,139	8,503	1,276	1,360	12,036
2007	12,413	9,472	1,482	1,458	11,808	8,982	1,442	1,384	11,784	8,982	1,418	1,384	11,997	9,161	1,377	1,459	13,228
2008	13,702	10,470	1,642	1,590	12,906	9,822	1,591	1,494	12,743	9,724	1,541	1,478	12,870	9,830	1,477	1,563	14,540
2009	15,168	11,605	1,824	1,739	14,148	10,771	1,759	1,617	13,780	10,527	1,674	1,578	13,813	10,548	1,592	1,673	16,009
2010	16,790	12,862	2,026	1,901	15,508	11,812	1,946	1,750	14,901	11,397	1,819	1,685	14,815	11,319	1,707	1,789	17,606
2011	18,585	14,256	2,251	2,078	17,000	12,954	2,153	1,893	16,114	12,339	1,976	1,799	15,890	12,149	1,829	1,912	19,325
2012	20,573	15,800	2,501	2,271	18,636	14,206	2,381	2,048	17,426	13,358	2,148	1,920	17,033	13,034	1,958	2,041	0
2013	22,773	17,512	2,779	2,482	20,429	15,579	2,634	2,216	18,844	14,462	2,334	2,049	0	0	0	0	0
2014	25,208	19,409	3,087	2,712	22,394	17,084	2,914	2,396	20,379	15,656	2,536	2,186	0	0	0	0	0
2015	27,905	21,511	3,430	2,963	24,549	18,735	3,223	2,591	22,038	16,949	2,755	2,333	0	0	0	0	0

**Fig. 4-6 Creating variation on the file "RESULT\_ADJUSTED "**

## 5. Verification of forecasting results

To check the propriety of the results and to understand the meaning of the results, verification should be carried out by several types of analysis. This chapter presents these methods of analysis.

### STEP 1: Create growth curve and comparison with the last PEP results

The first check should be comparison of the results with the previous forecasting results. For example, in the forecasting work in PDP 2004-2013, the following type of figure is prepared to show the difference among the results of the growth curve includes the previous forecasting results.

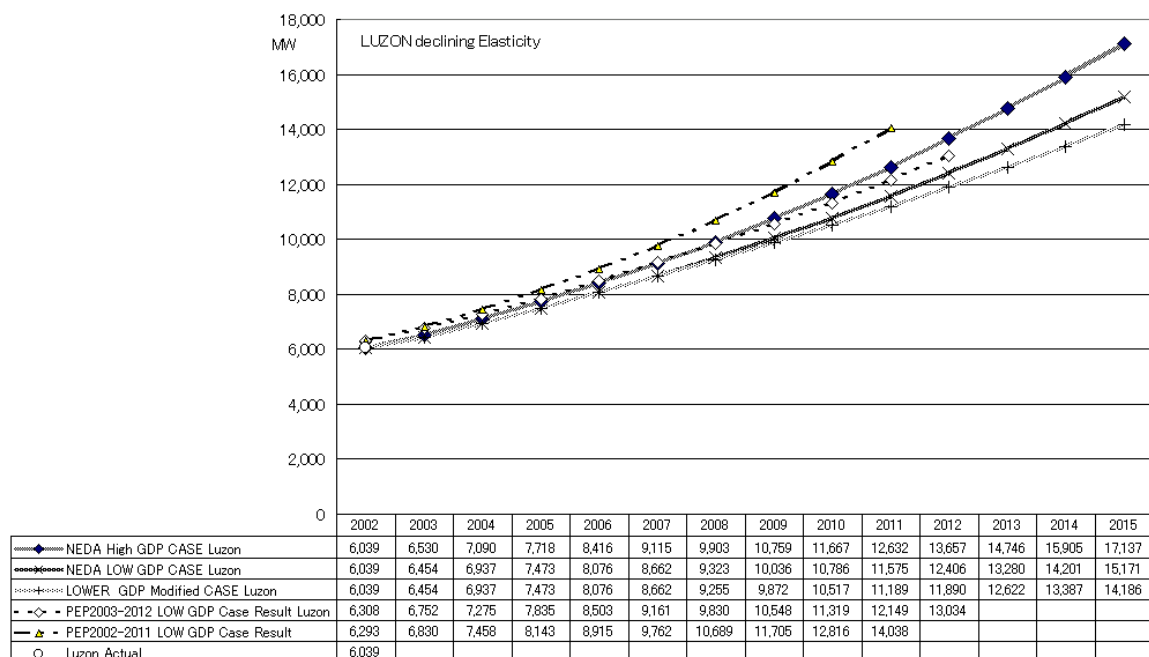
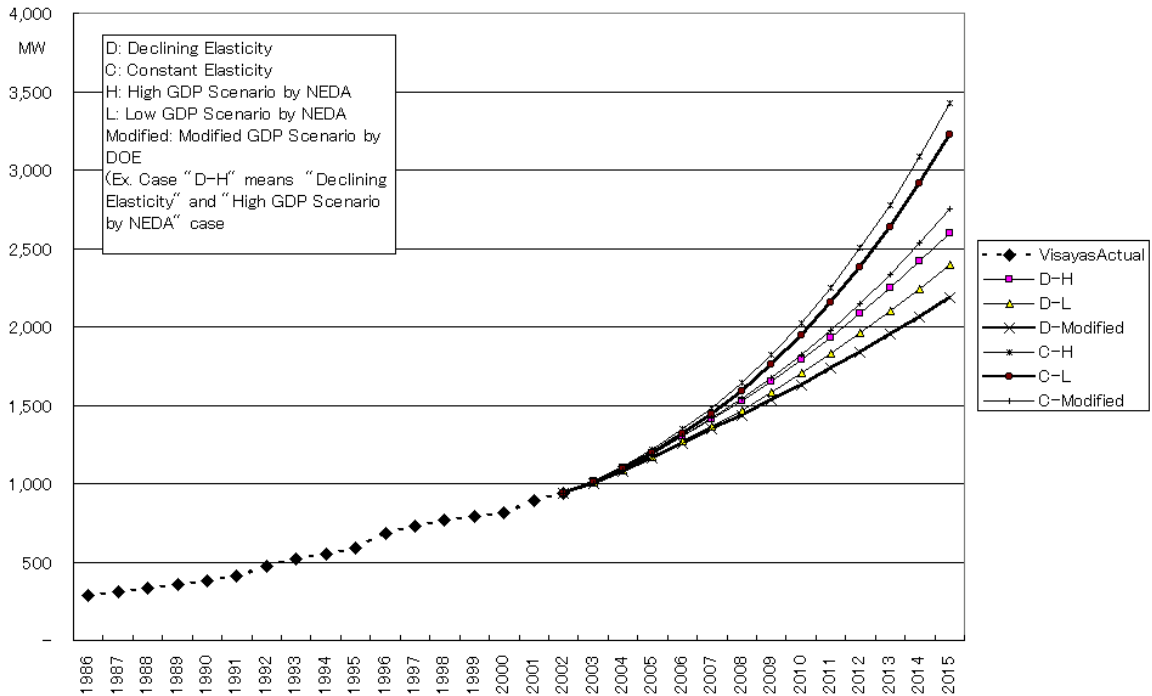


Fig. 5-1 Comparison among growth curves

### STEP 2: Comparison with historical demand

Comparison with historical data in the graphics is useful for checking the continuity of the curve based on each scenario. For example, the following graph shows the historical growth curve and the forecasted curve by scenario. Looking at this graph, we can understand that

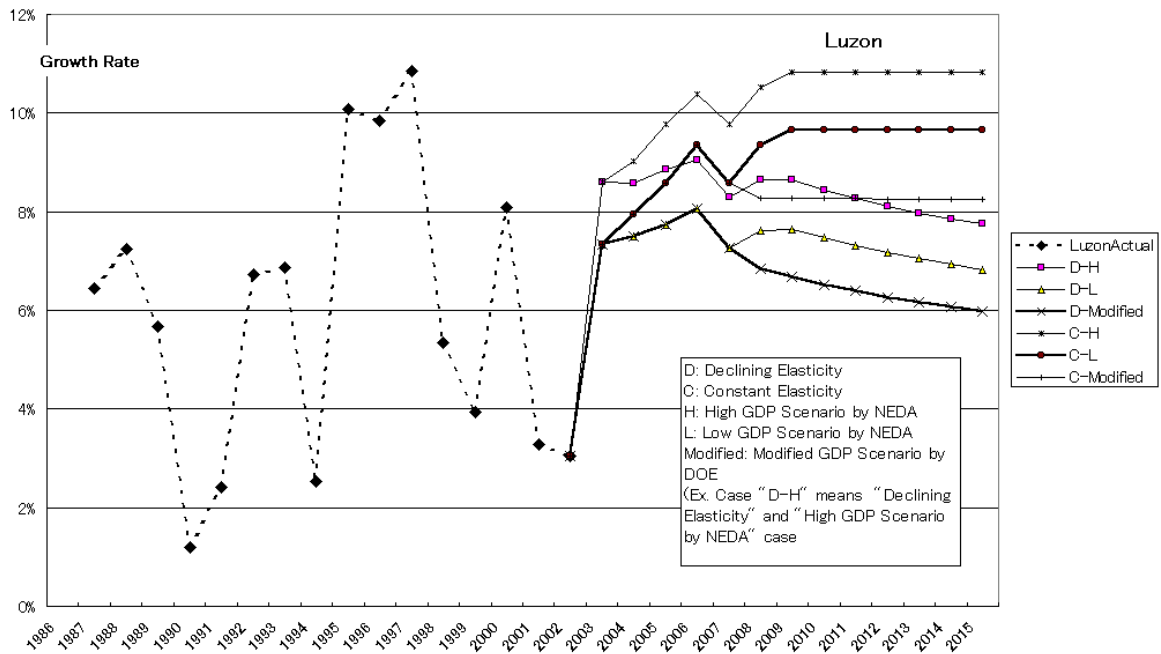
positive growth requires better economic conditions because the most pessimistic growth curve is on the trend of the past growth curve visually.



**Fig. 5-2 Comparison with the historical growth curve**

### STEP 3: Checking by growth rate

Checking the growth rate with historical data is important in assessing the propriety of the results. These checks are usually examined in the demand forecasting process. The following figure is an example of this type of check in the forecasting works of PDP2004-2013.



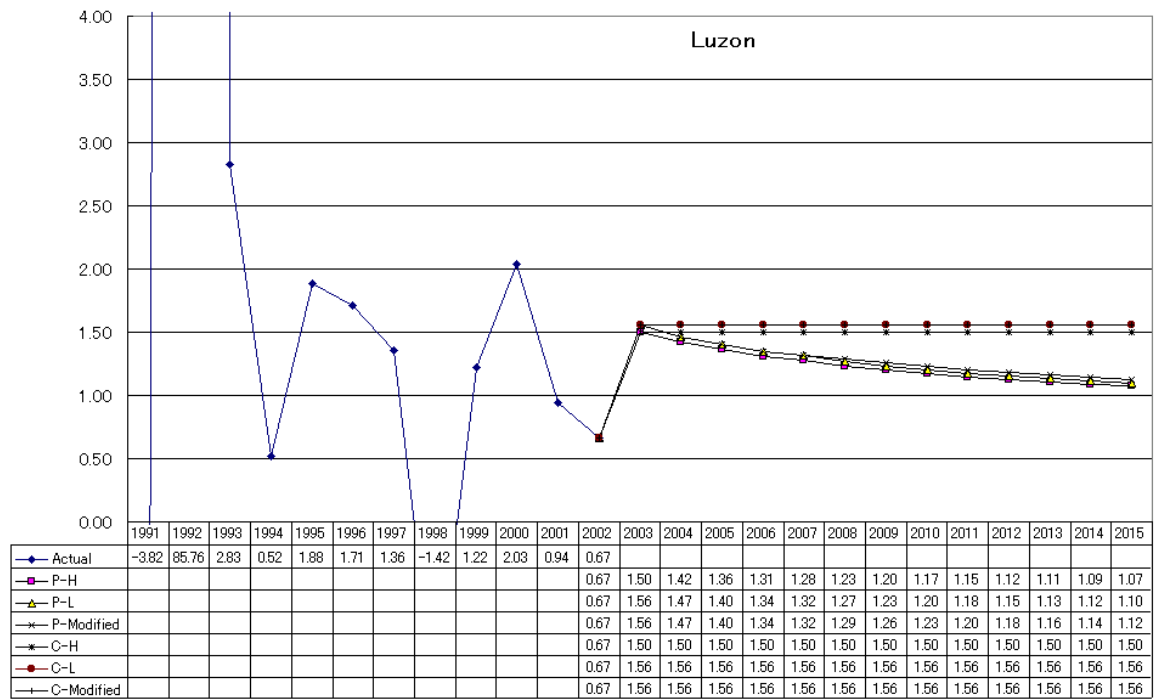
**Fig. 5-3 Example of a graph showing growth rate trends**

**STEP 4: Checking by elasticity**

In addition, with elasticity defined by the following formula, it is important to check the propriety of the results. Elasticity in the Philippines is declining. Forecasting results more strongly depends on how we estimate this trend in the future rather than GDP projection.

In addition, this graph visually shows the meaning of the difference in scenario from the view point of elasticity.

$$\text{Elasticity} = \frac{\text{the growth rate of Demand}}{\text{the growth rate of GDP or GRDP}}$$



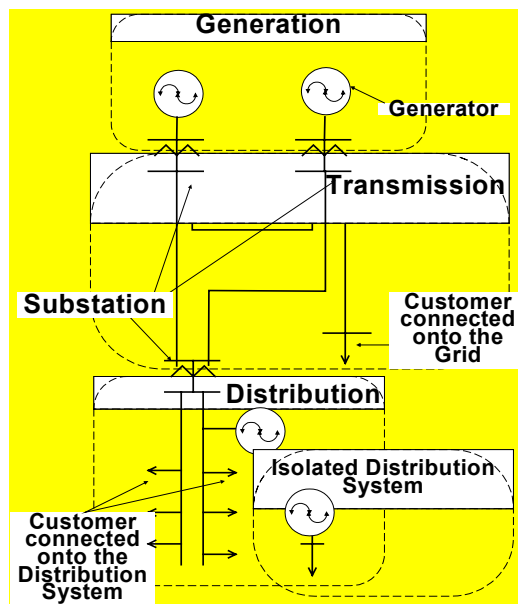
**Fig. 5-4 Example of a graph showing elasticity trends**

## 6. Remarks

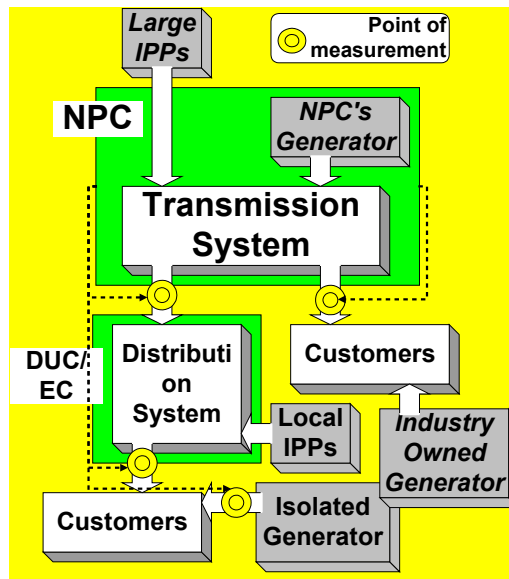
The process of demand forecasting in Year 2003 was carried out in the transient situation of the liberalization process. Historical data can be collected and measured in the traditional way. However, the data collection scheme should be changed considering the status of liberalization in demand forecasting works after Year 2003.

The facilities in the power system have not changed since restructuring as shown in the following figure. This means that the terms of collected data after restructuring are the same as before restructuring.

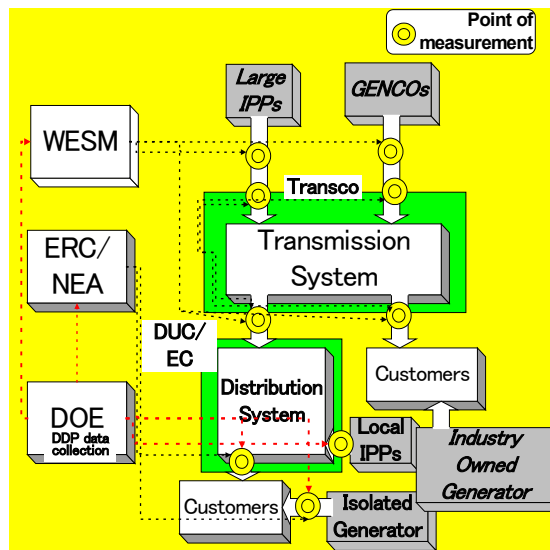
However, real power flow among entities will be changed after restructuring of power sector market. Through comparison with the relations among entities based on real-time power transfer before and after restructuring, NPC, which is the entity most responsible for national planning in the power sector, is unbundled. Therefore, DOE must collect data by itself. Thus, DOE must approach these data on distribution by establishing a DDP data collection scheme. If this is not established, DOE should depend on data collection by NEA and ERC.



**Fig. 6-1 Structure of facilities in the power system**



**Fig. 6-2 Real power flow among entities before restructuring**

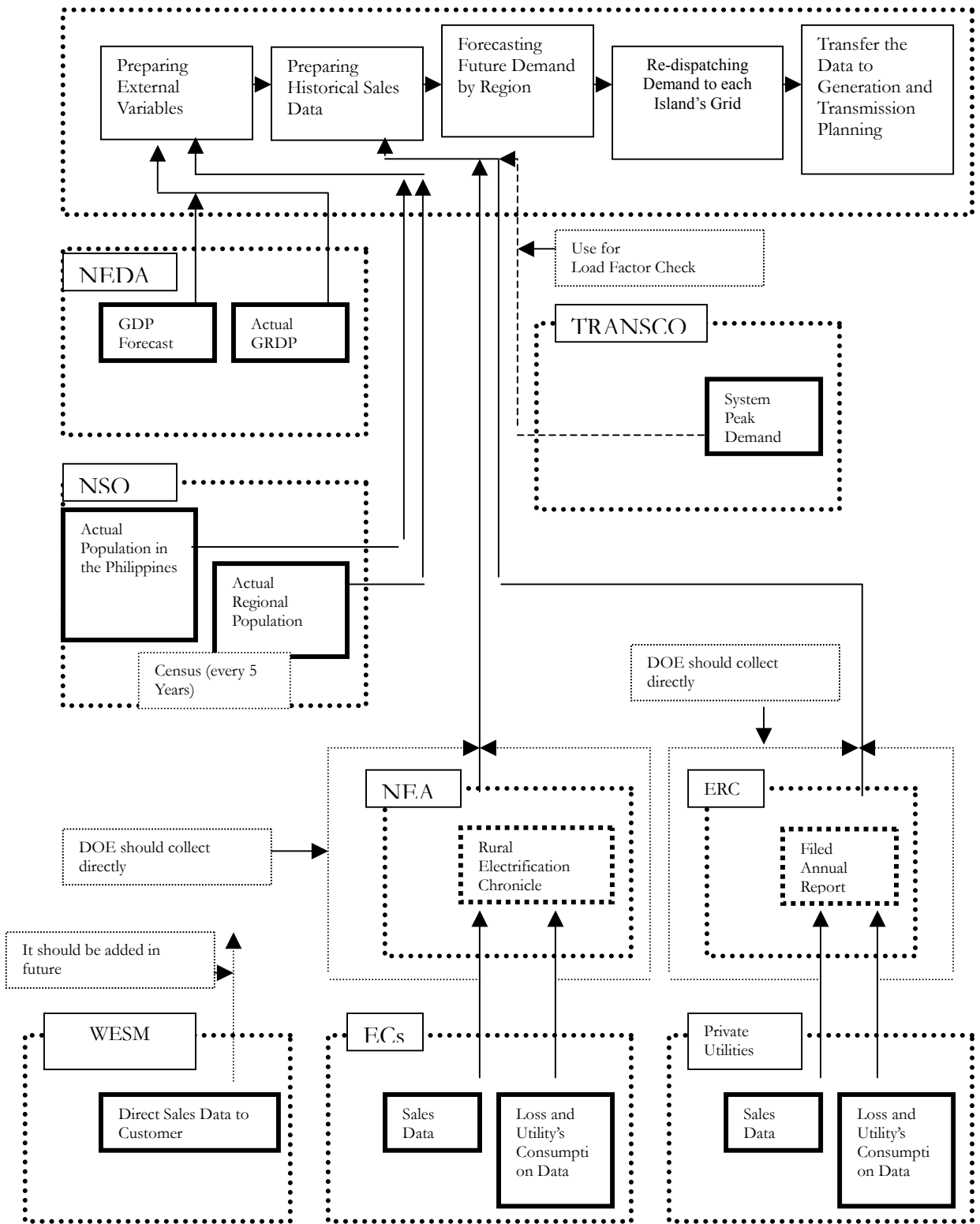


**Fig. 6-3 Real power flow among entities after restructuring**

It is difficult to collect data on the transmission level. From this year, historical direct sales data on the transmission system can be obtained from TRANSCO. After WESM starts, WESM will record settlement data, including actual bilateral transfers. Therefore, DOE should establish a data collection scheme from WESM.



In addition, TRANSCO will be only responsible to TRANSCO Peak demand. There is no guaranty to prepare System Peak data. Therefore, DOE also estimate system peak by adding embedded capacity supplying demand collected by DDP data collection scheme.



**Fig. 6-4 Data flows among entities**

## 7. Reference

### 7.1 Data Source

In the work for PDP 2004-2013, the following data sources were referenced.

Philippines Energy Plan 2002-2011 (DOE)  
Philippines Energy Plan 2003-2012 (DOE)  
National Year Book 2002 (NSO)  
Statistics on GDP in 2002 (NSO)  
Chronicle 2000 (NEA)  
Chronicle 2003 (NEA)  
Approved Summaries of sales data of PIOUs (DOE/ERC)  
Annual Reports of PIOUs (DOE/ERC)  
System and TRANSSCO Peak data (TRANSCO)  
NPC's historical direct sales data (TRANSCO)  
GDP projection (NEDA)

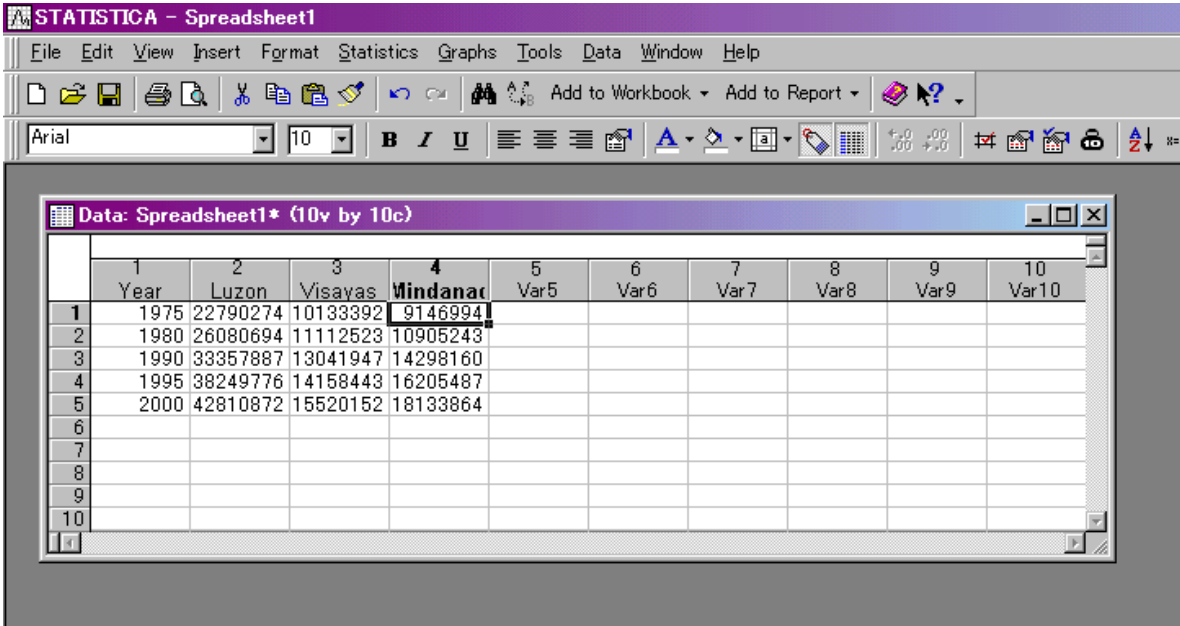
## 8. STATISTICA

### 8.1 Single regression

#### STEP 1: Open and prepare the spreadsheet

- 1) First, click the STATISTICA Icon and open a new spreadsheet.
- 2) Copy and paste each stream of data in the longitudinal direction on the spreadsheet.
- 3) Change the name from “Var#” to the discretionary name of the data.

In the figure below, “Var1” was changed to “Year.” In addition, other columns have the names of areas. In those columns, actual population data associated with the year in the first column are input.



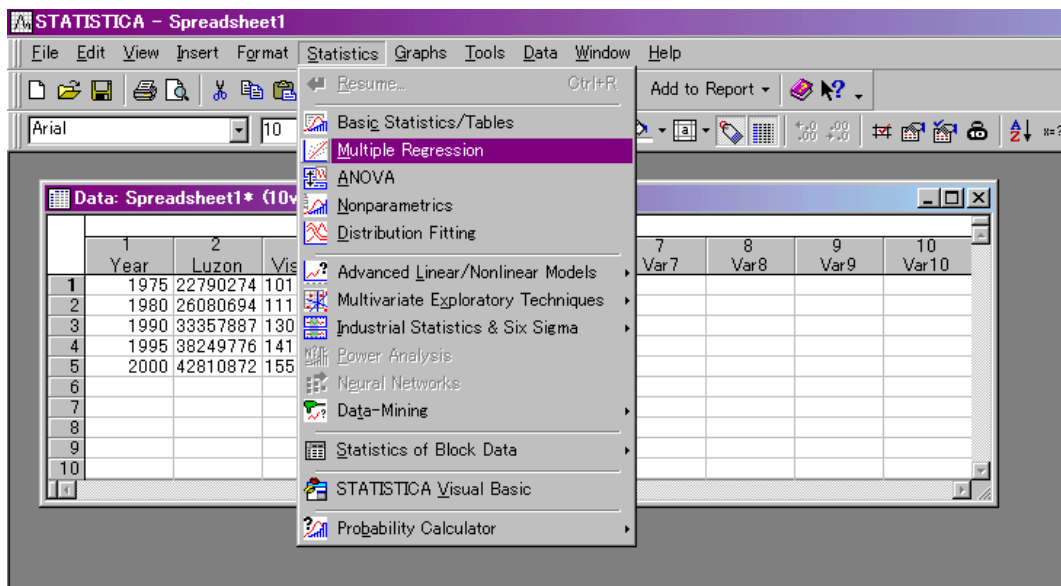
The screenshot shows the STATISTICA software interface with a spreadsheet titled "Data: Spreadsheet1\* (10v by 10c)". The spreadsheet has 10 columns and 10 rows. The first column is labeled "Year" and contains the years 1975, 1980, 1990, 1995, and 2000. The next three columns are labeled "Luzon", "Visayas", and "Mindanac", representing population data for these regions. The remaining columns are labeled "Var5", "Var6", "Var7", "Var8", "Var9", and "Var10", which are currently empty. The data for the first five rows is as follows:

	1 Year	2 Luzon	3 Visayas	4 Mindanac	5 Var5	6 Var6	7 Var7	8 Var8	9 Var9	10 Var10
1	1975	22790274	10133392	9146994						
2	1980	26080694	11112523	10905243						
3	1990	33357887	13041947	14298160						
4	1995	38249776	14158443	16205487						
5	2000	42810872	15520152	18133864						
6										
7										
8										
9										
10										

Fig. 8-1 Data input on the spreadsheet

#### STEP2: Start of regression process

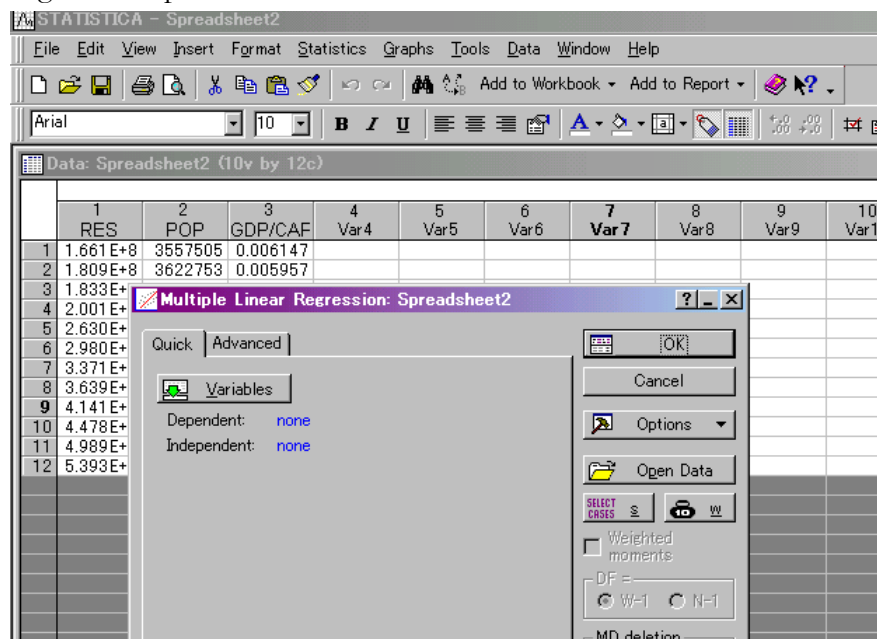
- 1) Pull down the “Statistics” menu
- 2) Click the “Multiple Regression” menu to open the “Multiple Linear Regression Spreadsheet2” menu.



**Fig. 8-2** Pull down menu of “Statistics” and the position of the “Multiple regression” menu

### **STEP3 :Identify target variable and explaining variable**

- 1) Push the “Variables” button to open the menu to select variables on the “Multiple Linear Regression Spreadsheet2” menu.



**Fig. 8-3** “Multiple Linear Regression Spreadsheet2” Menu

#### STEP 4: Selection of variables

- 1) Select one of the variable-dependent variables as the target variable.
- 2) Select one of the variables as the independent variable, which is the explaining variable.
- 3) Then push “OK” button and return to the “Multiple regression spreadsheet2” menu.  
\* In the case of the figure below, the year is selected as an independent variable, and Luzon is selected as a dependent variable.

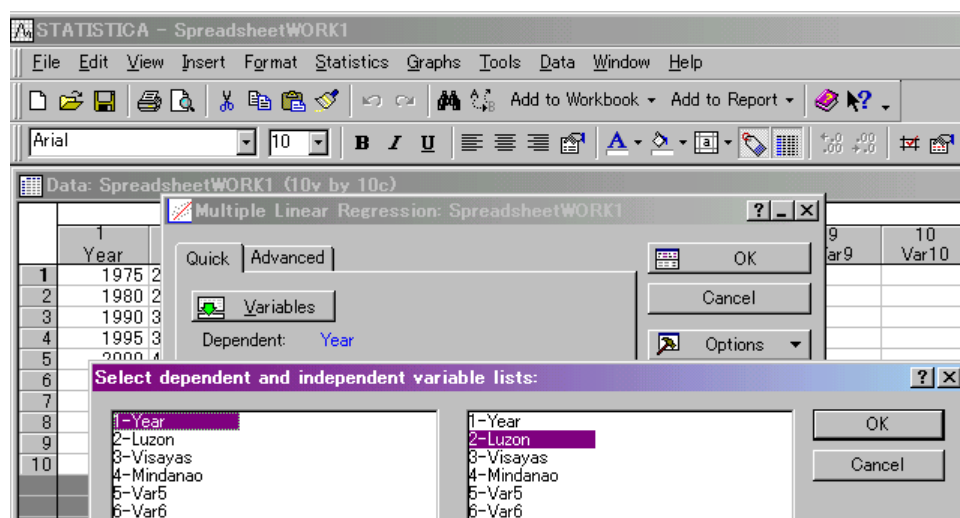
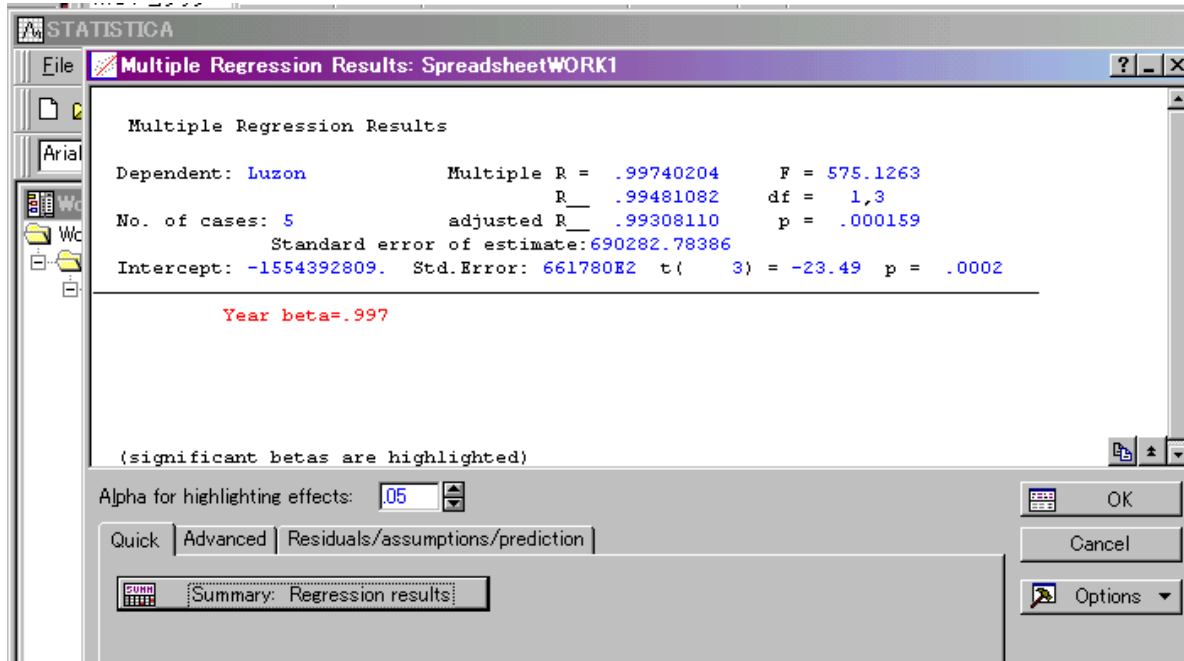


Fig. 8-4 Selection of variables

#### STEP5: Run regression

- 1) Click the “Run” button on the “Multiple regression Spreadsheet2” menu.
- 2) STATISTICA then opens the “Multiple regression results: Spreadsheet1” shown below.



**Fig. 8-5 “Multiple Regression Results: Spreadsheet1”**

**STEP6 :Open “Summary” and select the coefficient of the regressed formula**

- 1) Push the “Summary: Regression results” button on the “Multiple regression results: Spreadsheet1” to open the “Regression Summary”
- 2) Select the coefficient from the spreadsheet shown below.

$$\text{Luzon Population} = a * \text{Year} + b$$

$$a: \text{Column "B" and row "Luzon"} = 7.9831\text{E}+5$$

$$b: \text{Column "B" and "Intercept"} = -55439.3 \text{E}+9$$

In this case,  $R=0.997402$  and  $R^2=.99481082$ . This means this regression model will experience the dependent variable, “Luzon population,” by the independent variables “Year.”

STATISTICA - [Workbook2\* - Regression Summary for Dependent Variable: Luzon (SpreadsheetWORK1)]

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Arial 10 B I U

Workbook2\*
 

- Multiple Regress
  - Regression r
    - Summary
    - Regressio

Regression Summary for Dependent Variable: Luzon (SpreadsheetWORK1)  
 R= .99740204 R\_ .99481082 Adjusted R\_ .99308110  
 F(1,3)=575.13 p<.00016 Std.Error of estimate: 6903E2

	Beta	Std.Err. of Beta	B	Std.Err. of B	t(3)	p-level
N=5						
<b>Intercept</b>			-1.554393E+09	66178043	-23.4880	0.000169
Year	0.997402	0.041590	7.983152E+05	33288	23.9818	0.000159

Fig 8-6 “Regression Summary for Dependent Variables” spreadsheet

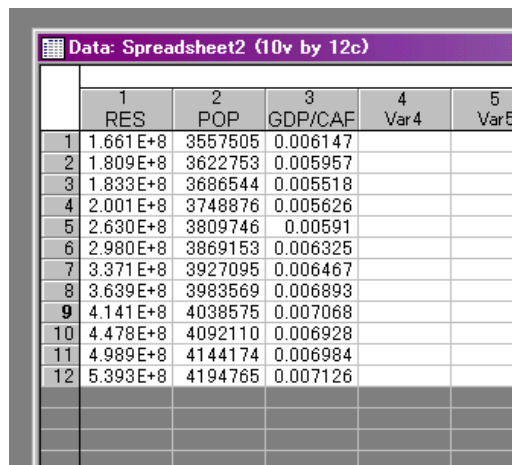


## 8.2 Multiple regression by STATISTICA

### STEP 1: Open and prepare the spreadsheet

- 1) First, click the STATISTICA icon and open a new spreadsheet.
- 2) Copy and paste each stream of data in the longitudinal direction on the spreadsheet.
- 3) Change the name from “Var#” to the discretionary name of the data,

These processes are the same as in the case of single regression. In the case of the figure below, “Var1” was changed to “RES,” which means “Residential consumption.” The second “POP” means population, and the third means GDP/Capita. In those columns, each data item in the same row are data of the same year.



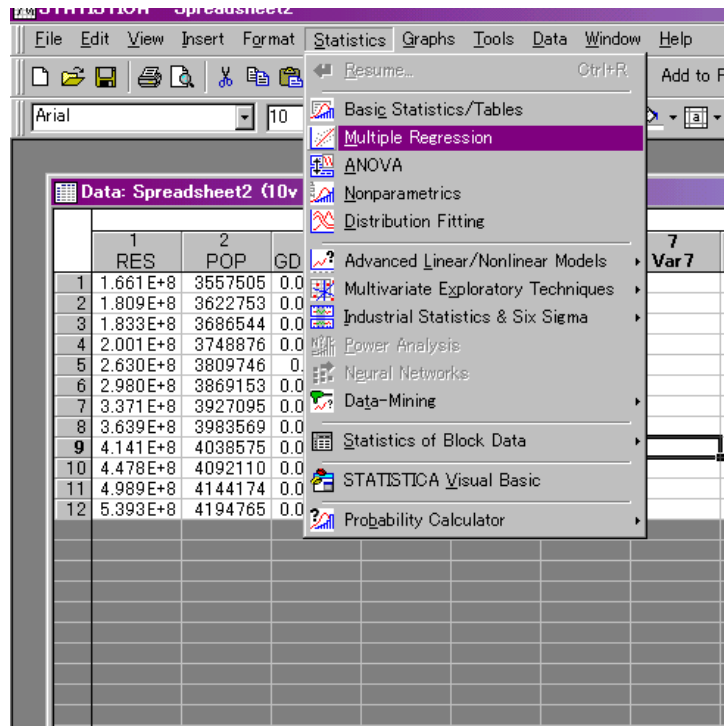
	1 RES	2 POP	3 GDP/CAF	4 Var4	5 Var5
1	1.661E+8	3557505	0.006147		
2	1.809E+8	3622753	0.005957		
3	1.833E+8	3686544	0.005518		
4	2.001E+8	3748876	0.005626		
5	2.630E+8	3809746	0.00591		
6	2.980E+8	3869153	0.006325		
7	3.371E+8	3927095	0.006467		
8	3.639E+8	3983569	0.006893		
9	4.141E+8	4038575	0.007068		
10	4.478E+8	4092110	0.006928		
11	4.989E+8	4144174	0.006984		
12	5.393E+8	4194765	0.007126		

Fig. 8-7 Data input on the spreadsheet

### STEP 2: Starting the regression process

- 1) Pull down the “Statistics” menu.
- 2) Click the “Multiple Regression” menu to open the “Multiple Linear Regression Spreadsheet2” menu.

These processes are same as in the case of single regression.

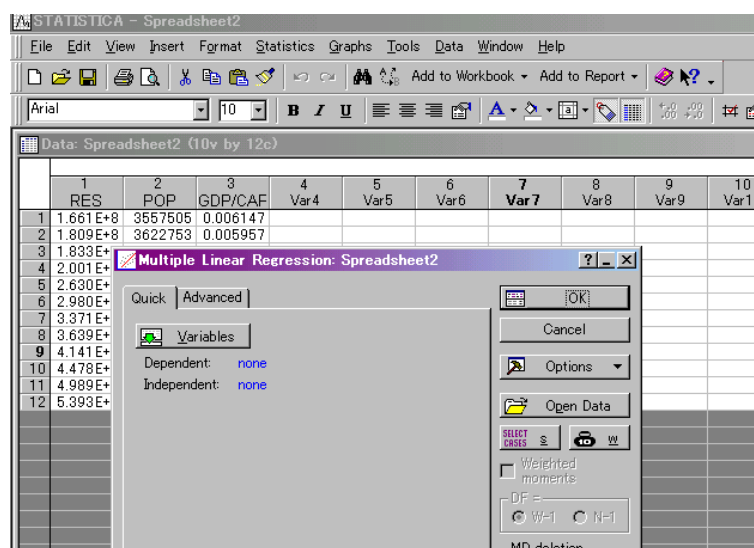


**Fig. 8-8** Pull down the “Statistics” menu and position the “Multiple regression” menu

**STEP 3: Identify the target variable and the explaining variable**

- 1) Push the “Variables” button to open menu for selecting variables in the “Multiple Linear Regression Spreadsheet2” menu.

This process is the same as in the case of single regression .



**Fig. 8-9** “Multiple Linear Regression Spreadsheet2” Menu

#### STEP 4: Selection of variables

- 1) Select one of the variables as the dependent variable, which is the target variable
  - 2) Select two of the variables as independent variables, which are explaining variables
  - 3) Then push the “OK” button and return to the “Multiple regression spreadsheet2” menu.
- \* In the case of the figure below, RES is selected as a dependent variable, and POP and GDP/Cap are selected as independent variables.

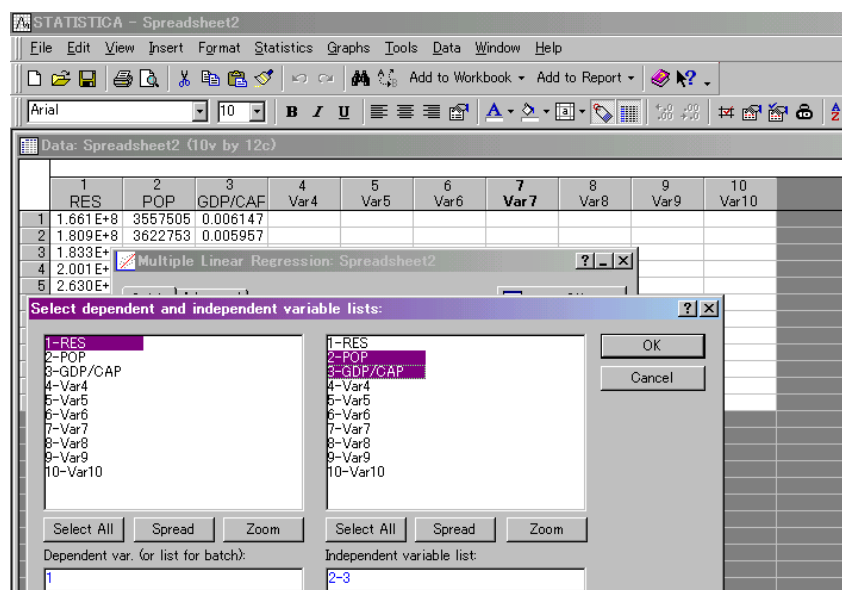
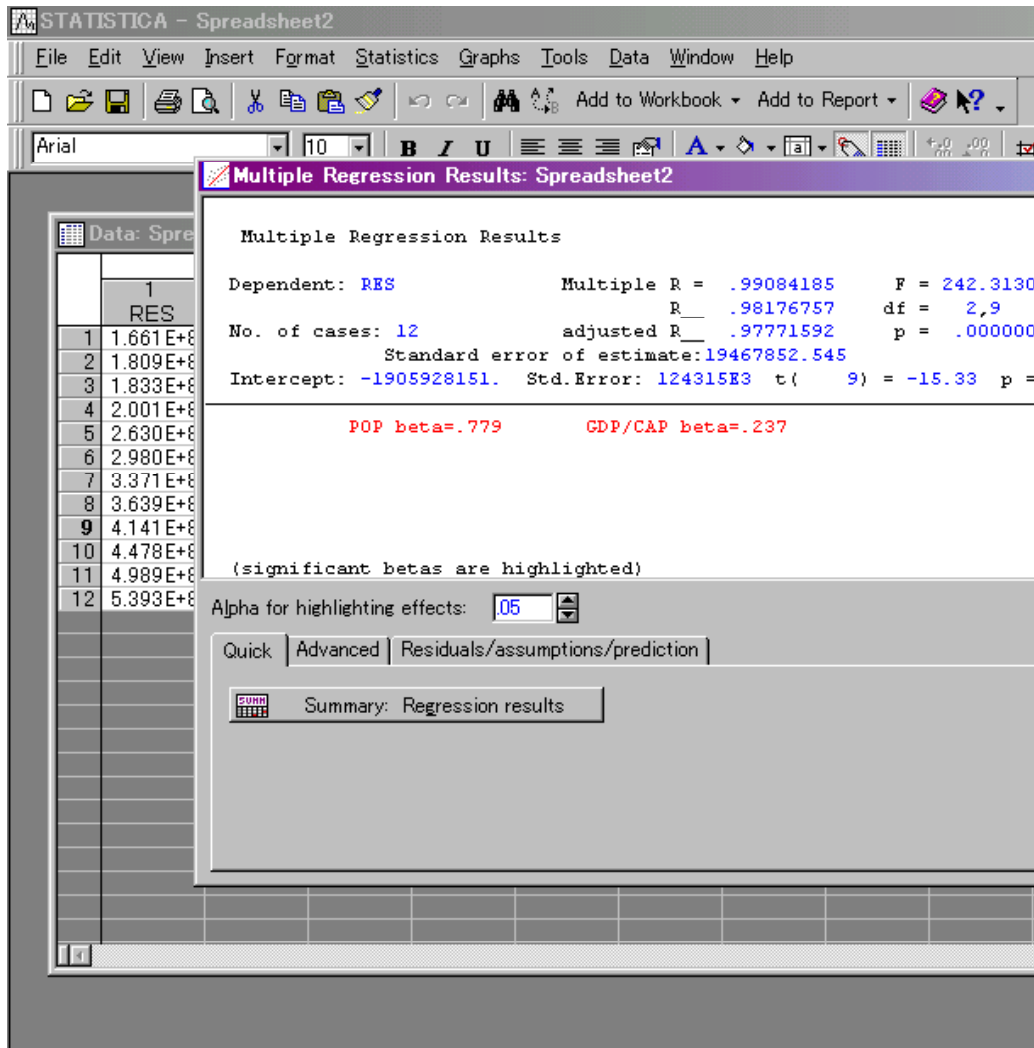


Fig. 8-10 Selection of variables

#### STEP5 :Run regression

- 1) Click the “Run” button on the “Multiple regression Spread sheet2” menu.
- 2) Then STATISTICA opens the “Multiple regression results: Spreadsheet1” shown below.



**Fig. 8-11 “Multiple Regression Results: Spreadsheet1”**

**STEP 6: Open “Summary” and select the coefficient of the regressed formula**

- 1) Push the “Summary: Regression results” button on the “Multiple regression results: Spreadsheet1” to open the “Regression Summary.”
- 2) Select the coefficient from the spreadsheet below.

$$\text{RES (residential consumption)} = a * \text{POP (Population)} + b * \text{GDP/Cap (GDP/Capita)} + c$$

a: Column “B” and row “POP” = 4.857272 E+2

b: Column “B” and “GDP/Cap” = 5.3182866E+10

c: Column “B” and “Intercept” = -1.905928 E+8

In this case,  $R=0.997402$  and  $R^2=.98176757$ . This means that this regression model will experience the dependent variable “Luzon population” by the independent variables “Year.”

STATISTICA - Workbook2\* - [Regression Summary for Dependent Variable: RES (Spreadsheet2)]

File Edit View Insert Format Statistics Graphs Tools Data Workbook Window Help

Regression Summary for Dependent Variable: RES (Spreadsheet2)  
 $R = .99084185$   $R^2 = .98176757$  Adjusted  $R^2 = .97771592$   
 $F(2,9) = 242.31$   $p < .00000$  Std. Error of estimate: 1947E4

	Beta	Std.Err. of Beta	B	Std.Err. of B	t(9)	p-level
N=12						
<b>Intercept</b>			-1.905928E+09	1.243150E+08	-15.3314	0.00000
POP	0.778595	0.089568	4.857272E+02	5.587705E+01	8.6928	0.00000
GDP/CAP	0.237174	0.089568	5.318286E+10	2.008434E+10	2.6480	0.02650

Fig. 8-12 “Regression Summary for Dependent Variables” spreadsheet



**Manual**  
**for**  
**the Power Development Plan**  
**Preparation**  
**(Power Supply Plan)**

## Section 3 Power Supply Plan

### 1. Outline of this Section

#### 1.1 Scope

This manual describes how to prepare the power supply plan as a part of the power development program. Here, the power development program (hereinafter referred to as the PDP) includes demand forecasting, the power supply plan and the transmission development plan.

#### 1.2 Contents

This manual consists of the following:

- Methodology of Data Collection
- Preparation of the Power Supply Plan
- Coordination with the Transmission Development Plan
- Checklist
- List of Technical Documents

#### 1.3 Simulation Software

The following simulation software is used for the preparation of the power supply plan.

- WASP-IV (Ver . 4.01)
  - : To prepare the least cost power development plan
- The GTMax (Ver. 4.0)
  - : To solve the optimal siting of power sources and interconnection issues

DOE has official licenses of this software. Since the license belongs to the (power supply bureau), the license registration form is kept there.

The latest version of WASP-IV can be obtained from IAEA. IAEA may send the latest version of the WASP-IV if it is upgraded.

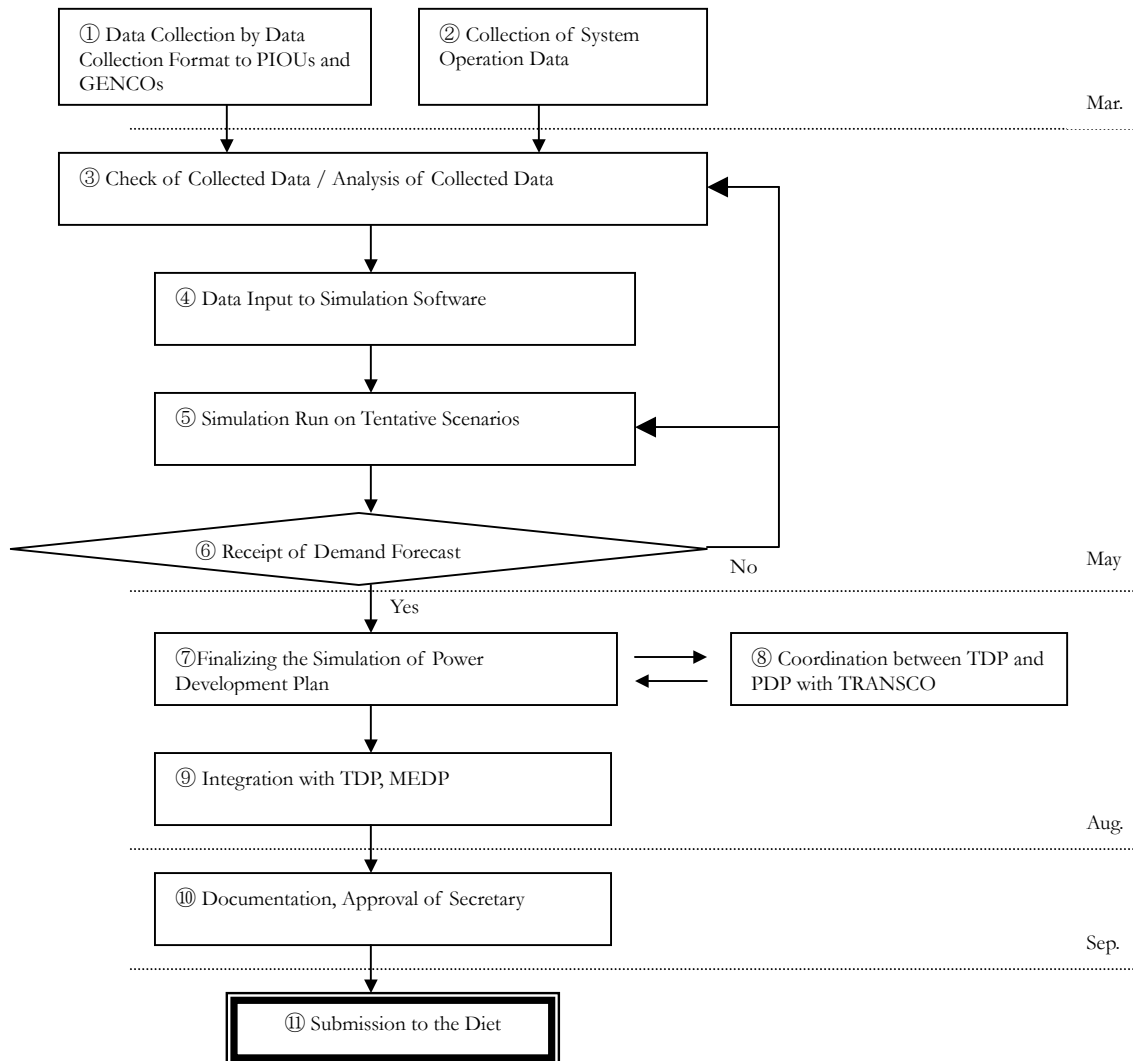
Regarding the GTMax, the DOE has a perpetual license only for the version 4.0. However the DOE also can have the latest version in the special discount. Please contact to the Adica Consulting.

Since these software have complete manuals, the handlings of the software is not described in this manual. Please refer the manuals to understand the software methodology.

## 1.4 Overall Workflow

Figure 1.1 shows the workflow diagram of PDP.

Receipt of the forecasted demand is considered a critical point in the schedule. Therefore, the data update of the simulation software should be conducted in advance, and the adjustment work with TDP should be conducted efficiently.

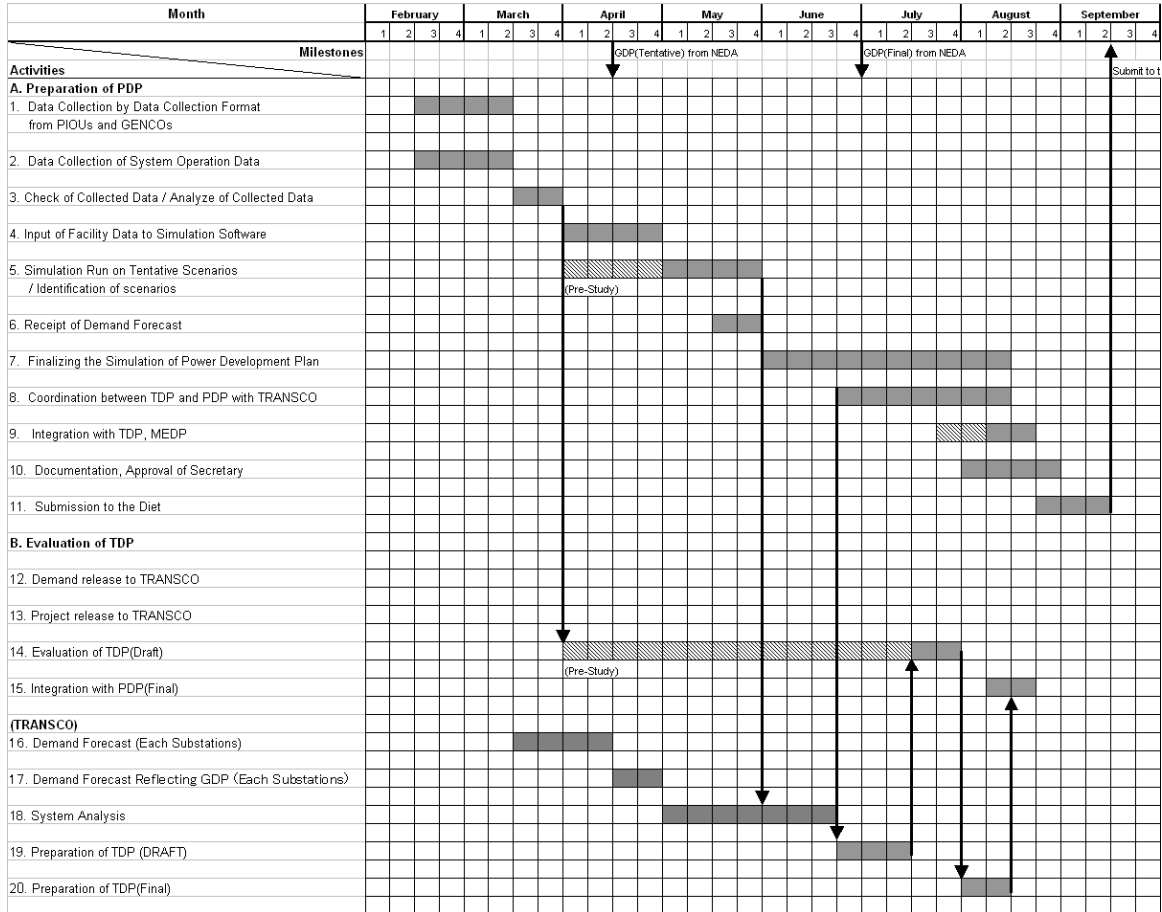


**Fig. 1.1 Workflow of PDP**



Table 1.1 shows the timetable of PDP

**Table 1.1 Overall Schedule for PDP**



The following is a brief explanation of the items to be conducted. Refer to the latter section for tips.

(1) Data Collection by Data Collection Format to PIOUs and GENCOs

Data collection from GENCOs, etc. should be conducted by using the special format.

Please refer to Chapter 2, Data Gathering.

(2) Collection of System Operation Data

Please refer to Chapter 2, Data Gathering.

(3) Checking Collected Data / Analyzing Collected Data

Before inputting the collected data, it is better to compare the collected data with the previous data. In addition, certain data should be arranged. Please refer Chapter 3, WASP-IV Tips.

(4) Data Input to Simulation Software

Data should be input to WASP-VI and the GTMax. Please see the tips on data input and operation in Chapter 3, WASP-IV Tips.

(5) Simulation Run on Tentative Scenarios

If the GDP growth forecast is delayed, the demand forecast may also be delayed. Therefore, a tentative simulation should be conducted to confirm the input data. In addition, a sensitive study should be conducted to determine policy.

(6) Receipt of Demand Forecast

Demand forecasting is not part of the power supply plan. However, the demand forecast is the most important milestone. Therefore, it is necessary to pay attention to the prospective schedule of the demand forecasting.

(7) Finalizing the power supply plan

The power supply plan is finalized based on the demand forecast. The scenarios are determined tentatively before being studied at length.

(8) Coordination between TDP and PDP with TRANSCO

Coordination work will be conducted by providing the information of indicative plants to TRANSCO. The interconnection issues will be studied at length.

(9) Integration of TDP and MEDP with PDP

Integration will be conducted with TDP and MEDP. The contents to be described in PDP should be confirmed for TDP. The equipment not connected with the national grid is described for MEDP. Simulation software is not used here.

(10) Documentation, Approval of the Secretary

Documentation of PDP will be conducted effectively at the same time as the simulation is running. Approval of the secretary is received, if necessary. The necessary information will be submitted for adjustment with PEP.

(11) Submission to the Diet

Pursuant to EPIRA, PDP will be prepared and submitted to the diet by September 15<sup>th</sup>.

## 2 Data gathering

### 2.1 Necessary Data

Table 2.1 shows the necessary data for the WASP-IV and the GTMax. Most of the data can be used as common data.

**Table 2.1 necessary data for the PDP simulation**

Data Name	Contact	Remarks
Load Shape	System Operator - Luzon - Visayas - Mindanao	Data should be collected from the system operator directly by area.
System Operation Report	System Operator	Used to confirm the results of simulation
System Maintenance Plan	System Operator	Used to confirm the results of simulation
GDP forecast	NEDA	
Discount Rate	NEDA	
Generation Data for Existing Plants	NPC PIOUs GENCOs	By using the attached questionnaire
Generation Data for Indicative Plants	Historical Data General Documents	Historical Construction Cost Technical sheet such as Gas turbine world
Fuel Cost	NPC PIOUs GENCOs	- Results of open bidding can be available for coal or oil - DOE has to preserve the confidentiality of proprietary or commercially sensitive information
Schedule of Committed Projects	Related Organizations	
Transmission Development Plan	TRANSCO	As an initial plan

## 2.2 EPIRA Regulations

The following is a description for data gathering in EPIRA. DOE can order the submission of necessary data to companies, paying attention to confidentiality, etc.

< EPIRA Regulations >

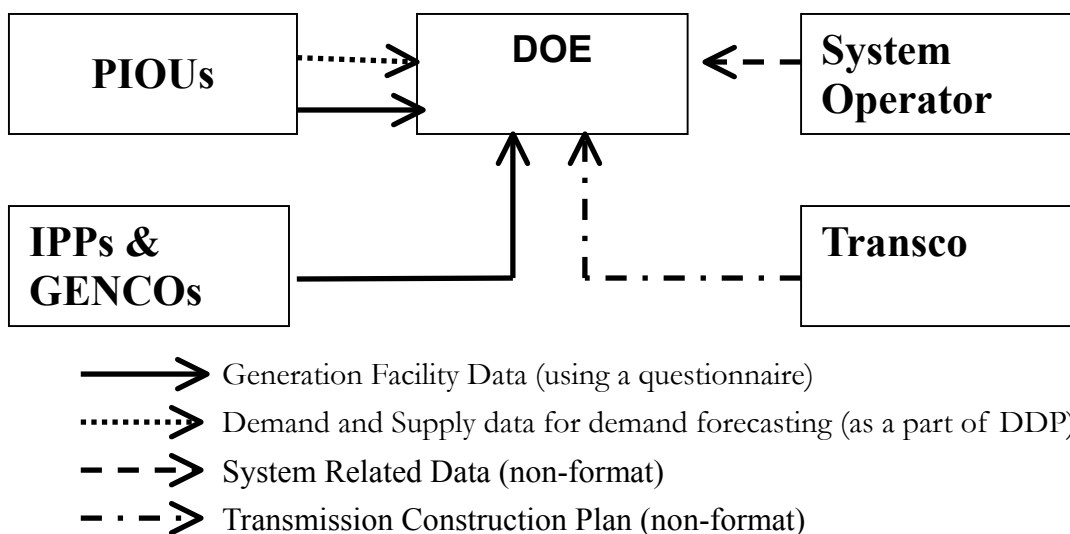
A Generation Company shall submit to DOE any information as may be required by the DOE for the preparation of the PDP, subject to appropriate measures to preserve the confidentiality of proprietary or commercially sensitive information.

## 2.3 Data Gathering

### 2.3.1 Generation facility data

The data gathering must be conducted as shown in Fig. 2.3.1.

The questionnaire attached at the end of this manual should be used for data gathering of existing facilities. Data for ongoing projects can be also collected by using the same questionnaire. Regarding the regional demand – supply plan, DDP should be used as a data-gathering tool.



**Fig. 2.3.1 Data Gathering system**

### 2.3.2 System-Related Data

System operation data is very useful for evaluating simulation results. This is released by the system operator in March. Forced outage rates and other data are given in the report. The system maintenance plan is also released in March. By using the above documents, the actual condition of the existing facility can be obtained.

Although the short-term power supply plan is different from the long-term power supply plan, the data is useful. Therefore, the short-term supply plan prepared by the system operator should also be collected.

The load shape does not need to be replaced every year. If DOE wants to replace it, it can be received from regional system operator.

### 2.3.3 Data for Indicative Plants

#### a. Construction Cost

“Gas Turbine World” is available to determine the construction cost for gas turbine and combined cycle power plants. Since the figures given in “Gas Turbine World” is not included civil work, transmission connection cost or fuel facilities, adjustment is required. The adjustment should be conducted by using historical data or using the following equation.

Total investment = Facility Cost (based on the gas turbine world) x 130%  
\*30% is for the “complementally investment” based on the experience of the JICA study team.

Historical data should be applied to determine coal-fired power plants. Historical data can be obtained from the website or from IPPs. The data may not be confidential because capital and assets are given in the annual report. Inflation should be considered. The actual inflation data can be obtained from the governmental website of the National Statistics Office in the Philippines.

#### b. Fuel Price

NPC can submit coal price and oil price. The information is not confidential because they procure their fuel by open bidding.

DOE has to collect gas price from NPC and MELALCO. Since the data is confidential, measures to preserve confidentiality should be taken.

#### c. Unit Performance Data

The questionnaire described before is used to collect performance data. Since sensitive

data as well as fuel cost is collected, necessary measures to preserve confidentiality should be taken.

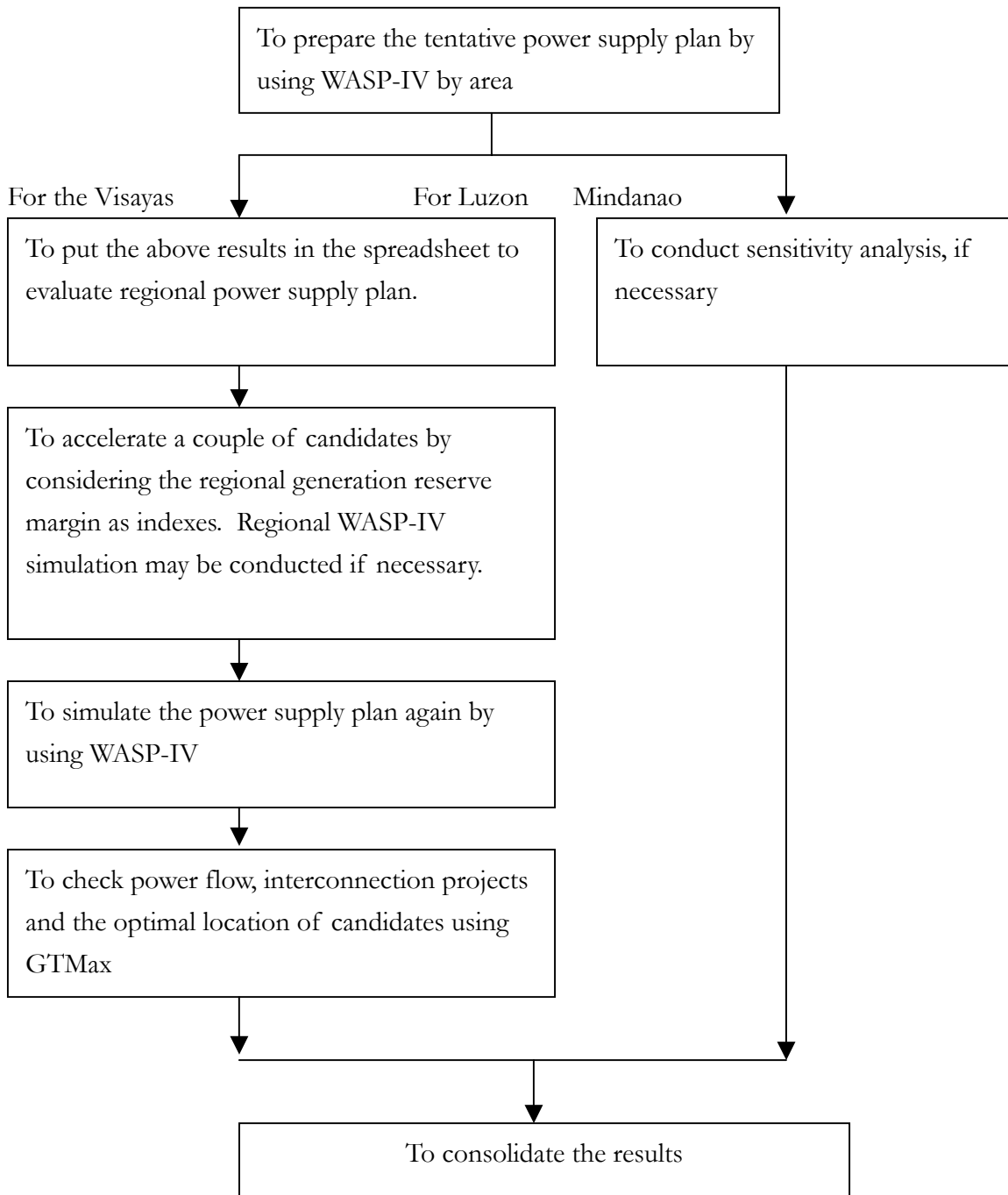
#### **2.3.4 Common Data**

The discount rate should be replaced if NEDA changes the standard. GDP is also released by NEDA in June.

### 3. Preparation of the Power Supply Plan

#### 3.1. Preparation Flow

Figure 3.1 shows the preparation workflow for simulation.



**Fig. 3.1 Workflow for Simulation**

## 3.2 WASP-IV calculation

### 3.2.1 Folder Structure of the WASP-IV

Consider Study ID and Case ID. These data are given as the following folders.

```
Study ID = 1 ----->  WASP-IV\Study_01
Case ID = 1 ----->  WASP-IV\Study_01\Case_01
Case ID = 2 ----->  WASP-IV\Study_01\Case_02
```

The information of the folders is given in the file of

```
----->  WASP-IV\system\BasicInfo.DAT
```

### 3.2.2 Data folder of WASP-IV

The WASP-IV data are so small that they can be sent by e-mail .

The following are the necessary files to be sent:

```
CCD.DAT          --- for common data
loadsy.dat       --- for loadsy module data
fixsys.dat       --- for fixsys module data
VARSYS.dat      --- for varsys module data
congen.dat       --- for congen module data
mersim.DAT      --- for mersim module data
mergeibin.dat   --- for mersim module data
DYNPRO.dat      --- for dynamic module data
remersim.SAV    --- for remersis module data
reprobat.dat     --- for reprobat module data
```

Unfortunately, the following files cannot be copied automatically when a new case is created by copying the old case. Therefore, they have to be copied manually.

```
*remersim.SAV   --- for remersis module data
*reprobat.dat    --- for reprobat module data
```



### 3.2.3 TIPS for operation

Data update of the WASP-VI should be conducted first. Most of the collected data can be used directly to the WASP-IV. Please check the manual of WASP-IV first. The following are remarks for the data input by module.

#### a. COMMON

The first problem you meet maybe caused by a change of calculation year. If you change the first year of study, all the data of first year will be deleted. As a result, there may be problems with FIXSYS, VARSYS and REPROBAT. Specifically, if you change the first year from 2003 to 2004, change the following:

##### Problem 1: Schedule of committed projects and retirement

The schedule of committed projects and retirement in FIXSYS may include some important information in the first year. For example, the constraints of transmission lines are described by deducting the number of power plants as retirement plants. This information is all deleted. In this case, check if the number of retirement units does not exceed the current number.

##### Problem 2: Mismatch of the calculation period

The calculation period or calculation year must be described separately from the common module in DYNPRO and REPROBAT.

This needs to be checked if there are problems with this module after changing the calculation period.

#### b. LOADSY

Forecasted demand should be input in LOADSY. Since calculation is conducted for 15 years, some data should be arranged. (The calculation period may need to be extended.)

A coincident peak should be prepared for VISAYAS demand. Of course, it is possible to use the non-coincident peak when the regional, island power development plan is calculated. In this case, pay attention to the energy. When you use the non-coincident peak for the simulation, calculated energy becomes greater than the necessary energy.

After running the LOADSY, it is necessary to at least check the load factor.

#### c. FIXSYS

Almost all collected data can be input to the WASP-IV directly except for incremental heat

rate. This is calculated by the following equation.

$$\begin{aligned} \text{Incremental Heat Rate} \\ = & \quad [ (\text{Maximum Output}) \times (\text{Heat Rate at Maximum Output}) \\ & \quad - (\text{Minimum Output}) \times (\text{Heat Rate at Minimum Output}) ] \\ & \quad / (\text{Maximum Output} - \text{Minimum Output}) \end{aligned}$$

If the minimum output data are not available, you can assume it to be 40% of the maximum output. Since WASP-IV calculates the optimal operation in the duration method, data at minimum output does not greatly affect the results. However, it is necessary to pay attention to the data at maximum output. Shutdown and startup loss should be included in the heat rate. The simplest way to consider the above is to use the actual heat rate as the heat rate at maximum output.

It is necessary to pay attention to periods when you input the data. Since the WASP-IV has a Fortran-based future, almost all data should be input with a “period.” In some cases, WASP-IV makes an error in the data read if you forget the “period.” as follows.

Example: “300” means “0.300”; it is necessary to input it as “300.” with a period

However, forced “outage rate” and “maintenance day” should be input in integers.

#### d. VARSYS

The same as with FIXSYS, almost all collected data can be input to WASP-IV directly. If the design data is not available, the data of the latest unit should be applied.

Before inputting the data, drawing to the screening curve is strongly recommended. Please see the WASP-IV manual.

#### e. CONGEN

It is necessary to determine the initial configuration. The easiest way to determine the initial configuration is to solve the fix expansion plan first. After solving this, you can move to the optimal expansion plan. Once you move to the optimal expansion plan, you cannot go back to the fix expansion plan. You may be in trouble that all tunnel width data is deleted and it is necessary to initialize the configuration again.

It is also necessary to consider the maximum number of configurations. Many configuration courses take a lot of calculation time. The maximum number of

configurations is 500 for a year and 5000 in total.

### **Special Remarks / Tips**

There may sometimes be problems with index errors. The following are considered to be the reasons:

#### Reason 1.

A mismatch of data among LOADSY, FIXSYS, VARSYS and temporary files stored.

(Solution)

Clear the old simulation file by using the common module. Then simulate LOADS, FIXSYS and VARSYS again.

#### Reason 2.

A data mismatch of temporary files between CONGEN and DYMPRO. Some data, such as the previous best solution, is sent from DYMPRO to CONGEN as the index. Therefore, DYMPRO should be completed before opening the CONGEN except for initial run. If the MERSIM is complete and DYMPRO results in fault, you cannot open the CONGEN again.

(Solution)

Most of these cases are caused by configuration in CONGEN. It may occur in the configuration that the generation reserve is OK but LOLP is not satisfied. Therefore, change (delete) the LOLP index in DYNPRO and run DYNPRO again. After this, you can open CONGEN.

#### f. MERSYM

You can simulate using MERSYM easily. The point of MERSYM is to evaluate the simulation results. Initially, it is necessary to check the loading order of the power sources. You can check the operation situation of every year in the output files. Some temporary files are arranged and integrated at the running of REPROBAT. Therefore, in order to check the capacity factor of each power source, REPROBAT should be completed.

The WASP-IV uses old simulation files to save calculation time for the MERSYM. Therefore, if you change some data in LOADY, FIXSYS or VARSYS, it is necessary to clear the old simulation files. Otherwise, you will obtain have wrong solution.

Clearing the old simulation files and a confirmation run is strongly recommended at the end of optimization as well.

g. DYNPRO

It is necessary to complete DYNPRO. If an error occurs in DYMPRO, the CONGEN file cannot be opened. Most of these cases are caused in the LOLP criteria. You may complete DYNPRO by deleting the LOLP criteria.

In addition, after the completion of REPROBAT, you cannot go back to DYNPRO directly. It is necessary to go back to CONGEN again for further simulation.

h. REMERSIM

This is a module only to calculate the amount of fuel. This module is not affected to the results of optimization.

The data file is independent of FIXSYS and VARSYS. Therefore, it is necessary to check the data of REMERSIM again when you replace the data in one of these modules.

The data file of REMERSYM is not copied automatically. Therefore, it is necessary to copy the “REMERSIM .sav” manually to the expected data folder.

i. REPROBAT

You can use this module easily. However, running REPROBAT affects the temporally files of DYMPRO and MERSIM. Specifically:

- Before checking the capacity factor in the report of MERSYM, complete REPROBAT.
  
- After running REPROBAT, go back to CONGEN, even when you need to replace the LOLP criteria.

The data file of REPROBAT is not copied automatically. Therefore, it is necessary to copy the “REPROBAT.dat” manually to the expected data folder.

## Special Remarks / Tips

As WASP-IV uses the WordPad as the viewer, you can easily transfer data from REPROBAT to EXCEL

The steps are:

- (1) To cut out the necessary data
- (2) To rename and save the data as “#####.txt”
- (3) To start the Excel, open the “#####.txt” with Fixed Width
- (4) To adjust the width and open it

### 3.2.4 Tips for Sensitivity Analysis

#### (1) Take or Pay Contract

WASP-IV can treat the loading order of the power plant directory. However, inputting the loading order is too messy. It is necessary to indicate the loading order twice for a power plant because the loading order of minimum capacity operation and intermediate – maximum loading order are treated separately in the WASP-IV. Moreover, it is necessary to allocate the loading order for all plants. This means that the economic loading order should be scrutinized before using the loading order module.

To lessen the above work, to “fake” input is effective.

Example:

- If you allocate the take or pay contract to a natural gas power plant, you can input 10% of the fuel cost instead of 100% of the fuel cost. The loading order of gas-fired power plants is changed automatically. The optimal power development can be calculated in this manner.
- If you calculate the total investment of the system, it is necessary to adjust the operation cost of gas-fired power plants. Multiply 10 times the operation cost of these power plants. You can confirm it in the MERSIM module.
- Of course, you can confirm the cost by putting in the loading order.

## (2) How to consider transmission constraints in the WASP-IV

WASP-IV cannot treat multiple areas and interconnection issues. However, if you know the constraints of the transmission line, you can treat the constraints by using “fake” input in the same way as the take or pay contract.

Example:

- If you know the impact of the transmission lines like “only 500 MW of 1000 MW can be dispatched at some power plants,” you can reflect the current situation by changing the capacity itself to 500 MW.
- You can change the installed capacity; however, it is necessary to prepare two power plants to describe this, and it is too messy. Therefore, the simplest way to describe this is to reduce the unit number by using the retirement schedule. You can change the total capacity of plants very easily.

## (3) Group limit

You can use the group limit module. However, if you use this module, the calculation time will be too long. (Of course, it depends on the input data)

If you want to calculate constraint development such as energy constraints or environmental emission constraints, it is necessary to use this module. However, if you want to calculate the amount of emission, it is better to calculate by hand.

## (4) Fuel Cost Impact

You can calculate fuel cost impact by using the fuel cost escalation module in DYNPRO. However, the loading order still remains at the current price. Therefore, it is better to change the cost directly in FIXSYS or in VARSYS if the change is dramatic.

## (5) Data input for the PDP (2004-2013)

For the PDP (2004 - 2013), the following input is applied for the study:

- Take or Pay contract by using the fuel cost reduction tips for Santa Rita, Ran Lorenzo and Ilijan. Gas price is set at 10%.
- Constraints of the transmission line between Batangas to Manila by deducting the number of units in Batangas.

### 3.3 Preparation of the Regional Supply Plan

#### 3.3.1 Basic Approach for Preparation of the Regional Supply Plan

Since WASP-IV cannot treat multiple areas, a regional supply plan has to be prepared step by step. In this report, the development plan for the VISAYAS is prepared as an example. The basic approach is as follows:

(1) Preparation of the Total Development Plan for Areas by using WASP-IV.

You can prepare the power development plan for an area considering the regions as a system. In this case, the power development plan for the total VISAYAS is prepared. The results are shown in Table 3.3.1.

**Table 3.3.1 Initial run of the WASP-IV for VISAYAS**

<b>Total VISAYAS</b>									
	Demand	Ex.Cpa	Install				I.C.	Total	G.R.M
			DS	GT05	CL05	acc			
<b>2003</b>	1,006	1,470				0	0	1,470	46.1%
<b>2004</b>	1,085	1,567				0	0	1,567	44.4%
<b>2005</b>	1,172	1,602				0	0	1,602	36.7%
<b>2006</b>	1,269	1,602				0	0	1,602	26.3%
<b>2007</b>	1,363	1,576	50	100		150	0	1,726	26.6%
<b>2008</b>	1,469	1,576				150	0	1,726	17.5%
<b>2009</b>	1,582	1,576		100		250	0	1,826	15.4%
<b>2010</b>	1,702	1,576		150		400	0	1,976	16.1%
<b>2011</b>	1,827	1,485	50	150		600	0	2,085	14.1%
<b>2012</b>	1,959	1,485	150			750	0	2,235	14.1%
<b>2013</b>	2,097	1,485	50	50	50	900	0	2,385	13.7%

(2) Distribution of Candidates

Based on Table 3.3.1, distribute the indicative plants to islands by using the special table as shown in Table 3.3.2. The interconnection constraints between islands are considered in this table.

By using this spreadsheet , you can see that the regional power supply is not sufficient in Panay and Negros.

**Table 3.3.2 Initial Distribution of Candidates to Islands**

2003/10/17 15

	Leyte-Samar Grid									Bohol									Cebu Grid											
	Demand	Ex.Cpa	Install	Acc	I.C. Out	Total	G.R.M	TL	Demand	Ex.Cpa	Install				I.C.	Total	G.R.M	TL	Demand	Ex.Cpa	Install				I.C. in	I.C. out	Total	G.R.M	TL	
											DS	GT05	CL05	acc							DS	GT05	CL05	acc						
2003	182	695		0	-163	532	192.4%	440	41	49				0	2	52	25.0%	35	406	427.5				0	160	-80	508	25.0%	200	
2004	200	695		0	-207	487	143.9%	440	46	49				0	8	57	25.0%	35	438	427.5				0	199	-80	547	25.0%	200	
2005	220	695		0	-284	410	87.0%	440	51	6				0	57	64	25.0%	100	472	427.5				0	227	-64	590	25.0%	400	
2006	242	695		0	-277	418	72.8%	440	56	6				0	64	71	25.0%	100	510	427.5				0	213	-3	637	25.0%	400	
2007	264	695		0	-343	352	33.1%	440	62	6				0	72	78	25.0%	100	547	427.5				0	271	-15	684	25.0%	400	
2008	289	695		0	-355	340	17.4%	440	69	6				0	75	81	17.5%	100	588	427.5				0	280	-17	691	17.5%	400	
2009	317	695		0	-329	365	15.3%	440	76	6				0	81	87	15.4%	100	633	427.5		100		100	248	-46	730	15.4%	400	
2010	346	695		0	-293	402	16.0%	440	83	6		50		50	41	97	16.1%	100	679	427.5		50		150	252	-41	789	16.1%	400	
2011	378	695		0	-264	431	14.1%	440	92	6				50	48	105	14.1%	100	728	336.7		0	150		300	215	-21	831	14.1%	400
2012	411	695		0	-225	469	14.1%	440	100	6				50	58	115	14.1%	100	779	336.7		50			350	167	35	889	14.1%	400
2013	447	695		0	-186	508	13.7%	440	110	6				50	69	125	13.7%	100	833	336.7		50			400	117	93	947	13.7%	400

	Negros									Panay									Total VISAYAS											
	Demand	Ex.Cap	Install Cap.				I.C.		Total	G.R.M	TL	Demand	Ex.Cap	Install Cap.				I.C.	Total	G.R.M	TL	Demand	Ex.Cpa	Install				I.C.	Total	G.R.M
			DS	GT05	CL05	Acc	in	out						DS	GT05	CL05	Acc							DS	GT05	CL05	acc			
2003	194	166				0	80	-80	166	-14.6%	80	182	132.6				0	80	213	16.5%	80	1,006	1,470				0	0	1,470	46.1%
2004	205	166				0	80	-15	230	12.2%	80	196	230.5				0	15	246	25.0%	80	1,085	1,567				0	0	1,567	44.4%
2005	218	243				0	64	-34	273	25.0%	80	212	230.5				0	34	265	25.0%	80	1,172	1,602				0	0	1,602	36.7%
2006	232	243		50		50	3	-6	290	25.0%	160	229	230.5		50		50	6	286	25.0%	160	1,269	1,602		100		100	1,702	34.2%	
2007	244	243				50	15	-2	306	25.0%	160	246	204.8	50			100	2	307	25.0%	160	1,363	1,576	50			150	0	1,726	26.6%
2008	258	243				50	17	-6	304	17.5%	160	264	204.8				100	6	311	17.5%	160	1,469	1,576				150	0	1,726	17.5%
2009	273	243				50	46	-23	315	15.4%	160	284	204.8				100	23	328	15.4%	160	1,582	1,576		100		250	0	1,826	15.4%
2010	288	243				50	41	0	334	16.1%	160	305	204.8		50		150	0	354	16.1%	160	1,702	1,576		150		400	0	1,976	16.1%
2011	303	243				50	21	32	346	14.1%	160	327	204.8	50			200	-32	373	14.1%	160	1,827	1,485	50	150		600	0	2,085	14.1%
2012	318	243	50			100	-35	55	363	14.1%	160	350	204.8	50			250	-55	399	14.1%	160	1,959	1,485	150			750	0	2,235	14.1%
2013	333	243	50			150	-93	79	379	13.7%	160	374	204.8		50		300	-79	426	13.7%	160	2,097	1,485	50	50	50	900	0	2,385	13.7%

Here DS: Diesel (50MW)  
 GT05: Gas Turbine (50MW/Oil)  
 CL05: Coal (50MW)



Here, the generation reserve margin is calculated by the following equation.

$$\begin{aligned}
 \text{- Supply Capacity (MW)} &= (\text{Existing Capacity} + \text{Additional Capacity}) \\
 &\quad + (\text{Interchange IN} - \text{Interchange Out}) \\
 \text{- Generation Reserve Margin} &= \frac{\text{Supply Capacity} - \text{Peak Demand}}{\text{Peak Demand}} \\
 \text{(}\% \text{)} &
 \end{aligned}$$

It is necessary to distribute all power plants to the areas by considering the generation reserve margin as an index. It is not necessary to be too sensitive since the optimal location of plants is finally determined by GTMax.

### (3) Acceleration of candidates

To meet regional supply and balance, a couple of power plants should be accelerated. In this case, 100 MW of gas turbine is accelerated until 2003, and 50 MW of diesel is accelerated until 2006. To calculate the necessary capacity addition (acceleration) that satisfies LOLP = 1 day /year, use WASP-IV. To determine the island's capacity addition, adapting the non-coincident peak is recommended.

In this case, the necessary capacity addition that satisfies LOLP = 1 day /year in Panay and Negros is as follows:

	Panay	Negros
2006	50 MW	50 MW
2008	50 MW	

Table 3.3.3 shows the revised power development plan reflecting the islands' capacity addition. You can determine the necessary capacity addition for all of the Visayas except for the optimal location / siting.

### (4) Confirmation Run of WASP-IV

You can calculate the optimal power development plan in the above condition by treating accelerated capacity as fixed development. For this purpose, you should only put the necessary configuration in CONGEN, then calculate again.

**Table 3.3.3 Power Development Plan (Second Draft)**

	Leyte-Samar Grid								Bohol								Cebu Grid													
	Demand	Ex.Cpa	Install	Acc	I.C. Out	Total	G.R.M	TL	Demand	Ex.Cpa	Install				I.C.	Total	G.R.M	TL	Demand	Ex.Cpa	Install				I.C.		Total	G.R.M	TL	
											DS	GT05	CL05	acc							DS	GT05	CL05	acc	in	out				
2003	182	695		0	-155	540	196.7%	440	41	49				0	2	52	25.0%	35	406	427.5				0	153	-72	508	25.0%	200	
2004	200	695		0	-134	561	180.8%	440	46	49				0	8	57	25.0%	35	438	427.5				0	126	-6	547	25.0%	200	
2005	220	695		0	-184	510	132.5%	440	51	6				0	57	64	25.0%	100	472	427.5				0	127	36	590	25.0%	400	
2006	242	695		0	-227	468	93.5%	440	56	6				0	64	71	25.0%	100	510	427.5				0	163	47	637	25.0%	400	
2007	264	695		0	-343	352	33.1%	440	62	6				0	72	78	25.0%	100	547	427.5				0	271	-15	684	25.0%	400	
2008	289	695		0	-355	340	17.4%	440	69	6				0	75	81	17.5%	100	588	427.5				0	280	-17	691	17.5%	400	
2009	317	695		0	-329	365	15.3%	440	76	6				0	81	87	15.4%	100	633	427.5			100		100	248	-46	730	15.4%	400
2010	346	695		0	-293	402	16.0%	440	83	6			50		41	97	16.1%	100	679	427.5			50		150	252	-41	789	16.1%	400
2011	378	695		0	-264	431	14.1%	440	92	6				50	48	105	14.1%	100	728	336.7	0		150		300	215	-21	831	14.1%	400
2012	411	695		0	-225	469	14.1%	440	100	6				50	58	115	14.1%	100	779	336.7	50				350	167	35	889	14.1%	400
2013	447	695		0	-186	508	13.7%	440	110	6				50	69	125	13.7%	100	833	336.7			50		400	117	93	947	13.7%	400

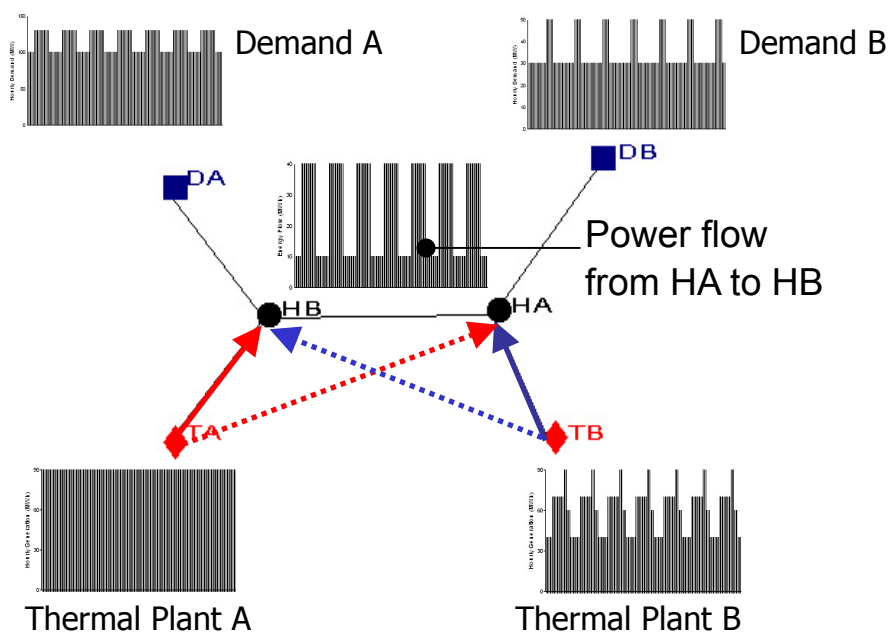
	Negros								Panay								Total VISAYAS																
	Demand	Ex.Cap	Install Cap.				I.C.		Total	G.R.M	TL	Demand	Ex.Cap	Install Cap.				I.C.	Total	G.R.M	TL	Demand	Ex.Cpa	Install				I.C.	Total	G.R.M			
			DS	GT05	CL05	Acc	in	out						DS	GT05	CL05	Acc							DS	GT05	CL05	acc						
2003	194	166			50		50	72	-45	242	25.0%	80	182	132.6		50		50	45	228	25.0%	80	1,006	1,470		100		100	0	1,570	56.1%		
2004	205	166					50	6	35	257	25.0%	80	196	230.5				50	-35	246	25.0%	80	1,085	1,567				100	0	1,667	53.6%		
2005	218	243					50	-36	16	273	25.0%	80	212	230.5				50	-16	265	25.0%	80	1,172	1,602				100	0	1,702	45.2%		
2006	232	243					50	-47	44	290	25.0%	160	229	230.5	50			100	-44	286	25.0%	160	1,269	1,602	50			150	0	1,752	38.1%		
2007	244	243					50	15	-2	306	25.0%	160	246	204.8				100	2	307	25.0%	160	1,363	1,576				150	0	1,726	26.6%		
2008	258	243					50	17	-6	304	17.5%	160	264	204.8				100	6	311	17.5%	160	1,469	1,576				150	0	1,726	17.5%		
2009	273	243					50	46	-23	315	15.4%	160	284	204.8				100	23	328	15.4%	160	1,582	1,576		100		250	0	1,826	15.4%		
2010	288	243					50	41	0	334	16.1%	160	305	204.8			50		150	0	354	16.1%	160	1,702	1,576		150		400	0	1,976	16.1%	
2011	303	243					50	21	32	346	14.1%	160	327	204.8	50				200	-32	373	14.1%	160	1,827	1,485	50	150		600	0	2,085	14.1%	
2012	318	243					100	-35	55	363	14.1%	160	350	204.8	50				250	-55	399	14.1%	160	1,959	1,485	150			750	0	2,235	14.1%	
2013	333	243					150	-93	79	379	13.7%	160	374	204.8				50		300	-79	426	13.7%	160	2,097	1,485	50	50	50	900	0	2,385	13.7%

Here DS: Diesel (50MW)  
 GT05: Gas Turbine (50MW/Oil)  
 CL05: Coal (50MW)

### 3.4 Optimal Location / Interconnection Issues

#### 3.4.1 outline of GTMax

GTMax is used to determine the optimal location and for interconnection analysis. The least cost dispatch for regional demand is determined by linear programming. The interconnection power flow is calculated automatically in this process. As the total system operating cost can be calculated, the optimal location of indicative power plants can be determined by switching the connected point to the system (in particular, by comparing the operation cost of both “real line connection” and “break line connection” in Fig. 3.4.1)



**Fig. 3.4.1 Outline of the GTMax**

#### 3.4.2 Determining the Optimal Location

As mentioned in Section 3.3, the optimal location can be determined by the GTMax by comparing the object functions. Location in Table 3.3.3 is only the initial location. You can determine the optimal location to be the case that achieves the minimum object function.

To optimize the location smoothly, it is necessary to understand the condition that realizes the minimum object function. It is necessary to pay attention to the interconnection power flow because the interconnection power flow may not be constrained in the optimized location. Therefore, place the location of the candidate in another area to alleviate the congestion of the interconnection power flow. It is better to determine the location of the

base power plant first. The location of peak power plants will not be affected by the objective function. In this case, location should be determined only using the regional generation reserve margin.

### 3.4.3 GTMax data preparation

Almost all data for the GTMax can be diverted from the data of WASP-IV. However, the following data should be collected additionally only for the GTMax, which calculates the supply plan of a typical week:

- 1) Chronological load curve for each area
- 2) Capacity of interconnection between areas
- 3) Actual operation data for hydro power plants

It is desirable to collect the actual data accurately. However, the GTMax can simulate the system operation with some assumptions even if you cannot collect all data. (The validity of simulation result should be verified deliberately in this case.)

#### 1) Chronological load curve

The GTMax requires hourly demand data (8760 hours / year) for each year by area. However, the future demand is forecasted only on the peak demand (kW) and on the production (GWh). Therefore, the future load shape should be prepared by using the historical load shape in the following manner:

$$PL(t) = PL0(t) * (Pmax(y) / Pmax0) * k(t)$$

t: time (1-8760)

y: year

PL(t): hourly demand in future

PL0(t): actual hourly data (data of 1996 is used in this study)

Pmax(y): future peak demand of the year (from demand forecast)

Pmax0: actual peak demand (data of 1996 is used in this study)

k(t): compensation value of energy (adjust total energy for the year)

Compensation Value k is calculated as follows:

$$k(t) = 1 - u(t) * \alpha$$

Where,  $u(t)$  is the rank of the demand(t) in a year, for example,  $u(t) = 1$  for the maximum peak demand in a year and  $u(t) = 8760$  for the minimum demand in a year: Alpha is used for adjusting the total of hourly demand to the forecasted production in a year. Alpha can be calculated by using the attached excel worksheet.

## 2) Hydro

Hydro plants operation data are prepared by each hydro plant.

-

As the GTMax simulates the weekly operation, data of dependable capacity and available production in a week should be input. Monthly data can be applied by breaking down into weekly energy. To remove the affects of rainfall by year, it is desirable to apply an average data in a couple of years.

If dependable capacities data are not available, it is necessary to assume them from the monthly energy and the capacity factor. 80% in load factor is usually picked up as a typical condition. If the actual capacity factor is greater than 80% in capacity factor, the install capacity can be use as the dependable capacity. If the actual capacity factor is smaller than 80%, the dependable capacity is set at the capacity calculated from the actual generation by assuming the capacity factor at 80% as follows:

Calculated dependable capacity

$$= \text{Monthly energy} / (\text{Hours of the month} * 80\%)$$

(80% is an assumption value)

Note: 80% is good assumption for the run-of-river-type hydros. However, it cannot be applied to the reservoir type hydro because of peaking operation. Therefore the data should be collected with all efforts in order to determine the realistic data.

### 3) Thermal

#### a) Forced Outage Rate

Average maintenance days cannot be treated in the GTMax although it can be treated in the WASP-IV. . For the long-term simulation by the GTMax, maintenance day should be converted to the maintenance outage rate. The total of maintenance and forced outage rate should be deducted as “outage rate”. Specifically, the dependable capacity is set lower than the capacity used in WASP-IV considering the outage.

Example: F.O.R. = 5%, Maintenance outage = 36 days / year

- Total Outage Rate =  $5\% + 36\text{days}/365\text{days} = 15\%$

- Dependable capacity input in the GTMax

= 85% of the dependable capacity( of WAASP-IV.)

Therefore, the total of generation capacity is different from the installed capacity.

#### b) Thermal Cluster

In GTMax, the number of nodes (thermal, hydro, firm purchase, etc.) affects the memory and calculation time requirements. Therefore it is better to reduce the number of thermal nodes by using the thermal cluster. . However, there are certain limitations when using a thermal cluster as follows:

-Although the number of thermal units is *not* limited, the price function is limited at most nine.

- Therefore, it is necessary to create the thermal cluster by at most nine units in order to express the operation of each unit accurately.

- In addition, the GTMax cannot clarify the operation of unit consisting the thermal cluster. Therefore, the units require the sensitivity study should not be treated as a part of thermal cluster.

#### c) Minimum generation

Since the GTMax cannot treat stop operation, or not in service, the minimum generation capacities input in the GTMax are not the same as the actual.

Although the minimum generation capacities of base – or middle type units are set at the same value to actual, however, that of peaking units should be set at zero. (To set the minimum generation capacity means to guarantee the must-run of tease unit.) Therefore, the simulated capacity factors should be examined deliberately. If the result differs from the

actual greatly even in the middle load unit, the capacity should be change at the reasonable capacities.

d) Variable cost function

In this study, variable cost function is calculated from WASP-IV's minimum and incremental heat rate and fuel cost as follows:

Base type units: at minimum capacity block

$$\text{Costmin} = \text{HRmin} * \text{FuelCost}$$

$$\text{CostMax} = \text{HRmax} * \text{FuelCost}$$

$$\text{Where, HRmax} = \text{HRmin} + \text{HRinc}(\text{Pmax} - \text{Pmin})$$

4) Which week should be chosen for the simulation?

The GTMax can simulate every week of the year (52week/year) although it takes a very long time. Therefore, a typical week of the year should be chosen for the simulation.

The necessary conditions for a typical week are:

- a) It should include the largest demand in critical areas or islands.
- b) Other islands' or areas' peak demands are also should be relatively great. (Between the 3rd and the 5th greatest is desirable.)

The 45th week is chosen as the typical week in this study, because the Panay's, Negros' and Cebu's peak demands are close to the peak of the year.

5) Firm purchase

The GTMax cannot treat the must-run unit directly. Therefore, IPPs that have Take-or Pay contracts should be represented as firm purchases. Necessary maximum – and minimum-transaction is set as the contract. Geothermal plants are treated as firm purchases because each of these plants have a target capacity factor. Forced and maintenance outage should be represented by deducting the average outage capacity from the maximum capacity. The minimum capacity is set at zero or its own minimum capacity.

6) General issues

Hourly, daily and weekly generation or purchase should have a consistency. For example, the maximum weekly generation should be greater than the minimum daily generation \* 7(days/week), or the minimum hourly generation \* 168 (hours/week). Since the GTMax checks the mismatch or consistency of data, the calculation does not complete with the mismatched data.

7) Which transmission line should be modeled in the GTMax?

Although the GTMax can model all transmission lines, it takes a very long time to simulate it. In addition, all data should be input accurately if the loop connection is included. It is too messy to prepare the long-term planning. Therefore, the simple transmission model that satisfies enough accuracy should be prepared as follows:

a) Interconnection between areas. The definition of 'area' is that it has its own load curve and load forecast, and its own power development plan.

b) Transmission lines that affect with the results of GTMax in an area: for example, transmission lines between huge power plants and substations. Pay attention to the limitation of power flow. If the transmission line capacity is too small against the both sides demand, the area should be divided into two areas.

8) Checkpoints of the results

After completing the data input on demand, thermal, hydro, firm purchase, etc, simulate the system operation. Be careful on the run note's message and status. If you find any error message, go back to the data edit to correct any errors. In order to simulate the realistic operation, the result should be verified deliberately from the following viewpoints:

a) Check the market value of substations. There should be *no* substation of which market value exceeds \$9999. Since it represents a power deficit (black out) at the substation, check the transmission line's capacity, the hourly thermal output, or the hourly output of thermal cluster. If the error cannot be remove by replacing the above values, check the system demand and supply capacity. If these figures are appropriate, the result is correct, that is power deficit will occur. Therefore the result of WASP-IV and / or transmission development plan should be reviewed.

b) Check the hourly generation of thermal, hydro, firm purchase. If hourly output change is too great or is fluctuating, the hourly **rump rate** should be checked. The hourly or daily minimum output of the thermal cluster should be checked also. It may be due to fluctuation in the load curve.

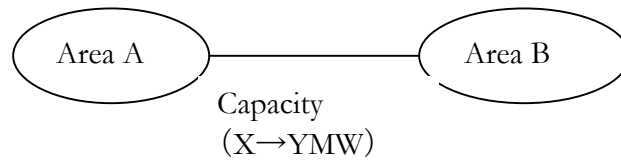
c) Check the hourly power flow of the transmission line with its capacity limit. If the power flow is not the same as anticipated, the hourly load, hourly generation of thermal, thermal



cluster and hydro should be checked again.

### 3.4.5 Interconnection Issues

Figure 3.4.2 shows the methodology of the study. The GTMax is used as the simulation software.



**Fig. 3.4.2 Methodology of the study**

The following is the study flow:

- 1) To calculate the supply cost for Area A and Area B considering interconnection constraints (Cost 1 for Transmission Capacity X)
- 2) To calculate the supply cost for the same area considering transmission reinforcement (Cost 2 for Transmission Capacity Y)
- 3) Cost 1 minus Cost 2 equals the merit of transmission line reinforcement.
- 4) To calculate the Net Present Value by considering investment cost

## 4. Checklist

Table 4.1 shows the checkpoint at milestones for preparing PDP. The items to be completed with the preparation of PDP, and the contact addresses of related organizations are given. It can be used as the checklist based on the workflow.

**Table 4.1 Checklist for preparing PDP**

No.	Items to do	Deadline	Contact
1.	Were DDPs submitted as scheduled?	Mar. 15	PIOUs NEA
2.	Were data format already distributed?	Mar. 15	PIOUs IPPs NPC
3.	Was system operation report collected?	Mar. 15 -31.	System Operator
4.	Were all data formats submitted?	Mar. 31	
5.	Check of the current operation status by collected data	Mar.31 Apr. 30	DOE
6.	Confirmation of new projects	Mar.31 Apr. 30	PIOUs IPPs NPC TRANSCO
7.	Data input in simulation software - Confirmation of simulation run	Apr. 30	DOE
8.	Confirmation of energy policy -Sensitivities analysis - Trend of recent demand	May. 31	DOE
9.	Schedule check of the demand forecast - NEDA's scenario	May.1,15	DOE
10.	Confirmation of the demand forecast	May. 31	DOE
11.	Provision of the demand forecast to the TRANSCO?	May. 31	TRANSCO
12.	Provision of the information of indicative plants to the TRANSCO - Necessary capacity addition by draft development plan - Candidates of indicative plants	May. 31	TRANSCO
13.	Confirmation run of simulation software	May. 31 - Aug.15	DOE
14.	Provision of power development plan to the TRANSCO?	3 <sup>rd</sup> week of Jun.	TRANSCO
15.	Coordination with TDP	Jun.- Jul.15	TRANSCO
16.	Evaluation of TDP	Jul.31	TRANSCO
17.	Documentation -Coordination with sub ordinate plans	Aug. 15	
18.	Public Consultation	Aug. 31	
19.	Approval of PDP by Secretary	Aug. 31	
20.	Submission to the congress	Sep.15	

## 5 Technical Documents

### 5.1 Manuals

Manuals written in Bold letter is strongly recommended to read before using the software.

#### (a) WASP-IV

##### - **Wien Automatic System Planning (WASP-IV) Package user's manual**

- The theory of optimization is described in Chapter 1.
- The limitation of WASP-IV is described in Chapter 2.
- How to use the WASP-IV is described in Chapter 3 to Chapter 11.
- The new future of WASP-IV is described in Chapter 12.
- Wien Automatic System Planning (WASP-III plus) user's manual (Vol. 1)
- Wien Automatic System Planning (WASP-III plus) user's manual (Vol. 2)
  - The calculation flow of each module is described. Although some of contents are different from Version 4, the most of contents is the same. To know the calculation flow is very helpful to understand the WASP.
- **Materials distributed in Technical Seminar (Feb. 8 to 28, 2003)**
  - The calculation theory is described briefly. Especially, explanation on MERSYM is very useful to understand the system operation analysis.

#### (b) GTMax

##### - **GTMax Users Manual (Version 4.0)**

- The basic information on GTMax is described briefly. To read with the seminar materials is recommended.
- **Materials distributed in Technical Seminar (Feb. 8 to 28, 2003)**
  - How to use the GTMax is described step-by-step.

### 5.2 Technical Report submitted by JICA

JICA submitted many technical reports. These are kept in the power bureau. Some of them are useful for understanding how to prepare the PDP. Especially the following reports are recommended to read.

- Technical Report (June 23,2003)
  - This is the first report by JICA. Basis of data used in the simulation are described. Also the initial analysis on interconnection issue are explained.

**- Technical Report (June 23,2003)**

- This is the first report by JICA. Basis of data used in the simulation are described.

Also the initial analysis on interconnection issues is explained.

- Technical Report (July 9,2003)

- Screening curve is explained.

- Technical Report on Necessity of Interconnection between Leyte -Mindanao

- How to solve the necessity of interconnection roughly by using WASP-IV is described.

**- Technical Report on Necessity of Interconnection**

- How to solve the necessity of interconnection by using GTMax is described.

**5.3 General Publication**

The following publication is recommended to read for understanding the least cost planning.

**- A Guidebook of Expansion Planning for Electrical Generation Systems**

IAEA (Technical Report Series No.241)

- How to prepare the power development plan is explained from the demand forecasting to power development plan.

**Appendix**

Appendix 1. Table of Abbreviations used in WASP-IV and the GTMax

Appendix 2. Data Collection Format



**Manual  
for  
the Power Development Plan  
Preparation  
(TDP)**

## Section 4 Transmission Development Plan

This manual for TDP evaluation and approval consists of the following:

### **1 Purpose of Evaluation**

### **2 Scope of Evaluation**

### **3 Work Flow**

### **4 Schedule**

### **5 Methodology of Evaluation**

### **6 Checklist**

## 1. Purpose of Evaluation

### 1.1 Purpose of Evaluation

Under Section 2 of the act (EPIRA), the policy of the state is to ensure the quality, reliability, security and affordability of the electric power supply. TDP evaluation by DOE ensures that the transmission plan in the Philippines is coordinated with demand increase and the power development plan, and that the quality, reliability, security and affordability of the system are at an appropriate level. If necessary, DOE will order TRANSCO to improve TDP.

Meanwhile, separate from the TDP evaluation by DOE, ERC and NEDA evaluate each project considering transmission charges and funding, respectively.

### 1.2 Responsibilities of DOE and TRANSCO

DOE has to prepare and update the Power Development Program (PDP) annually and integrate it into the Philippine Energy plan (PEP) under Section 37 of the act.

TRANSCO shall be responsible for the preparation of TDP, and shall submit TDP for approval by DOE for integration into PDP and PEP under Section 9 of the act and Section 10 of Rule 6.

## 2. Scope of Evaluation

### 2.1 Evaluation Period

As DOE prepares PDP and PEP for ten years, TRANSCO also has to prepare TDP for ten years and likewise, DOE has to evaluate it for ten years, although the evaluation period is not stated under the act or the rules.

Meanwhile, Grid Code 6.2.6 states that TRANSCO shall collate and process the planning data submitted by the users into a cohesive forecast and use this in preparing the data for the five-year statement of TDP. However, this does not mean that TRANSCO does not have to prepare TDP for the latter five years. From this, TRANSCO can assume the data to prepare TDP for the latter five years.

### 2.2 Facilities for Evaluation

#### 2.2.1 Scope of TDP and DDP

The scope of TDP prepared by TRANSCO and DDPs prepared by DUs is clarified as follows:

**Table 2.1: Scope of TDP and DDP**

Assets	Planning Entity	Program
Transmission (Subtransmission*1)	TRANSCO	TDP
Subtransmission Distribution	DUs	DDP

\*1 Before the transfer of subtransmission assets to DUs

## 2.2.2 Distinction between Transmission Assets and Subtransmission Assets

Under Section 7 of the act, ERC shall set the standards of voltage transmission that shall distinguish the transmission from the subtransmission assets. Pending the issuance of these new standards, the distinction between transmission and subtransmission assets shall be as follows:

**Table 2.2: Distinction between Transmission and Subtransmission Assets**

	Transmission Assets	Subtransmission Assets
Luzon Grid	500 kV, 230 kV	115 kV, 69 kV
Visayas Grid	230 kV, 138 kV, 69 kV	69 kV*
Mindanao Grid	138 kV	69 kV

\* In case of not forming part of the main transmission grid and being directly connected to the substation of the distribution utility

Under Section 4 of Rule 6, the function as well as the voltage has to be considered to distinguish between transmission and subtransmission assets. Currently, TRANSCO owns some subtransmission assets, and TRANSCO shall transfer them to the DUs under Section 8 of the act.

Although the current TDP includes subtransmission lines, they will be included in the DDPs prepared by DUs after the transfer.



### 3. Work Flow

#### 3.1 TDP Preparation and Evaluation

##### 3.1.1 Work Flow

Figure 3.1 shows the workflow for TRANSCO and DOE to prepare and evaluate TDP, respectively.

In advance of TRANSCO's preparation of TDP, DOE makes a demand forecast, prepares the power development plan and hands over the information to TRANSCO.

Table 3.1 and Table 3.2 show the information that should be provided by DOE to TRANSCO.

**Table 3.1: Information Provision by DOE to TRANSCO**

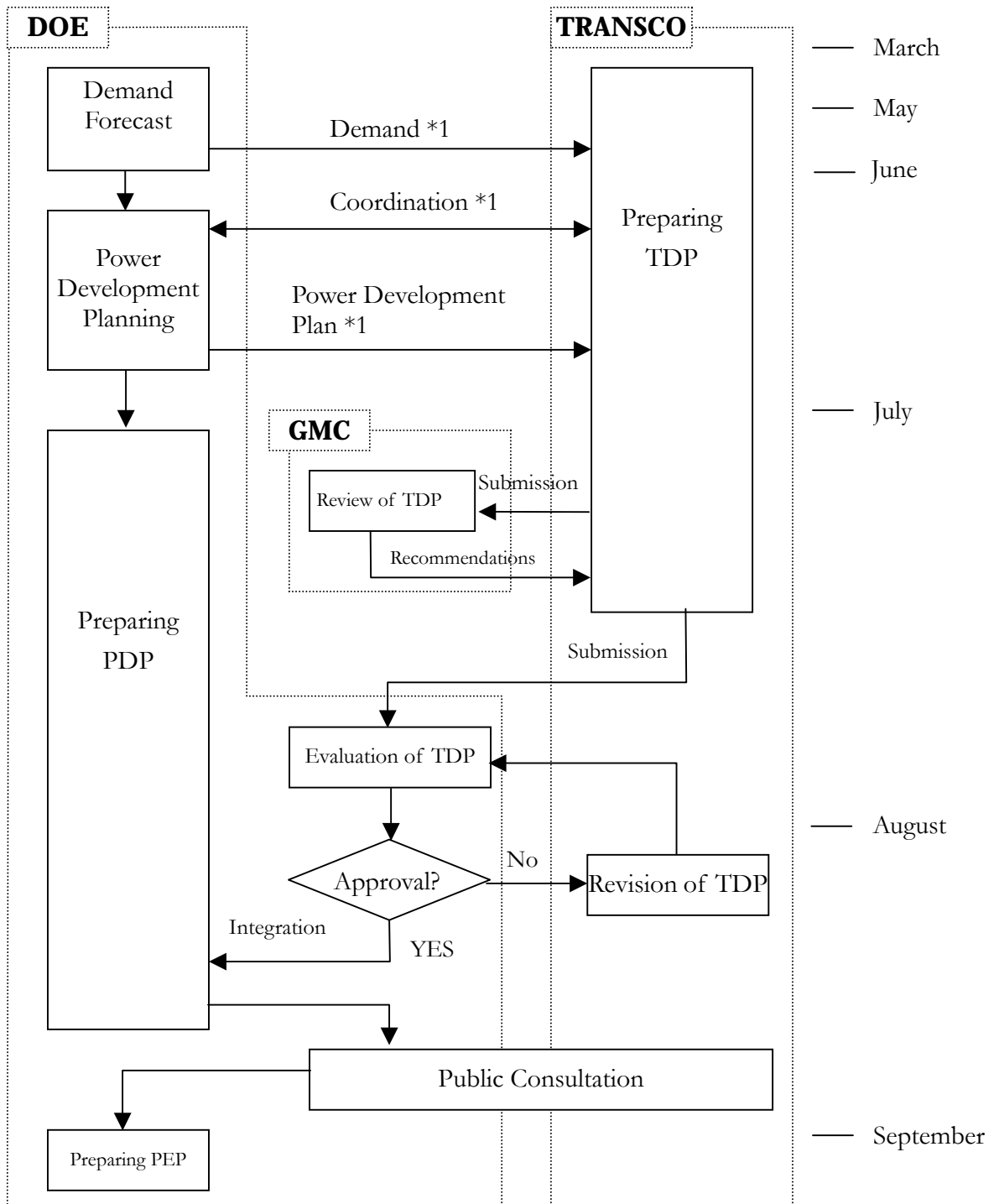
Items	Contents
Demand Forecast	<ul style="list-style-type: none"><li>- For 10 years</li><li>- For Luzon, the Visayas (Leyte-Samar, Cebu, Negros, Panay, Bohol) and Mindanao</li></ul>
Power Development Plan	<ul style="list-style-type: none"><li>- Results of WASP simulation</li><li>- List of committed projects</li><li>- List of indicative projects that should be included in the TDP from political point of view</li><li>- List of decommissioned plants</li></ul>

**Table 3.2: Information regarding Power Development Plan**

Items	Contents
Project Data	<ul style="list-style-type: none"><li>- Location of the site</li><li>- Fuel Type</li><li>- Capacity</li><li>- Year of commissioning</li></ul>
Decommissioning Data	<ul style="list-style-type: none"><li>- Plant Name</li><li>- Generator Number</li><li>- Capacity</li><li>- Year of decommissioning</li></ul>

After preparing TDP, TRANSCO submits TDP to the Grid Management Committee (GMC). GMC reviews TDP and makes recommendations based on it. TRANSCO then submits TDP to DOE. DOE evaluates and approves it, and integrates it into PDP and PEP.

**Fig 3.1: Work Flow**



\*1: To exchange information, meetings with TRANSCO are necessary.

As transmission development planning is closely related to power development planning, it is impossible to make transmission development plan independently. To accommodate demand increase in an area, there are two options: one is power development in the area, and the other is transmission expansion. Therefore, DOE and TRANSCO need to cooperate and decide which option should be taken.

To coordinate the power development plan and the transmission development plan, exchanging of a lot of data and feedback of the results of the study are necessary between DOE and TRANSCO. Therefore, holding periodic meetings is necessary during TDP preparation. Generating companies, such as NPC and IPPs, and distribution utilities, such as MERALCO, should attend the meetings, if necessary.

### **3.1.2 Contents of TDP**

The contents that should be included in the TDP are the following:

- (1) Planning Assumptions  
(Demand Forecasts, List of Power Development Projects)
- (2) Planning Criteria
- (3) Summary of the existing facilities  
(Transmission Lines, Substations)
- (4) List of Transmission Development Projects  
(Voltage, Capacity, Year of commissioning, Cost, etc.)
- (5) Maps of the Grids (Luzon, the Visayas, Mindanao)
- (6) Profile of Total Investment
- (7) Historical Values of Performance Indicators

### 3.1.3 Materials for Submission

In addition to TDP, DOE requires the following documents and data for TDP evaluation. TRANSCO has to submit them to DOE annually.

- (1) Data of PSS/E
- (2) Single-line Diagram (Luzon, the Visayas, Mindanao)
- (3) Grid Map (the Philippines)
- (4) List of Individual Existing Facilities

Table 3.3 shows the list of individual existing facilities that should be submitted by TRANSCO.

**Table 3.3: Contents of the List of Individual Existing Facilities**

Items		Contents
Transmission Line		<ul style="list-style-type: none"> <li>- Rated Voltage</li> <li>- Names of the Terminals</li> <li>- Number of circuits</li> <li>- Size of conductors and number of conductors per phase</li> <li>- Thermal Capacity</li> <li>- Line Constant</li> </ul>
Substation	Transformer	<ul style="list-style-type: none"> <li>- Rated Voltage</li> <li>- Rated Capacity</li> <li>- Number</li> <li>- Reactance</li> </ul>
	Shunt Capacitor Shunt Reactor	<ul style="list-style-type: none"> <li>- Rated Capacity</li> <li>- Number</li> </ul>
	Series Capacitor Series Reactor	<ul style="list-style-type: none"> <li>- Rated Capacity</li> <li>- Number</li> </ul>
	Circuit Breaker	<ul style="list-style-type: none"> <li>- Rated Voltage</li> <li>- Rated Capacity</li> <li>- Rated Breaking Capacity</li> </ul>

## 3.2 Planning of Interconnection

### 3.2.1 Work Flow

Interconnection connects independent island systems to supply power for the economical operation of the generators and to improve reliability.

Table 3.4 lists the entities responsible for the planning and construction of interconnection. In the case of major interconnections, such as those between Luzon, the Visayas and Mindanao and those between the main islands of the Visayas (Leyte, Samar, Cebu, Negros, Panay and Bohol), DOE and TRANSCO are responsible for planning.

In the case of small-island interconnections, TRANSCO and DUs are responsible for planning.

**Table 3.4: Classification of Interconnection**

	Assets	Responsible Entities	
- Major Interconnection (Luzon-Visayas-Mindanao) - Visayas-Main-Island Interconnection (between Leyte, Samar, Cebu, Negros, Panay, Bohol)	Transmission	Planning	DOE & TRANSCO
		Construction	TRANSCO
- Small-Island Interconnection	Transmission	Planning	TRANSCO & DUs
		Construction	TRANSCO
	Sub- transmission Distribution	Planning	DUs
		Construction	DUs

To plan interconnection between islands, comparison between power development of the island or interconnection is required to clarify which method is appropriate.

Table 3.5 shows the responsibilities of DOE and TRANSCO regarding planning main interconnections.

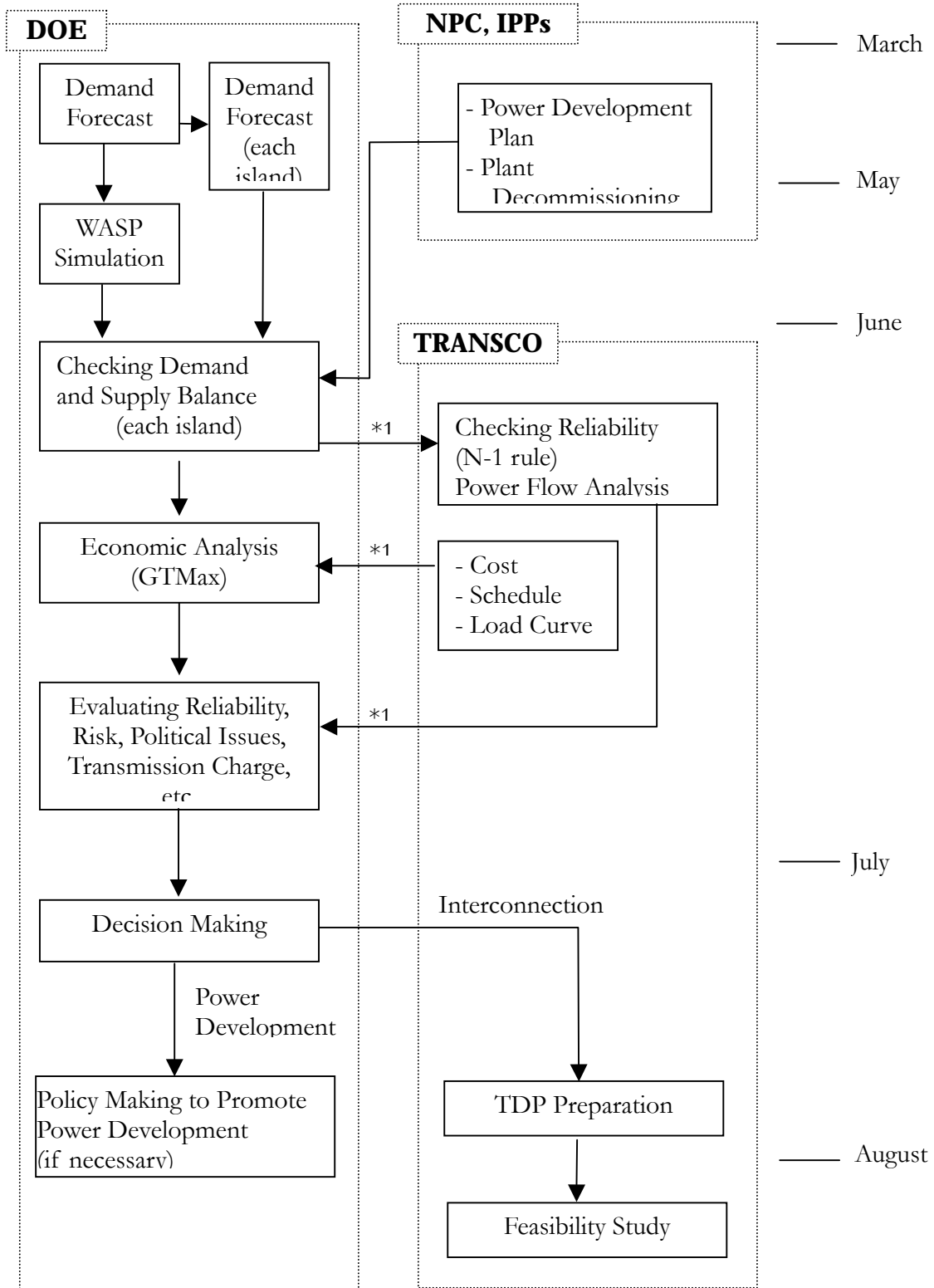
Coordination between DOE and TRANSCO is necessary for planning interconnection, and meetings are therefore necessary. If necessary, generating companies and distribution utilities should join these meetings.

Figure 3.2 shows the workflow for planning interconnections.

**Table 3.5: Responsibilities of DOE and TRANSCO**

	Responsibility
DOE	<ul style="list-style-type: none"><li>- Demand Forecast (each island)</li><li>- Power Development Planning (including the decommissioning program)</li><li>- Economic Analysis (using GTMax)</li><li>- Policy Making</li><li>- Planning in the case of the delay or cancellation of power development</li></ul>
TRANSCO	<ul style="list-style-type: none"><li>- Power Flow Analysis (PSS/E)</li><li>- Feasibility Study</li><li>- Cost Estimation</li><li>- Schedule Estimation</li><li>- Reliability Check (N-1 rule)</li></ul>

**Fig 3.2: Work Flow (Interconnection)**



\*1: To exchange the information, meetings with TRANSCO are necessary.

### 3.2.2 Methodology for Planning Interconnection

Table 3.6 shows the items to be considered for planning interconnections. When making a decision on interconnection, all of these items should be considered.

**Table 3.6: Items to be considered for planning interconnections**

Items	Contents
Economic Analysis	- Fuel reduction - Capital cost for interconnection - Capital cost reduction by reducing power development
Demand and Supply Balance	- Probability of power shortage - Risk of unpredicted demand increase - Risk of delay or cancellation of power development
Reliability	- Satisfaction of the N-1 rule
Other	- Impact on the transmission charge - Advantage of a united system for the spot market - Political issues

#### (1) Economic Analysis

When economic analysis is conducted, the following items needs to be considered:

**Table 3.7: Economical Effects of Interconnection**

New Interconnection	Upgrade of Existing Interconnection
- Saving of fuel cost - Reduction in peak demand - Reduction in reserve margin	- Saving of fuel cost

In the case of adopting an interconnection, fuel cost will be reduced due to the optimal operation of the generators. Fuel cost reduction by optimal operation can be calculated with GTMax (refer to Chapter 3).

Reduction in peak demand is expected due to interconnection because the load curves of each system are different, and there is a time lag between the peak demands of the each system. The amount of expected reduction is calculated based on the actual load curves of each system.

Reduction in reserve margin is also expected with interconnection. However, for reduction in the reserve margin, consultation with TRANSCO is necessary.

According to TRANSCO, the necessary reserve margin for the Luzon System, the Visayas System and the Mindanao System is currently 13.2%.

With reduction in the peak demand and the reserve margin, power development can also be reduced. As a result, capital cost (depreciation and interest) can be reduced in relation to



power development.

The steps for economical analysis are as follows:

- 1) Calculate fuel cost reduction with interconnection annually  
(using  $GT_{max}$ )
- 2) Calculate investment reduction regarding power development
  - Considering peak-demand reduction and reserve-margin reduction
  - Adopting a gas turbine unit price
- 3) Add the net present values of the following items:
  - Fuel cost reduction
  - Investment and salvage value of the interconnection
  - Investment reduction in power development
  - Annual maintenance cost of the interconnection

Table 3.8 is an example of economic analysis. The negative numbers indicate outgoings and the positive numbers indicate income. In this case, as the total NPV is negative, the interconnection is not economical.

**Table 3.8: Example of Economic Analysis for Interconnection (M\$)**

	Interconnection		Operation Cost Saving		Power Development Reduction	Project NPV
	Construction Cost	Salvage Value	Actual Value	Present Value		
<b>2003(NPV)</b>	<b>-185.57</b>	<b>33.79</b>		<b>55.64</b>	<b>10.80</b>	<b>-85.34</b>
2004						
2005						
2006						
2007	-292.00				17.00	
2008			5.11	2.90		
2009			5.65	2.86		
2010			30.31	13.71		
2011			27.09	10.94		
2012			18.46	6.66		
2013			12.53	4.03		
2014			12.53	3.60		
2015			12.53	3.21		
2016			12.53	2.87		
2017			12.53	2.56		
2018		184.93	12.53	2.29		

Discount Rate = 12%

Life of Interconnection = 30years

Ignoring Maintenance Cost of Interconnection

(2) Demand and Supply Balance

The demand and supply balance of each island needs to be checked. Power shortages may occur due to the delay or cancellation of power development. Therefore, it is necessary to check the probability of each power development project.

It should also be considered that interconnection avoids power shortages caused by unpredicted demand increase.

### (3) Reliability

Reliability also needs to be checked for interconnection planning. If the system does not satisfy the N-1 rule, an interconnection is necessary.

Reliability can be also improved by power development in the island.

### (4) Other

The impact on the transmission charge, the advantage of a united system for the spot market and political issues should also be evaluated in planning interconnection.

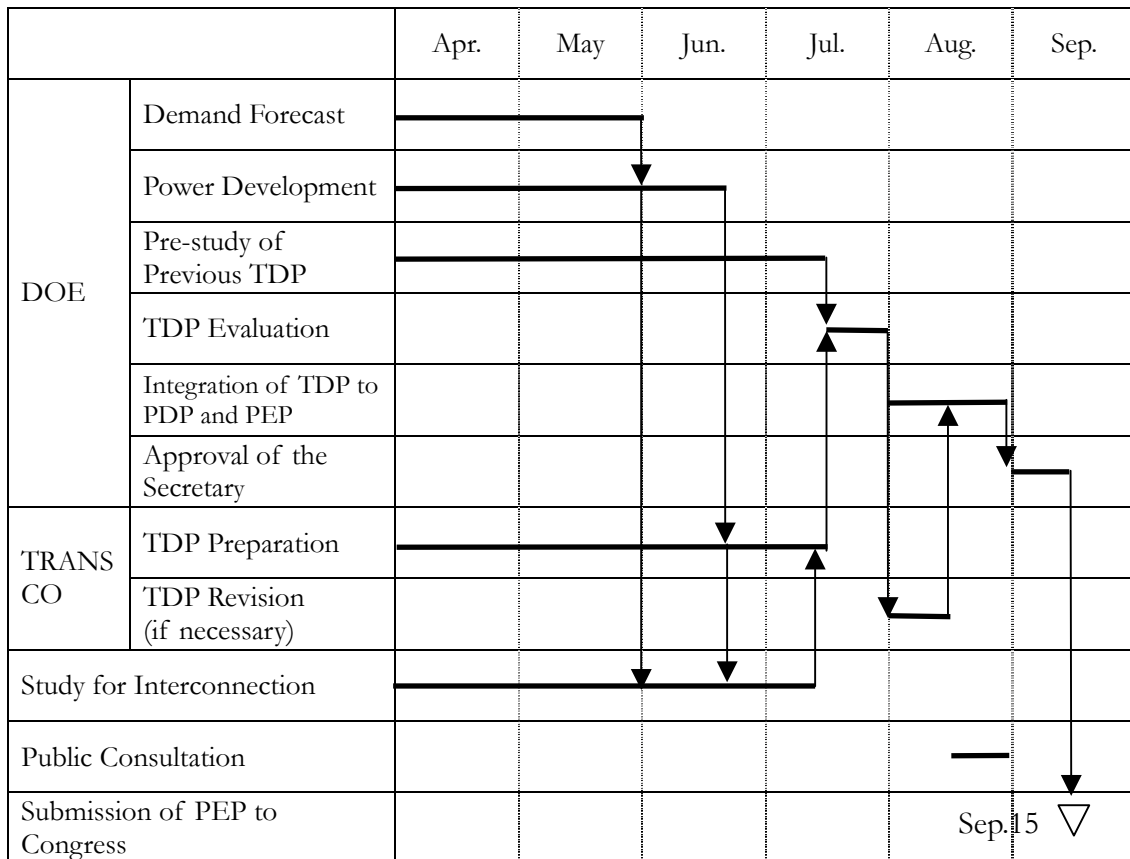
## 4. Schedule

Figure 4.1 shows the schedule for TDP preparation and TDP evaluation.

TRANSCO prepares TDP in coordination with the demand forecast and the power development plan prepared by DOE. After submission of TDP by TRANSCO, DOE evaluates and approves it, and integrates it into PDP and PEP. Therefore, the schedule is very tight.

To cope with this tight schedule, a pre-study for TDP evaluation is implemented from April based on the previous TDP and the latest information. After the demand forecast and power development plan are finalized, and the latest TDP is prepared, the points that have changed from the previous TDP are checked.

**Fig 4.1: Schedule for TDP preparation and evaluation**



## 5. Methodology for Evaluation

### 5.1 Reliability

#### 5.1.1 Reliability Criteria

For power development, probabilistic methodology has been established, such as the Loss of Load Probability (LOLP) Method. However, regarding transmission planning, where such methodology has not been developed, the N-1 rule is internationally adopted.

This means that not only is there no interruption without a contingency, but also that all demand can be supplied with an N-1 outage contingency (such as the outage of one generator, one circuit of transmission line or one transformer). In addition to this, the criterion that does not allow large area and long period blackouts is often adopted.

Under Section 2 of the act, the policy of the state is to ensure the quality, reliability, security and affordability of the electric power supply. TRANSCO shall comply with the provision of the Grid Code in the process of improving and expanding its transmission facilities under Section 9 of the act and Section 9 of Rule 6.

Although the criteria for system expansion are not concretely stated in the Grid Code, Chapter 7 (Grid Operations) states that the N-1 rule should be adopted for grid operation criteria.

To accommodate continuing to operate in the normal state following the loss of one generating unit, transmission line, or transformer, the N-1 rule needs to be applied for planning.

However, as the transmission system in the Philippines is evolving, strict application of the criteria may not be suitable or practical for specific stages in transmission planning. Therefore, it is desirable to develop the system step by step to accommodate the N-1 rule, considering the effect of blackouts and investment.

**[Grid Code]**

**Chapter 7 Grid Operations**

**7.2 Grid Operating States, Operating Criteria, and Protection**

**7.2.1 Grid Operating States**

7.2.1.1 The Grid shall be considered to be in the Normal State, when:

- (a) The Operating Margin is sufficient;
- (b) The Grid Frequency is within the limits of 59.7 and 60.3 Hz, as specified in Section 3.2.2;
- (c) The voltages at all Connection Points are within the limits of 0.95 and 1.05 of the nominal value, as specified in Section 3.2.3;
- (d) The loading levels of all transmission lines and substation Equipment are below 90% of their continuous ratings; and
- (e) The Grid configuration is such that any potential fault current can be interrupted and the faulted Equipment can be isolated from the Grid.

**7.2.2 Grid Operating Criteria**

7.2.2.1 The Grid shall be operated so that it remains in the Normal State.

7.2.2.2 The Grid shall be operated and maintained to meet the Power Quality standards specified in Article 3.2.

7.2.2.3 The Security and Reliability of the Grid shall be based on the Single Outage Contingency criterion. This criterion specifies that the Grid shall continue to operate in the Normal State following the loss of one Generating Unit, transmission line, or transformer.

### 5.1.2 Performance Indicators

The reliability level of TRANSCO is evaluated by checking the historical trend of the following indicators, which are specified in Section 7 (C) of Rule 6:

(1) Number of Interruption Events

Number of interruption incidents per year (caused by failure of the TRANSCO system)

(2) Sustained Average Interruption Frequency Index (SAIFI)

$$\text{SAIFI} = \frac{\text{Summation of connected MVA impacted by outages } > 10 \text{ min.}}{\text{Total connected MVA}}$$

(3) Momentary Average Interruption Frequency Index (MAIFI)

$$\text{MAIFI} = \frac{\text{Summation of connected MVA impacted by outage } \leq 10 \text{ min.}}{\text{Total connected MVA}}$$

(4) Sustained Average Interruption Duration Index (SAIDI)

$$\text{SAIDI} = \frac{\text{Summation of (Outage MVA x minutes } > 10 \text{ min.)}}{\text{Total connected MVA}}$$

(5) System Interruption Severity Index (SISI)

$$\text{SISI} = \frac{\text{Total Delivery Point Unserved Energy (MWh)}}{\text{System Peak Load (MW)}}$$

(6) Frequency of tripping per 100 c-km (FOT)

$$\text{FOT} = \frac{\text{Summation of Tripping Incidents}}{\text{Total Ckt length/100 ckt.km.}}$$

(7) Average Forced Outage Duration (AOD)

$$\text{AOD} = \frac{\text{Summation of Outage Duration}}{\text{Sum of Frequency}}$$

(8) Accumulated Time Error (ATE)

The yearly summation of the number days, of which accumulated time error is +/- 7.5 seconds or more

(9) Frequency Limit Violation (FLV)

The yearly summation of the number of days in case the number of violations of the permissible frequency deviation (plus minus 0.3 Hz, based on the Grid Code) exceeds 25 (rainy season) or 30 (dry season)

(10) Voltage Limit Violations (VLV)

The yearly of the number of days, in case the voltages violate the permissible deviation (+/- 5%, based on the Grid Code)

It should be noted that SAIFI and SAIDI in the Philippines are different from those applied internationally. Internationally, SAIFI stands for the System Average Interruption Frequency Index, which means the number of interruptions per customer. SAIDI stands for the System Average Interruption Duration Index, which means the duration of interruptions per customer.

### 5.1.3 Power Quality

Under Grid Code 3.2, TRANSCO has to ensure the quality of electric power in the grid.

A power quality problem exists when at least one of the following conditions is present and significantly affects the normal operation of the system:

- (1) The system Frequency has deviated from the nominal value of 60Hz;
- (2) Voltage magnitudes are outside their allowable range of variation;
- (3) Harmonic Frequencies are present in the system;
- (4) There is imbalance in the magnitude of the phase voltages;
- (5) The phase displacement between the voltages is not equal to 120 degrees;
- (6) Voltage Fluctuations cause Flicker that is outside the allowable Flicker Severity limits; or
- (7) High-frequency Overvoltages are present in the Grid.

However, these matters are the responsibility of ERC regulation. Therefore, DOE does not need to check all of these problems unless they threaten the reliability of the power system and safety.



## 5.2 Technical Check Points

### 5.2.1 Grid Code

Under Section 9 of Rule 6, TRANSCO needs to comply with the Grid Code in improving and expanding its transmission facilities to ensure and maintain the reliability, adequacy, security, stability and integrity of the grid.

Chapter 6 of the Grid Code states the responsibilities of TRANSCO regarding grid planning. Based on this, TRANSCO needs to conduct impact studies regarding the connection of new facilities, such as generating plants and load.

The following items are stated in the Grid Code:

- Load Flow Studies
- Short Circuit Studies
- Transient Stability Studies
- Steady-State Stability Analysis
- Voltage Stability Analysis
- Electromagnetic Transient Analysis
- Reliability Analysis

Transient stability analysis is sometimes substituted for the steady-state stability analysis. Electromagnetic transient analysis is usually conducted for detailed study. Reliability analysis is basically studied by DOE under the new act.

Therefore, these three items can be omitted from the TDP evaluation.

#### (1) Load Flow (Power Flow)

Based on Grid Code 6.3.2, TRANSCO shall perform load flow studies to evaluate the behavior of the Grid for the existing and planned Grid facilities under forecasted maximum and minimum Load conditions and to study the impact on the Grid of the connection of new Generating Plants, Loads, or transmission lines.

DOE needs to check the following points:

- (a) No transmission facilities are overloaded in the normal condition.
- (b) No transmission facilities are overloaded in case of an N-1 contingency (adoption of emergency rating).
- (c) The voltage of each bus is between 0.95 and 1.05 on in the normal condition.

#### (2) Short Circuit

Based on Grid Code 6.3.3, TRANSCO shall perform short circuit studies to evaluate the

effect on Grid Equipment of the condition of new Generating Plants, transmission lines, and other facilities that will result in increased fault duties for Grid Equipment. These studies shall identify the Equipment that could be permanently damaged when the current exceeds the design limit of the Equipment such as switchyard devices and substation buses. The studies shall also identify the circuit breakers, which may fail when interrupting possible short circuit currents.

DOE needs to check following points:

- (a) The short-circuit currents are within the design limits of the equipment (three-phase short circuit current and single-phase short circuit current are applied).

### (3) Transient Stability

Based on Grid Code 6.3.4, TRANSCO shall perform transient stability studies to verify the impact of the connection of new Generating Plants, transmission lines, and substations and changes in Grid circuit configurations on the ability of the Grid to seek a stable operating point following a transient disturbance.

DOE needs to check following points:

- (a) The grid remains stable after any single outage contingency for all forecasted load conditions.
- (b) The grid remains controllable after a multiple outage contingency. In the case of grid separation, no total blackout should occur in any Island Grid.

### (4) Voltage Stability

Based on Grid Code 6.3.6, TRANSCO shall perform voltage studies to determine if the Grid is vulnerable to voltage collapse under heavy loading conditions. A voltage collapse can proceed very rapidly if the ability of System's Reactive Power supply to support system voltages is exhausted. The studies shall identify solutions such as the installation of dynamic and static Reactive Power compensation devices to avoid vulnerability to collapse.

DOE needs to check the following point:

- (a) Voltage collapse does not occur under heavy loading conditions.

## 5.2.2 Planning Criteria of TRANSCO

TRANSCO applies the N-1 rule for TDP preparation to comply with the Grid Code. Meanwhile, in the case of multiple failures, voltage collapse and cascaded outages are not allowed, although load shedding and generation shedding are accepted. Table 5.1 shows the planning criteria of TRANSCO.

[Conditions of the N – 1 Rule]

- The generators must remain stable.
- The under-frequency load shedding must not be activated.
- The power flows must remain lower than the rating of the network equipment and must not overload the remaining element.
- The bus voltages must remain within the limits.

**Table 5.1: Planning Criteria of TRANSCO**

Acceptable Limits	Allowable Remedial Actions
<b>1. Normal Condition</b>	
- Transmission line loading: <100%	Line reinforcements
- Transformer loading: <100%	Transformers additions
- Steady-state voltage range: +/-5%	Reactive power dispatch or compensation
<b>2. Single-Line Outage (N-1) Contingencies</b>	
- Transmission line loading: <100%	Line reinforcement
- Transformer loading: <100%	Line reinforcement
- Steady-state voltage range: +/-10%	Reactive power dispatch or compensation
- Transiently stable for 3-phase fault with normal clearing	Generator control fine tuning, reactive power dispatch, compensation or additional reinforcement
<b>3. Severe contingencies</b>	
- Transmission line loading: <120%	Automatic load dropping (ALD), generator tripping (GT), transfer tripping scheme (TTS)
- Transformer loading: <120%	
- No voltage collapse	
- No cascaded outages	
<b>4. Load Rejection</b>	
- Dynamic overload: 30%	Excitation system specification, reactive power compensation
- Peak Volts/Hertz ratio: 1.5p.u./p.u.	
- No self-excitation	
<b>5. Line Restoration</b>	
- Maximum voltage difference: 15%	Reactive power compensation
- Maximum open-end voltage: 120%	

Source: TDP 2002-2012 (September 2002)

## **5.3 Consistency with other Programs**

### **5.3.1 PDP**

Consistency with the power development plan prepared by DOE is required for TDP.

Therefore, a check is conducted to determine whether the transmission plan for each power development plan is precisely included in TDP and whether the timing and capacity are consistent with the development plan.

With respect to indicative projects planned by DOE, because definite sites have not been decided, TRANSCO assumes provisional sites for transmission planning. Therefore, the validity of the provisional sites assumed by TRANSCO has to be checked.

### **5.3.2 DDP**

Consistency with distribution development plans prepared by the distribution utilities is required for TDP.

Therefore, a check is conducted to determine whether the distribution plans, such as substation and subtransmission line plans, are consistent with TDP.

Under Distribution Code 6.2.2.2, all Users shall submit the demand forecast to the Distributor for the five succeeding years by calendar week 23 (June) annually. The Distributors prepare DDPs and submit them by March 15 based on the data. Therefore, the demand forecasts for DDPs are based on the previous year in comparison with the demand forecast by DOE.

### **5.3.3 Transmission Plan of Generation Companies**

Under Section 9 of the act, a generation company may develop and own or operate dedicated point-to point limited transmission facilities. Therefore, checking their consistency with TDP is necessary.

Under the act, provided that such assets are required for competitive purposes, their ownership shall be transferred to TRANSCO at a fair market price.

## 5.4 Other Check Points

### 5.4.1 Economics

The plan needs to be economical from a long-term perspective. For comparison with an alternative plan, the total present values of investments should be compared. It should be noted that reliability should be at the same level for economical comparison. Table 5.2 shows an example of economic comparison.

**Table 5.2: Example of Economic Comparison (MP)**

	Alternative 1		Alternative 2	
	Actual Investment	Present Value	Actual Investment	Present Value
2006 (Present)	1,666	1,666	11,660	11,660
2007		0		0
2008	7,816	6,231	857	683
2009		0		0
2010	2,025	1,287	1,366	868
2011		0		0
2012	3,067	1,554	683	346
Total	14,574	10,738	14,566	13,557

Note: Discount Rate = 12%

If the initial investment is too large, an alternative plan should be considered, otherwise the initial investment could become stranded cost with the changing situation in the future.

### 5.4.2 Long-term Planning

After the privatization of TRANSCO, the concessionaire might reduce investment, and appropriate reinforcement might not be implemented for demand increase and power development from a short-term perspective.

In the case of expansion from a short-term viewpoint, reinforcement could be repeated during the short term and this may not be economical. In some cases, as many transmission lines could be constructed in the same area, the landowner would oppose the plan and it would be difficult to implement it.

Therefore, it is desirable that the scales of the facilities accommodate twice or three times the demand.

The adopted voltage should also be checked. In some cases, the transmission lines should be designed for higher voltage for upgrading in the future.

### 5.4.3 Unit Capacity of Generators

A check is conducted to determine whether the unit capacity of the generator is too large considering frequency drop and load dropping caused by the generator tripping.

Currently, the largest capacities of the generators of each system are as follows:

**Table 5.3: Largest Current Unit Capacities**

System	Unit Capacity	Plant
Luzon System	654.8 MW	Sual Coal Unit1-2
Visayas System	77.5 MW	Malitbog Geothermal Unit 1-3
Mindanao System	85.0 MW	Pulangui IV Unit 1-3

### 5.4.4 Interconnection between Islands

#### (1) Major Interconnection

Interconnections between the main islands are planned by DOE and TRANSCO. Therefore, evaluating them is basically unnecessary.

#### (2) Small-Island Interconnections

For evaluation of small-island interconnection, the results of economic analysis should be checked between power development with diesel generation on the island and the construction of interconnection. The assumptions for the study also have to be checked.

In addition, the demand and supply balance on the island and reliability should be checked. (Refer to 3.2.2 Methodology for planning interconnection.)

## 5.4.5 Transmission Charge

The impact on the transmission charge also needs to be checked, if necessary. For a rough estimation, the following calculation can be used:

Incremental Transmission charge for each year =

$$\frac{\text{Additional capital cost for each year (depreciation plus interest)}}{\text{Energy sales of the year}}$$

If the maintenance cost regarding the transmission plan can be estimated, it should be added to the additional cost for each year.

Table 5.4 shows the example of calculation of the incremental transmission charge.

**Table 5.4: Example of Incremental Transmission Charge**

		2005	2006	2007	2008	2009	2010
Peak Demand (MW)	Luzon	7,473	8,076	8,662	9,323	10,036	10,786
	Visayas	1,172	1,269	1,363	1,469	1,582	1,702
	Mindanao	1,181	1,259	1,331	1,412	1,498	1,586
	Total	9,827	10,604	11,357	12,204	13,117	14,074
Increase Rate			7.9%	7.1%	7.5%	7.5%	7.3%
Load Factor			70.0%	70.0%	70.0%	70.0%	70.0%
Station Use			4.0%	4.0%	4.0%	4.0%	4.0%
Transmission Loss			4.0%	4.0%	4.0%	4.0%	4.0%
Sales Energy (GWh)	(a)		59,822	64,070	68,848	73,997	79,398
<b>[Interconnection]</b>							
Investment (Mp)		4,500.0					
Remaining Value (Mp)		4,500.0	4,350.0	4,200.0	4,050.0	3,900.0	3,750.0
Depreciation (Mp/y)	(b)		150.0	150.0	150.0	150.0	150.0
Interest Rate			12.0%	12.0%	12.0%	12.0%	12.0%
Interest (Mp/y)	(c)		540.0	522.0	504.0	486.0	468.0
Capital Cost (Mp/y)	(d) = (b) + (c)		690.0	672.0	654.0	636.0	618.0
Incremental Transmission Charge (p/kWh)	(e) = (d) / (a)		0.011534	0.010489	0.009499	0.008595	0.007784
5-Year Average			0.00958	0.00958	0.00958	0.00958	0.00958

Ignoring Maintenance Cost

## 6. Checklist

### 6.1 Reliability

Items	Check Points
Reliability Criteria	(1) Do the reliability criteria comply with the Grid Code? - Application of the N-1 rule
Reliability Standard	(1) Are the following performance indicators becoming worse? (a) Number of Interruption Events (b) Sustained Average Interruption Frequency Index (c) Momentary Average Interruption Frequency Index (d) Sustained Average Interruption Duration Index (e) System Interruption Severity Index (f) Frequency of Tripping per 100c-km (g) Average Forced Outage Duration (h) Accumulated Time Error (i) Frequency Limit Violation (j) Voltage Limit Violations

### 6.2 Technical Check Points

Items	Check Points
Power Flow	(1) No transmission facilities are overloaded in the normal condition. (2) No transmission facilities are overloaded in case of an N-1 contingency. [cf. TRANSCO adopts an emergency capacity rating (110% of the normal capacity rating) in case of an N-1 contingency.] (3) The voltage of each bus is between 0.95 and 1.05 in the normal condition. [cf. TRANSCO adopts a voltage range between 0.9 and 1.1 in case of an N-1 contingency.]
Short circuit	(1) The short-circuit currents are within the design limits of the equipment (a three-phase short circuit current and single-phase short circuit current are applied.)
Transient Stability	(1) The grid remains stable after any single outage contingency for all forecasted load conditions. (2) The grid remains controllable after a multiple outage contingency. In the case of grid separation, no total blackout should occur on any island.
Voltage Stability	(1) Voltage collapse does not occur under heavy loading conditions. [cf. TRANSCO adopts no voltage collapse with a severe contingency.]



### 6.3 Consistency with other Programs

Items	Check Points
Consistency with PDP	(1) Is TDP consistent with the power development plans prepared by DOE?
Consistency with DDP	(1) Is TDP consistent with the development plans of substations and sub-transmission lines prepared by the distribution utilities?
Consistency with other planning	(1) Is TDP consistent with the transmission planning of generation companies?

### 6.4 Other

Items	Check Points
Economics	(1) Is the plan economical? (2) Is the initial investment not too large?
Long-term planning	(1) Are expansions not repeated over a short period? (It is desirable that the scales of the facilities should accommodate the twice or three times the demand) (2) Do the facilities have adequate margins to accommodate additional power development and demand increase? (3) Is the adopted voltage adequate? (4) Should the facilities be designed for higher voltage for upgrading in the future?
Unit capacity of generator	(1) Is the unit capacity of the generator too large considering frequency drop with a generator tripping? (With a generator fault, does a lot of load need to be rejected?)
Interconnection between small Islands	(1) Is power shortage expected on the island? (2) Is the interconnection plan economical compared with power development? (3) Is the interconnection needed for reliability? (4) Are the timing and the capacity of the interconnection appropriate considering the demand forecast? (5) Do the advantages of the interconnection outweigh the disadvantages?
Transmission Charge	(1) Is the impact of the plan on the transmission charge at an allowable level?



**Manual  
for  
the Power Development Plan  
Preparation  
(MEDP)**

## Section 5 Rural Electrification

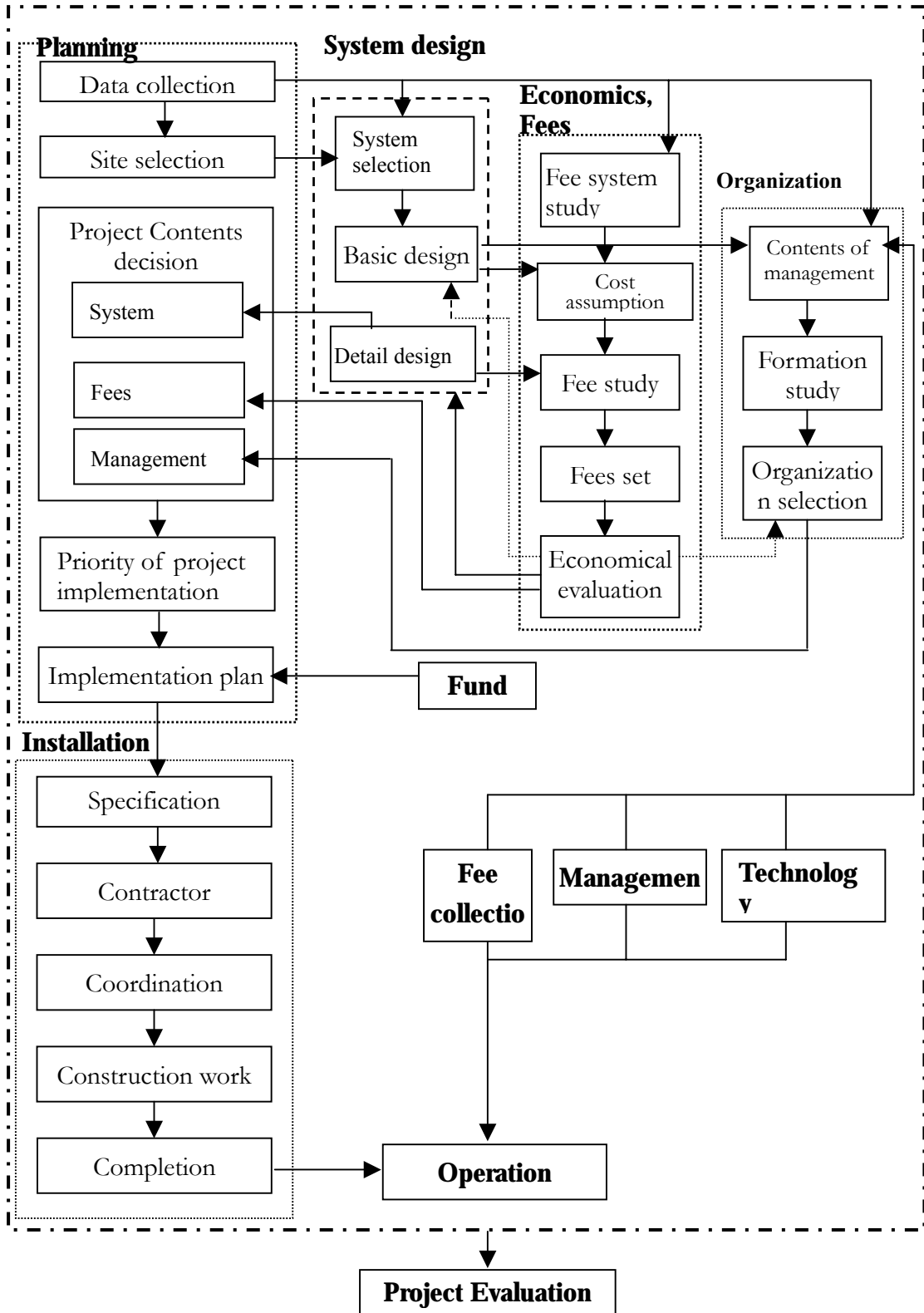
Rural electrification projects have been implemented in many areas over the world. However, sustainable system management was not considered sufficient after their introduction. Therefore, many systems could not be managed appropriately for a long time because of lack of maintenance. Currently, based on these experiences, it is important to carry out a sustainable project where a system can be carefully maintained for a long time.

To prepare the rural electrification plan, it is necessary to consider the whole process flow of the project that includes planning, system design, installation, fee setting and building management organizations, etc. From this point of view, therefore, this manual is consists of the following.

- 1 General process flow of the rural electrification project and planning steps**
- 2 Concept of the manual**
- 3 Workflow and organizations concerned**
- 4 Schedule**
- 5 Key points**
- 6 Data collection and database**
- 7 Selection procedure for electrification**
- 8 Training**
- 9 Establishment of the operation and management system**

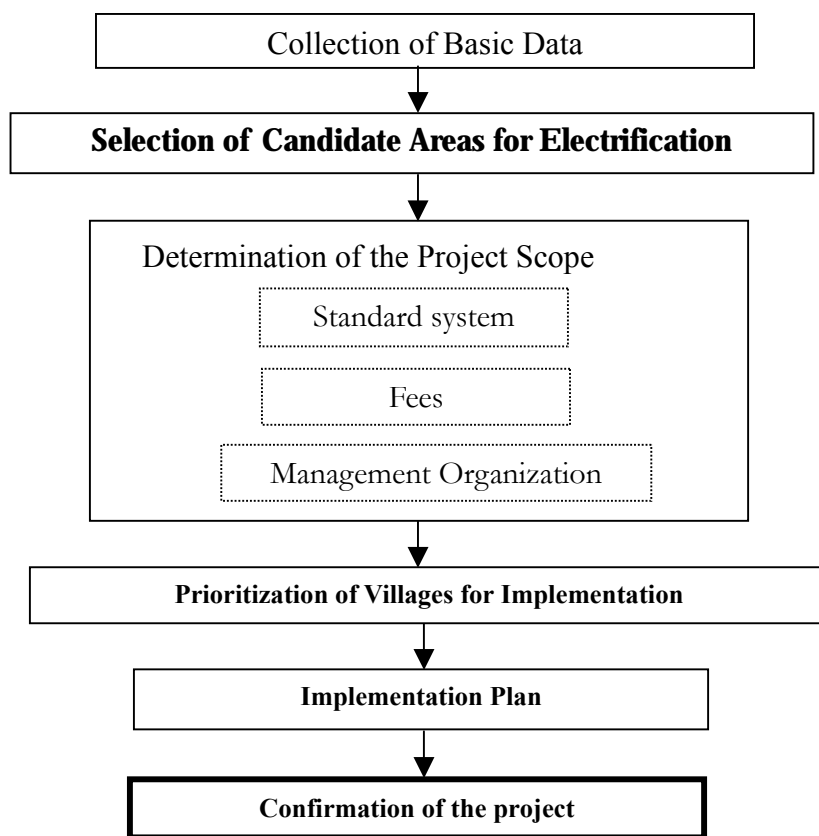
# 1. General process flow of the rural electrification project

General process flow of the rural electrification project is described as follows. The project promotion steps are indicated to show how they relate.



To implement the rural electrification project, it is necessary to make a specific project plan considering scope, site and cost. This work is planning. The flow of planning is shown in the diagram below. First, basic data needed to determine the scope of a project and sites are collected. Based on these data, an area to implement rural electrification project is selected. Then the appropriate scope of the project, such as the standard system, fees and management organization, etc., is studied. Next, the appropriateness of the planned project is verified through economic analysis, etc., and the scope of the project is determined. Finally, to decide on the project, a priority order of areas selected for the project is determined, necessary costs are calculated, and a financial plan is made.

**< Flow of planning >**



[Points for Planning]

(1) Sustainable project

A sustainable project is a system that is carefully maintained for a long time. Project cost, such as system cost and maintenance cost, is collected as an electricity charge or a service charge. When the government starts a rural electrification project, the most important issues are funds and technical foundation. There are many fund options such as grant support and

various loans. It is desirable that the necessary cost is collected from residents and through government assistance in promoting a project. It is also important to decide on the electricity charge by considering capability of resident payment. For technical foundation, it is desirable that installed systems are easy to handle and maintain, as residents are not familiar with the system or with electricity. Furthermore, it is important to establish an organization that trains, educates and provides technical support for the site engineer, to maintain the systems for a long time.

(2) Clarification of the project objective

It is important to clarify the role, policy and objective of rural electrification projects for planning and implementing. The project scope, such as system design, fee setting and management organization should be studied according to the policy and the objective. If the policy and the objective are not clear, the project will become unfocused project.

(3) Collection of appropriate data

As planning is carried out based on the collected data, appropriate data is needed. These data can be collected from the related authorities using various ways such as interview and questionnaire survey. For data collection, it is important to select items and effectively pick necessary data for compilation and arrangement. It is also important to verify the reliability of the data.

(4) Project evaluation

It is important to evaluate a planned project considering the appropriateness of content and problems. This work should be carried out before implementation of a project. If funds are procured from international organizations, etc., the results of project evaluation will be reflected for financing examination by these organizations.

## 2. Concept of the manual

Rural electrification, which is described in this manual, is included not only in the Missionary Electrification Development Plan (MEDP) decided by EPIRA, but also in the expansion of the electrification area where the existing grid line is extended by the Distribution Utilities.

This manual concentrates on the following points:

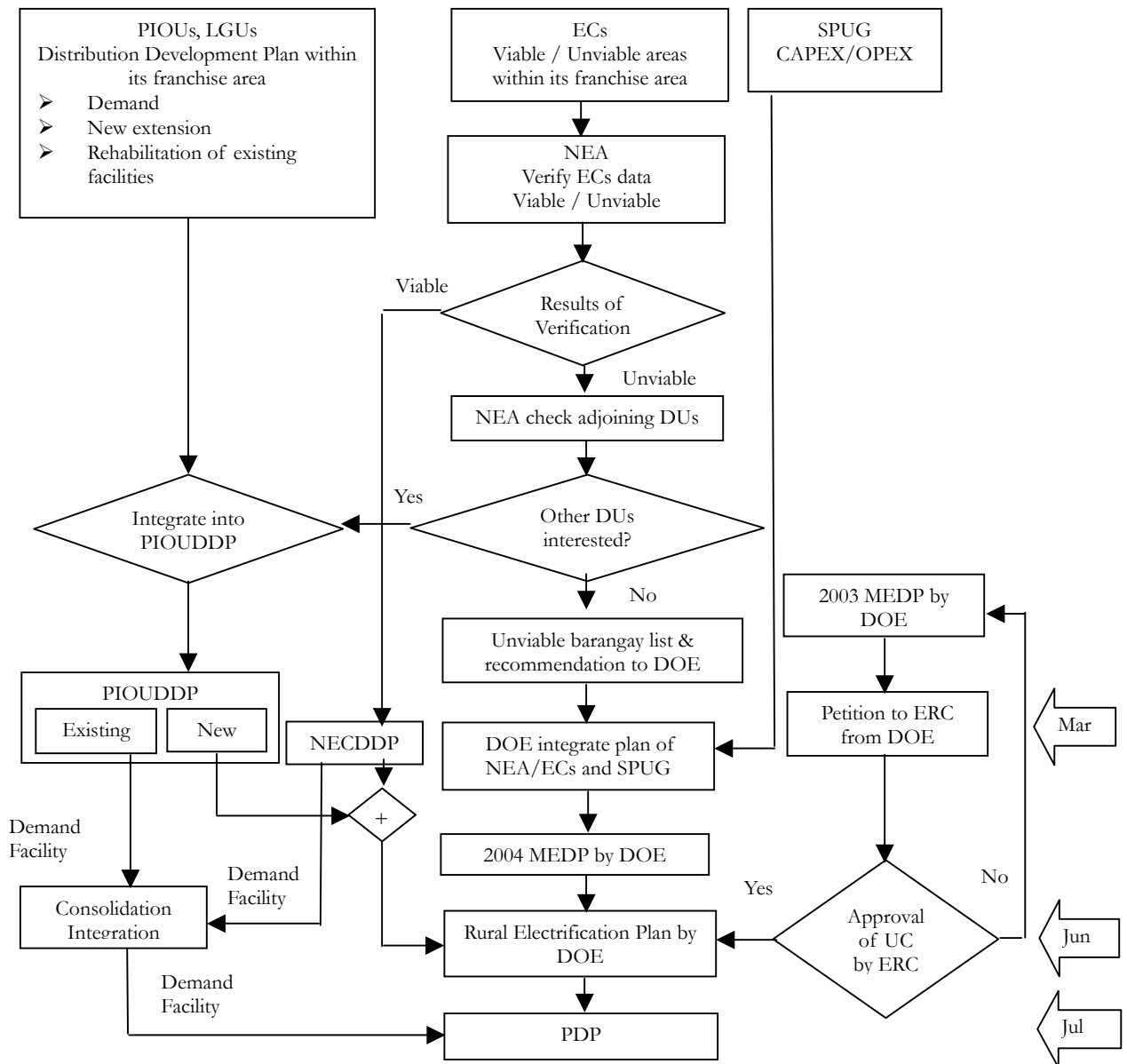
- Work flow and schedule
- Responsibilities of the organizations concerned in rural electrification

This manual has been created to prepare rural electrification plans. However, the prepared plan based on this manual is not for evaluating individual plans. This plan provides a comprehensive view of rural electrification in the Philippines. The rural electrification plan is a subordinate plan of PDP and is prepared so that the necessary data of this plan are considered as being consolidated into PDP and PEP. PDP and PEP has to show a prospect of power development to private sectors. Therefore, the manual is prepared from the perspective of both the customer and the investor. It is not prepared from the perspective of the supplier. The procedure for preparing the manual is described in the following paper.

### 3. Workflow and organization concerned

#### 3.1 Workflow of preparation of the rural electrification plan

The workflow for the preparation of rural electrification is described in Fig. 3.1.



**Fig. 3.1 Workflow of preparation of the rural electrification plan**

Based on this workflow, the key points are as follows.

- (1) Classification of viable / unviable barangay in the franchise area of the distribution



utilities and NEA/ECs.

The distribution utilities and NEA/ECs classify all unenergized barangays as viable / unviable in their the franchise area. The criteria of classification are given below.

- 1) Grid extension
  - It is comparatively easy to access the existing grid network.
  - Grid extension is the most economical.
  - The number of customers is comparatively high.
- 2) Introduction of new and renewable energy systems
  - Location of the barangay is far from the existing grid network

General criteria are as follows:

Land/coastal area : 10 km or more from the existing grid

Mountainous area : 3 km or more from the existing grid

Island area : 1 km or more from the existing grid

  - Number of customers exceeds 20
  - Customers who can pay fees

### **3.2 Confirmation of contents of the submitted document from the subordinate organization by NEA/DOE**

NEA evaluates and integrates the unenergized barangay list, which is classified and prepared by ECs and submitted to DOE. On the other hand, DOE evaluates and integrates the electrification plan, which is submitted directly from the distribution utilities and the local government utilities.

### **3.3 Investigation of electrification method of unenergized area by NEA**

Based on the unenergized barangay list by the ECs, according to the promotion management map on NEA, NEA asks the adjoining ECs about the availability of grid extension. If the adjoining ECs decide to extend the grid line, these nominated barangays are added to the grid extension list (viable list). If the distribution utilities are not interested, the names of these barangays are kept on the unviable barangay list.

### **3.4 Consolidation of each electrification plan by DOE**

DOE consolidates the viable/unviable barangay list from NEA, the electrification plan of the distribution utilities and the SPUG plan (OPEX and CAPEX is included), and prepares the rural electrification plan.

### 3.5 Appraisal and approval of the universal charge by ERC

Based on MEDP, DOE petitions ERC for a universal charge to implement rural electrification. DOE confirms the results of the appraisal of the universal charge by ERC. Based on these results, DOE reviews the plan if necessary.

### 3.6 Responsibilities of the organizations concerned

Various governmental organizations and power companies etc., promote rural electrification. Therefore, to achieve the target of barangay electrification, it is important that there is mutual communication among these organizations and that the responsibilities of each organization are clarified at each step of the workflow. The relation of the organizations concerned is described below.

**Table 3.1 Related organizations**

Organization	Prepared Plan	Responsibilities	Fund Source
DOE	MEDP DDP	Preparation of PEP (Philippine Energy Plan) and PDP (including subordinate plans) Promotion of utilization of indigenous and renewable energy Promotion of rural electrification	ER1-94 National Budget
NEA-EC	NEA	Management of ECs Improvement of ECs operation Promotion of electrification by grid extension	NEA Budget ECs investment
	EC	Preparation of electrification plan in its franchise area Promotion of electrification by grid extension	
NPC-SPUG	MEP	Promotion of electrification in the missionary area (management of UC use) Management of existing facilities	UC
ERC		Appraisal and approval of universal charge	
PNOC-EDC		Promotion of electrification by introduction of renewable energy	PNOC-EDC own ER1-94 National Budget
PIOUs	PIOUDDP	Promotion of electrification by grid extension Collection of universal charge from beneficiaries	PIOUs own ER1-94

#### 4. Preparation schedule of rural electrification plan

Benchmarks in the preparation of the rural electrification plan are as follows.

15<sup>th</sup> Mar: Submission of electrification plans to DOE from the organization concerned

End of June: Approval of the universal charge / finalization of MEDP / consolidation with PDP

15<sup>th</sup> Sep: Opening of list of unviable barangays

The schedule of rural electrification preparation is described in the following chart.

## 5. Key points in preparing the rural electrification plan

### 5.1 Data collection

- Basically, by 15<sup>th</sup> of Mar, NEA/ECs and PIOU (Private Investor Owned Utilities) submit their own plan to DOE. To do this, NEA collects the necessary data from EC and makes a decision on viability. Finally, viable barangays are listed in NECDDP (grid extension plan) and unviable barangays are listed in the missionary electrification plan.
- PIOU prepare their own plan; however, this plan includes the new electrification of unenergized areas and rehabilitation of existing facilities. DOE only considers integrating new electrification plans into the rural electrification plan. However, PIOU make a decision on viability in preparing the viable/unviable list.
- Format for collecting data will be attached.

Regarding the distribution plan, which is submitted by the distribution utilities, demand forecast and the facility plan are evaluated, and necessary data are transferred to the fixed format, which is distributed by DOE.

### 5.2 Evaluation of subordinate programs

- DOE consolidates the list of unviable barangays, which is submitted by NEA/EC and PIOU, and prepares MEDP adding CAPEX (Capital Expenditure)/OPEX (Operation Expenditure) and new SPUG installation.
- Rural electrification, which consolidates MEDP, NECDDP by NEA/EC and DDP by PIOU, is finalized in July and consolidated into PDP.
- SPUG prepares the management and operation plan of the existing facilities and calculates OPEX and CAPEX. SPUG also prepares the new installation plan and submits it to DOE.
- DOE evaluates the validity of the new installation plan and contents of OPEX/CAPEX. After evaluation, DOE submits the rural electrification plan to ERC.

### 5.3 Consolidation with PDP

- For an unviable barangay electrification plan, MEDP is prepared based on the introduction of an individual power source. MEDP is combined with the grid extension plan, which is part of NECDDP by NEA and DDP by PIOU, to make the rural electrification plan.

- The facility plan and demand forecast of DDP, which are prepared by the distribution utilities and rural electrification plan, will be integrated into PDP. Demand forecast will be used for checking the demand forecast using macro demand analysis.

#### **5.4 Petition for the universal charge**

- Criteria of prioritization of MEDP projects will be clarified and described.
- The portion of OPEX, which is required during existing operation hours for the existing diesel facilities, is evaluated for application of appraisal by ERC.

#### **5.5 Promotion of practical electrification**

- DOE submits PEP to Congress of the Philippines on 15<sup>th</sup> of Sep. Parallel to this, the new MEDP list and the existing SPUG facility list are opened to QTP (Qualified Third Parties) and Distribution Utilities.
- If QTP can assist financially, electrification will be promoted using QTP funds and will be deleted from the MEDP list. If QTP do not participate, SPUG assumes care of the barangays on the MEDP list and prepares MEP (Missionary Electrification Plan) using the universal charge. CAPEX and OPEX will be included in this plan.
- MEP is submitted to ERC to obtain approval for UC use. At this stage, when ERC approves UC, practical rural electrification is promoted.
- If UC is not approved by ERC, MEP will be returned to DOE and will be prioritized again as MEDP project. At this stage, barangays that are rejected by DOE are listed again in the following year's MEDP.

## 6. Basic Data Collection and database

In planning, generally, collected data are on the power system situation and village survey data. This chapter explains the forms and methods of data collection, etc.

### 6.1 Basic data collection

#### (1) Situation of power sector

The data of the related power sector are used to verify the situation of electrification and the electrification plan in the country concerned, and to select a project site. The data of electricity fees and organizations will become reference for considering the formation of a project.

##### 1) Power facilities

The existing power facilities introduced by the government or the private sector are surveyed.

- Generation : type and capacity of facilities
- Grid Network: capacity, network diagrams of transmission and distribution, electrified area by grid (including future plan)
- Costs : generating cost, cost of extending transmission and distribution lines.

##### 2) Future plans

The expansion plans of power facility that will be constructed in 5 years by the government or by the private sector.

- Generation : type and capacity of facilities
- Grid Network : capacity, network diagrams of transmission and distribution, electrified area by grid (including future plan).

##### 3) Management organization

The system, personnel and managing conditions of the organizations that supply power is surveyed.

- System : organization chart, location of branch, related organizations

- Personnel : the number of employees and engineers
- Managing conditions : businesses, income and expenditure, wages
- Training : method, program

#### 4) Electricity fees

The rules of power supply, contracts, electricity fees and collection method are surveyed.

- Rules and contract : contents of rules and contract, action in the case of non-payment.
- Electricity fees : sums of each contract, reasons for and method of fee setting.
- Fee collection : collector, period.

#### b. Data collection methods

Some methods to collect data are shown below. Data is usually collected by Methods 1) and 2).

- 1) Directly from an organization that supplies power
- 2) From a governmental organization that manages power sector organization or makes an electrification plan
- 3) From a local governmental organization

#### (2) Village society data

Village society data could be reflected to consider a general view of the project, such as selection of project candidate areas, system design, management organization, and fee setting.

#### a. Data item

##### 1) Statistic data

- Population, number of households, electrification rate, income level, etc.

##### 2) Situation of rural area village

- Location of houses, number of rooms in a house, organizations in the village, main industry, etc.

##### 3) Use of electricity and lighting:

- Use of independent power sources, conditions of electric appliances and lighting equipment, etc.

#### 4) Residents request

- Residents request the local governmental organization or the electric authority, usage hours of electric appliances, affordable electricity fees

#### b. Data collection methods

There are several methods of collecting data as follows. The data can usually be collected by Method 1). Methods 2) and 3) will be used to obtain detailed data.

- 1) Data that have been compiled as statistical data.
- 2) Interviews with or questionnaire surveys of the local organizations concerned.
- 3) Interviews with or questionnaire surveys of several villages selected at random.

#### c. Data collection format

Regarding information and data collection for power sector, DDP data collection format is applied. Whereas, village social data is a different point of view and these data are reflected to study number of potential customer, demand forecast etc. Therefore, common format for data collection is needed to prepare. Through this study, we found that NEA has a useful format. The following materials indicate sample formats which NEA use for barangay survey.



**Fig 6.1 Social baseline data collection format by NEA (No.1)**

<b>National Electrification Administration</b>			
Survey on Barangay Profiling/Identification of Energy Resource in a Barangay			
EC NAME: _____			
<b>A. General Characteristics</b>			
Name of :	Barangay _____	Municipality _____	Province _____ Region _____
Brgy. Classification :	Inland _____	Upland _____	Coastal _____ Island _____
Total land area :	_____ sq. km.	Number of Households :	_____ Total Population :
No. of Sitios in the barangay :	_____	No. of Houses :	_____
Presence of :	School/s _____	Health/Medical Center _____	Other Public Bldg/s. _____
<b>B. Socio-Economic Information</b>			
Transportation :	Jeep _____ Tricycle _____ Motocycle _____ Boat _____ Animal _____ Others _____	Major Produce :	Rice _____ Corn _____ Coconut _____ Vegetables _____ Fruits _____ Others _____
Livelihood Activities :	Grain Mill _____ Copra Drying _____ Vulcanizing, Motor Shop _____ Furniture Making _____ Handicrafts _____ Fishing _____ Others _____	Recreational :	Movie House _____ Billiard/Pool _____ Pvt VCR _____ Beerhouse _____ Videoke _____ Others _____
Local Organizations :	_____ Government _____ NGO _____ Cooperatives _____ Women _____ Youth _____ Religious _____ Others	Water Supply :	_____ Stream _____ River _____ Lakes _____ Wells _____ Stand Pipe System _____ Others
Livestock & Poultry :	_____ Swine/Pig _____ Cattle _____ Chicken _____ Duck _____ Others	Financial/Commercial Org'ns. _____	_____ Banks _____ Cooperatives _____ Pawnshops _____ Groceries _____ Markets _____ Others
Educational Inst.	_____ Day Care _____ Elementary _____ High School	_____ College _____ Vocational _____ Others	
<b>C. Energy Supply/Availability</b>			
Kms. away from the nearest tapping point : _____			
No. of gensets installed :	_____	Capacity :	_____
		No. of Households Served :	_____

**Fig 6.2 Social baseline data collection format by NEA (No.2)**

Commonly Used Source/s of Energy (At present) :		
Charcoal : _____ Cooking _____ Lighting _____ Ironing _____ Others _____ _____	LPG : _____ Cooking _____ Lighting _____ Others _____	Genset : _____ Water Pump _____ Lighting _____ Appliance Operation _____ Others _____ _____
Kerosene : _____ Cooking _____ Lighting _____ Others _____	Dry Cell _____ Lighting Batteries : _____ Appliance Operation _____ Others _____	Biomass, _____ Cooking Coconut _____ Ironing Husks, _____ Lighting etc. : _____ Others _____ _____
Fuel : _____ Cooking _____ Lighting _____ Others _____	Wet Cell _____ Lighting Batteries : _____ Appliance Operation _____ Others _____	Wood : _____ Cooking _____ Lighting _____ Others
Potential Sources of Energy in the Barangay :		
Type	No. of Units	Capacity
Diesel/Generator	_____	_____
Solar PV System	_____	_____
Wind System	_____	_____
Micro Hydro	_____	_____
Biomass, etc.	_____	_____
Others	_____	_____

**(3) Other rural electrification projects**

If rural electrification projects in the country concerned or neighbor countries are carried out, the system configurations and management conditions of these projects are investigated. The problems and subjects of these projects are also investigated. The other projects are useful as reference in every aspect. In particular, electricity fees of the other projects are an important factor in evaluation for setting fees.

- 1) Project content: Policy, objectives, system configuration, scope of the plan
- 2) Management system : Organization concerned, personnel, location of branch, services to be provided
- 3) Raising funds :Sources, proportion, kinds, repayment plan

- 4) Fees: Fee setting, fee collection method, refund target
- 5) Engineer training: Organization, program of implementation, situation
- 6) Management condition: Income and expenditure of the project
- 7) Subjects: Problems and subjects experienced through the project.

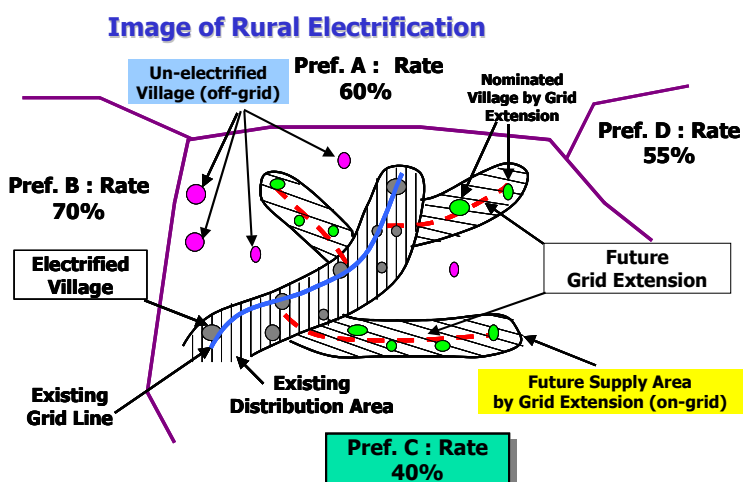
## 6.2 Database

Basically, the objective of the rural electrification project is to electrify unenergized areas, thus all unenergized areas in the Philippines are candidates. Therefore, selecting and prioritizing candidates are issues to be considered. Moreover, if the current situation is unenergized, the area has recently been electrified. Thus, duplication of future plans and postponement of the existing plan must be avoided. On the other hand, the management of actual project promotion is also important. Here, the current situation of the database and the map to manage project promotion is described.

### (1) Concept for electrification promotion

Basic concept of rural electrification promotion is described below.

- 1) Select prefecture (municipality) with a lower rate of electrification than the administrative unit.
- 2) Write the existing power system on a map of the selected prefecture (municipality). The areas electrified by distribution lines are colored.
- 3) Write plan of the transmission and distribution line on the above-mentioned map, according to the expansion plans, for the next 3 years. The target barangays for grid extension are indicated in green circle.
- 4) Uncolored areas in the map are candidate areas for missionary electrification. The target barangays for off-grid electrification are indicated in red circle.



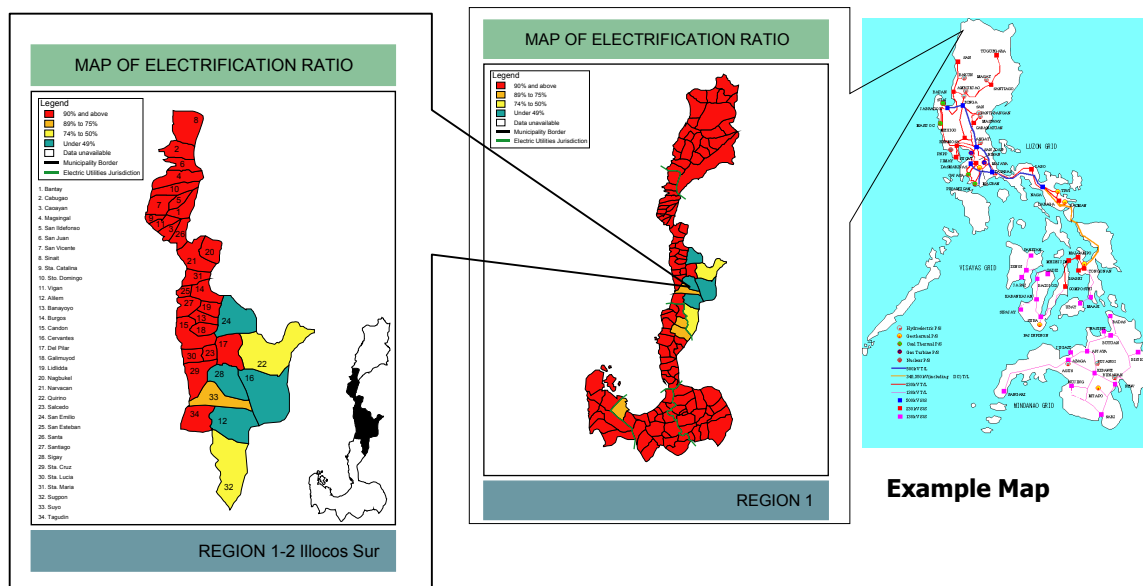
As a result, for planning and promoting rural electrification, exact location of the target barangay and exact root of the distribution network is important.

(2) Map for project management and planning

The rural electrification project is required to prepare future plans, and in parallel, it is necessary to manage actual project promotion. From these points of view, a map that manages project promotion including the electrification rate visually is a useful tool and database for DOE. Through this project, the study team prepared a nationwide map using different colors to indicate the electrification rate by municipality level. During this survey, the study team found a nationwide map that indicates barangay boundaries. Therefore, the study team will select some sample areas and make distribution network roots as a sample based on the NEA chronicle. Finally, the study team will transfer these maps to DOE and ask to DOE to complete this map for the database.

1) Electrification rate management by municipality level

The electrification rate can be viewed for each EC or municipality as shown in Fig. 6.3. Based on this map, the nationwide differential of electrification rate can be grasped, and the preparation of the plan to correct this differential will be studied.



**Fig. 6.3 Map for the management of electrification rate by ECs and municipalities**

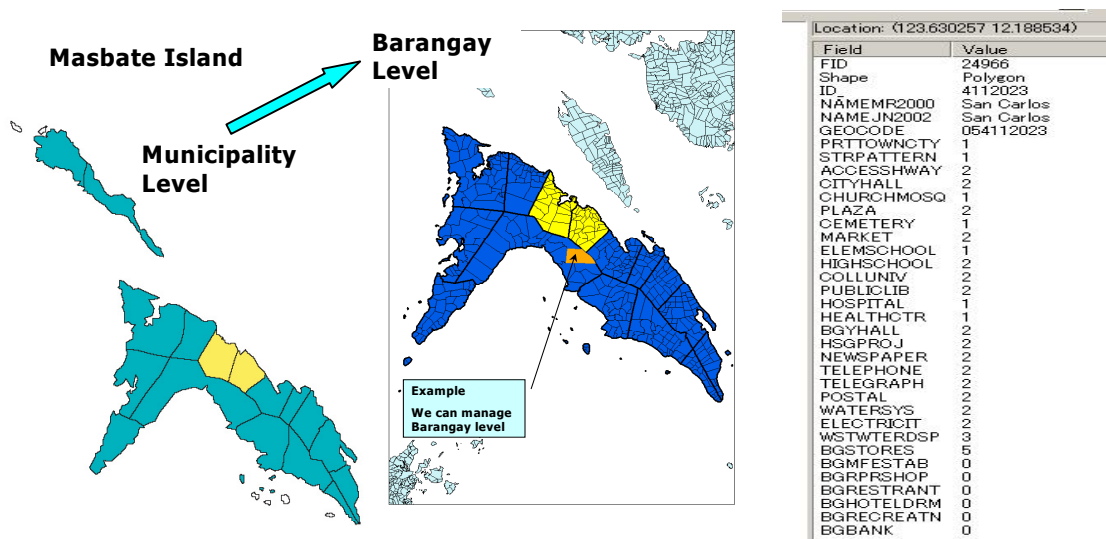
2) Electrification situation by barangay level

Using Fig. 6.4, more precise project management such as the electrification situation at barangay level can be realized. Also, color of every barangay can be changed according to an

electrification condition, for example, categorized as follows.

- Electrified by on-grid or off-grid
- How many houses are electrified?  
(% of household electrification rate) etc

In parallel, the baseline data of a barangay which is collected utilizing the above-mentioned baseline data collection format can be added and reviewed in the right-hand table in Fig 6.2.

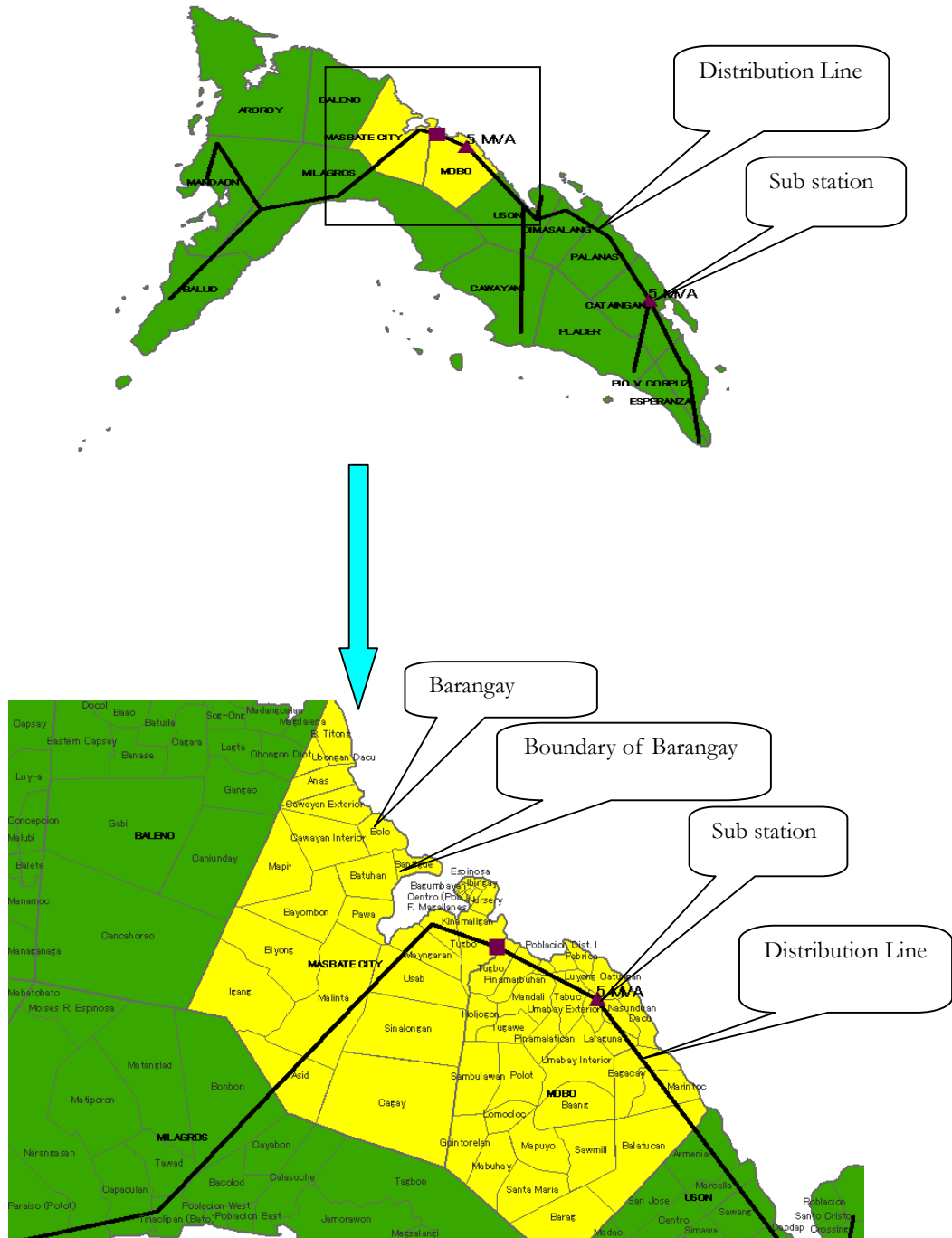


**Fig. 6.4 Map for management of electrification rate by barangay**

3) Example map with grid network

Based on the mentioned-above basic concept, to prepare electrification plan, it is important to know exact location of barangay and grid network system. According to this idea, the study team picked up Masbate and prepared a sample map with distribution lines in MASELCO franchise area. The example map of Masbate is described in Fig 6.5(a) and 6.5(b). This also makes the relation between the location of the barangay and grid network easy to understand. Here, an example for selecting electrification method using two figures is mentioned.

**Fig. 6.5(a) Map for management of electrification rate by barangay with grid line**



**Fig. 6.5(b) Map for management of electrification rate by barangay with grid line**

a) Preparation of electrification plan

First, lower electrification municipalities are nominated to give priority for electrification. In

Fig 6.5(a), green area is a lower electrification rate, which is less than 49%, than yellow area, which is 50 to 74%. Therefore, technically, municipalities in green area are given priority. From the point of view of the electrification procedure, municipality which is far from grid network is a candidate for introducing individual power system such as PV system. Whereas, municipality, which is close to grid or already grid was passed is a candidate for grid extension. From this point of view, for example, municipality Aroroy is the candidate for individual system and municipality Uson is the candidate for grid extension.

Secondly, in Fig 6.5(b), same point of view can be applied for barangay electrification. Regarding unenergized barangay, the barangay which is far from grid line is a candidate for installation of individual system. If the barangay is close to a grid line, grid extension is applied for electrification. One of method to select electrification method is economic comparison, which will be mentioned in the following chapter.

The study team adds some more information in this example GIS database such as specification of substation and distribution lines etc.

As the study team mentioned, these maps contribute not only to the investigation of future electrification plans after barangay electrification but also to practical project management. Detail instruction manual for this GIS database is attached as Annex.

## (2) Potential of renewable energy

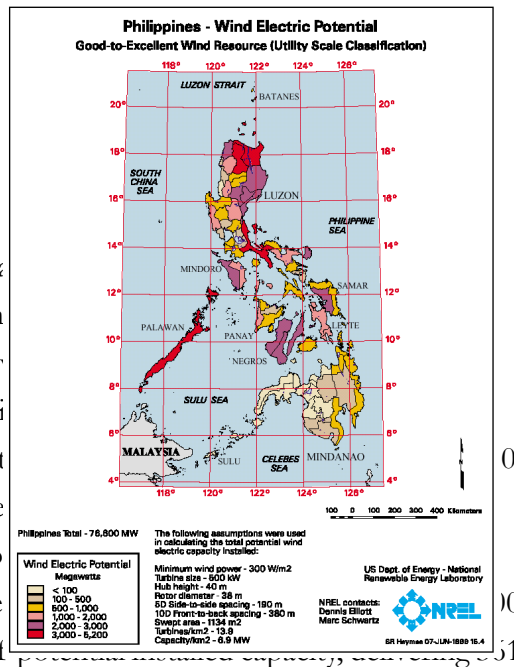
The rural areas of the Philippines such as islands and mountainous areas are difficult to access. Therefore; it is difficult to promote electrification by grid extension. In this case, the introduction of individual power systems utilizing renewable energy is useful for electrification of these areas. Here, insolation, rainfall and wind energy data are indicate and describe the utilization idea. Possibly, it is also need to collect indigenous energy such as biomass. It is better to collect these data for as long as possible, but at least 5 years is required.

### 1) Wind power (Source: Wind Energy Resources Atlas of the Philippines)

The assumption and methods for converting wind resources to wind energy potential are based on the report of [Wind Energy Resources Atlas of the Philippines] and listed in the following table. Each square kilometer on the map has an annual average wind power density, in  $W/m^2$ , at 30m-height. If the wind power density was less than  $200W/m^2$ , these grid cells (square kilometer) have insufficient wind potential for the economic development of utility-scale wind energy. Although the areas with  $100-200 w/m^2$  are not economical for



utility-scale, these areas have the potential for isolated electrification. There is estimated to be more than 70,000 MW of potential installed capacity, delivered according to the figure, there are 47 provinces out of 73 with at least 1,000 MW of wind potential and 25 provinces with at least 500 MW of wind potential. According to the figure, there are 47 provinces out of 73 with at least 1,000 MW of wind potential and 25 provinces with at least 500 MW of wind potential. To consider the areas that have a moderate wind resource for rural power applications, the estimate is 170,000 MW of wind potential over 170,000 km<sup>2</sup>. This land could support over 170,000 MW of wind potential, or 170 billion kWh per year. The figure shows 51 provinces out of 73 with at least 1,000 MW of wind potential and 64 provinces with at least 500 MW of wind potential.



### Philippines – Wind Power Potential

#### Good to excellent Wind Resource at 30m (Utility scale)

Wind resource Utility Scale	Wind Power W/m <sup>2</sup>	Wind Speed m/s	Total Area km <sup>2</sup>	Total Cap installed MW	Total Power GWh/yr
Good	300 - 400	6.4 - 7.0	5,541	38,400	85,400
Excellent	400 - 500	7.0 - 8.0	2,841	19,700	52,200
Excellent	500 - 700	8.0 - 8.8	2,258	15,600	47,900
Excellent	700 - 1,250	8.8 - 10.1	415	2,900	9,700
Total			11,055	76,600	195,200

#### Moderate to excellent Wind Resource at 30m (Utility scale)

Wind resource Utility Scale	Wind Power W/m <sup>2</sup>	Wind Speed m/s	Total Area km <sup>2</sup>	Total Cap installed MW	Total Power GWh/yr
Moderate	200 - 300	5.6 - 6.4	14,002	97,000	165,800
Good	300 - 400	6.4 - 7.0	5,541	38,400	85,400
Excellent	400 - 500	7.0 - 8.0	2,841	19,700	52,200
Excellent	500 - 700	8.0 - 8.8	2,258	15,600	47,900
Excellent	700 - 1,250	8.8 - 10.1	415	2,900	9,700
Total			25,057	173,600	361,000

\* Wind speeds are based on a Weibull K value of 2.0

[Assumptions]

Turbine Size : 500 kW Hub Height : 40 m Rotor Diameter : 38 m

Turbine Spacing : 10D by 5D Capacity/km<sup>2</sup> : 6.9MW

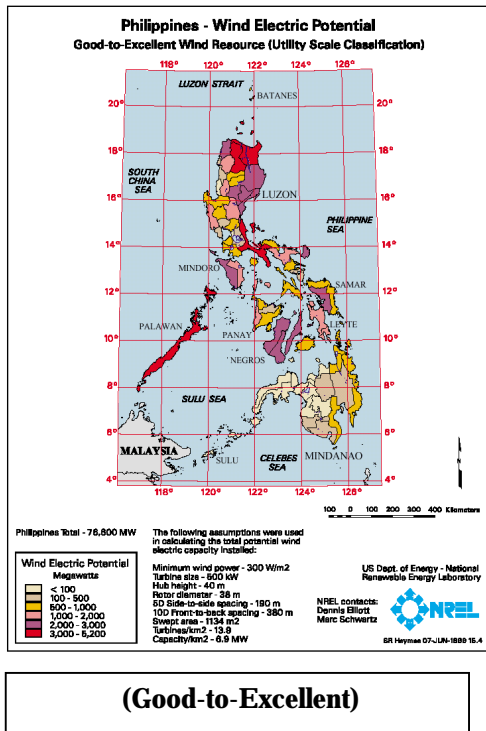


Fig. 6.6 Average Wind Energy

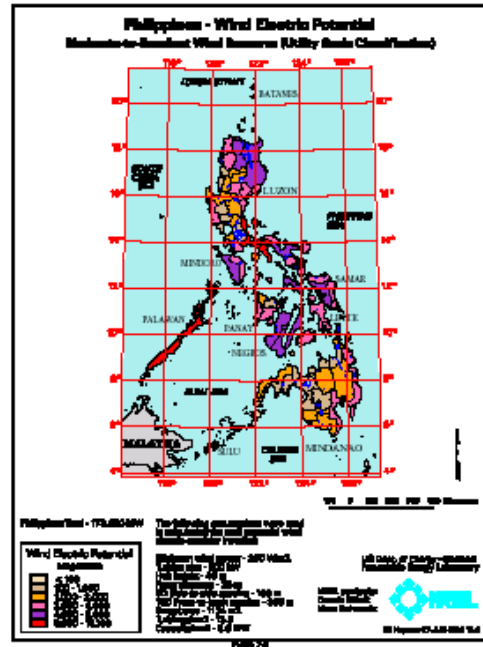
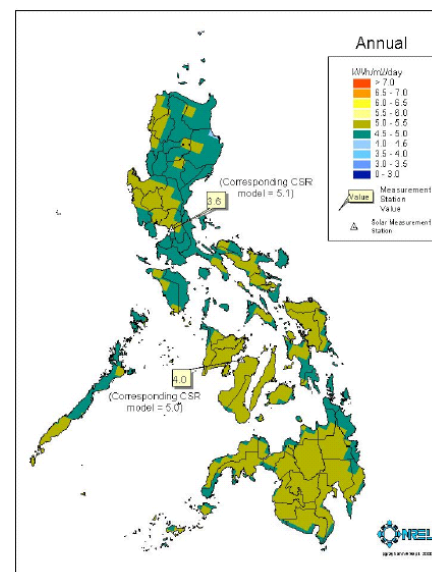


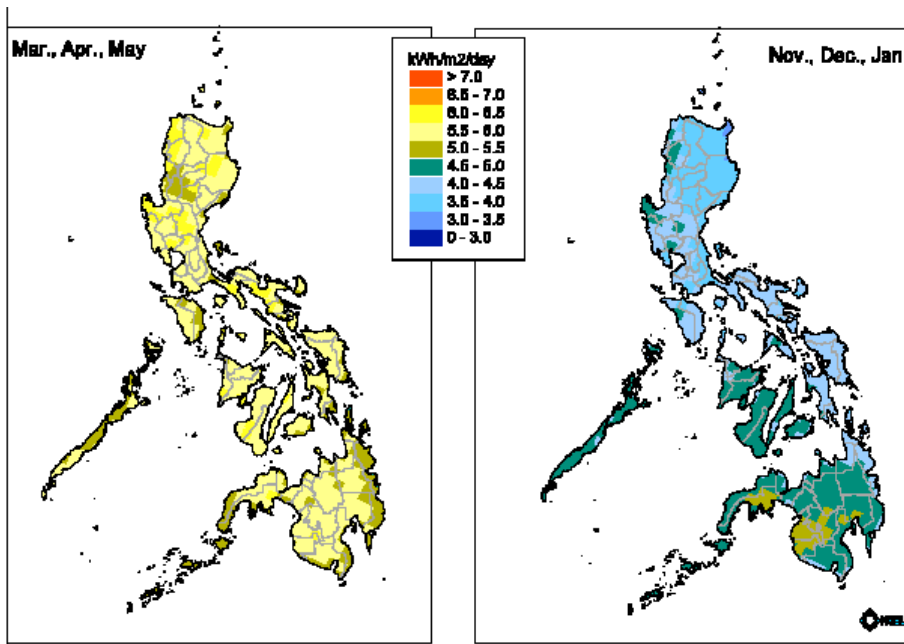
Fig. 6.7 Average Wind Energy

2) Insolation (Source: Assessment of Solar Resources in the Philippines)

Regarding insolation, the yearly average is 4.5~5.5 kWh/m<sup>2</sup> in the Philippines. It is 50% or higher than the average of Japan, which is about 3.5 kWh/m<sup>2</sup>. This data indicates that availability of the PV system is one of the useful methods for promoting electrification of barangays, which are located far from the grid line. Figure 6.8 indicates annual average and Figure 6.9 indicates the difference between the dry and rainy season.

Fig. 6.8 Annual average of Isolation

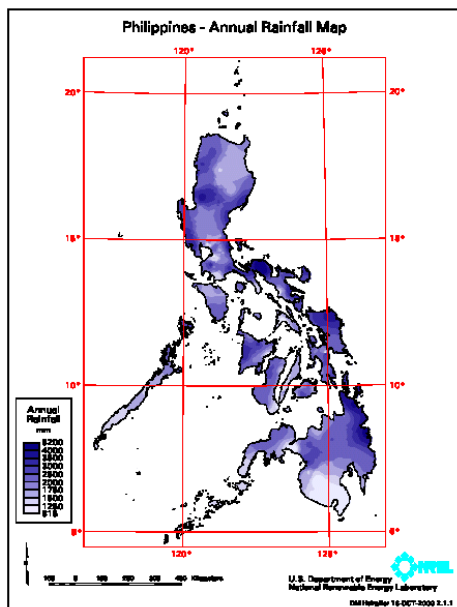




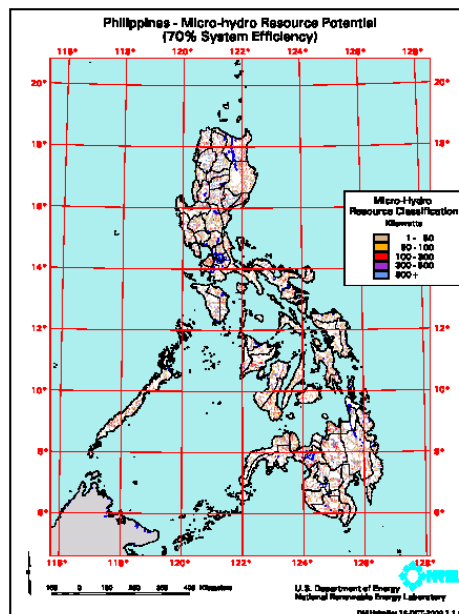
**Fig. 6.9 Difference between dry and rainy season**

3) Rainfall

The southern part of the Mindanao area and Parawan has lower rainfall than the other areas. However, the average of the other areas is relatively high, and these areas have the potential for introducing micro-hydro systems depending on the geographical condition.



**Fig.6.10 Annual rainfall**



**Fig.6.11 Micro-Hydro Resource Potential**

Data on renewable energy potential, the map of the existing grid network and the location of energized barangays are compared. These works are useful for utilizing renewable energy for rural electrification.

Detail renewable energy resources which includes insolation, rainfall and wind power studied by USAID are transferred to DOE by electronics files.

(3) Inventory of renewable energy utilization system

We need to know the location, capacity, application, installed date and current situation, etc of the inventory of the RE utilization system. The following table is a sample of data format. DOE needs to prepare this kind of format for information collection.

MICRO-HYDROPOWER PROJECTS IN THE CORDILLERAS							
REGION	LOCATION	APPLICATION	CAPACITY (kW)	PROPONENT	DATE COMMISSIONED	STATUS	
CAR	Dulao, Malibcong, Abra	Lighting	7.500	DLSU		Operational	
	Gacab, Malibcong, Abra	Lighting	20.000	DLSU		Operational	
	Mallag, Kabugao, Apayao	Battery Charging	-		08/07/96	Not Operational	
	Capuyoan, Buguias, Benguet	Battery Charging	0.100		09/15/95	Operational	
	Gadang, Kapangan, Benguet	Battery Charging	0.100		09/18/96	Operational	
	Gadang, Kapangan, Benguet	Battery Charging	0.100		09/18/96	Operational	
	Camandag, Asipulo, Ifugao	Coffee Milling	.0500	PRRM	09/14/99	Operational	
	Bangaan, Banaue, Ifugao	Rice Milling	3.000	PRRM	10/01/99	Operational	
	Batad, Banaue, Ifugao	Battery Charging	0.100		11/15/99	Operational	
	Cambulo, Banaue, Ifugao	Battery Charging	0.070		04/09/92	Operational	
	Ubuag, Hingyon, Ifugao	Battery Charging	0.030		05/01/94	Operational	
	Umalbong, Hingyon, Ifugao	Battery Charging	0.060		08/01/95	Operational	
	Abatan, Hungduan, Ifugao	Lighting	20.000	PRRM	07/23/00	Operational	
	Abatan, Hungduan, Ifugao	Battery Charging	0.100		04/01/97	Operational	
	Ba-ang, Hungduan, Ifugao	Lighting	3.000	BSU-ANEC	04/29/97	Operational	
	Ba-ang, Hungduan, Ifugao	Battery Charging	0.750	BSU-ANEC	04/12/97	Operational	
	Bokiawan, Hungduan, Ifugao	Battery Charging	0.300	PRRM	02/15/97	Operational	
	Gode, Hungduan, Ifugao	Lighting	3.000	PRRM	05/10/97	Operational	
	Magkok, Hungduan, Ifugao	Lighting	40.000	PRRM		Under construction	
	Polod, Hungduan, Ifugao	Battery Charging	0.100		04/01/95	Operational	
	Tiwan, Hungduan, Ifugao	Rice Milling	4.500		08/01/96	Operational	
	Inwaloy, Mayoyao, Ifugao	Battery Charging	0.100		09/05/95	Operational	
	Magulon, Mayoyao, Ifugao	Battery Charging	0.100		11/13/95	Operational	
	Binablayan, Tinoc, Ifugao	Lighting	0.750		12/31/95	Operational	
	Poblacion, Tinoc, Ifugao	Lighting	5.000	BSU-ANEC	01/02/98	Operational	
	Balantoy, Balbalan, Kalinga	Battery Charging	0.100		06/11/96	Operational	
	Balbalasang, Balbalan, Kalinga	Lighting	25.000	SIBAT	01/25/01	Operational	
	Bulalayaw, Balbalan, Kalinga	Lighting	7.500	KSAC-ANEC	Feb. 2000	Operational	
	Dalayap, Balbalan, Kalinga	Lighting	3.000	KSAC-ANEC		Under construction	
	Dao-angan, Balbalan, Kalinga	Lighting	20.000	DAIMI/DOE		Under construction	
	Gawa-an, Balbalan, Kalinga	Lighting	10.000	DAIMI/DOE		Operational	
	Poswoy, Balbalan, Kalinga	Lighting	25.000	DAIMI/DOE		Under construction	
	Pantikian, Balabalan, Kalinga	Lighting	25.000	DOE-KASC-ANEC		For implementation	
	Sesecan, Balbalan, Kalinga	Lighting	8.000	KSAC-ANEC		Operational	
	Salagsag, Balbalan, Kalinga	Lighting	30.000	LGU-Municipal		For implementation	
	Western Uma, Lubuagan, Kalinga	Lighting	20.000	DAIMI/DOE		Under construction	
	Lower Uma, Lubuagan, Kalinga	Lighting	15.000	DAIMI/DOE		Requires add'l. funding	
	Upper Uma, Lubuagan, Kalinga	Lighting	10.000	DAIMI/DOE		Under construction	
	Ableg, Pasil, Kalinga	Lighting	3.000	KSAC-ANEC(demo project)	1999	Operational	
	Bulanao, Tabuk, Kalinga	Lighting	3.000	SIBAT/Pastoral Council	1998	Operational	
	Guilayon, Tabuk, Kalinga	Lighting	2.000	KSAC-ANEC(Thesis)		Not Operational	
	Dananao, Tinglayan, Kalinga	Lighting	30.000	SIBAT		Operational	
	Ngibat, Tinglayan, Kalinga	Lighting	5.000	MRDC	01/01/93	Operational	
	Sumadel, Tinglayan, Kalinga	Lighting	50.000	LGU-Barangay		Requires add'l. funding	
	Balintaugan, Bauko, Mt. Province	Battery Charging	0.100		12/30/95	Operational	
	Poblacion, Natonin, Mt. Province	Lighting	1.200		01/01/91	Operational	
	Poblacion, Natonin, Mt. Province	Battery Charging	0.100		11/01/95	Operational	
	<b>TOTAL</b>			<b>346.550</b>	<b>kW</b>		

#### (4) Unenergized barangay list

For preparation of electrification plan, it is important to grasp exact situation of unenergized barangay for barangay electrification planning. To apply this, through this study, the study team got unenergized barangay list from NEA. An example of list is shown below. The electronics file is transferred to DOE.

NATIONAL ELECTRIFICATION ADMINISTRATION  
 REGION VI - GUIMARAS ELECTRIC COOPERATIVE, INC. (GUIMELCO)  
 PROPOSED BARANGAY ENERGIZATION SCHEDULE (2002-2005)  
 As of June 2002

YEAR	NO.	TAPPING POINT		BARANGAY CLASSIFICATION	FEASIBILITY (Road Network, Transportation, Security, etc.)	BARANGAY	MUNICIPALITY	CONGRESS DISTRICT	IDENTIFIED CONN.	INITIAL CONN.	KMS.	
		SITIO/BRGY.	POINTING/SCHED OF EN.								3-Ph	2-Ph
2002	1	ALEGRIA		COASTAL		SAN ISIDRO	SIBUNAG	LONE	313	22		5.10
	2	BUBOG		COASTAL		SABANG	SIBUNAG	LONE	291	25		5.00
	3	SEBASTE		COASTAL		BUBOG	SIBUNAG	LONE	129	33		1.30
	4	SEBASTE		COASTAL		SEBARIO	SAN LORENZO	LONE	232	45	2.20	
	5	LINGUAN		INLAND		SAPAL	SAN LORENZO	LONE	265	12		
	6	SUPANG		INLAND		SAN PEDRO	BUENAVISTA	LONE	136	12		
	7	NAZARETH		INLAND		TINADTARA	BUENAVISTA	LONE	244	23		
	8	MABINI		INLAND		TAMINLA	BUENAVISTA	LONE	131	12		
						Sub-total			1,741	184	2.20	11.40
2003	POPS	SAN ROQUE		COASTAL		LAPAZ	NUEVA VALENTIN	LONE	360	58		
						Sub-total			360	58	0.00	0.00
2004	1	TANGLAD		INLAND		AYANGAN	SIBUNAG	LONE	215	28		
	2	MILLAN		INLAND		TANGLAD	SIBUNAG	LONE	150	23		
	3	SEBARIO		COASTAL		IGCAUAYAN	SAN LORENZO	LONE	204	23		3.00
						Sub-total			569	74	0.00	3.00
2005	1			ISLAND		INAMPOLO	SIBUNAG	LONE	43	32		
	2			ISLAND		GUIWANON	NUEVA VALENTIN	LONE	312	27		
	3			ISLAND		PANOBOLO	NUEVA VALENTIN	LONE	159	32		
						Sub-total			514	91	0.00	0.00
	14					Grand Total			3,184	407	2.20	14.40

- Every year, these lists need to revise by reflecting a result of practical project promotion. This revised list is a material for preparing electrification plan.
- Already electrified barangays are needed to delete their name from the unenergized barangay list. On parallel, this information is reflected into the GIS mapping database review.
- Information of unenergized barangays which are nominated to electrify is checked their situation such as location, social condition etc using GIS database. .

These works are useful to evaluate SPUG's list and to prepare MEDP and DDP.

## 7. Selection of optimum electrification procedure

Regarding rural electrification, grid extension and individual systems such as PV, Micro-hydro, Biogas and Diesel are considered to electrify. The method adopted is considered for the nominated area. To do this, the parameters, which are scale of the target village, and demand and distance from the grid line are first set. In general, based on power-generated cost, economic feasibility is compared among electrification methods and the optimum method that has the least generated cost is selected. Here, the basic concept of the economic evaluation in selecting the electrification method is explained using a sample case of PV and grid. Detailed information is given in another version.

### 1) Basic concept for selection

When plant and equipment investment is to be made, economic analysis is very important. When a decision is made and once a facility is constructed, facilities whose funds have been invested cannot be replaced even if an unexpected event should happen. Hence, in developing a facility plan that provides the basis of investment, various conditions should comprehensively be identified and considered. In this case, economic analysis is used in fields where certain quantifiable aspects of alternative facility plans are examined. One feature of this analysis is that, under a given condition, all costs, which are needed in planning alternative facilities, are identified to produce case studies, and where the total sum of the present values of these costs is minimal, it is judged to be optimal. Aspects that cannot be quantified are considered to make the final plan.

For example, when planning a complicated power source development, demands are assumed, and to keep constant supply reliability, various factors for new power sources such as hydro, thermal and nuclear power plants are provided. According to these assumptions, a new power source is set up to satisfy the reliability considering repair and maintenance plans. The sum of the present values of the fixed cost for the new power source and the fuel expenses of the new and existing facilities is the lowest, and the case is considered the best mix of power source development.

### 2) Basic concept for economic evaluation

When investment in equipment (including the purchase of a house, etc.) is to

be made by a person or an enterprise, funds are procured from a bank, etc. With a person, this investment provides security as compensation. With an enterprise, the investment provides profitability as compensation. Procured funds must be repaid within the predetermined term. There are various repayment methods including the fixed installment method, fixed percentage method, and methods with some exceptions. In any case, the total sum of the present values of the payments within the term at interest rate “i” is the same. For example, if procured funds “A” are paid back immediately, the repayment is “A.” In extreme cases, if repayment is to be made after “n” years, the present value of the repayment at the time is  $A \times (1+i)^n / (1+i)^n = A$ , and there is no difference. However, the repayment at the time is necessarily  $A \times (1+i)^n$  that includes interest. In an economic calculation, it is convenient to use a method in which the annual repayment plus interest is the same every year throughout the repayment term. In this case, the total sum in present value “A” for “n” years of repayment period is given by

$$A = \sum_{n=1}^n \frac{a}{(1+i)^n} = \frac{(1+i)^n - 1}{(1+i)^n i} a$$

and “a” is given by

$$a = \frac{(1+i)^n i}{(1+i)^n - 1} A$$

Coefficient  $(1+i)^n i / ((1+i)^n - 1)$  is called the Capital Recovery Factor (hereinafter called CRF). A PV system comprises various components having different lives, such as the PV module, inverter, controller and battery. Hence the annual cost of each component is calculated by applying different CRF, which reflect the different lives of various components, and the facility cost of the PV system is determined by calculating these annual costs. When inflation “f” is taken into consideration,  $(1+f)^n$  that considers inflation for the period of replacement of each component should be reflected in the initial acquisition cost. In addition to these, personnel expenses and repair and maintenance expenses are needed to operate and manage PV system. Normally, the former facility cost is fixed and is called the fixed cost. The latter expenses fluctuate depend on the conditions of respective components and are called variable costs. All fixed and variable costs relating to the PV system should be identified and calculated for the useful life of the major component, here, 20 years of useful life of the PV module. The annual expenses comprising the fixed costs and the variable costs are converted to



the present value by applying interest rate “i.” Then the total sum of expenses over the useful life is obtained. When this total sum of expenses is multiplied by CRF, the annual expenses equalized over the useful life are obtained.

Interest rate “i” usually changes depending on business fluctuation. When business activity revives and there is fear of inflation, interest rate “i” rises. When business activity slackens, interest rate “i” is reduced to encourage investment in equipment. It is therefore important to invest with due attention to interest rate trends.

A) Assumption of demand

The electric appliances used in rural area are mostly fluorescent lamps and TVs. The capacity of these electric appliances and duration time are indicated in the table and the load pattern is indicated in the figure

Electric appliances and duration

	Appliances	[W] (a)	No (b)	Avarage Duration (c)	Eff. (d)	[Wh]
Night	Flourescent	9	3	2	1.0	54.0
	TV	24	1	2	1.0	48.0
	Night Total	-	-	-	-	102.0

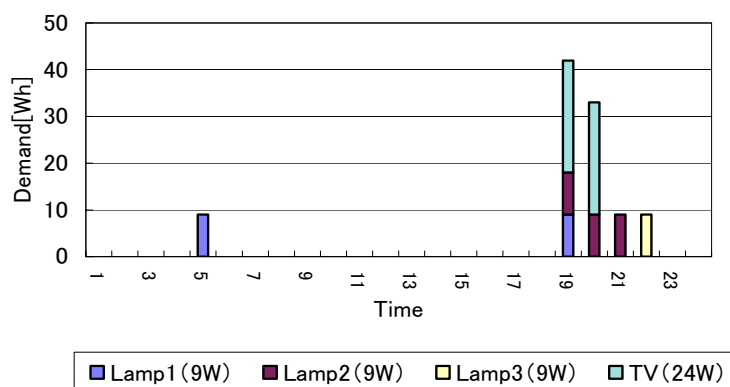


Fig. 7.1 Assumption of daily power usage pattern

2) Calculation of power generated cost

Here, for example, based on the generated cost, the PV system and grid extension are

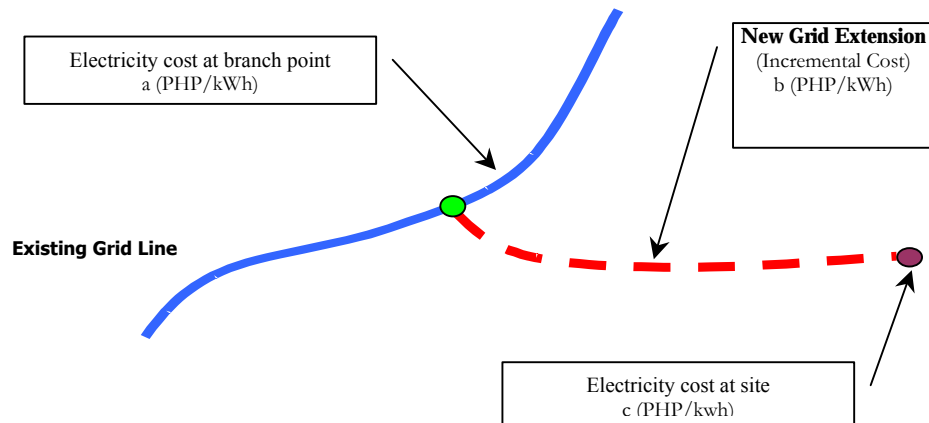
economically compared. To compare generated cost, the same amount of demand is assumed for both generation systems.

A) Grid extension

Assumption is indicated in the following table.

Grid Extension + Mini Grid			
Grid unit cost	475	P1000/km	Yellow-boxed figures are variables.
Length of Grid extension	25.0	km	
Grid extension cost	11,875	P1000	
Annual maintenance cost	10%	of Grid cost	Electricity cost at branch point
	1187.5	P1000	
Electricity cost	0.004	P1000/kWh	
Transformer CIF (10kVA)	0	P1000	estimated
Transformer tax	0	46% of CIF	
Transformer market price	0	P1000	
Annual demand/household	37	kWh/year	
Total demand	6,329.1	kWh/year	
Daily demand	0.102	kWh/day	
No of household	170	households	
Length of distribution line per hh	0.05	km	estimated
Distribution cost	238	P1000/km	estimated
Service wire cost (20m)	1.5	P1000	
Distribution loss	8%		
Discount rate	6.5%		estimated
Calculation term	20	years	

<Image of generated cost for grid extension>



$$C \text{ (PHP/kWh)} = a \text{ (PHP/kWh)} + b \text{ (Incremental cost) (PHP/kWh)}$$

Based on this assumption, the generated cost is calculated using 20 years' total cost and is shown in the following table. According to the results, in the case of 25 km of grid extension

and 102 Wh/day of demand, the power-generated cost is 0.37P1000/kWh.

Generated cost for grid extension

	PW factor	Initial	Maintenance Elect. Cost	Total	Total PW	Demand	Demand PW
0	1.00	12,142		12,142	12,142		
1	0.94		1,188	25	1,213	1,139	6,329
2	0.88		1,188	25	1,213	1,069	6,329
3	0.83		1,188	25	1,213	1,004	6,329
4	0.78		1,188	25	1,213	943	6,329
5	0.73		1,188	25	1,213	885	6,329
6	0.69		1,188	25	1,213	831	6,329
7	0.64		1,188	25	1,213	780	6,329
8	0.60		1,188	25	1,213	733	6,329
9	0.57		1,188	25	1,213	688	6,329
10	0.53		1,188	25	1,213	646	6,329
11	0.50		1,188	25	1,213	607	6,329
12	0.47		1,188	25	1,213	570	6,329
13	0.44		1,188	25	1,213	535	6,329
14	0.41		1,188	25	1,213	502	6,329
15	0.39		1,188	25	1,213	472	6,329
16	0.37		1,188	25	1,213	443	6,329
17	0.34		1,188	25	1,213	416	6,329
18	0.32		1,188	25	1,213	390	6,329
19	0.30		1,188	25	1,213	367	6,329
20	0.28		1,188	25	1,213	344	6,329
					25,505	P1000	69,737

$$25,505/69,737=$$

In the assumption table, according to the location and geographical condition of a targeted barangay, every cost for grid extension such as extension cost per km needs to review. This work is required to every barangay which is nominated for electrification.

B) PV system

In the case of the PV system, introduction of the SHS base is described below.

Module unit cost	0.1500 P1000/W		
Module cost	1,178 P1000		
Trans cost for module	79 P1000	System efficiency	60%
Insurance for module	5.98 P1000	Irradiation	4 kWh/m <sup>2</sup> /day
Total system capacity	7,853 W		
Total module cost (CIF)	1,263 P1000		
Tax for module	126 P1000	Consecutive cloud da	3 days
Total module price	1,389 P1000	Depth of discharge	70%
System capacity/household	46 W	Battery voltage	12 V
Battery unit cost (200Ah)	14.00 P1000/piece	Day time demand	30% of daily demand
Battery lifetime	3 years		
No of battery	29 pieces	Other material costs	10% of system cost (CIF)
Total battery cost	407 P1000	Installation cost	20% of system cost (CIF)
Controller unit cost	0.35 P1000/Amp	Transportation cost	0.01 P1000/W for module from Europe
Controller capacity	628 Amp	Transportation cost	0.0025 P1000/W for controller from Europe
Controller cost	220 P1000	Transportation cost	0.0025 P1000/W for inverter from Europe
Trans cost for controller	20 P1000	Insurance ratio	0.5075% for module & controller
Insurance for controller	1.12 P1000		
Total controller cost (CIF)	241 P1000	Tax for module	10%
Tax for controller	10 P1000	Tax for controller	4%
Total controller price	250 P1000	Tax for inverter	4%
Controller lifetime	10 years		
Inverter unit cost	0.05 P1000/W		
Inverter capacity	7,853 W		
Inverter cost	393 P1000		
Trans cost for inverter	20 P1000		
Insurance for inverter	2.0 P1000		
Total inverter cost (CIF)	414 P1000		
Tax for inverter	17 P1000		
Total inverter price	431 P1000		
Inverter lifetime	10 years		
Annual maintenance cost	1% of system cost (CIF)		
System cost (CIF)	2,324 P1000	(module, battery, controller, inverter)	
Other iron materials and cable	232 P1000		
Installation cost	465 P1000		
Total system cost (CIF)	3,021 P1000		
Total system cost (CIF)/Wp	0.38 P1000/Wp		

In the case of PV system, when daily consumption is assumed as 102wh/day, the power-generated cost is 0.08P1000/kWh.

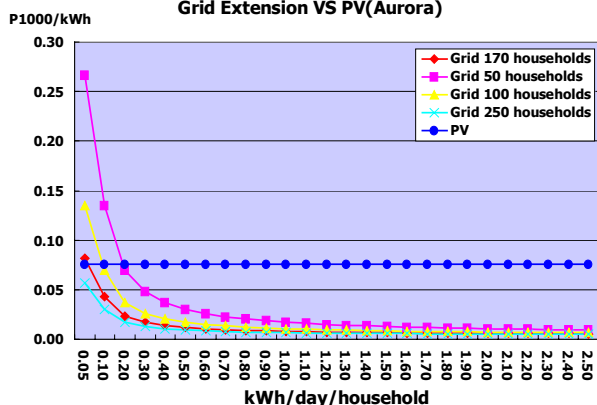
	PW factor	Initial	Maintenance Total	Total PW	Demand	Demand PW
0	1.00	3,440		3,440	3,440	
1	0.94		23	23	22	6,329
2	0.88		23	23	20	6,329
3	0.83		23	23	19	6,329
4	0.78	406.5	23	430	334	6,329
5	0.73		23	23	17	6,329
6	0.69		23	23	16	6,329
7	0.64	406.5	23	430	277	6,329
8	0.60		23	23	14	6,329
9	0.57		23	23	13	6,329
10	0.53	406.5	23	430	229	6,329
11	0.50	681	23	704	352	6,329
12	0.47		23	23	11	6,329
13	0.44	406.5	23	430	190	6,329
14	0.41		23	23	10	6,329
15	0.39		23	23	9	6,329
16	0.37	406.5	23	430	157	6,329
17	0.34		23	23	8	6,329
18	0.32		23	23	7	6,329
19	0.30	406.5	23	430	130	6,329
20	0.28		23	23	7	6,329
				5,282 P1000		69,737 kWh

$$5,282/69,737 = 0.08P1000/kWh$$

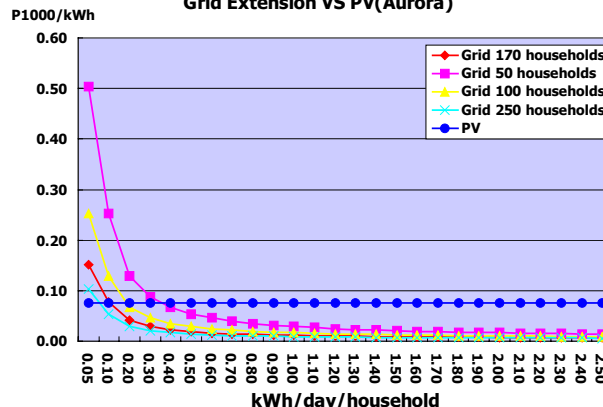
C) Sensitivity analysis

So far, based on the demand for PV system application, the power-generated cost is compared among the alternative systems. However, the assumption of the generated cost for each system to calculate the generated cost is not the same. For example, in the case of grid extension, distance from the grid was assumed to be 25 km at first; however, the generated cost was changed because of the amount of demand and the distance from the grid line. The power-generated cost is compared between the PV system and grid extension when demand changes. In addition, the power-generated cost is compared between both systems when demand is constant and the distance from grid line changes.

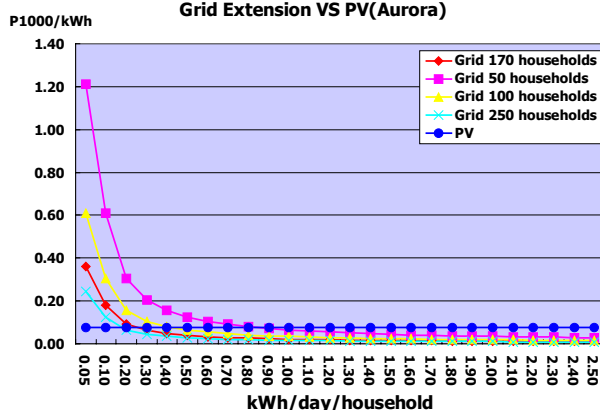
**5km from Grid Line**  
**Grid Extension VS PV(Aurora)**



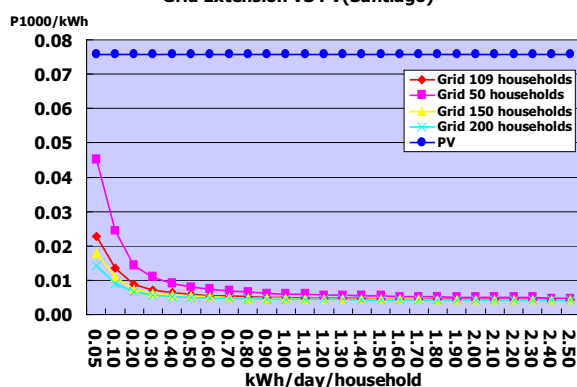
**10km from Grid Line**  
**Grid Extension VS PV(Aurora)**



**25km from Grid Line**  
**Grid Extension VS PV(Aurora)**



**0.5km from Grid Line**  
**Grid Extension VS PV(Santiago)**



According to this figure,

Number of customers: 170

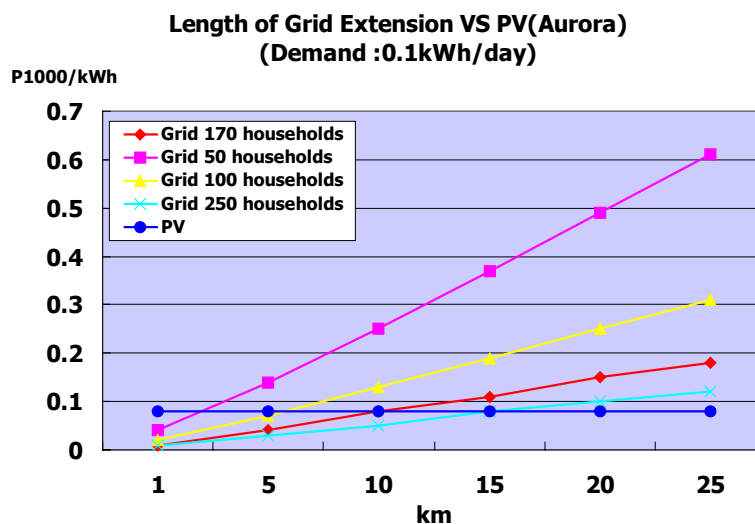
In the case of 25 km of grid extension, 0.3 kWh/day of power consumption is the breakeven point between the PV system and grid extension. When the distance is down to 10 km, the breakeven point between the PV system and grid extension is 0.1kWh/day. In the

case of 5 km, the breakeven point is 0.07kWh/day. For 500 m, the PV system has no advantage.

**Number of customers: 50 houses**

In the case of 25 km of grid extension, 0.8 kWh/day of power consumption is the breakeven point between the PV system and grid extension. When the distance is down to 10 km, the breakeven point between the PV system and grid extension is 0.4kWh/day. In the case of 5 km, the breakeven point is 0.2kWh/day. For 500 m, the PV system has no advantage.

Even when the distance from the existing grid line to the village is small, if the number of households in the village is small, the generating cost by grid extension will be expensive and the PV system has an advantage. If distance grows, the generating cost will increase in proportion to the distance. In the figure when the demand is fixed at 102Wh/day/house, the relation between grid extension and the PV system is described based on the number of customers.



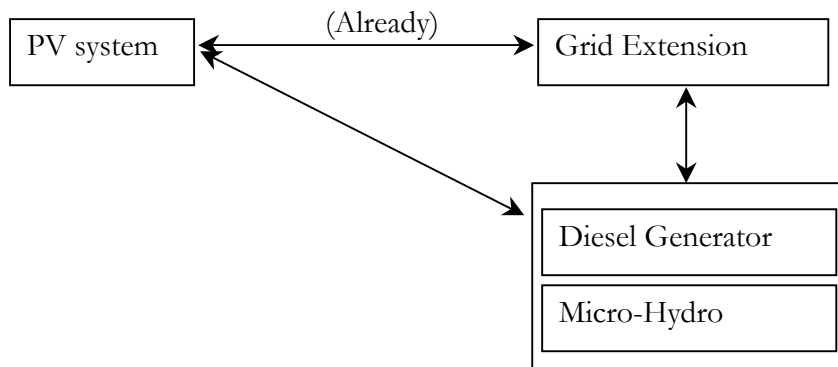
Generation cost comparison between grid extension and PV system

d) Options

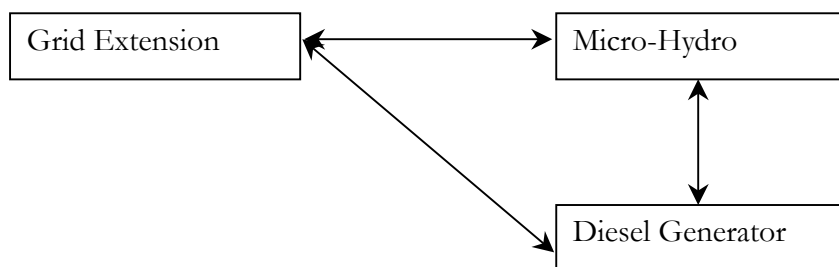
A procedure of a comparison grid extension and PV system which is mentioned above is an example of the economic comparison. We are going to prepare the following procedure

option.

<Relatively small demand>



<Relatively larger demand than PV system>



(The result of this comparison will be indicated in one graph.)

<Demand forecast in rural areas >

Regarding the basic concept of demand forecast in rural areas, NEA and SPUG create the next 10-year demand forecast based on the previous 5 years of sales data. However, growth of the number of customers is not taken into account; only the average demand growth per customer is considered. This concept applies to the customer who receives power from the NPC network or the customer that assumes the same demand growth as that of a big island EC. However, this method cannot be applied to small-scale unenergized areas because insufficient baseline data have been collected for those areas. Therefore, for the demand forecasts of missionary areas, the following points are currently being considered.

- Within 5 years of the project term, 25% of all customers in the target area will be electrified.

In barangays where houses are built together, according to economic feasibility, diesel generation, wind power and hybrid, and micro hydro are options for electrification. Lighting, radio and fans, which satisfy the basic needs of the

customer, are used for 4 to 6 hours and the maximum peak load is assumed to be about 100 W.

- In barangays where houses are built apart, SHS (Solar Home System) is useful. The capacity of the PV system assumes that 25% of customers use the 75 W PV system and 75% of customers use the 50 W system. About 4 hours of supply is considered for both PV systems. 300 W of BCS (Battery Charge Station) can charge for a battery for 20 customers. BCS and SHS can be interdependent.

Currently, the following criteria are considered as a yardstick.

Number of customers is less than 30 : SHS

Number of customers is 30 to 60 : parallel use of SHS and BCS

More than 60 customers and total grid length is less than 4 km :

parallel use of mini grid system and BCS



## 8 Training

Renewable energy systems used as individual power sources can stop not only due to faults in the components but also due to simple problems such as loose connections and defective contacts. Even if the problems are simple, if troubleshooting and repairing methods are not known, stoppage of the system over a long period may result. Therefore, it is very important to train engineers to maintain the long-term, stable operation of the systems.

### **[Points of engineer training]**

#### (1) Establishment of engineer training programs

In promoting renewable energy system projects, it is important to train engineers within the country. Various methods may be used to train engineers. However, it is desirable to train engineers stage-by-stage depending on the roles and levels of the engineers. To this end, it is important to establish engineer-training programs for the respective levels and train engineers according to the programs.

#### (2) Selection of appropriate engineers

Engineers who operate and maintain the systems must have adequate basic capability depending on the system style and the required technical level. It is also important to select engineers who work diligently. Training engineers who have knowledge of electricity can be simplified, and more advanced technical training can be given. However, it should be noted that even if their technical level is high, engineers who are not diligent may execute inspection and maintenance carelessly, and the quality of maintenance management services for customers may deteriorate.

#### (3) Training of instructors

To train engineers within the country, it is necessary to have instructors who can train these engineers. In the initial stage of a project, expert engineers may be invited from overseas as trainers. However, to execute sustainable training for engineers, it is important to train instructors within the country.

#### (4) Implementation of follow-up training

The technical level of the engineers improves through the actual operation and maintenance. However, knowledge and technical capability that are not frequently used may deteriorate. To maintain the technical capability of engineers at a certain level and to provide the latest technical information, it is important to give the engineers not only initial training but also periodical follow-up training.

### **[Method of Training Engineers]**

(1) Attending overseas training programs

Some international organizations and manufacturers have developed engineer-training programs for renewable energy systems and have been extensively inviting engineers to these training programs. Some countries have programs for inviting trainees as a part of technical cooperation. The engineers are dispatched and attend these training programs to receive training. It is desirable to dispatch engineers who are appropriate for the training course.

(2) Invitation of overseas expert engineers

Overseas experts and trained engineers of the country are invited through technical training and lectures. Some international organizations and countries have programs for dispatching experts as a part of their technical cooperation. Therefore, it is possible to use these programs. In receiving experts, it is important to clarify what is needed as contents of technology transfer and technical guidance.

(3) Education at training organizations

Engineers are trained at the organizations that have training courses. There are two aspects for training organization. One is to establish training centers. The other is to utilize existing training centers and colleges. It is desirable for training courses to establish not only courses for engineers but also courses for instructors to train instructors.

(4) On-the-job training

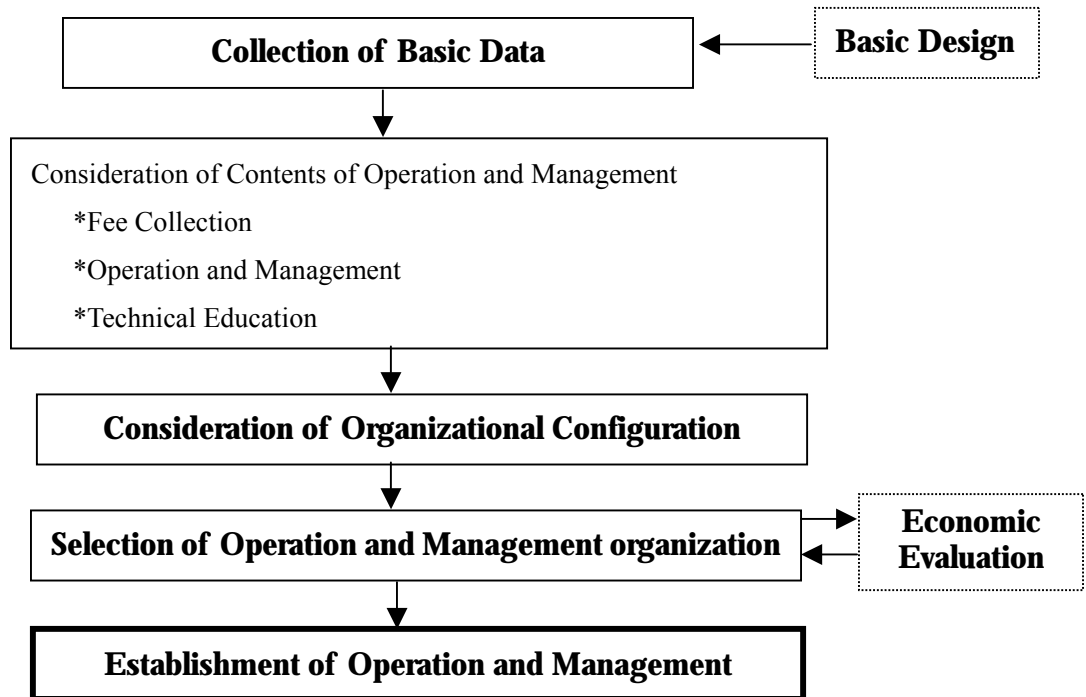
At the project site village, technical training is executed through installation, inspection on completion, operation and maintenance using the actual system. This on-the-job training has variety of practical contents, and engineers can be deepen their understanding of the renewable energy system.

## **9 Establishment of the Operation and Management System**

For example, to sustain the stable and proper operation of PV systems, it is necessary to make periodical maintenance. It is also necessary to establish an organization system to support system operation in case faults and problems, supply replacement parts and collect fees. To properly execute maintenance and fee collection, etc., , it is important to provide technical training to engineers and users.

To develop a sustainable project, it is necessary to clarify the roles of the organizations concerned from the viewpoint of project management, system maintenance, fee collection, fund management and engineer training. It is also necessary to establish a management system in which all the concerned organizations are coordinated with each other. For the establishment of management organizations, first, a management procedure that is suitable for the project based on the basic data is studied. Then suitable organization for operation and management is selected, and eventually the operation and management system is established.

< Flow of establishment of the operation and management system >



**[Points of establishing an operation and management system]**

(1) Development of a system that meets the social system  
 Collection of fees and provision of various services are widely practiced and are not limited to PV system projects. If the operation and management system is developed by the following existing systems and rules, the operation and management system will be able to provide services that can be easily appreciated by users. If there are organizations within each village and organizations supervising these villages, it will be effective to use these

organizations for maintenance and fee collection.

(2) Selection of an appropriate operation and management organization  
To implement the operation and management of PV systems that are installed in rural areas, it is important to select an operation and management organization that can carry out operation management speedily and properly. Regarding candidates for such an operation and management organization, governmental organizations and existing power enterprises, NGOs, cooperatives, and private enterprises are considered for participation. The cost can be reduced to utilize the existing organization rather than to establish a new organization.

(3) Transfer of some duties to the infrastructure organizations  
The operation and management is implemented by each stage, which are the central stage, the local stage and village levels. If engineers of the central level or the local level operate and manage, high quality services can be provided. On the other hand, the time and the area of activity of these engineers are limited, and their services will generate higher costs. If problems occur in rural areas, response to problems may be delayed. If engineers of the local level or the village level directly carry out operation and management, there can be a quick response to any problem, and costs can be reduced, although their services are limited.

Operation management at the village level may be difficult in some cases, depending on the configuration of the system and the condition of the village. However, it is desirable that operation and management organization at village level be established.



**Manual  
for  
the Power Development Plan  
Preparation  
(DDP)**

## Section 6 Distribution Development Plan

### 1. Introduction

This summary presents the Distribution Development Plan (DDP) of DUs in line with its mandated responsibilities under Republic Act 9136, and the Electric Power Industry Reform Act (EPIRA).

The preparation of DDP follows an iterative process of simulation to determine the appropriate additions, expansions, and rehabilitation of the distribution backbone that would meet the planning criteria referred to as the performance indices used by the utilities to assess the future reliability of the distribution system.

### 2. Framework

DOE's Electric Power Industry Management Bureau (EPIMB), as part of its mandate, will review the list of distribution development projects to encourage the private sector to prepare project proposals in a competitive environment and provide indicative timetables to ensure sufficient lead times in the construction of power facilities.

DOE's review of DDPs will consider consistency with general and specific policies for the energy sector, the assumptions used in formulating these plans, and the consistency of these plans with national and regional resource assessments, development programs, and project timetables of various energy upstream activities.

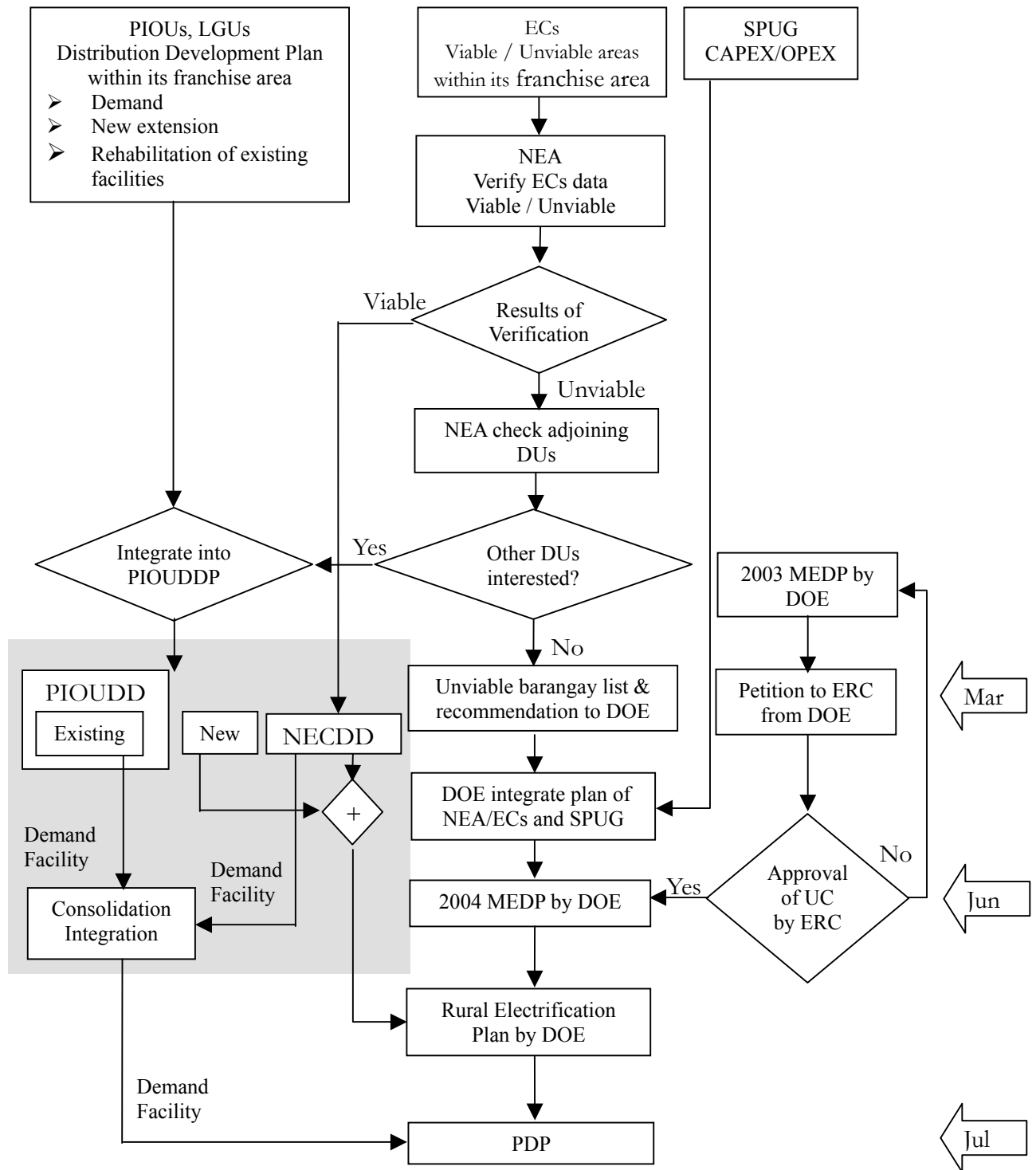
EPIMB will also use the data described in DDP submitted by each distribution utility for the following purposes.

- To validate electricity demand forecasts at the macro level in the next ten years
- To simulate a power supply plan based on the demand forecasts and produce an indicative plant line-up

After evaluating the results of the simulations, DOE, if necessary, requests further clarification and/or amendments from the concerned distribution utilities. EPIMB will recommend DOE's approval and the adoption of DDPs and their integration with PDP/PEP no later than June 30 of each year.

The integrated PDP/PEP will be submitted to Congress on or before September 15th every

year. The workflow to prepare DDP is described as follows.



Each item of data gathered from each DU based on the workflow is integrated into the following three sections: Existing Facilities, Long-term Vision and Investment Requirement. In addition, the data are divided into three main areas (LUZON, the VISAYAS and MINDANAO), and the total is integrated into the Philippines. The data of the distribution and the sub-transmission lines are in circuit kilometers in accordance with each of the voltage levels listed. Moreover, the data of substation transformers are in accordance with each of the sizes listed.

The current data of the distribution, the sub-transmission lines and the substation transformers are integrated into [3. Existing Facilities].

The forecasted data are integrated into [4. Long-term Vision] in which expansions plans are integrated into [4.1 Expansions] and rehabilitation plans are integrated into [4.2 Rehabilitation]. Furthermore, the data of demand are integrated into [4.3 Demand Forecast] as the sales lists in mega watt-hours. Finally, the data of critical conditions, for example, unbalanced demand and supply, are integrated into [4.4 Critical Conditions] as facilities lists.

Capital expenditure is integrated into [5. Investment Requirement] as each list. All amounts are to be expressed in units of a million pesos.



### 3.Existing Facilities

- The existing data of facilities is understood.
- Comparison between areas and comparison between voltage classes are conducted. Compared with the data of last year, the rate of expansion is analyzed for every area and for every voltage class.
- Furthermore, the reasons are considered and documented.

**Table3-1. Summary of Existing Facilities (Lines)**

<b>Area</b>		<b>Amount (Ckt-kms)</b>
<b>LUZON</b>	230 kV and over	
	138 kV and less than 230 kV	
	115 kV and less than 138 kV	
	69 kV and less than 115 kV	
	34.5 kV and less than 69 kV	
	13.8 kV and less than 34.5 kV	
	6.2 kV and less than 13.8 kV	
	2.4 kV and less than 6.2 kV	
<b>VISAYAS</b>	230 kV and over	
	138 kV and less than 230 kV	
	115 kV and less than 138 kV	
	69kV and less than 115 kV	
	34.5 kV and less than 69 kV	
	13.8 kV and less than 34.5 kV	
	6.2kV and less than 13.8 kV	
	2.4kV and less than 6.2 kV	
<b>MINDANAO</b>	230 kV and over	
	138 kV and less than 230kV	
	115 kV and less than 138kV	
	69 kV and less than 115 kV	
	34.5 kV and less than 69 kV	
	13.8 kV and less than 34.5 kV	
	6.2 kV and less than 13.8 kV	
	2.4 kV and less than 6.2 kV	
<b>PHILIPPINES</b>	230 kV and over	
	138 kV and less than 230 kV	
	115 kV and less than 138 kV	
	69 kV and less than 115 kV	
	34.5 kV and less than 69 kV	
	13.8 kV and less than 34.5 kV	
	6.2 kV and less than 13.8 kV	
	2.4 kV and less than 6.2 kV	

- The existing data of facilities is understood.
- Comparison between areas and comparison between voltage classes are conducted. Compared with the data of last year, the rate of expansion is analyzed for every area and for every voltage class.
- Furthermore, the reasons are considered and documented.

**Table3-2. Summary of Existing Facilities (Transformers)**

	<b>Area</b>	<b>Amount (MVA)</b>
<b>LUZON</b>	Transformer Capacity, 100 and over	
	Transformer Capacity, 50 and less than 100	
	Transformer Capacity, 25 and less than 50	
	Transformer Capacity, 10 and less than 25	
	Transformer Capacity, less than 10	
<b>VISAYAS</b>	Transformer Capacity, 100 and over	
	Transformer Capacity, 50 and less than 100	
	Transformer Capacity, 25 and less than 50	
	Transformer Capacity, 10 and less than 25	
	Transformer Capacity, less than 10	
<b>MINDANAO</b>	Transformer Capacity, 100 and over	
	Transformer Capacity, 50 and less than 100	
	Transformer Capacity, 25 and less than 50	
	Transformer Capacity, 10 and less than 25	
	Transformer Capacity, less than 10	
<b>PHILIPPINES</b>	Transformer Capacity, 100 and over	
	Transformer Capacity, 50 and less than 100	
	Transformer Capacity, 25 and less than 50	
	Transformer Capacity, 10 and less than 25	
	Transformer Capacity, less than 10	

## 4. Long-term Vision

### 4.1 Expansions

- The data of expansion plans for every fiscal year is understood.
- The difference in the amount of construction for every fiscal year is documented.  
Comparison between areas is conducted.
- The difference in the amount of construction for every area is documented.  
Comparison between voltage classes is conducted.
- The difference in the amount of construction for every voltage class is documented.  
The rate of expansion is analyzed for every area and for every voltage class.
- Furthermore, the reasons are considered and documented.

**Table4-1. Summary of Expansions (2003-2007) (Ckt-kms)**

<b>Area</b>		<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>
<b>LUZON</b>	230 kV-and over					
	138 kV-230 kV					
	115 kV-138 kV					
	69 kV-115 kV					
	34.5 kV-69 kV					
	13.8 kV-34.5 kV					
	6.2 kV-13.8 kV					
	2.4 kV-6.2 kV					
	Sub-Total					
<b>VISAYAS</b>	230 kV-and over					
	138 kV-230 kV					
	115 kV-138 kV					
	69 kV-115 kV					
	34.5 kV-69 kV					
	13.8 kV-34.5 kV					
	6.2 kV-13.8 kV					
	2.4 kV-6.2 kV					
	Sub-Total					
<b>MINDANAO</b>	230 kV-and over					
	138 kV-230 kV					
	115 kV-138 kV					
	69 kV-115 kV					
	34.5 kV-69 kV					
	13.8 kV-34.5 kV					
	6.2 kV-13.8 kV					
	2.4 kV-6.2 kV					
	Sub-Total					
<b>PHILIPPINES</b>	230 kV-and over					
	138 kV-230 kV					
	115 kV-138 kV					
	69 kV-115 kV					
	34.5 kV-69 kV					
	13.8 kV-34.5 kV					
	6.2 kV-13.8 kV					
	2.4 kV-6.2 kV					
	Sub-Total					

- The data of expansion plans for every fiscal year is understood.
- The difference in the amount of construction for every fiscal year is documented.  
Comparison between areas is conducted.
- The difference in the amount of construction for every area is documented.  
Comparison between voltage classes is conducted.
- The difference in the amount of construction for every voltage class is documented.  
The rate of expansion is analyzed for every area and for every voltage class.
- Furthermore, the reasons are considered and documented.

**Table4-2. Summary of Substation Capacity (Transformers, 2003-2007) (MVA)**

Area		2003	2004	2005	2006	2007
<b>LUZON</b>	Transformer Capacity, 100 and over					
	Transformer Capacity, 50 and less than 100					
	Transformer Capacity, 25 and less than 50					
	Transformer Capacity, 10 and less than 25					
	Transformer Capacity, less than 10					
<b>VISAYAS</b>	Transformer Capacity, 100 and over					
	Transformer Capacity, 50 and less than 100					
	Transformer Capacity, 25 and less than 50					
	Transformer Capacity, 10 and less than 25					
	Transformer Capacity, less than 10					
<b>MINDANAO</b>	Transformer Capacity, 100 and over					
	Transformer Capacity, 50 and less than 100					
	Transformer Capacity, 25 and less than 50					
	Transformer Capacity, 10 and less than 25					
	Transformer Capacity, less than 10					
<b>PHILIPPINES</b>	Transformer Capacity, 100 and over					
	Transformer Capacity, 50 and less than 100					
	Transformer Capacity, 25 and less than 50					
	Transformer Capacity, 10 and less than 25					
	Transformer Capacity, less than 10					

## 4.2 Rehabilitation

- The data of rehabilitation plans for every fiscal year is understood.
- The difference in the amount of construction for every fiscal year is documented.  
Comparison between areas is conducted.
- The difference in the amount of construction for every area is documented.  
Comparison between voltage classes is conducted.
- The difference in the amount of construction for every voltage class is documented.  
The rate of rehabilitation is analyzed for every area and for every voltage class.
- Furthermore, the reasons are considered and documented.

**Table4-3. Summary of Rehabilitation (2003-2007) (Ckt-kms)**

<b>Area</b>		<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>
<b>LUZON</b>	230kV-and over					
	138kV-230kV					
	115kV-138kV					
	69kV-115kV					
	34.5kV-69kV					
	13.8kV-34.5kV					
	6.2kV-13.8kV					
	2.4kV-6.2kV					
Sub-Total						
<b>VISAYAS</b>	230kV-and over					
	138kV-230kV					
	115kV-138kV					
	69kV-115kV					
	34.5kV-69kV					
	13.8kV-34.5kV					
	6.2kV-13.8kV					
	2.4kV-6.2kV					
Sub-Total						
<b>MINDANAO</b>	230kV-and over					
	138kV-230kV					
	115kV-138kV					
	69kV-115kV					
	34.5kV-69kV					
	13.8kV-34.5kV					
	6.2kV-13.8kV					
	2.4kV-6.2kV					
Sub-Total						
<b>PHILIPPINES</b>	230kV-and over					
	138kV-230kV					
	115kV-138kV					
	69kV-115kV					
	34.5kV-69kV					
	13.8kV-34.5kV					
	6.2kV-13.8kV					
	2.4kV-6.2kV					
Sub-Total						

- The data of rehabilitation plans for every fiscal year is understood.
- The difference in the amount of construction for every fiscal year is documented. Comparison between areas is conducted.
- The difference in the amount of construction for every area is documented. Comparison between voltage classes is conducted.
- The difference in the amount of construction for every voltage class is documented. The rate of rehabilitation is analyzed for every area and for every voltage class. Furthermore, the reasons are considered and documented.

**Table4-4. Summary of Decommissioning (Transformers, 2003-2007) (MVA)**

Area		2003	2004	2005	2006	2007
<b>LUZON</b>	Transformer Capacity, more than 100					
	Transformer Capacity, 50 and less than 100					
	Transformer Capacity, 25 and less than 50					
	Transformer Capacity, 10 and less than 25					
	Transformer Capacity, less than 10					
<b>VISAYAS</b>	Transformer Capacity, more than 100					
	Transformer Capacity, 50 and less than 100					
	Transformer Capacity, 25 and less than 50					
	Transformer Capacity, 10 and less than 25					
	Transformer Capacity, less than 10					
<b>MINDANAO</b>	Transformer Capacity, more than 100					
	Transformer Capacity, 50 and less than 100					
	Transformer Capacity, 25 and less than 50					
	Transformer Capacity, 10 and less than 25					
	Transformer Capacity, less than 10					
<b>PHILIPPINES</b>	Transformer Capacity, more than 100					
	Transformer Capacity, 50 and less than 100					
	Transformer Capacity, 25 and less than 50					
	Transformer Capacity, 10 and less than 25					
	Transformer Capacity, less than 10					



### 4.3 Demand Forecast

- Demand forecasting for every fiscal year is analyzed. Comparison between areas is conducted. The difference in the demand for every area is documented.
- Every kind of demand is compared. The difference in the kinds of demand is documented. The rate of expansion is analyzed for every kind of every area and demand.
- Furthermore, the reasons are considered and documented.
- These Sales data are from the distribution level and do not include Sales in Transmission.

**Table4-5. Summary of Demand Forecast (2003-2007) (MWH)**

Area		2003	2004	2005	2006	2007
<b>LUZON</b>	Direct Sales to Customers					
	Utility's Energy Consumption					
	Electricity Purchased or Generated					
<b>VISAYAS</b>	Direct Sales to Customers					
	Utility's Energy Consumption					
	Electricity Purchased or Generated					
<b>MINDANAO</b>	Direct Sales to Customers					
	Utility's Energy Consumption					
	Electricity Purchased or Generated					
<b>PHILIPPINES</b>	Direct Sales to Customers					
	Utility's Energy Consumption					
	Electricity Purchased or Generated					

**Table4-6. Summary of Demand Forecast (2008-2012) (MWH)**

Area		2008	2009	2010	2011	2012
<b>LUZON</b>	Direct Sales to Customers					
	Utility's Energy Consumption					
	Electricity Purchased or Generated					
<b>VISAYAS</b>	Direct Sales to Customers					
	Utility's Energy Consumption					
	Electricity Purchased or Generated					
<b>MINDANAO</b>	Direct Sales to Customers					
	Utility's Energy Consumption					
	Electricity Purchased or Generated					
<b>PHILIPPINES</b>	Direct Sales to Customers					
	Utility's Energy Consumption					
	Electricity Purchased or Generated					

#### 4.4 Supply Forecast

- Supply forecasting for every fiscal year is analyzed. Comparison between areas is conducted. The difference in the demand for every area is documented.
- Every electric power demand is measured by the capacity with which it can be supplied. The difference in the capacity that can be supplied the amount of electric power is documented. The rate of expansion and the capacity that can be supplied for electric power are analyzed in every area.
- Furthermore, the reason is documented.
- These Supply data are from the distribution level and do not include Supply in Transmission.

**Table4-7. Summary of Total Supply Forecast (2003-2012) (KW, MWH)**

Area		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LUZON	Capacity										
	Energy										
VISAYAS	Capacity										
	Energy										
MINDANAO	Capacity										
	Energy										
PHILIPPINES	Capacity										
	Energy										

**Table4-8. Summary of Supply-Demand Surplus Forecast (2003-2012) (KW, %, MWH)**

Area		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LUZON	Capacity										
	Capacity Margin										
	Energy										
VISAYAS	Capacity										
	Capacity Margin										
	Energy										
MINDANAO	Capacity										
	Capacity Margin										
	Energy										
PHILIPPINES	Capacity										
	Capacity Margin										
	Energy										

#### 4.5 Critical Conditions

- Prediction of the amount of short supply for every fiscal year is analyzed. Comparison between areas is conducted. The difference for every area is documented.
- With reserve power reductions and insufficient power supply, it is expected to be that supply will be difficult to grasp.
- Furthermore, the reasons are documented.
- The data of higher voltage systems are checked. Furthermore, to design evasion measures, adjustment is necessary with the people concerned.

**Table4-9. Summary of Critical Conditions (2003-2007)**

Area		2003	2004	2005	2006	2007
<b>LUZON</b>	Sub-transmission Banks Critically Loaded (MVA)					
	Distribution Lines Critically Loaded (Ckt)					
<b>VISAYAS</b>	Sub-transmission Banks Critically Loaded (MVA)					
	Distribution Lines Critically Loaded (Ckt)					
<b>MINDANAO</b>	Sub-transmission Banks Critically Loaded (MVA)					
	Distribution Lines Critically Loaded (Ckt)					
<b>PHILIPPINES</b>	Sub-transmission Banks Critically Loaded (MVA)					
	Distribution Lines Critically Loaded (Ckt)					

**Table4-10. Summary of Critical Conditions (2008-2012)**

Area		2008	2009	2010	2011	2012
<b>LUZON</b>	Sub-transmission Banks Critically Loaded (MVA)					
	Distribution Lines Critically Loaded (Ckt)					
<b>VISAYAS</b>	Sub-transmission Banks Critically Loaded (MVA)					
	Distribution Lines Critically Loaded (Ckt)					
<b>MINDANAO</b>	Sub-transmission Banks Critically Loaded (MVA)					
	Distribution Lines Critically Loaded (Ckt)					
<b>PHILIPPINES</b>	Sub-transmission Banks Critically Loaded (MVA)					
	Distribution Lines Critically Loaded (Ckt)					

## 5. Investment Requirement

- The amount of investment for every fiscal year is understood.
- Every comparison between areas and contents of construction is compared. Compared with the amount of investment that was scheduled for last year, the rate of change is analyzed between areas or for every construction content. Furthermore, the reasons are documented.

**Table5-1. Summary of Investment Requirement (2003-2007) (Million PHP)**

Area		2003	2004	2005	2006	2007	Total
<b>LUZON</b>	Distribution/ Sub-transmission	Local					
		Foreign					
	Substation	Local					
		Foreign					
	Electrification	Local					
		Foreign					
Sub-total	Local						
	Foreign						
<b>VISAYAS</b>	Distribution/ Sub-transmission	Local					
		Foreign					
	Substation	Local					
		Foreign					
	Electrification	Local					
		Foreign					
Sub-total	Local						
	Foreign						
<b>MINDANAO</b>	Distribution/ Sub-transmission	Local					
		Foreign					
	Substation	Local					
		Foreign					
	Electrification	Local					
		Foreign					
Sub-total	Local						
	Foreign						
<b>PHILIPPINES</b>	Distribution/ Sub-transmission	Local					
		Foreign					
	Substation	Local					
		Foreign					
	Electrification	Local					
		Foreign					
Total	Local						
	Foreign						

## 6. Attachments

>NECDDP

>PIOUDDP

