

A Handbook on Power Sector Diagnostic Assistance Tool

August 2014

Industrial Development and Public Policy Department
Japan International Cooperation Agency

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Contents

1. Power Sector Diagnostic Assistance Tool	1
1.1 Objectives	1
1.2 Notes and Remarks	1
2. Outline of Power Sector Diagnostic Assistance Tool	3
2.1 Functions of the Tool	3
2.2 Analyzing Items	4
2.3 Radar Chart	5
2.4 System in Excel	5
3. Analysis Items	7
3.1 Access	7
3.1.1 Definition of Basic Index	7
3.1.2 Sub-Indexes	8
3.1.3 Supplemental Index	9
3.2 Low Cost	12
3.2.1 Definition of Basic Index	12
3.2.2 Sub-Indexes	13
3.2.3 Supplemental Index	15
3.3 Low Carbon	19
3.3.1 Definition of Basic Index	19
3.3.2 Sub-Indexes	20
3.3.3 Supplemental Index	21
3.4 Low Risks	23
3.4.1 Definition of Basic Index	23
3.4.2 Sub-Indexes	25
3.4.3 Supplemental Index	25
3.5 Efficiency	28
3.5.1 Definition of Basic Index	28
3.5.2 Sub Index	30
3.5.3 Supplemental Index	30
3.6 Financial Soundness	32
3.6.1 Definition of Basic Index	32
3.6.2.1 Financial Soundness of Electricity Supply Utilities and Enterprises	34
3.6.2.1 Financial Soundness of Subsidy under the Government Budget	37
3.6.3 Supplemental Index	37

Tables

Table 2- 1 6 Items to be Analyzed.....	5
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Figures

Figure 2- 1 Functions of Power Sector Diagnostic Assistance Tool (Red Circle Area)	4
Figure 3- 1 Analysis Tree for Access	7
Figure 3- 2 Analysis Tree for Low Cost	12
Figure 3- 3 Analysis Tree for Low Carbon	19
Figure 3- 4 Analysis Tree for Low Risks	23
Figure 3- 5 Analysis Tree for Efficiency	28
Figure 3- 6 Analysis Tree for Financial Soundness	32

Abbreviations

BBL(bbl)	Barrel
CEB	Ceylon Electricity Board ----- [Sri Lanka]
CFL	Compact Fluorescent Light
EAC	Electricity Authority of Cambodia
EDC	Electricite Du Cambodge ---- [Cambodia]
FIT	Feed-In Tariff
GCV	Gross Calorific Value
GJ	Giga joule (=10 ⁹ joule)
GTCC	Gas Turbine Combined Cycle
GW	Gigawatt (=10 ⁹ watts)
GWh	Gigawatt hour (=10 ⁹ watts hours)
HHV	High Heat Value
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
KenGen	Kenya Electricity Generating Company Limited
KETRACO	Kenya Electricity Transmission Company Limited
KJ	Kilo joule (=10 ³ joule)

KPLC	Kenya Power and Lighting Co., Ltd.
kW	kilowatt (=10 ³ watts)
kWh	kilowatt hour (10 ³ watts hours)
LHV	Low Heat Value
MJ	Mega joule (=10 ⁶ joule)
MW	Megawatt (=10 ⁶ watts)
MWh	Megawatt hour (10 ⁶ watts hours)
NCV	Net Calorific Value
PJ	Peta joule (=10 ¹⁵ joule)
PLN	Persahaan Perseroan PT Perusahaan Listrik Negara - [Indonesia]
REA	Rural Electrification Authority --- [Kenya]
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SCFT	Standard Cubic Feet
TJ	Tera joule (=10 ¹² joule)
UNFCCC	United Nations Framework Convention on Climate Change

Energy Conversion

To	kJ	BTU	kWh	kcal
From	multiplied by:			
kJ	1	0.9478	0.000278	0.2389
BTU	1.0551	1	0.000293	0.252
kWh	3,600	3,412	1	860
kcal	4.1868	3.968	0.001163	1

1. Power Sector Diagnostic Assistance Tool

1.1 Objectives

Since the middle of 2000s, energy shift is found in the world energy sources under high crude oil market prices and response to global environmental issues, including in electricity generation towards lower carbon dioxide emission for mitigation of climate change. In the 2010s, the shale gas revolution in United States and the Fukushima nuclear power plant accident have been inducing impacts to the primary energy markets and trades. The impact may be the largest after the oil crisis experienced in 1970s, and are involving developing countries.

Under those circumstances as mentioned above, Japan International Cooperation Agency (JICA) issued the Thematic Guidelines on Energy Sector of May 2013, in which the 3 L Policy on energy sector assistance in developing countries was introduced to mean energy development toward targeting Low Cost, Low Carbon and Low Risks as important developing priorities for achieving sustainable development of developing countries. JICA has been continuously implementing assistance to the energy and power sector in developing countries so as to establish better policy and planning, improving electricity access, low carbon generation development, more efficient power transmission and distribution, and improved energy efficiencies as aimed in the 3L Policy.

For planning ODA assistance by JICA in energy and power sector of developing countries, information gathering and analysis have to be carried out in the initial beginning stage. The next stage requires, based on the information and the analysis having been carried out in the first stage, to make further researches and studies on development policies and plans for developing most suitable ones to the country. The final stage is to design JICA's assistances contributing to needs of the country with limited assistance resources for achieving the largest development benefits in line with the 3 L Policy. This study on this Power Sector Diagnostic Assistance Tool started to develop such tools as providing supportive information and analysis in initial stages.

Power Sector Diagnostic Assistance Tool developed in this study is a simple analysis tool to provide hints and references for solutions. It is designed to produce visual analysis of quantitative information for easy understanding and practical use. It will contribute to finding hints for solutions of issues involved in power sector in each country.

1.2 Notes and Remarks

This Power Sector Diagnostic Assistance Tool does not provide final goals nor solutions of

issues in power sector of each country beyond of its capabilities. Proper understanding and analysis are not obtained only from on quantitative information but also on other information, structure, society, history, culture, law on electricity and legal regime of the country, and policies on development and electricity supply as well as economy and government revenue and spending budget. It is always necessary to make analysis adequately on all issues involved so that development policies and assistance programs can be properly established. This Power Sector Diagnostic Assistance Tool being still in early development stage has to be developed for more useful and practical tool.

This Power Sector Diagnostic Assistance Tool is designed to proceed analysis from outlines to details. However, as history, customs, society, culture and economy are different in each country, solution for the same issue may be different in many cases depending on country. Priority also may be different. It is better to recognize that this Power Sector Diagnostic Assistance Tool is not fully capable. In use of this Power Sector Analysis Tool, further adequate analysis and studies are necessary to establish policies and programs.

Cross-country comparison and analysis between similar countries and among countries in its region provide helpful information on issues to require assistances. The information are expected to provide hints and references on what information, studies and analysis are additionally required for establishing policies and programs adequately. On the other hand, historical comparison and analysis provide information on progress and achievements of the issues, and may suggest issues and points having not been recognized in past. The analysis also provides information on successful cases. Successful example provides lots of useful information, even though some modifications are required for application in other country.

This Handbook on Power Sector Diagnostic Assistance Tool was developed in a JICA project study performed from March 2014 to July 2014. It is intended that many JICA staff concerning power sector development will use and utilize this handbook as a tool for studying assistance policy and program. The Handbook as well as Power Sector Diagnostic Assistance Tool being not perfect, still requires improvements with comments and opinions from users.

2. Outline of Power Sector Diagnostic Assistance Tool

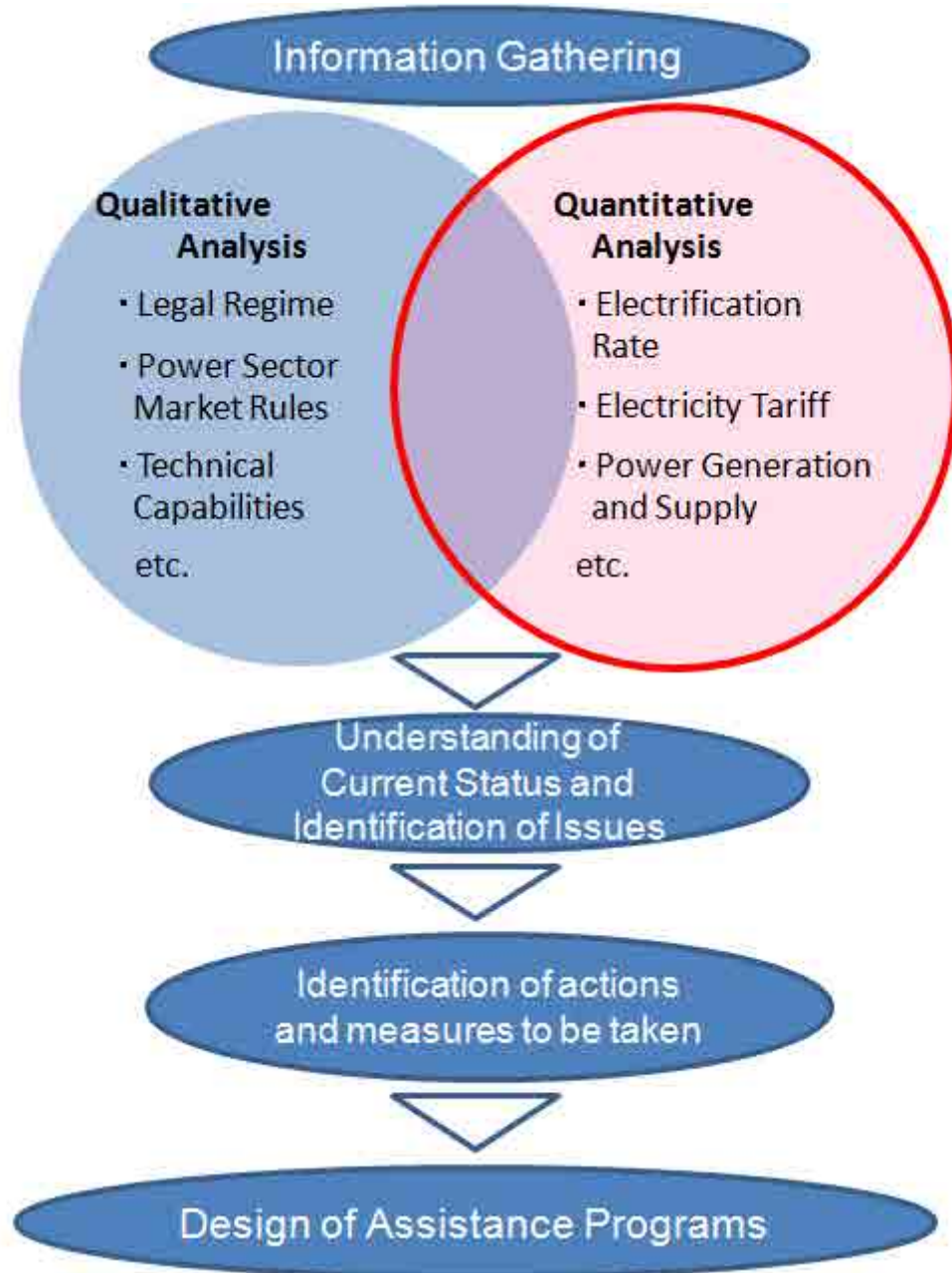
2.1 Functions of the Tool

Functions of the Power Sector Diagnostic Assistance Tool are described in Figure 2-1, in which the red circle area at upper right corner shows the functions. The tool analyzes mainly quantitative information with some descriptive information. As mentioned in 1.1, the first step for designing JICA assistance program is to gather information and analyze it for recognizing and identifying issues. The next step procedure is to identify actions and measures to be taken in the country. When these two steps are fully performed, comprehensive and effective discussions can be carried out on actions and assistances, which shall be provided by JICA. This procedure is important, and reminded, when thinking on designing assistance programs for developing countries. This Power Sector Diagnostic Assistance Tool intends to help the analysis in the initial stage.

Power Sector Diagnostic Assistance Tool functions as a tool to make analysis mainly on quantitative principle information, but also may provide suggestions on further necessary studies. Power Sector Diagnostic Assistance Tool working under limited functions, with lacking some data and information, also may provide hints and suggestions on next step for making information gathering, surveys and studies. Use of this Power Sector Diagnostic Assistance Tool expects to assist users to make analysis effectively and design next steps for developing assistance programs for developing countries.

It expects that Power Sector Diagnostic Assistance Tool will provide good assistances, when used and applied adequately.

Figure 2- 1 Functions of Power Sector Diagnostic Assistance Tool (Red Circle Area)



2.2 Analyzing Items

Power Sector Diagnostic Assistance Tool makes analysis on 6 items as described in Table 2-1. Investigation on 6 items is to cover almost all necessary issues to be analyzed in the area as mentioned in the red circle area of the Figure 2-1, so that hints and suggestions would appear in the analysis on 6 items in the initial stage.

Table 2- 1 6 Items to be Analyzed

Analysis Item	Contents
1) Access	Access to Electricity services for people and industries
2) Low Cost	Cost and Price of Electricity services
3) Low Carbon	CO2 Emission for Electricity Supply
4) Low Risks	Reliability of Electricity Supply
5) Efficiency	Efficiency of Electricity and Energy Consumption
6) Financial Soundness	Financial Soundness and Sustainability of Power Utilities

Power Sector Diagnostic Assistance Tool is designed to produce tables and charts as output of the system tool in format of cross-country style or historical style so that users can recognized visually to help comprehensive understanding. Such output also helps to design the next step for making additional surveys and studies properly and adequately. Issues will be identified more efficiently. The 6 items are not independent, but has close relations among them. Analysis on each item is a view from that point.

In this Power Sector Diagnostic Assistance Tool , index to the 6 items is called as basic index. Such basic index consists from several sub-indexes. For a proper scoring of sub-indexes, supplemental indexes are used in necessary cases and for such case as requiring more deeper analysis. The supplemental indexes include not only quantitative information but also qualitative information so that the information would support comprehensive analysis on relating issues.

2.3 Radar Chart

Radar chart output is available in use of the system developed under Power Sector Diagnostic Assistance Tool . The radar chart is designed to provide a quick cross-country analysis in visual style so that comprehensive initial information could be obtained. The radar chart output system expects to provide good visual information for stepping to the next stage. When the radar chart output system is developed through experiences in use and application, it works as a useful tool.

2.4 System in Excel

A database system in use of excel is developed in project study of Power Sector Diagnostic Assistance Tool . The system is comprised from data input excel file, database excel file and output excel files, which are, at present, cobweb output excel file, historical output excel file and cross-countries output excel files.

The data input excel and the database can store not only qualitative information but also descriptive information. Descriptive information provides some fundamental understanding on system and structures, while analysis is sometimes not so easy compared to quantitative information. Recording descriptive information correctly to avoid miss understanding and miss leading sometime requires a long description. No mandatory input data cell is designed in the system, so that the system works with the minimum input data. However, the system will require further modifications and upgrading for more practical and useful system with feeding backs from users of the system.

3. Analysis Items

3.1 Access

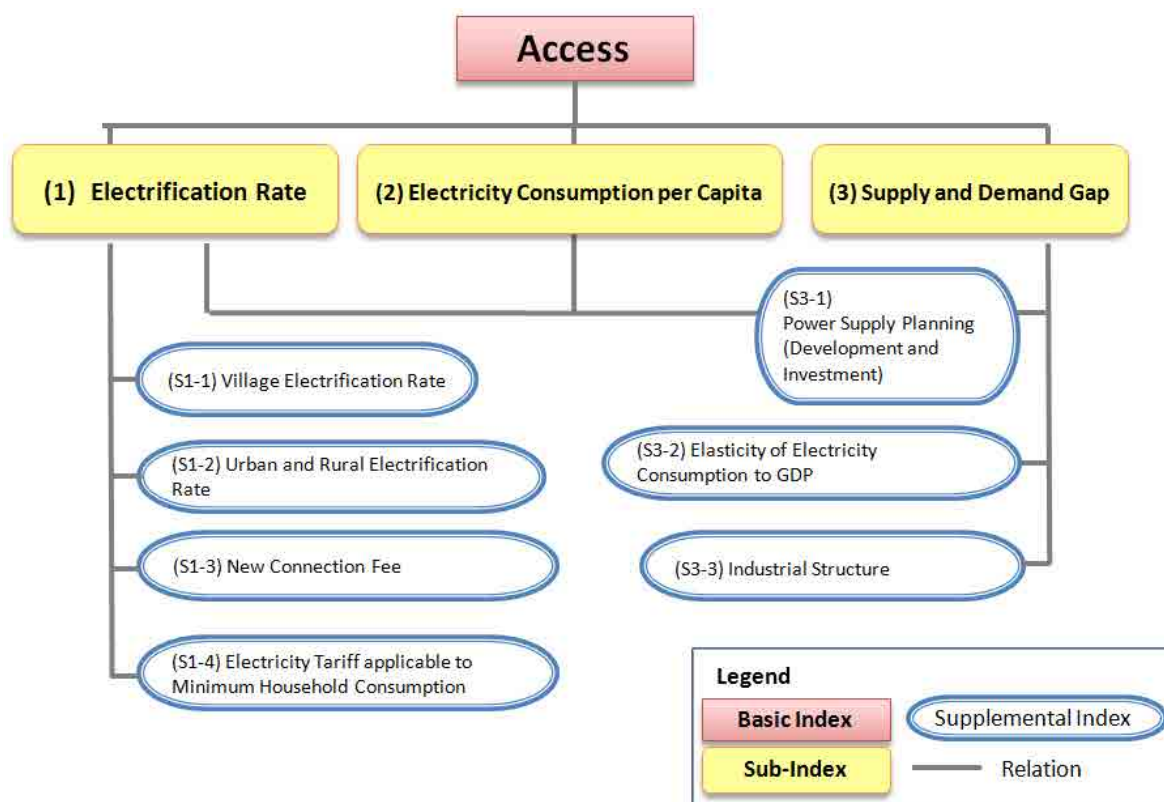
3.1.1 Definition of Basic Index

There is a close relationship between economic growth and energy consumption increase. It is one of the key issues in analysis of electricity sector in developing countries whether electricity is supplied to people and industries for a quantity as necessary. Therefore, in this Power Sector Diagnostic Assistance Tool, Access is selected as one of the basic indexes, being defined as below, together with sub-indexes. Analysis tree for Access and explanation on those sub-indexes follow as mentioned as below:

Access (A) = Electrification Rate (X) + Electricity Consumption per Capita (Y) + Demand and Supply Gap (Z)

$A = \alpha \times "X" + \beta \times "Y" + \gamma \times "Z"$

Figure 3- 1 Analysis Tree for Access



Background for selection of the sub-indexes

Electrification rate is often used as meaning of access to electricity. 100% electrification achievement is important as early as possible for improvement of people's living standard and as mitigation of inequality. Analysis on electrification about the whole country and other aspects like on comparison of electrification in urban and rural area are also important.

Electricity consumption per capita can be dealt to stand for index of development and modernization. Comparison of electricity consumption per capita between countries of similar development will provide interesting references.

Supply demand gap reveals whether electricity is supplied to users for a quantity as required necessary. Existence of supply demand gap means that electricity supply may be disturbing potential of growth. Study and analysis on electricity demands including potential demands are important at the same time on electricity supply capacity and capability.

【Scoring Formula for Visualization】

Indexation score is calculated by the formula below:

$$\text{Access Score} = \alpha \times \text{“X”} + \beta \times \text{“Y”} + \gamma \times \text{“Z”}$$

Where;

$$\alpha = 0.5, \beta = 0.3 \text{ and } \gamma = 0.2$$

X is electrification rate, being 100 points for 100% electrification rate and 0 point for no electrification

Y is based on electricity consumption per capita, being 100 points for 3,000kWh per person per year

Z is based on demand and supply gap, being 0 points, when the gap is larger than 20%, and 100 points for no gap.

Indexation on sub-indexes X, Y and Z is described in 3.1.2.

3.1.2 Sub-Indexes

(1) Electrification (Access to Electricity services for People)

Electrification to people is in many cases measured by households electrification rate, and this

sub-index is expressed by households electrification rate calculated by the formula below:

$$\text{Households Electrification Rate} = \left[\frac{\text{Number of Households Electrified}}{\text{Number of Households in the Country}} \right] \text{ (percent)}$$

(Note 1) Number of households electrified is number of households electricity supply contract by electricity utilities. If statistics of such number of supply contracts to households or total number of households in the country is unavailable, households electrification rate has to be estimated in use of other data like number of all types of electricity supply contracts and/or electrification target or policy paper telling some references to electrification rates of people, households or villages.

(2) Electricity Consumption per Capita

$$\text{Electricity Consumption per Capita} = \left[\frac{\text{Annual Electricity Consumption in the Country}}{\text{Population}} \right] \text{ (kWh/person-year)}$$

(Note 2-1) Year on Electricity Consumption should be the same year on Population. In case electricity consumption data being based on fiscal year, 6 months difference does not cause problems.

(Note 2-2) Electricity consumption being equal to total volume (kWh, MWh or GWh) of electricity sold to final consumers, can be obtained by the sum of electricity retails sales in the country. This is not gross generation nor electricity supply volume to grid. No transmission and distribution losses are included. Cross-country comparison and analysis needs the criteria being the same.

(3) Supply and Demand Gap

$$\text{Supply and Demand Gap} = \left[\frac{\text{Demand including Potential Demand} - \text{Actual Supply}}{\text{Demand including Potential Demand}} \right] \text{ (percent)}$$

(Note 3) Electricity demand changes from time to time. Supply capability also changes due to change of circumstances and events including facility outage due to maintenance and repair. The supply and demand gap is the largest record in a year.

3.1.3 Supplemental Index

For a proper scoring of sub-indexes, supplemental indexes are used in necessary cases and for such case as requiring more deeper analysis. The supplemental indexes include not only quantitative information but also qualitative information so that the information would support

comprehensive analysis on relating issues.

Supplemental indexes for Access are defined as follows:

(1) Supplemental Index for Electrification

(S1-1) Village Electrification Rate

Village Electrification Rate =

$$\left[\frac{\text{Number of Villages in which major public facilities are electrified}}{\text{Total Number of Villages in the Country}} \right] \text{ (percent)}$$

Village electrification is an approach to count number of villages in which major public facilities in the village are electrified. Public facilities are like schools, trading centers, health centers, administration centers, churches/mosques and other public facilities. In a way to achieve 100% electrification to households, village electrification is a milestone to be identified in the electrification planning and program. Definition of villages electrified is not always the same in all countries. Definition of village also is not the same. In a country, village is defined as administrative unit, and in other country as a community village smaller than administrative unit. In cross-country analysis of village electrification rate, it may be better to check definition of village electrified.

(S1-2) Urban and Rural Electrification

Electrification rate in urban area and in rural area provides reference information and hints on electrification policy. However, definition on urban and rural is not the same for calculating electrification rate in all the countries. Therefore, cross country analysis under urban and rural electrification rate may need some cares.

(S1-3) New Connection Fees

There may be a case that households electrification is still low in the village already having been electrified due to high new connection fee compared to income of household being desirous for accessing to electricity. New connection fee includes wiring cost from existing wire to the households, meter and deposit for which the new consumer has to pay for connection application. When electrification rate is low, study and analysis on new connection fee are suggested.

(S1-4) Electricity Tariff applicable to Minimum Household Consumption

Electricity consumption by low income households is mainly for lighting, and consumption volume is small. Electricity tariff in many countries is designed and structured to apply for low consumption of low tariff rate such as “lifeline tariff system” and gradually for higher consumption of higher tariff rate. Tariff design and structure may influence to electrification rate. In cross-country comparison, the lowest tariff applicable to the minimum consumption is considered to be adequate.

(2) Supplemental index to Supply and Demand Gap

(S3-1) Power Supply Planning (Development and Investment)

In almost all developing countries, where economy is growing up, planning for future electricity supply backed up by necessary investment is important. If financing arrangement takes a longer period or construction delays, it may cause a power shortage due to supply and demand gap. Power supply planning includes rural electrification planning having a direct relation with electrification rate. Issues involved in power supply planning are so wide that include planning capability and ability, plan itself, technical and engineering capability, financing capacity, operation arrangement and administrative capabilities. For proper analysis on power supply planning, a comprehensive study including interviews and site surveys is required, but information gathering and analysis based on available information is also important in this Power Sector Diagnostic Assistance Tool .

(S3-2) Elasticity of Electric Consumption to GDP

Elasticity of electricity consumption is 1.0, if consumption and GDP increase at the same rate. In developing countries, it is many times found that elasticity of electricity consumption is larger than 1.0, which means electricity demand increase is larger than GDP growth. The elasticity larger than 1.0 is understood to be caused by (i) increase of electrification rate and (ii) industrialization to consume more electricity. When the elasticity of electricity consumption is lower than 1.0, there may be a possibility that supply and demand gap is increasing. A survey is suggested in such case.

(S3-3) Industrial Structure

Industrialization brings increase of electricity consumption. Existence of large electricity consuming industry in a country affects to electricity consumption per capita or per GDP of that country. When demand and supply gap is found, it may be necessary to check change of industrial structure of the country.

3.2 Low Cost

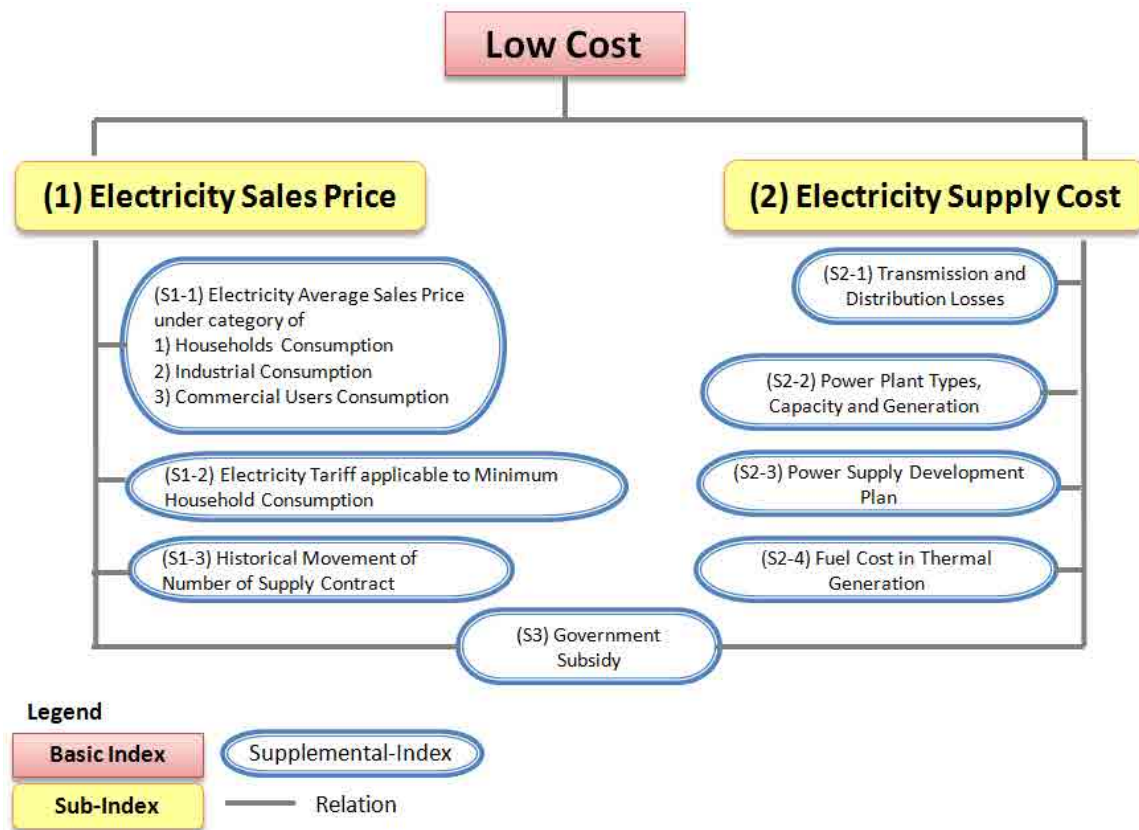
3.2.1 Definition of Basic Index

Modern society is supported by energy consumption. Electricity cost and price relate to economy and industrial activities. Lowest cost and lowest price electricity as much as possible contributes to higher development of developing countries. In understanding that low cost and price electricity is important, Low Cost is defined as one of basic index together with sub-indexes.

$$\text{Low Cost (B)} = \text{Electricity Sales Price (X)} + \text{Electricity Supply Cost (Y)}$$

$$B = \alpha \times \text{“X”} + \beta \times \text{“Y”}$$

Figure 3- 2 Analysis Tree for Low Cost



Background for selection of the sub-indexes

Electricity sales price is cost to consumers, who consume for themselves, or consume for production of goods or for providing services. Electricity sales price is selected as one of sub-index for Low Cost.

While electricity cost is not an issue of consumers' side but of suppliers' side, a real low price supply can be achieved by lower cost production and delivery. If price is too low compared to its cost to involve money losing situation, it is not sustainable, and higher price will be involved upon or before business crush. Analysis on electricity supply cost is selected as one of sub-index for Low Cost.

【Scoring Formula for Visualization】

Indexation score is calculated by the formula below:

$$\text{Low Cost Score} = \alpha \times \text{“X”} + \beta \times \text{“Y”}$$

Where;

$$\alpha = 0.6 \text{ and } \beta = 0.4$$

Score on X (Electricity Sales Price) is 50 points, when it is equal to Benchmark Price¹. If lower than Benchmark Price, differences expressed as percentage shall be added to 50, and if higher, differences expressed as percentage shall be deducted from 50. No negative points and no higher points to exceed 100 is not given.

Score on Y (Electricity Supply Cost) is 50 points, when it is equal to Benchmark Cost¹. If lower than Benchmark Cost, differences expressed as percentage shall be added to 50, and if higher, differences expressed as percentage shall be deducted from 50. No negative points and no higher points to exceed 100 is not given. Therefore, the calculation manner is the same as that for X.

3.2.2 Sub-Indexes

(1) Electricity Sales Price

¹ Benchmark Price and Benchmark Cost: low or high in price and in cost is a comparison with others or a benchmark. One idea for a benchmark of price and of cost is to use an average price and an average cost of electricity in the world.

As an approach to obtain the world average from data in all countries involves so much works, an alternative is to calculate Benchmark Price and Cost by formula of;

$$\text{Benchmark Price (US Cents/kWh)} = \text{Benchmark Cost (US Cents/kWh)} =$$

$$\text{International Crude Oil Price (USD/bbl)} \times 0.1886 \text{ (1/100bbl/kWh)} + 3.5 \text{ (US Cents/kWh)}$$

(Note) The formula assumes that electricity supply involves consumption of fuel at 0.001886bbl (0.3L)/kWh and fixed cost 3.5 US Cents/kWh. 0.3L fuel consumption per kWh is equivalent to 31.7% thermal efficiency. The assumed efficiency 31.7% is considered to be a benchmark standard, as electricity supply involves auxiliaries consumption at power plant and transmission and distribution losses for supply.

In a cross-country comparison of selected similar countries, the benchmark can be an average of those countries.

Electricity Sales Price for Sub-Index shall be calculated by the formula below as average unit revenue per kWh including tariff subsidy to be paid by the government.

$$\text{Electricity Sales Price} = \left[\frac{\text{Electricity Sales Revenue (Converted to USD)}}{\text{Total Electricity Sales Volume (GWh)}} \right] \text{ (US Cents/kWh)}$$

(Note 1-1) When subsidy is paid by government for tariff control, such subsidy should be included in Electricity Sales Revenue so that Electricity Sales Price stands for real price not subsidized price.

(Note 1-2) Electricity Sales Revenue shall be revenue from electricity sales but can include new connections fees and other electricity related revenue. When utility provides other services such as gas or water, revenue in the formula should contain only of electricity. If financial statement is published only for consolidated, electricity revenue shall be picked out from such in segment information. If income statement recognizes fuel cost adjustment revenue as negative value of cost, such negative value should be added to revenue.

(Note 1-3) Conversion to USD shall be done with average exchange rate during the term (accounting period). When historical analysis is intended, conversion to USD is not necessary.

(Note 1-4) There are electricity sales utilities or retail suppliers more than one, the revenue and the sold electricity volume should be the sum of all retail sales.

(Note 1-5) Electricity Sales Volume shall be such volume as sold and delivered to consumers, and not generated or dispatched electricity, because generated or dispatched electricity volume is larger than consumed electricity volume as some parts being lost including transmission and distribution losses.

(2) Electricity Supply Cost

Electricity Supply Cost for Sub-Index shall be calculated by the formula below as average gross cost per kWh including all associated costs like corporate income tax.

$$\text{Electricity Supply Cost} = \left[\frac{\text{Electricity Supply Gross Cost in Electricity Utilities (Converted to USD)}}{\text{Total Electricity Sales Volume (GWh)}} \right] \text{ (US Cents/kWh)}$$

(Note 2-1) Electricity Supply Gross Cost shall include all costs including generation, transmission and distribution as well as general and administrative expenses, interest and financing expenses, and corporate income tax. Costs associated to other businesses shall be

excluded. If no breakdown is available to separate other business costs and expenses, reasonably estimated amount shall be deducted.

(Note 2-2) Interest revenue as well as foreign currencies exchange rates fluctuation gains shall be deducted from gross costs, as far as those were recognized as results of electricity supply business. If corporate income tax is recognized as tax benefit together with deferred tax assets and liabilities, such tax benefit amount shall reduce the gross expenses.

(Note 2-3) Conversion to USD shall be done with average exchange rate during the term (accounting period). When historical analysis is intended, conversion to USD is not necessary.

(Note 2-4) There are electricity sales utilities or retail suppliers more than one, the gross costs and the sold electricity volume should be the sum of all retail sales utilities and supplier. Costs in whole sale utilities including IPPs shall be excluded, as such costs are recognized as purchase by retail sales utilities or suppliers. Transaction by small utilities can be excluded, if such effects are negligible small.

(Note 2-5) Electricity Sales Volume shall be such volume as sold and delivered to consumers, and not generated or dispatched electricity, because generated or dispatched electricity volume is larger than consumed electricity volume as some parts being lost including transmission and distribution losses.

3.2.3 Supplemental Index

For a proper scoring of sub-indexes, supplemental indexes are used in necessary cases and for such case as requiring more deeper analysis. The supplemental indexes include not only quantitative information but also qualitative information so that the information would support comprehensive analysis on relating issues.

Supplemental indexes for Low Cost are defined as follows:

(1) Supplemental Index for Electricity Sales Price

(S1-1) Electricity Average Sales Price in Consumer Categories

Average Sales Price for Households Consumers =

$$\left[\frac{\text{Electricity Sales Revenue for Households (Converted to USD)}}{\text{Total Electricity Sales Volume to Households (GWh)}} \right] \text{ (US Cents/kWh)}$$

Average Sales Price for Industrial Consumers =

$$\left[\frac{\text{Electricity Sales Revenue for Industries (Converted to USD)}}{\text{Total Electricity Sales Volume to Industries (GWh)}} \right] \text{ (US Cents/kWh)}$$

Average Sales Price for Commercial Consumers =

$$\left[\frac{\text{Electricity Sales Revenue for Commercial Users (Converted to USD)}}{\text{Total Electricity Sales Volume to Commercial Users (GWh)}} \right] \text{ (US Cents/kWh)}$$

In many countries electricity tariff has consumers categories as mentioned above, and statistical information on sales volume and amount is available. If the tariff system is different and average sales prices are different depending on electricity utility or supplier, then analysis can be made on typical or major utilities or suppliers.

(S1-2) Electricity Tariff applicable to Minimum Household Consumption

It is the same as of (S1-4) of paragraph 3.1.3.

(S1-3) Historical Movement of Number of Supply Contract

Increase of electricity supply contract should be reasonable compared to growth of population, industrial activities or GDP. Analysis on historical movements on number of contacts of each tariff category for households, for industrial and for commercial users is suggested.

(2) Supplemental Index for Electricity Supply Cost

(S2-1) Transmission and Distribution Losses

Transmission and Distribution Losses =

$$\left[\frac{\text{Total Sold Electricity Volume (GWh)} - \text{Total Dispatched Electricity (GWh)}}{\text{Total Dispatched Electricity (GWh)}} \right] \text{ (percent)}$$

Total Dispatched Electricity shall include power purchase and import. Transmission and distribution losses means lost or consumed electricity energy after electricity dispatch from power plants and before delivery to consumers. Power plants auxiliaries like pumps and fans consume electricity energy. However, such power plant auxiliaries consumption shall not be included in transmission and distribution losses, as it is consumed before dispatching electricity from power plant.

If successful in reducing transmission and distribution losses, such reduction corresponds to saving. For the same electricity supply, generation can be reduced by the successful saving of transmission and distribution losses. Fuel can be saved. Facilities will have wider safety margins. Investment may be saved. Saving effects from transmission and distribution losses are not small.

Transmission and distribution losses are caused only by physical reasons like inefficient equipment and inadequate design including selection of conductors but also by other non-technical reasons like power theft. If transmission and distribution losses are larger than 15%, there may be high possibility that non-technical losses are involved, and it is better to make survey.

(S2-2) Power Plants Types, Capacity and Generation

For the lowest cost electricity supply, types, capacity and generation of power plants should be optimized to electricity generation and supply under energy resources available in the country. Analysis on this point is important at each plant type like hydro, thermal (oil, gas, coal), diesel, gas turbine, renewable energy (small hydro, geothermal, wind, solar, biomass and others). If several utilities are active, analysis on each utility including other category as IPPs is necessary. In case that thermal generation share is high, fuel price increase influence is large. Power purchase price from IPPs is one of issues.

(S2-3) Power Supply Development Plan

Power supply development plan needs to be analyzed in terms of electricity supply cost in addition to access as mentioned at Section 3.1. Electricity supply cost is also better to be analyzed in future projection under Power Supply Development Plan.

(S2-4) Fuel Cost in Thermal Generation

As Fuel cost portion in thermal generation cost being generally large, analysis is necessary on fuel cost value in each type of thermal generation and fuel purchase cost as well as cost share of fuel in thermal generation and also in electricity supply. Fuel procurement is sometimes influenced by several reasons including environment, resources available, transportation conditions and politics. Analyzing circumstances on generation fuel in the country is also suggested.

Fuel consumption performance of thermal power plant is analyzed by using either of Thermal Efficiency, Heat Rate or Fuel Consumption Rate as mentioned below:

$$\text{Thermal Efficiency} = \left[\frac{\text{Energy of Generated Electricity}}{\text{Energy in Fuel Burnt}} \right] \text{ (percent)}$$

$$\text{Heat Rate} = \left[\frac{\text{Energy in Fuel Burnt}}{\text{Generated Electricity (kWh)}} \right] \text{ (kJ/kWh or BTU/kWh or Kcal/kWh)}$$

$$\text{Fuel Consumption Rate} = \left[\frac{\text{fuel Burnt (g)}}{\text{Generated Electricity (kWh)}} \right] \text{ (g/kWh)}$$

(Note 1) Energy conversion table is provided at page iii as reference.

(Note 2) Fuel energy is expressed by HHV (High Heat Value) or LHV (Low Heat Value). Both HHV and LHV are used to Thermal Efficiency and to Heat Rate. Therefore, cautions are necessary on Thermal Efficiency and to Heat Rate, because difference is about 10% in case of natural gas.

(Note 3) Quality of coal is very wide, and difference of energy in 1 kg of coal is very wide from low energy content coal to high energy content coal. In the same country, it is usual that coal supply mines are different depending on power plant.

(3) Government Subsidy

In some countries, the government subsidizes electricity utility to supply electricity so as to maintain tariff at controlled level by the government. Sometimes the government subsidizes fuel purchase so that the utility can procure fuel at subsidized price for avoiding tariff hike. In general, government subsidy for controlling price often induces negative economic impacts, because subsidy restricts market competitions. In case of electricity supply under monopoly by the government owned utility, impact by subsidy may be different, but may involve some effects to internationally trading goods or induce negative impacts to energy efficiency as well as mitigation for climate change. If there is a possibility towards market liberalization in electricity supply business, the government subsidy is contrary to that. It is necessary to check whether the government subsidy is paid or not, and if paid, information on the subsidy types and amount are to be collected as well as percentage in the government revenue and expenses budget.

3.3 Low Carbon

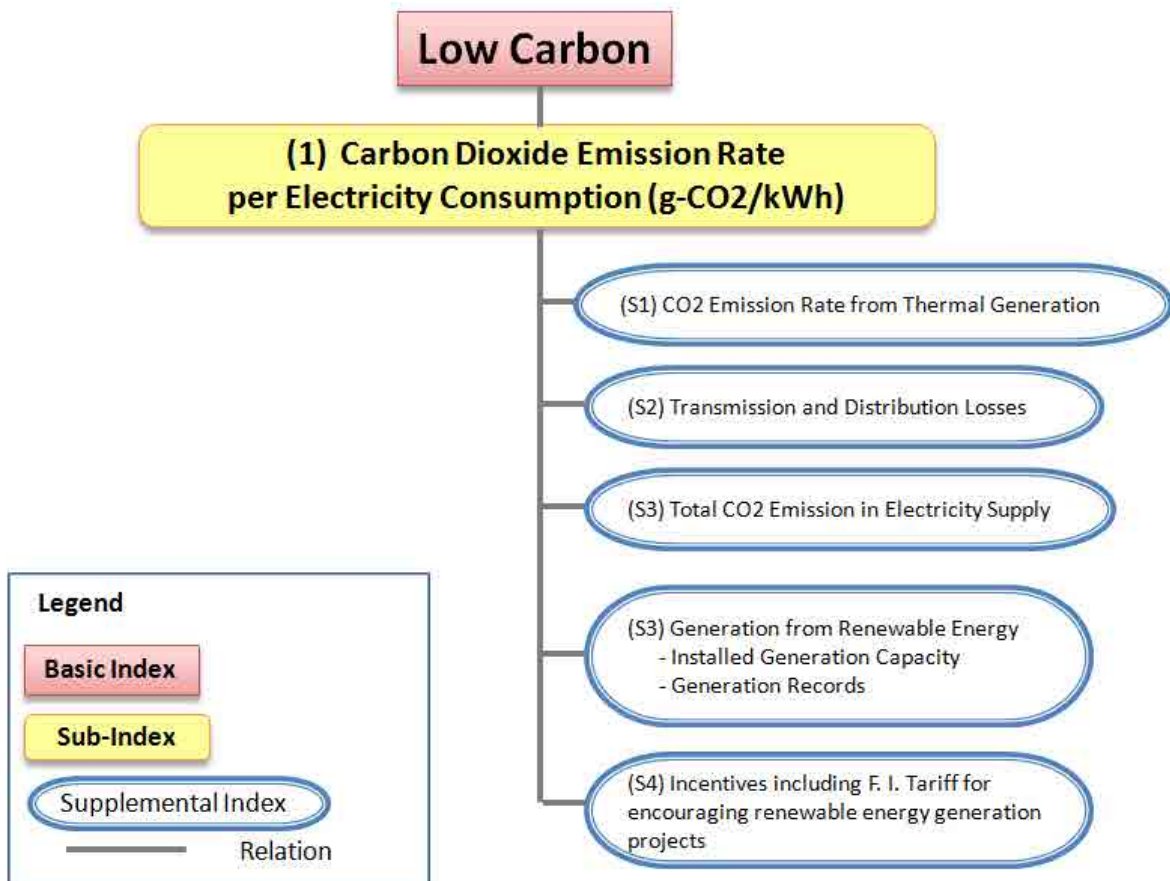
3.3.1 Definition of Basic Index

Sustainable development in harmony with global environment is common everywhere in the world. All projects in developed or developing country are required to respond requests for mitigation on climate change. Analysis on CO₂ emission in electricity supply is one of issues to need analysis. Low carbon is selected one of the basic indexes to be measured in terms of CO₂ emission per electricity consumption.

Low Carbon (C) = Carbon Dioxide Emission Rate (X)

$C = \alpha \times "X"$

Figure 3- 3 Analysis Tree for Low Carbon



Background for selection of the sub-index

The index Carbon Dioxide Emission Rate per Electricity Consumption indicates overall CO₂ emission performance of all facilities of generation, transmission and distribution as well as operation.

【Scoring Formula for Visualization】

Indexation score is calculated by the formula below:

$$\text{Access Score} = \alpha \times "X"$$

Where;

$\alpha = 1.0$, and X is CO₂ Emission Rate per Electricity Consumption.

Score on X is 50 points, when it is equal to Benchmark CO₂ Emission Rate. If lower than the Benchmark CO₂ Emission Rate, difference (Benchmark Rate - Emission Rate) divided by 8 shall be added, and if higher, the difference divided by 8 shall be deducted. Formula expression is;

$$\text{Score} = 50 - (\text{CO}_2 \text{ Emission Rate of the Country} - \text{Benchmark CO}_2 \text{ Emission Rate}) \times 1/8$$

As Benchmark CO₂ Emission Rate, 600 g-CO₂/kWh being current world average, is suggested. Use of 600 g-CO₂/kWh provides 100 points to countries emitting CO₂ less than 200 g-CO₂/kWh, and 0 point, if higher than 1,000 g-CO₂/kWh.

3.3.2 Sub-Indexes

(1) Carbon Dioxide Emission Rate per Electricity Consumption

CO₂ Emission Rate per Electricity Consumption

$$= \left[\frac{\text{Total Annual CO}_2 \text{ Emission from Fossil Fuel in Generation}}{\text{Total annual Sold Electricity}} \right] (\text{g-CO}_2/\text{kWh})$$

(Note 1) Year on CO₂ Emission should be the same year on Sold Electricity. In case electricity sales data being based on fiscal year, 6 months difference does not cause problems.

(Note 2) In case electricity is imported, such import volume of electricity shall be deducted from sold electricity so as to compensate zero emission of import electricity. If export electricity is not included in sold electricity volume, such export volume shall be added to sold electricity.

(Note 3) Total Annual CO₂ Emission from Fossil shall include all thermal generation. In case IPPs do not disclose fuel burnt in their power plants, information has to be obtained from other sources like statistics or energy balance diagram.

3.3.3 Supplemental Index

For a proper scoring of sub-indexes, supplemental indexes are used in necessary cases and for such case as requiring more deeper analysis. The supplemental indexes include not only quantitative information but also qualitative information so that the information would support comprehensive analysis on relating issues.

Supplemental indexes for Low Carbon are defined as follows:

(S1) Carbon Dioxide Emission Rate of Thermal Generation

CO₂ Emission Rate of Thermal Generation =

$$\left[\frac{\text{Total Annual CO}_2 \text{ Emission from Fossil Fuel in Generation}}{\text{Total annual Electricity Generation by Thermal Power Plant}} \right] \text{ (g-CO}_2\text{/kWh)}$$

In electricity supply, CO₂ is emitted from thermal power plants in burning fossil fuel. Reduction of CO₂ can be obtained by less consumption of fossil fuel for the same amount of generation. Higher thermal efficiency makes possible. Change of fuel to lower CO₂ emission factor makes also possible, though facility modification or re-building may be required in these option. Other options to reduce CO₂ emission are electricity generation by non CO₂ emitting generation like renewable energy, hydro, geothermal. Reduction of transmission and distribution losses also contributes to CO₂ emission reduction.

When making cross-country comparison of CO₂ emission rate of thermal generation, it is better to care about base of thermal generation kWh. Some statistics only publishes gross generation at generator terminal, and do not mention about plant net output energy dispatched

(S2) Transmission and Distribution Losses

This is the same index as mentioned at (S2-1) of Supplemental Index in Low Cost. As mentioned at S2-1 of Supplemental Index in Low Cost, successful reduction in transmission and distribution losses, can reduce generation volume, and contributes to reducing CO₂ emission rate.

(S3) CO₂ Emission from Electricity Supply

It is necessary not only focus on CO₂ emission rate per kWh but also on total amount of CO₂ emission (ton-CO₂). In some countries option on primary energy selection is limited. For islands country, limitations relating to electricity supply may not be only on choice of primary energy but also on location and land area of facilities. Total CO₂ emission is also necessary to be included in supplemental index.

(S4) Generation from Renewable Energy

Now renewable energy generation facilities are installed and working in almost all countries. Information on the renewable energy generation facilities is necessary to be obtained about installed capacity (MW) and annual generation records (MWh) with breakdown to types of renewable energy, small hydro, geothermal, wind, solar PV, solar thermal, biomass, urban waste and other sources of renewable energy. Accurate data on off-grid facilities is not easy to be obtained, and such off-grid facilities can be excluded from information to be collected. Renewable energy applications only for thermal energy such as heating or cooking are also excluded.

(S5) Incentives Encouraging Renewable Generation Projects

For encouraging renewable generation projects, many countries have incentive programs to accelerate investment in renewable energy generation project. Those programs include (i) Feed-in Tariff system to apply incentive tariff for power purchase, (ii) Renewable Energy Portfolio Standard system to provide purchasing obligations to utilities of certain amount of renewable source electricity, (iii) government subsidy to renewable energy projects on capital investment or for preferable taxes or duties. Information on renewable energy policy and programs is to be obtained. At the same time, analysis and study on those programs are also suggested whether they are reasonable.

3.4 Low Risks

3.4.1 Definition of Basic Index

Energy stable supply is one of key elements for sustainable development. Risks on such energy stable supply should be identified and mitigated for development. Risks concerned even in for electricity supply include wide range as found in stability of primary energy security, optimized types of generation, weather and climate conditions and grid stability. In this Power Sector Diagnostic Assistance Tool , Low Risks are selected as one of the basic indexes, being defined as below, together with sub-indexes. Analysis tree for Low Risks and explanation on those sub-indexes follow as mentioned as below:

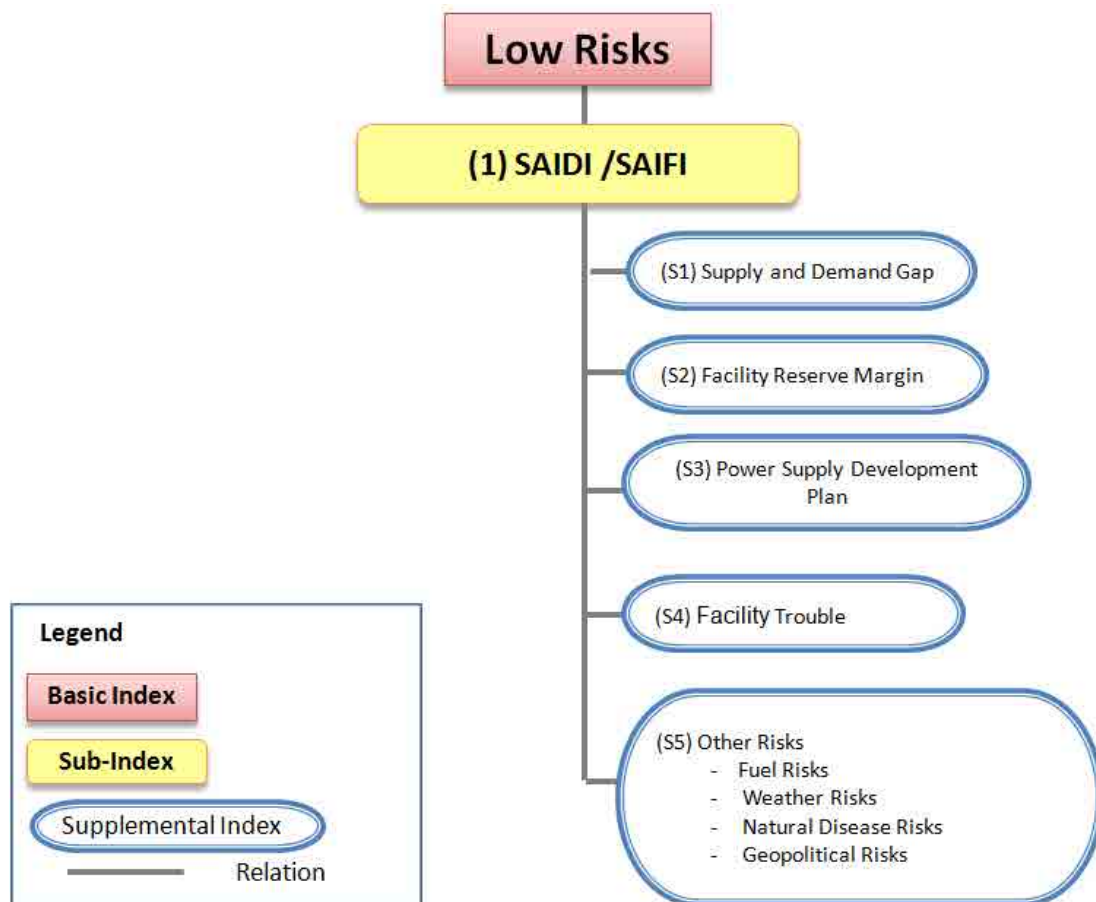
$$\text{Low Risks (D)} = \text{SAIDI (X)} + \text{SAIFI(Y)}$$

$$D = \alpha \times \text{“X”} + \beta \times \text{“Y”}$$

(Note 1) SAIDI means System Average Interruption Duration Index

(Note 2) SAIFI means System Average Interruption Frequency Index

Figure 3- 4 Analysis Tree for Low Risks



Background for selection of the sub-indexes

SAIDI and SAIFI are such indexes as reliability of supply of electricity to consumers. All events arising from risks involved in generation, transmission and distribution, appear to arise as supply risks and reliability to consumers. Therefore, SAIDI and SAIFI are selected as sub-index for Low Risks.

In some countries, statistics on SAIDI and SAIFI are not available or not published. In such cases, risks have to be analyzed in use of other statistics or information as supplemental indexes affecting reliabilities and risks in supply of electricity to consumers.

【Scoring Formula for Visualization】

Indexation score is calculated by the formula below:

$$\text{Low Cost Score} = \alpha \times \text{“X”} + \beta \times \text{“Y”}$$

Where;

$$\alpha = 0.5 \text{ and } \beta = 0.5$$

Score on X (SAIDI) is 100 points, when it is zero hour, and actual statistical SAIDI hours shall be deducted from 100 points. If larger than 100 hours per customer, the score becomes zero point.

Score on Y(SAIF) is 100 points, when it is zero times, and actual statistical SAIFI shall be deducted from 100 points. If larger than 100 times per customer, the score becomes zero point.

When statistics on SAIDI and SAIFI are not available, the score is calculated by formula below in use of Supply and Demand Gap as defined at (3) of sub-index for Access:

$$\text{Low Cost Score} = 50 - (\text{Supply and Demand Gap as percent}) \times 2.5$$

The maximum points obtained by this formula are 50, and become zero, when the gap is larger than 20%.

Reason why Supply and Demand Gap is selected, is that highest number of supply shut down is understood caused by power shortage due to supply and demand gap.

(Note) When SAIDI and SAIFI statistics are not available, the maximum score is 50. In other words, SAIDI and SAIFI is one of important statistics for analyzing electricity supply.

3.4.2 Sub-Indexes

(1) SAIDI (System Average Interruption Duration Index)

SAIDI =

$$\left[\frac{\text{Sum of (Duration of Blackouted Customers–Number of Blackouted Customers)}}{\text{Total Number of Customer}} \right]$$

(hours/customer)

(Note) SAIDI is expressed either in minutes or in hours. This Power Sector Diagnostic Assistance Tool uses hours for unifying unit for cross-country analysis.

(2) SAIFI (System Average Interruption Frequency Index)

$$\text{SAIFI} = \left[\frac{\text{Sum of (Number of Blackouted Customers)}}{\text{Total Number of Customers}} \right] \text{ (times/customer)}$$

3.4.3 Supplemental Index

Supplemental indexes are used to analyze events and issues, which affect reliabilities and risks in supplying electricity to customers, and include descriptive and qualitative information.

Supplemental indexes for Low Risks are defined as follows:

(S1) Demand and Supply Gap

The same index as applied as Supply and Demand Gap at (3) of sub-index for Access 3.1.2. When there is a supply and demand gap, electricity supply cut has to be carried out for preventing accident, damage to facility, grid instability and safety operation. Larger supply and demand gap needs larger involvement of customers affected for blackout and also of longer duration of blackout.

(S2) Reserve Margin of Facility

Plant, equipment and facilities in some occasions do not work as expected due to some troubles including unexpected events. Therefore, it is necessary for safety and reliable supply to keep some margins to absorb supply capacity down risks and also for demand increase beyond supply planned.

$$\text{Reserve Margin} = \left[\frac{\text{Dependable Capacity of System} - \text{Estimated Peak Demand}}{\text{Estimated Peak Demand}} \right] \text{ (Percent)}$$

When reserve margin is not published, reference reserve margin shall be estimated by formula below:

Reference Reserve Margin =

$$\left[\frac{\text{Total of Generation Plant Capacity} - \text{Estimated Peak Demand}}{\text{Estimated Peak Demand}} \right] \text{ (Percent)}$$

(Note) When making Reserve Margin accurately, Dependable Capacity of System is not a simple summation of power plants but needs evaluation of actual capacity affected by aging, maintenance outage and also transmission capacity and availability.

(S3) Power Supply Development Plan

While Power Supply Development Plan is selected also supplemental indexes in Access and in Low Cost, the plan is also important in low risks. When demand and supply gap is found, it is necessary whether the plan is contemplated to decrease power shortage due to the current demand and supply gap.

(S4) Facility Trouble

In developing countries, relatively high facility troubles involve electricity supply blackout or shutdown. Facility troubles information is necessary to analyze quality and magnitude on them as risks to electricity supply. Information on skill and capacity of staff and engineers is also important. However, these kinds of facility trouble information in details are in many cases not disclosed to public, and are necessary to be surveyed in by dispatching a study team, if necessary. Facility troubles are caused not only by technical inadequacy but also by mismanagement like allocation of insufficient budget for maintaining a performance or avoiding troubles and accidents. Electricity utilities in developing countries often need management ability level up. In facility trouble, it is also necessary to make evaluation and decision under estimation of budget on repair, replace, renewal or new addition.

(S5) Other Risks (Fuel, Weather, Natural Disaster etc)

Fuel procurement for thermal generation involves market price fluctuation risks and exchange rate fluctuation risks, when import fuel is used. Geopolitical risks may arise. Supply shutdown of fuel is a large risk. Even in use of domestic production fuel, declining reserve of

resources may alarm. Limited fuel supply sources conditions involve a volatile risk, should events happen relating to such resources.

Precipitation and cloud to decrease solar radiation affect to generation by renewable energy, and it can be told that renewable energy generation is involved in weather risks. For developing countries in which supply and demand gap is large, generation facility to produce fluctuating output energy depending on weather is not suitable for stable energy supply. Investment to batteries or backup thermal generation facility may involve double capacity. Generation in hydro power plant decreases in drought year. Backup generation facilities including rental generators are arranged in many cases.

Natural disaster like earthquake, tsunami, flood and storm surge of water cause damage to electricity supply facility. Backup generation plant and backup transmission lines mitigate risks. However, it is also experienced in many developing countries that a higher priority has to be for investment of new facility additions under a rapidly increasing demand situation.

A risk exists that renewable energy generation of highly variable output type like wind and solar PV increase to exceed a level causes grid system instability. Output energy fluctuation of large capacity wind power or solar PV may disturb power flow and frequency stability in case grid scale being small, and if over a limit, blackout is triggered to avoid large accident. For prevention of grid system instability because of renewable energy generation, it is recommended to make a grid system stability studies including simulation at operating conditions of planned large capacity wind power and solar PV.

3.5 Efficiency

3.5.1 Definition of Basic Index

Achieving highly energy efficient society and industries is one of important tasks for sustainable development to keep global environment and to save natural resources. Efficient consumption of electricity can decrease investment to unnecessary investment. Efficiency is selected as one of the basic indexes, being defined as below, together with sub-indexes.

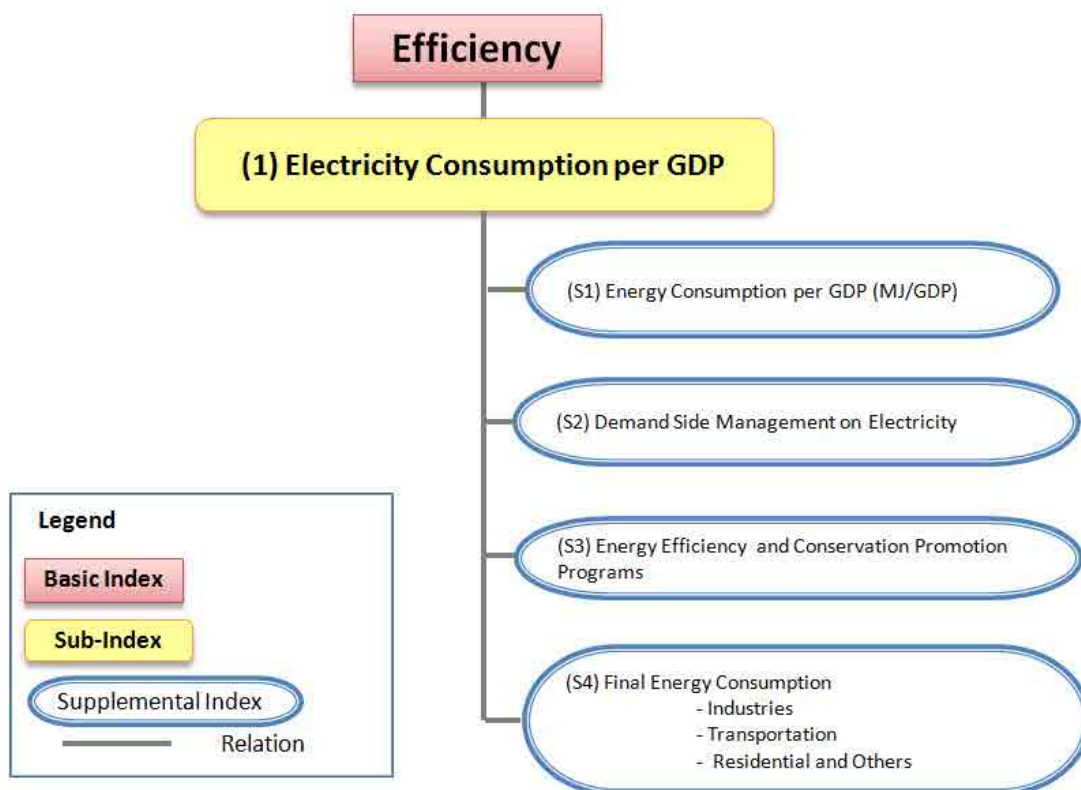
Availability of energy resources is different depending on country. Circumstances surrounding energy is also different on availability of natural resources, population, stage of development, industrial structure etc. Historical analysis on efficiency in use of index is possible. Cross-country analysis may require some adjustments.

Analysis tree for Low Risks and explanation on those sub-indexes follow as mentioned as below:

Efficiency (E) = Electricity Consumption per GDP (X) x Supplemental Index (Y) of Energy Consumption per GDP

$E = "X" \times "Y"$

Figure 3- 5 Analysis Tree for Efficiency



Background for selection of the sub-index

Efficiency has to focus electricity consumption and energy consumption how electricity and energy are consumed. Consumers of electricity and energy are wide in people and industry. Improvement in efficiency of consuming electricity and energy contributes not only to saving primary energy resources but also to saving investment to supply facility as well as financial benefits from savings.

The Electricity Consumption per GDP is selected as sub-index to express efficiency of electricity consumption and is analyzed together with supplemental index Energy Consumption per GDP. In case historical analysis is intended, GDP can be real GDP at constant value or new indexed manner applying real GDP at constant value.

【Scoring Formula for Visualization】

Indexation score is calculated by the formula below:

$$\text{Score (E)} = \text{“X”} \times \text{“Y”}$$

Where;

Score on X is 50 points, when it is equal to Benchmark Electricity Consumption per GDP. If lower than the Benchmark, 1 point shall be added on every 5Wh/GDP USD improvement. If higher, 1 point shall be decreased on every 5Wh/GDP USD additional consumption.

As Benchmark Electricity Consumption 300Wh/GDP USD is suggested, 50Wh/GDP USD consumption gets 100 points, and 550Wh/GDP USD consumption corresponds to 0 point.

Score on Y is coefficient 1.0, when it is equal to Benchmark Energy Consumption per GDP. If lower than the Benchmark, 0.01 shall be added to the coefficient on every 1MJ/GDP USD improvement. If higher, 0.01 shall be decreased from the coefficient on every 1MJ/GDP USD additional energy consumption under limitation of the minimum Y coefficient to be 0.8.

As Benchmark Energy Consumption 12MJ/GDP USD is suggested, 5MJ/GDP USD consumption makes the Y coefficient 1.07, and 20MJ/GDP USD consumption brings coefficient 0.92.

The minimum score (E) shall be 0, and the maximum 100 as result to “X” x “Y”

3.5.2 Sub Index

$$(1) \text{ Electricity Consumption per GDP} = \left[\frac{\text{Electricity Consumption}}{\text{GDP(converted to USD)}} \right] (\text{Wh/GDP USD})$$

Electricity Consumption per GDP is an index to count electricity consumption efficiency. However, the index is not reveal efficiency effect but consumption itself. Therefore, it is also possible that low number index is caused by low electrification rate or by shortage of supply capability. Analysis on these points is also necessary.

(Note) For historical analysis, GDP, in stead of nominal GDP converted to USD, can be real GDP at constant value or new indexed manner applying real GDP at constant value.

3.5.3 Supplemental Index

Supplemental indexes are used to analyze events and issues, which affect Efficiency, and include descriptive and qualitative information.

(S1) Energy Consumption per GDP

Energy Consumption per GDP is integrated in the formula to calculate score (E) of Efficiency. The Energy Consumption per GDP shall be obtained by:

$$\text{Energy Consumption per GDP} = \left[\frac{\text{Primary Energy Consumption}}{\text{GDP(converted to USD)}} \right] (\text{MJ/GDP USD})$$

(Note 1) Primary Energy Consumption is provided in energy balance diagram. However, if picked up from energy balance diagram, the publishing timing takes some period. In case of Japan, Japanese energy balance diagram for period from April 2012 to March 2013 was published on April 15, 2014 by the government. In calculation GDP and primary energy consumption shall be picked up from data of the same year.

(Note 2) Energy balance diagram is not published by the government, energy balance diagram in IEA website can be used. In use of energy balance diagram a caution is necessary on energy unit. For example, Japanese one uses GJ. IEA uses ton oil equivalent (TOE). Some country may use barrel equivalent oil or British Thermal Unit (BTU). Conversion to joule is necessary for cross-country analysis in this Power Sector Diagnostic Assistance Tool .

(S2) Demand Side Management on Electricity

When an electricity tariff system provides contract capacity tariff on MVA and energy tariff

on energy consumed (kWA), it induces an incentive to consumer for saving payment amount so that the same energy would be consumed under lower contract capacity. Such saving is possible, if the consumer can shift some parts of electricity consumption during high consuming hours to low consuming hours so that he can manage consumption under a lower contract capacity.

Above example brings advantages not only to consumers but also to electricity supplier, which can save some investments for plants and facilities; if peak hours supply (consumption) becomes low. This mechanism becomes more workable, when different rates tariff is introduced like peak hours tariff, off peak hours tariff, high season tariff and low season tariff.

For different rate tariff system it is necessary to install meters which can measure and record consumption in each different rate tariff hours. Further developed meter and system is to use smart meter having functions to measure, record and transmit consumption on every short interval like 5 minutes, 10 minutes, 30 minutes or 1 hour. Measurement of electricity consumption in short intervals makes expects further efficient electricity and energy consumption under more advanced tariff system and electricity trade in market.

There may be some demand side management system introduced in developing countries, it is suggest to collect information on electricity demand side management.

(S3) Energy Efficiency and Conservation Promotion Program

In many countries there are many energy efficiency and conservation promotion programs. Those include standards and labeling system on electricity and energy consuming apparatuses, equipments and machineries, building code for energy conservation, energy managers and auditors system. Information on programs for energy efficiency and conservation is suggested to collect information.

(S4) Final Energy Consumption

Final energy consumption by industry sector, by transportation sector and by residential and other sectors is to be analyzed.

3.6 Financial Soundness

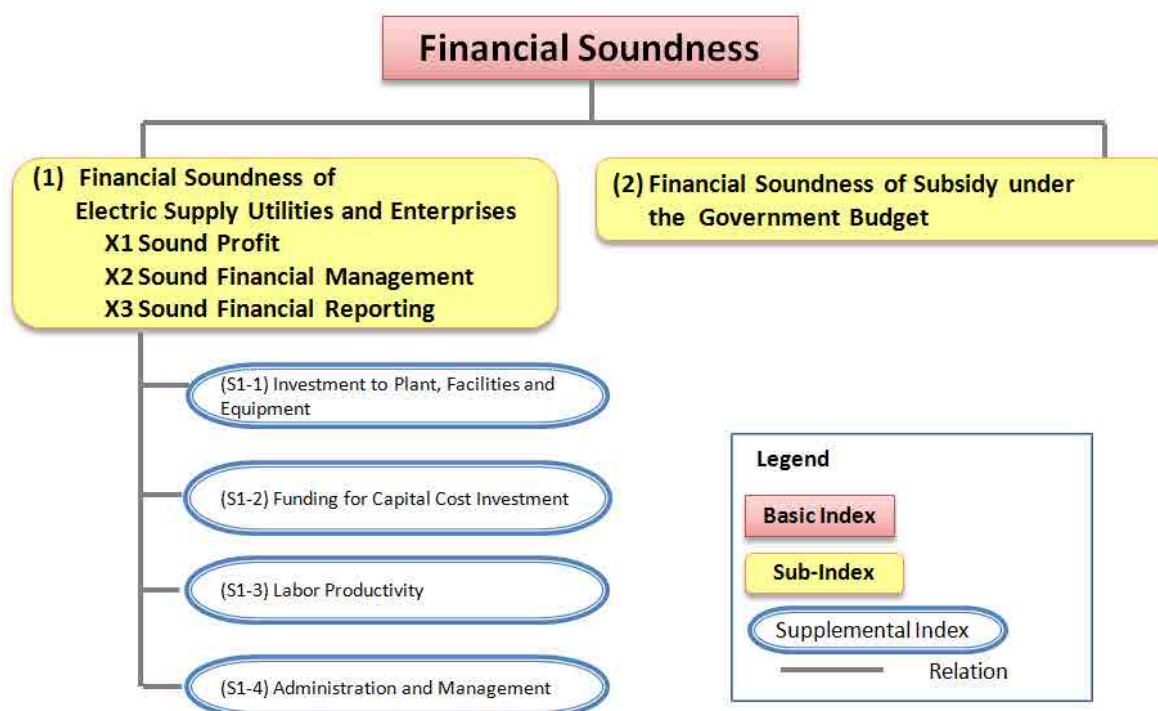
3.6.1 Definition of Basic Index

Sustainable development of power sector is achieved by successful operation of electricity supply industries. Financial soundness is one of the key elements in successful operation and sustainability. Power supply utilities and enterprises are to be analyzed on financial operations and performances. If subsidy is paid to power sector, financial soundness about the subsidy by the government also has to be analyzed. Financial soundness on power supply utilities and enterprises is selected one of the basic indexes as well as on subsidy by the government. The index for Financial Soundness shall be defined as below;

$$\text{Financial Soundness (F)} = \text{Financial Soundness of Electric Supply Utilities and Enterprises} + \text{Financial Soundness of Subsidy under the Government Budget}$$

$$F = \alpha \times \text{“X”} + \beta \times \text{“Y”}$$

Figure 3- 6 Analysis Tree for Financial Soundness



Background for selection of the sub-indexes

Financial Soundness should support and secure sustainable operation and development. Roles and duties of electricity supply utilities and entities are to supply electricity as necessary to people and industries, including those potential consumers having not been electrified.

Under Financial Soundness being obtained, electricity supply utilities and enterprises can secure operation with cash flows from their own business independent from financial support or subsidy from the government. In other words, important is that a reasonable profit is maintained, and that debt repayment and new fund arrangement for capital investments are carried out without problems. Electricity payment collection is one of the most important financial operation as well as payment to suppliers. Financial Soundness can be analyzed from financial reports, presenting fairly the financial position, financial performance and cash flows of entity. Fair presentation of financial statements also comprises Basic Index.

When a necessary profit is not maintained or loss is continuing and difficulty is predicted in continuing operation and investments by the electricity supply utility or entity, it is important to analyze, examine, study and identify reasons so that measures for sustainable operation could be established. Issues in Financial Soundness involve wide range of operations, which cannot be analyzed only by quantitative information. Interview to managing directors, managers and staffs is also important to get in touch issues, which really need measures for improvements. Such improvement may require changing a part of administration system in power sector.

In many developing countries, electricity supply utility(s) or enterprise(s) is/are owned by the government or major shares owned by the government. Electricity supply being an important infrastructure, subsidy may be paid to electricity supply utility(s) or enterprise(s). Part of necessary funding, to assist an operation or an investment, may be provided by the government. For IPP business, the government may provide a guarantee to the IPP enterprise to secure payment by the government owned utility. Subsidy by the government is also to be analyzed.

【Scoring Formula for Visualization】

Indexation score is calculated by the formula below:

$$\text{Financial Soundness Score} = \alpha \times \text{“X”} + \beta \times \text{“Y”}$$

Where;

$$\alpha = 1.0 \text{ and } \beta = \text{negative } 1.0$$

Score on X shall be calculated by manner described in the following sub-box.

$$X = \text{“A1”} \times \text{“X1”} + \text{“A2”} \times \text{“X2”} + \text{A3} \times \text{“X3”}$$

$A1 = 0.5, A2 = 0.4, \text{ and } A3 = 0.1$

(1-1) Score (X1) shall be calculated from (X1a) Profit Ratio of Electricity Sales and (X1b) Sum of Net Profit and Depreciation to Long Term Debt Ratio. Indexation formula of “X1a” and “X1b” is defined at 3.6.2.

Score (X1) calculation formula shall be:

$“X1” = “X1a” \times 12 \text{ (Maximum 60 points)} + (“X1b” - 10) \times 4 \text{ (Maximum 40 points)}$

X1 shall be total of (i) “X1a” multiplied by 12 subject to its ceiling 60 points at (“X1a” 5.0% reaches the maximum) and (ii) excess from 10 of “X1b” multiplied by 4 subject to ceiling 40 points (“X1b” 20% reaches the maximum).

(1-2) Score (X2) shall be calculated from (X2a) Average Payment Period of Electricity Sales and (X2b) Ratio of Purchase Obligation to Electricity Sales. Indexation formula of “X2a” and “X2b” is defined at 3.6.2.

Score (X2) calculation formula shall be:

$X2 = [70 - (“X2a” - 30 \text{ days})] + [30 - (“X2b” - 30\%)]$

Note: [] and () shall not be negative value.

If payment of Electricity sales is made within 30 days in average, 70 points are given, and over period to exceed 30 days shall be deducted from 70 points. If Purchase Obligation Ratio to Electricity Sales is not larger than 30%, 30 points are given, and 1% increase results in 1 points deduction.

(1-3) Score (X3) shall be 100 points, when financial reports are received within one year after the end of fiscal year, otherwise zero point.

3.6.2 Sub-Indexes

3.6.2.1 Financial Soundness of Electricity Supply Utilities and Enterprises

(1) Sound Profit

A reasonable profit is important for sustainable operation, and enables debt repayment and new fund arrangement for capital investments. When loss is recognized, two issues have to be

analyzed. One is on unreasonable low sales tariff, and the other is on cost saving possibilities. As profit producing operation being one of the most important requirements in Financial Soundness, loss producing situation continuing from previous year or several years ago requires analysis in details for establishment of measures for sustainable operation. In such case, analysis on projection of revenue, costs and profit in future years also important.

(1-1) Profit Ratio of Electricity Sales (X1a)

$$\text{Profit Ratio of Electricity Sales} = \left[\frac{\text{Net Profit}}{\text{Electricity Sales}} \right] \text{ (Percent)}$$

(Note 1) Analysis should be made on audited financial statements.

(Note 2) When operations by the utility or entity are comprised from several other business like water supply in addition to electricity supply, and further when sales and profit are not available for each segment, then profit ratio can be calculated by all businesses as an integral part.

(1-2) Sum of Net Profit and Depreciation to Long Term Debt Ratio (X1b)

$$\text{Ratio X1b} = \left[\frac{\text{Net Profit + Depreciation}}{\text{Long Term Debt}} \right] \text{ (Percent)}$$

The sum of net profit and depreciation corresponds to cash produced from operation. Such amount is possible to be allocated to repayment of borrowings including bond repayment. As operation of electricity supply industry requires large amount of capital investment to plant, machinery and equipment, which are generation, transmission and distribution facilities, management of long term debt is important under situation owing large amount of long term debt and still requiring new borrowing for new capital investment. The Ratio X1b is similar to debt service cover ratio, being one of the important financial ratios used in project financing.

In precise analysis of debt repayment capability, projection of revenue and costs/expenses, investment plan as well as projection of future financial performance and position are necessary to be examined.

(2) Financial Management

Even in case profit is recognized, bad payment in a part of bill collection does not produce financially sound situation. If supported by many honest payers, it is an unfair situation. If bad payment amount becomes large, such abnormal situation shall be improved. Loss recovery by the government fund needs improvement. Payment to suppliers also has to be made as required,

as supplier being not a financial supporter.

(2-1) Average Payment Period of Electricity Sales (X2a)

$$\text{Average Payment Period of Electricity Sales} = \left[\frac{\text{Trade Accounts Receivable}}{\text{Annual Electricity Sales}} \times 365 \right] \text{ (Days)}$$

(Note) When Trade Accounts Receivable in balance sheet is indicated by net amount after deduction of doubtful amount, such doubtful amount shall be added to the trade accounts receivable.

In case meter reading frequency being once a month, it is understood as common situation that payment would be made before the next meter reading, and that payment period is 30 days.

All business is based on that sales bring cash revenue. In other words, revenue collection is one of the fundamentals for business. Electricity supply business is infrastructure business for public, and bad payment shall not be allowed. In this sense, non-technical loss being a part of transmission and distribution losses shall not be allowed. In some developing countries, large amount of electricity bills is not paid for long period by government, local government and government entities. Delinquent in payment for electricity bills by government has to be solved by government. However, analysis on such bad payment by government is necessary for seeking solutions and for requesting government for improvement, because sustainable operation and development is achievable under financially sound conditions. Revenue bad payment sometimes induces bad payment to suppliers. When fuel is supplied by government owned entity, large amount may be left unpaid to the government owned fuel supplier in a bad scenario.

(2-2) Ratio of Purchase Obligation to Electricity Sales (X2b)

Ratio of Purchase Obligation to Electricity Sales =

$$\left[\frac{\text{Purchase Obligation on Balance Sheet Date}}{\text{Electricity Sales}} \right] \text{ (Percent)}$$

Purchase obligation is such obligation as results of purchase of raw material, products, semi-products or goods and services. In electricity supply business, purchasing is fuel, oil and lubricants, some consumables and electricity purchased from other entities including IPPs. In cost portion of electricity supply business, depreciation takes some parts and purchase cost is not so large, compared to other businesses. As far as profit being recognized, sales amount is larger than total cost amount, which includes not only purchase cost but also depreciation, interest payment, salary and pay roll cost, sales and administration cost. Purchase cost does not

share so large percent. As fuel is normally paid in short period, and also electricity purchase in short period, it is supposed that unpaid purchase obligation is normally less than 30% of annual sales revenue. Unpaid purchase obligation to exceed the 30% is treated to give lower scoring.

(3) Financial Reporting (X3)

When financial reports are received within one year after the end of fiscal year, 100 points score is obtained. It is understood financial report submission timing dead line date in most of rules in many countries is 6 months after the end of fiscal term. One year may be too long. However, there are many cases that financial reporting and annual reporting are not available after one year following the end of fiscal year. Financial report containing many important information needs to be analyzed in details, and auditing and accounting standards are also important. As analysis on those requires longer period, sub-index is determined only by timing of report submission date.

3.6.2.1 Financial Soundness of Subsidy under the Government Budget

This sub-index shall be calculated by formula below:

Financial Soundness of Subsidy under Government Budget =

$$\left[\frac{\text{Subsidy to Power Sector}}{\text{Government Revenue of Tax and Non Tax}} \right] \text{ (Percent)}$$

Subsidy to Power Sector includes subsidy to sales tariff, subsidy to fuel, financial support for loss situation and similar payment by government. ODA grant shall not be counted as subsidy. Government and local government support for rural electrification is also excluded from subsidy. Financial support by government in lending to spend for capital expenditure or in subscribing additional equity, or guarantee on debt repayment is not subsidy.

Government subsidy sometimes is complicated. The case of bad payment to a government owned fuel supplier might be a kind of subsidy to power sector by government through fuel sector. When government recognizes as subsidy, it is easy to get information. However, if it is recognized only in books of government owned entities, it is not so easy.

3.6.3 Supplemental Index

Supplemental indexes are used to analyze events and issues, which relates to Financial Soundness, and include descriptive and qualitative information.

(S-1) Investment to Plant, Facilities and Equipment

Investment to Plant, Facilities and Equipment = Balance of value at beginning of the fiscal term and at ending of the fiscal term of (Net Book Value of Property, Plant and Equipment + Accumulated Depreciation + Construction in Progress)

For increasing demand, investment to plant, facilities and equipment is important. Investment shortage may induce power shortage.

(S-2-1) Funding for Capital Cost Investment

(S-1) above is analysis on balance sheet data about assets. At the same time, other analysis is necessary on cash flow statement and on balance sheet about borrowing and funding arrangement for capital cost investment. This (S-2-1) analysis is funding side analysis on how funding was managed for capital cost investment.

(S-2-2) Long Term Debt for Capital Cost Investment

A part of fund for capital cost investment is brought from operation, but it is necessary to obtain fund by borrowing. Lenders are government, ODA multi lateral and bilateral loan, export credit, commercial banks and funding by bond issue may be possible. Analysis on long term debt lenders, provides much information about funding arrangement.

(S3) Labor Productivity

Labor productivity is analyzed by soled electricity volume (MWh) per employee, electricity sales per employee and net profit amount per employee. Historical analysis and cross-country analysis between similar countries provide good information. However, it should be noted that comparison between different market or system countries may involve misreading interpretation. In some countries, electricity industry is not vertically integrated, and generation, transmission and distribution are taken care by separate entities. There are some countries where generation share by IPPs is large. When the same utility continues business under the same circumstances, historical analysis provides good information about labor productivity.

(S4) Administration and Management

Information about administration and management includes many descriptive and qualitative information. For sound development, administration and management are important. Electricity law or tariff setting system should be fair and reasonable for supporting development of electricity supply. When electricity supply is provided by monopolized government owned

utility, management may need higher planning abilities under non market competition situation. In such case as of government owned monopolized electricity utility, analysis on management may be more important. While financial and accounting management system is important, internal administration system for accounting like monthly interval has be analyzed.