独立行政法人
国際協力機構

カンボジア国
カンボジア国政府鉱工業エネルギー省（MIME）

カンボジア国

電力技術基準及びガイドライン整備計画調査

最終報告書

本　文

Vol. II

ガイドブック
GUIDEBOOK

2004年2月

電源開発株式会社
中部電力株式会社

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JICA

GUIDEBOOK
FOR
POWER ENGINEERS

English Edition

Version 2004

MINISTRY OF INDUSTRY MINES AND ENERGY
ELECTRICITY AUTHORITY OF CAMBODIA
ELECTRICITE DU CAMBODGE

JICA

GUIDEBOOK
FOR
POWER ENGINEERS

English Edition

VOL.1: GENERAL
VOL.2: THERMAL POWER
VOL.3: HYDROELECTRIC POWER
VOL.4: RENEWABLE ENERGY
VOL.5: HIGH-VOLTAGE TRANSMISSION SYSTEM
VOL.6: MEDIUM & LOW VOLTAGE DISTRIBUTION SYSTEM
VOL.7: LOW VOLTAGE HOUSE WIRING

Dec. 2003

MINISTRY OF INDUSTRY, MINES AND ENERGY
ELECTRICITY AUTHORITY OF CAMBODIA
ELECTRICITE DU CAMBODGE

PREFACE

The 'Guidebook for Power Engineers' was prepared, by the JICA Study Team for *Establishment of Electric Power Technical Standards and Guidelines in the Kingdom* of Cambodia, for the government agencies of the power sector in Cambodia..

The JICA Study Team consists of eight study members from J-Power (EPDC: Electric Power Development, Co., Ltd. Tokyo, Japan), CEPCO (Chubu Electric Power Co., Inc. Nagoya, Japan) and KEPCO (Kansai Electric Power Co., Inc. Osaka, Japan).

The Guidebook was originally prepared by the JICA Study Team in English. Then, it was translated into Khmer under supervision of MIME.

On the request by MIME and JICA, the Guidebook has been opened to the persons/firms who are interested in the Cambodian power sector. Therefore, the additional information to be utilized for the existing licensees and consumers, the prospective licensees, and persons/firms who have privately owned generating facilities, has been included in the Guidebook.

The JICA Study Team is considered that the Guidebook is just a reference materials on the power sector in Cambodia and the contents of the Guidebook should be easy to understand and practical, therefore, some theory and detailed explanations have been excluded. Therefore, the users who wish to know more detail, kindly, study by the publications, textbooks and/or handbooks concerned, or gather information from the internet.

After issuance of the Guidebook, the JICA Study Team will not make the updating work of the information in the Guidebook and MIME will do it. If necessary, the user also could do it by itself since the most source of information has been indicated in the Guidebook.

Takuya TAKAOKA
Leader of the JICA Study Team

GUIDEBOOK FOR POWER ENGINEERS

General

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JICA

GUIDEBOOK
FOR
POWER ENGINEERS

English Edition

VOL. No.1
GENERAL

Dec. 2003

MINISTRY OF INDUSTRY, MINES AND ENERGY
ELECTRICITY AUTHORITY OF CAMBODIA
ELECTRICITE DU CAMBODGE

GUIDEBOOK FOR POWER ENGINEERS

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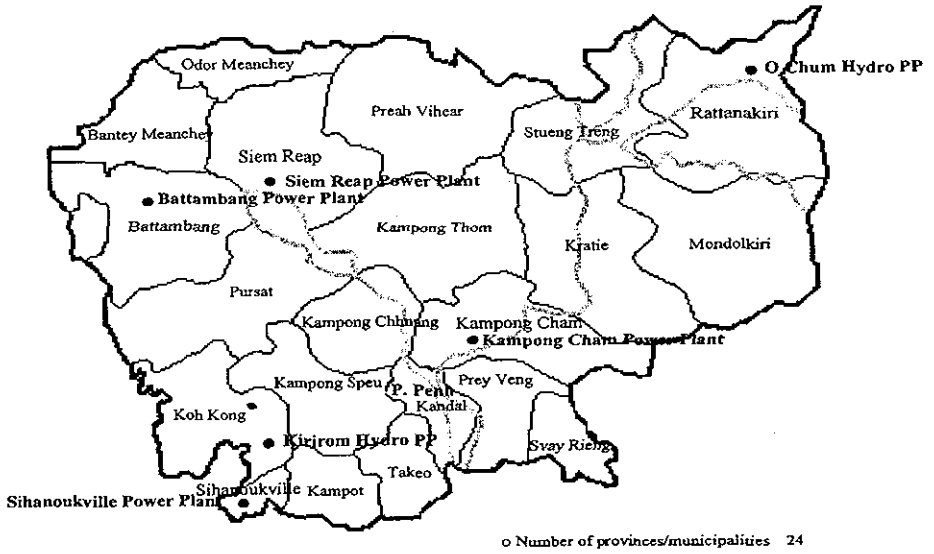
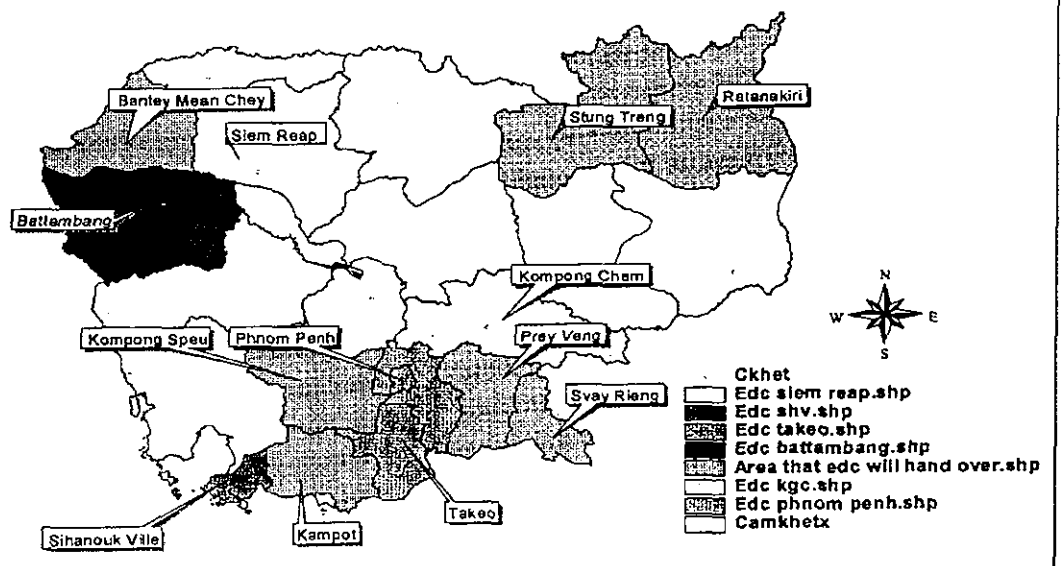
ES-9	Elements of a Contract Document

ES-10	Items on Some Contract Provisions
ES-11	The Project Manager

Category	General		Cambodia	Document No. GC-1
			Map	
Title	Map of Cambodia			



- Number of provinces/municipalities 24
- Number of districts 183
- Number of communes 1,609
- Number of villages 13,406



Remarks	Revisions	
	30/10/03	Original

Category	General		Cambodia	Document No.GC-2
Title	Statistical Figures of Cambodia			

	Survey	Cambodia	Lao	Thai	Viet Nam
Area (1,000km^2)	1999	181	237	513	332
Population (1,000.000)	1999	12	5	62	78
Population (per km^2)	1999	67	22	121	238
GDP (million USD)	1999	3,117	1,373	123,887	28,567
GDP per Capita (USD)	1999	260	280	1,960	370
Energy Sales (GWh)	2002	467			
kWh/Capita	2002	45			
Electrification (%)*	2002	15			
Elect. Sales in PNH (%)	2002	89.5	-	-	-
Technical Loss (%)	2002	12.46	-	-	-

*: Per Household

Remarks:
kWh/Capita: Electricity Consumption per capita
PNH: Phnom Penh

Revisions	
17/12/03	Original

Category	General		Cambodia	Document No. GC-3
			ASEAN Regional Study	
Title	Generation Requirement of the West ASEAN System			

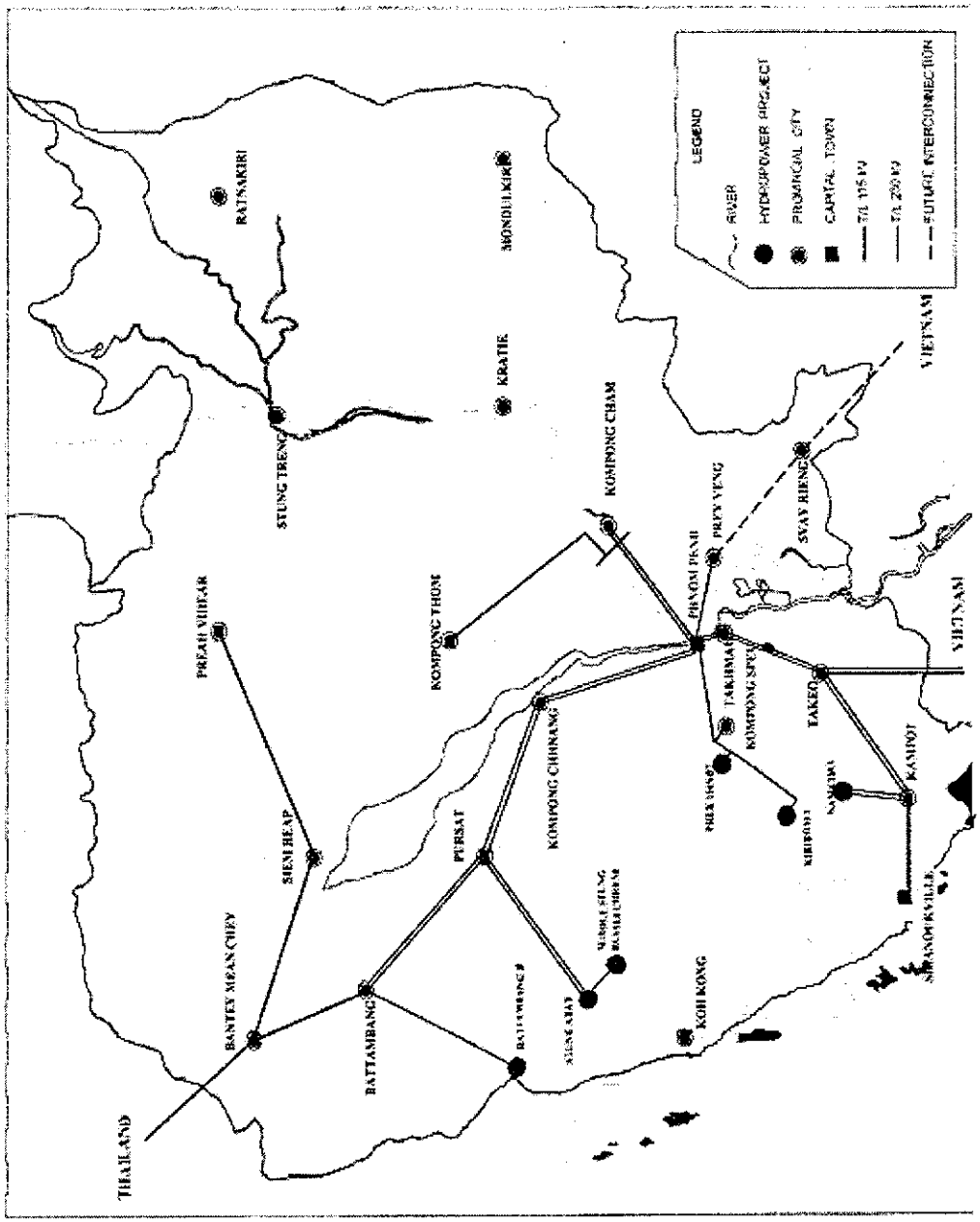
Table 5-1 Total Generation Requirement of the West ASEAN Systems

Year	Cambodia		Lao PDR		Penn. Malaysia		Singapore		Sumatra		Thailand		Vietnam	
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
2000	70	383	169	646	9,712	62,097	4,780	31,520	1,925	10,195	14,918	96,781	4,477	26,745
2001	71	405	198	760	10,184	66,407	5,120	33,620	2,074	10,998	16,184	103,496	4,988	30,187
2002	81	457	233	891	11,026	72,002	5,430	35,690	2,234	11,864	17,388	110,945	5,576	34,073
2003	95	522	279	1,171	11,989	78,379	5,730	37,610	2,471	13,145	18,587	118,540	6,250	38,461
2004	140	750	301	1,266	12,977	85,120	6,040	39,660	2,734	14,565	19,913	126,449	7,006	43,414
2005	180	979	325	1,375	14,148	93,090	6,340	41,680	3,026	16,142	21,222	134,794	7,838	49,008
2006	223	1,114	348	1,484	15,135	99,867	6,680	43,860	3,349	17,892	22,552	143,748	8,650	53,845
2007	293	1,456	372	1,599	16,165	106,936	7,020	46,110	3,707	19,835	23,951	152,743	9,552	59,159
2008	346	1,695	399	1,728	17,231	114,287	7,360	48,350	4,105	21,993	25,450	162,438	10,574	64,998
2009	398	1,939	429	1,870	18,351	121,997	7,710	50,650	4,540	24,359	27,232	173,532	11,716	71,415
2010	446	2,177	459	2,019	19,518	130,054	8,070	53,000	4,993	26,831	28,912	184,213	12,982	78,466
2011	500	2,430	488	2,155	20,732	138,443	8,400	55,150	5,490	29,554	30,587	194,930	14,236	86,304
2012	547	2,658	519	2,302	22,001	147,219	8,730	57,300	6,037	32,552	32,405	206,660	15,638	95,076
2013	623	3,016	551	2,458	23,334	156,460	9,060	59,450	6,638	35,855	34,352	219,134	17,166	104,669
2014	707	3,425	586	2,626	24,725	166,103	9,390	61,600	7,300	39,494	36,366	232,106	18,814	115,039
2015	809	3,917	623	2,806	26,185	176,248	9,720	63,750	8,027	43,501	38,519	245,948	20,703	126,947
2016	981	4,753	658	2,969	27,725	186,945	10,050	65,900	8,827	47,915	40,699	260,262	22,638	139,203
2017	1,122	5,434	695	3,143	29,340	198,185	10,380	68,050	9,706	52,777	42,852	274,031	24,826	153,085
2018	1,280	6,202	733	3,327	31,050	210,107	10,710	70,200	10,673	58,132	45,151	288,898	27,104	167,614
2019	1,466	7,103	774	3,522	32,854	222,673	11,040	72,350	11,736	64,031	47,525	304,264	29,646	183,861
2020	1,679	8,132	818	3,729	34,774	236,075	11,370	74,500	12,905	70,528	49,975	320,129	32,376	201,365

Remarks:
Source: ASEAN Interconnection Master Plan Study in March 2003

Revisions	
15/11/03	Original

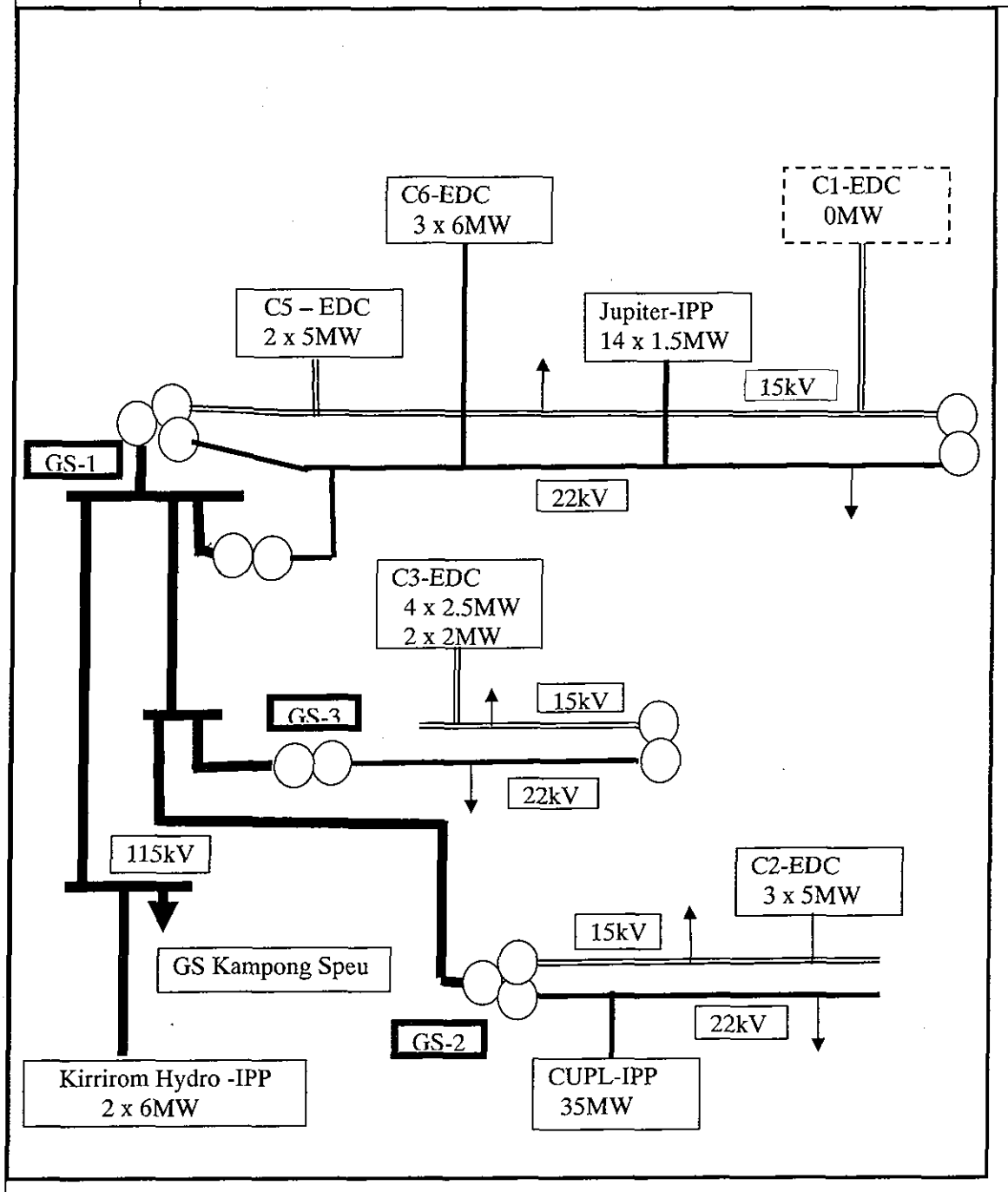
Category	General		Power System in Cambodia	Document No PS-1.
			Power System	
Title	Power Grid in Cambodia			



Cambodia Power System Map Stage 3 (2011-2016)
(As of December 2003, only 115kV Kirirom-PNH T/L has been completed)

Remarks:	Revisions	
MIME has reviewed the Master Plan prepared by the World Bank.		
	17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. –PS-2
			Power System	
Title	Power System in Phnom Penh			



Remarks:
As of 31December 2003

Revisions	
17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-3
			Law, Sub-Decree, Regulations, and etc.	
Title	Electricity Law in Cambodia			

The Electricity Law was promulgated on February 02, 2001, and consists of 13 Chapters and 79 Articles in total. The Contents are as follows:

CHAPTER 1. General Provision

CHAPTER II. Framework of the Electric Power Supply and Services

CHAPTER III. Establishment of the Electricity Authority of Cambodia

CHAPTER IV. Functioning of Electricity Authority of Cambodia

CHAPTER V. Type of Licenses

CHAPTER VI. Licensing of Electric Power Utilities

CHAPTER VII. Tariffs

CHAPTER VIII. Other regulations on the Electric Power Services

CHAPTER IX. Enforcement of the Authority

CHAPTER X. Administration

CHAPTER XI. Penalties, Sanctions and Fines

CHAPTER XII. Transitional Provisions

CHAPTER XIII. Final Provisions

Remarks:	Revisions	
The Regulation has been prepared by EAC empowered by the Electricity Law.		
	17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-4
			Law, Sub-Decree, Regulations, and etc.	
Title	Regulations on General Conditions of Supply of Electricity in Cambodia			

The Regulations have been publicized on January 17, 2002 by EAC, and consist of 14 Chapters and 116 Clauses in total. The Contents are as follows:

CHAPTER 1. Purpose, Title, Jurisdiction and Definitions

CHAPTER II. Category of Consumers and System of Supply

CHAPTER III. Application for New Supply

CHAPTER IV. Supplier's Equipment and Apparatus on Consumer's Premises

CHAPTER V. Consumer's Apparatus and Installation

CHAPTER VI. Contracted Load, Agreement and Security Deposit

CHAPTER VII. Request for Additional Supply

CHAPTER VIII. New Construction

CHAPTER IX. Meters

CHAPTER X. Tariff and Billing

CHAPTER XI. Unauthorized Use of Electricity and Compensation

CHAPTER XII. Continuity of Services and Force Majeure

CHAPTER XIII. Consumer Protection and Complaint Handling

CHAPTER XIV Power of EAC to Remove the Difficulties and Jurisdiction of Courts

Remarks: http://www.eac.gov.kh	Revisions	
	30/10/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-5
			Law, Sub-Decree, Regulations, and etc.	

Title	Draft of Electric Power Technical Standards (to be issued by MIME)

The Electric Power Technical Standards (Draft) is under preparation by JICA Study Team. The first Public Consultation was made on October 15, 2003 and the second Public Consultation was made in December 2003. It is to be issued by MIME in 2004.

The Contents of the Draft are as follows:

CHAPTER 1. General Provisions

- Paragraph 1: Definitions
- Paragraph 2: Purpose, Applied Area and Enforcement
- Paragraph 3: Quality of Electric Power
- Paragraph 4: Prevention of Electric Power Disasters
- Paragraph 5: Prevention of Electric Power Outage
- Paragraph 6: Preservation of Environment

CHAPTER II. Framework of the Electric Power Supply and Services

- Paragraph 1: General
- Paragraph 2: Generating Facilities (Thermal Power)
- Paragraph 3: Generating Facilities (Hydroelectric Power)
- Paragraph 4: Generating Facilities (Others)
- Paragraph 5: Transmission and Distribution Facilities (Common)
- Paragraph 6: Transmission and Distribution Facilities (High Voltage)
- Paragraph 7: Transmission and Distribution Facilities (Medium and Low Voltage)
- Paragraph 8: House Wiring

Remarks:		
	17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-6-1
			Law, Sub-Decree, Regulations, and etc.	

Title	Sample of Conditions of License (by EAC) (1/2)

The Sample of Conditions of License was issued by EAC in October 2001. The Sample has defined the General Conditions of the License. Therefore, the Specific Conditions of License shall be in accordance with each type of License Provided. The Sample may be changed by EAC, if EAC deems some changes are necessary. *Therefore, it is required to be referred to the newest version if it is necessary.*

The Contents of the Samples are as follows:

1. Sample of the General Conditions for all Licenses
   - Condition 1: General Obligation
   - Condition 2: Financial Statement of Licensee
   - Condition 3: Obligation on the Power Purchasing
   - Condition 4: Health and Safety of Employees
   - Condition 5: Provision of Information to EAC
   - Condition 6: Payment of License Fees

2. Sample of Conditions for Generating License
   - Condition 1: Addition of Generating Facilities
   - Condition 2: Planning of Licensee's Auxiliary System
   - Condition 3: Compliance with the Transmission and Distribution Codes
   - Condition 4: Generation Outage

3. Sample of Conditions for the National Transmission License
   - *Condition 1: Transmission Code*
   - Condition 2: Transmission System Security Standard & Quality of Services
   - Condition 3: Compliance with Distribution Code
   - Condition 4: Disposal of Relevant Assets
   - Condition 5: Restriction on Use of certain Information & Independence of the Transmission Business
   - Condition 6: Transmission System Outages

4. Sample of Conditions for the Distribution License
   - Condition 1: General Security Standards
   - Condition 2: Distribution System Planning Standards and Quality Services
   - Condition 3: Security and Safety of Supply
   - Condition 4: Detection and Prevention of Theft, Damage & Meter Interference
   - Condition 5: Distribution Code
   - Condition 6: Standards of Performance
   - Condition 7: Complaint Handling Procedure
   - Condition 8: Disposal of Relevant Assets
   - Condition 9: Compliance with Transmission Code
   - Condition 10 Compliance with the Rule on the Conditions of Supply

Remarks: http://www.eac.gov.kh For the type of License, refer to the Document No. PS-13.		
	17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-6-2
			Law, Sub-Decree, Regulations, and etc.	
Title	Sample of Conditions of License (by EAC) (2/2)			

5. Sample of the Conditions for the Connection and Supply

Condition 1: *Basic Conditions for Supply or Sales of Electricity to Other Distributors or Bulk Consumers*

1) Preparation of Statement on Connection Charge
2) Preparation of Statement on System Available Capacity
3) Tariff of Electricity for Other Distributors or Bulk Consumers
4) Revision of the Statements

Condition 2: Non-discrimination in the Provision of Electricity and Connection to the System

Condition 3: Requirement to Offer Terms

1) Offer of Terms for Connection of Other Distributors or Bulk Consumers to Supplier's System
2) Offer of Terms for Supply or Sales of Electricity

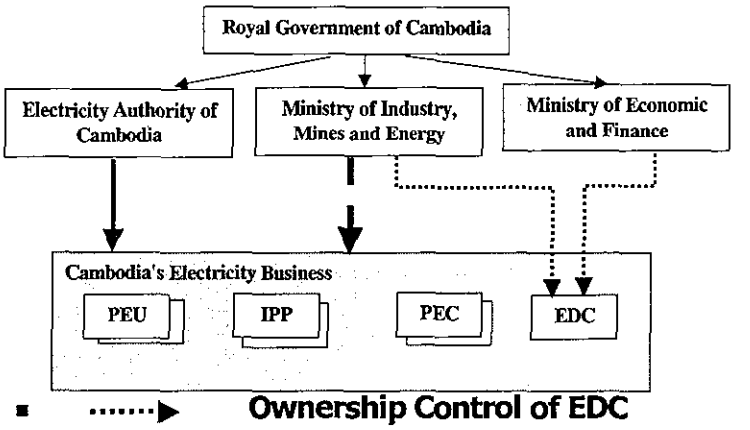
Condition 4: Standard Terms of Connection and Supply for Other Distributors and Bulk Consumers

Condition 5: Function of EAC

Condition 6: Payment of License Fees

Remarks: http://www.eac.gov.kh		
	30/10/03	Original

Category	General		Power Sector in Cambodia Organization	Document No. PS-7
Title	Power Sector in Cambodia			



Notes:

PEU-Public (or joint with Private) Electricity Utility;

IPP-Independent Power Producer;

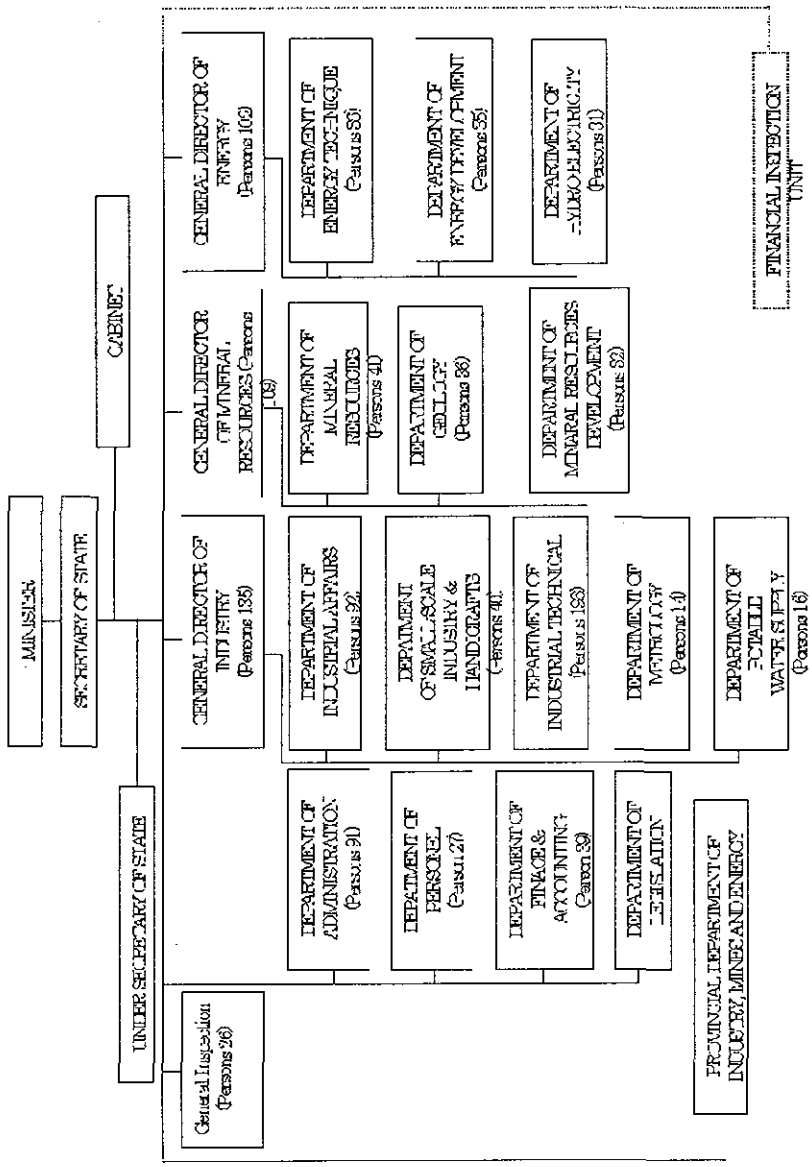
PEC-Private Electricity Company;

EDC-Electricité du Cambodge.

- ·····▶ **Ownership Control of EDC**
- – – ▶ **Policy; Planning; Development; Technical standard**
- ——▶ **Tariff; license; Review the Planned Investments, finances and performance; Enforce the regulations, rules and commercial standards.**

Remarks	Revisions	
	30/10/03	Original

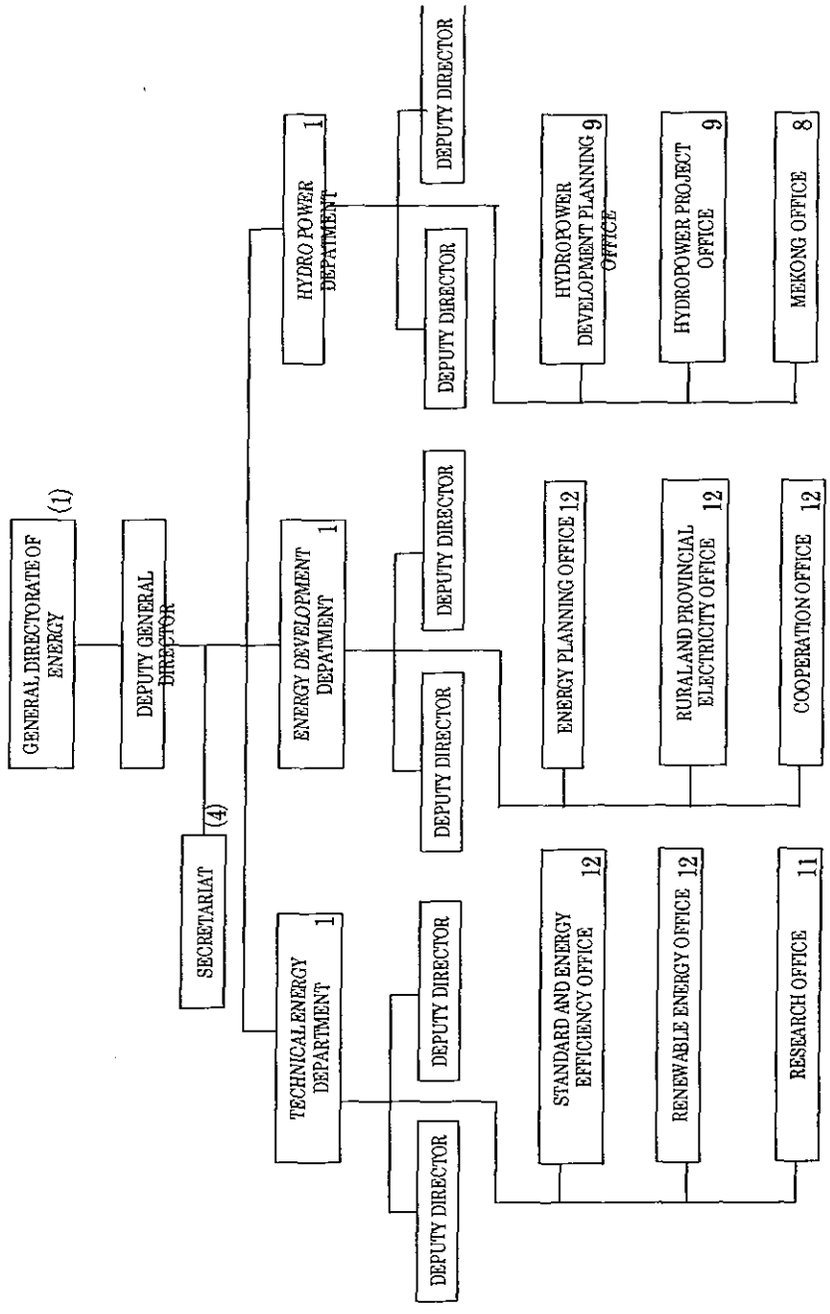
Category	General		Power Sector in Cambodia	Document No. PS-8-1
			Organization	
			MIME	
Title	Ministry of Industry, Mines and Energy (MIME) (1/2)			



Remarks	Revisions	
	30/10/03	Original

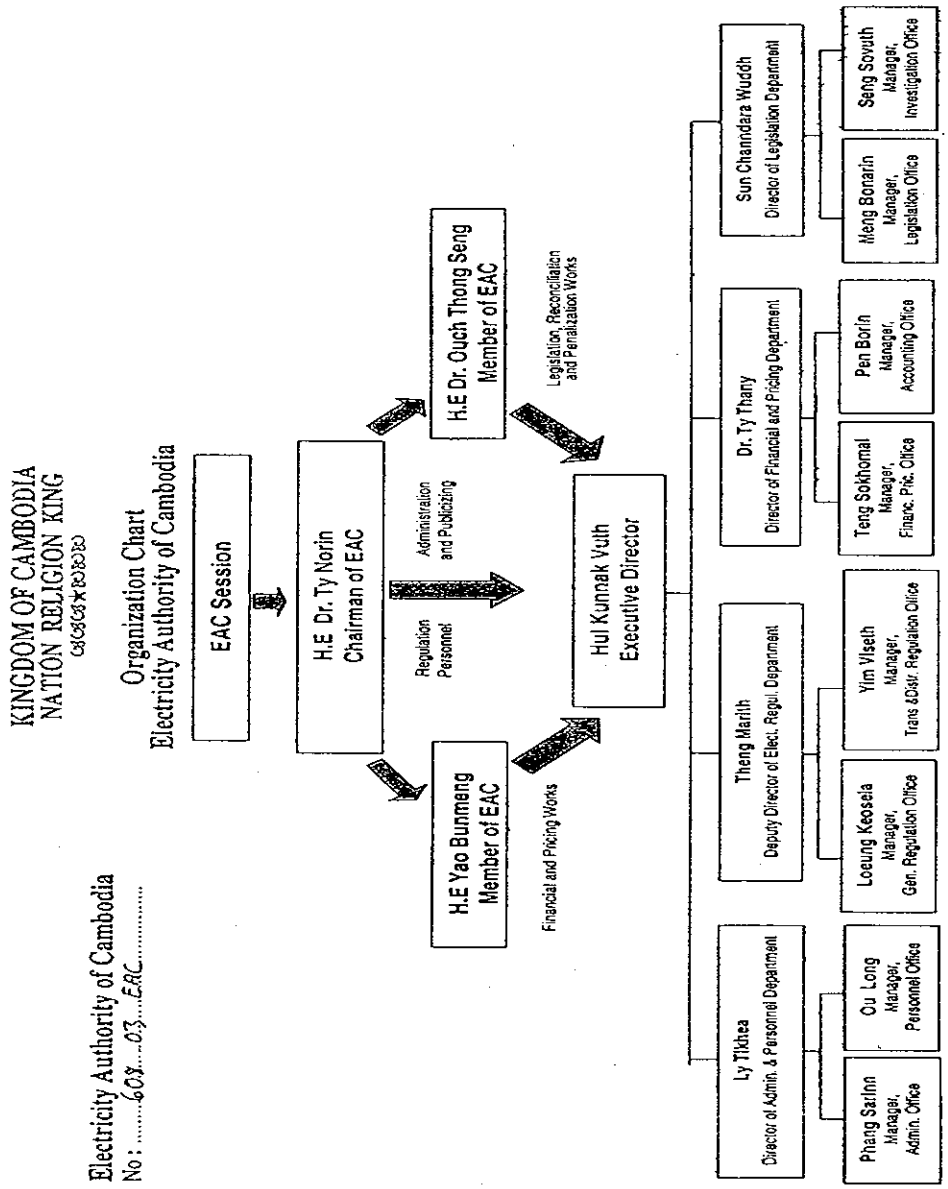
Category	General		Power Sector in Cambodia	Document No. PS-8-2
			Organization	
			MIME	

Title Ministry of Industry, Mines and Energy (MIME) (2/2)



Remarks	Revisions	
	30/10/03	Original

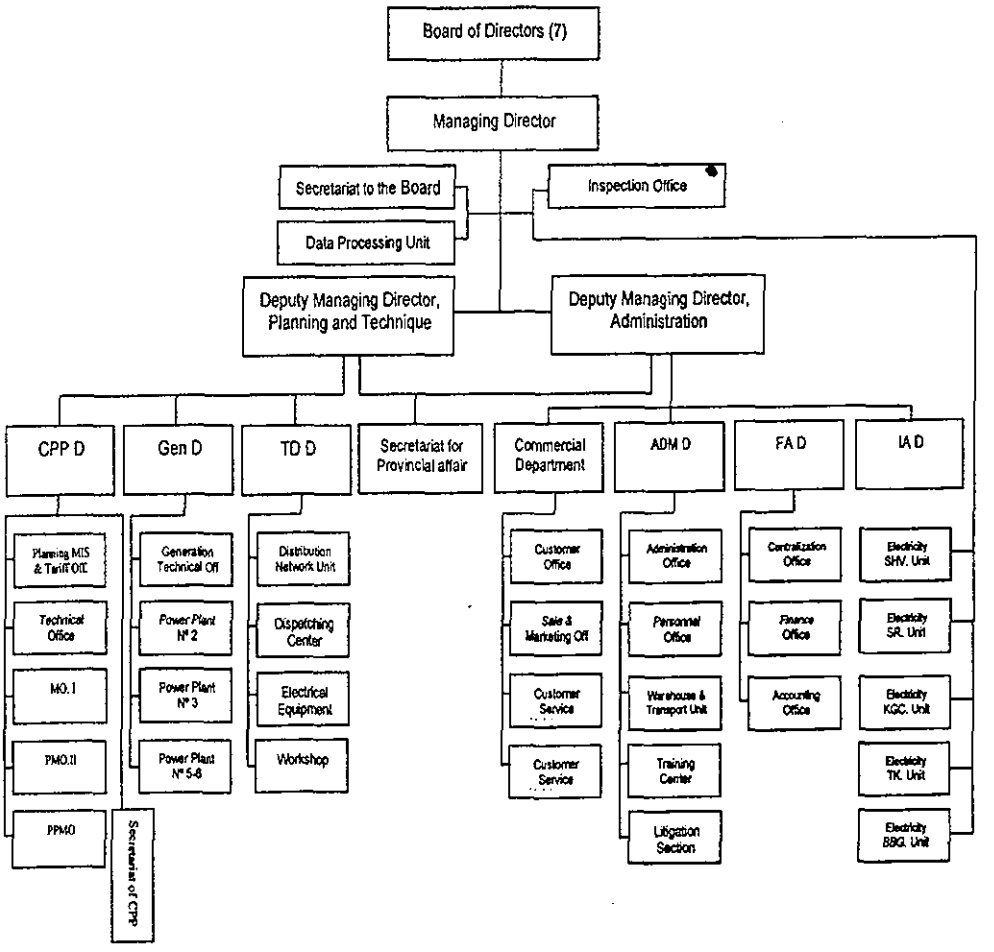
Category	General		Power Sector in Cambodia	Document No. PS-9
			Organization	
			EAC	
Title	Electricity Authority of Cambodia (EAC)			



Remarks: http://www.eac.gov.kh	Revisions	
	30/10/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-10-1
			Organization	
			EDC	
Title	Electricite du Cambodge (EDC) (1/2)			

Organizational structure of EDC



In 1992, Electricite du Phnom Penh (EDP) was re-named EDC and attached to MIME. In 1993, EDC was restructured under MIME and was responsible for the development, management and operation of Power system in Phnom Penh.

In March 1996, by the Royal Decree, Electricite du Cambodge became a wholly state-owned limited liability company to generate, transmit and distribute electric power through-out Cambodia. EDC is a juridical organization with administrative, financial and managerial authority. EDC is responsible for its profit and losses and liable for its debts to the extent of the value of its assets.

Remarks:	Revisions	
	30/10/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-10-2
			Organization	
			EDC	
Title	Electricite du Cambodge (EDC) (2/2)			

Function and its Responsibilities

EDC by law is authorized to under-take the following function:

1. the generation of electricity for the purpose of satisfying the needs of consumers;
2. the generation of electricity for purposes of exportation to neighboring countries and the importation of electric power from such countries;
3. the construction and operation of national grid transmission networks to ensure the reliable delivery of electric power; and construction the rural electrification;
4. the construction and operation of subsidiary networks for the distribution of electric power and co-ordination of connection and operation of EDC and other distribution networks;
5. the sale of electricity and associated services;
6. the acquisition, transfer and exchange of electric power; and
7. engage all legal acts necessary to achieve its commercial and corporate objectives.
8. the rehabilitation of electricity in provinces especially in the provinces that never do.
9. corporation with the neighboring countries and ASEAN for respected to the ASEAN interconnection system that in the future we can exchange energy;

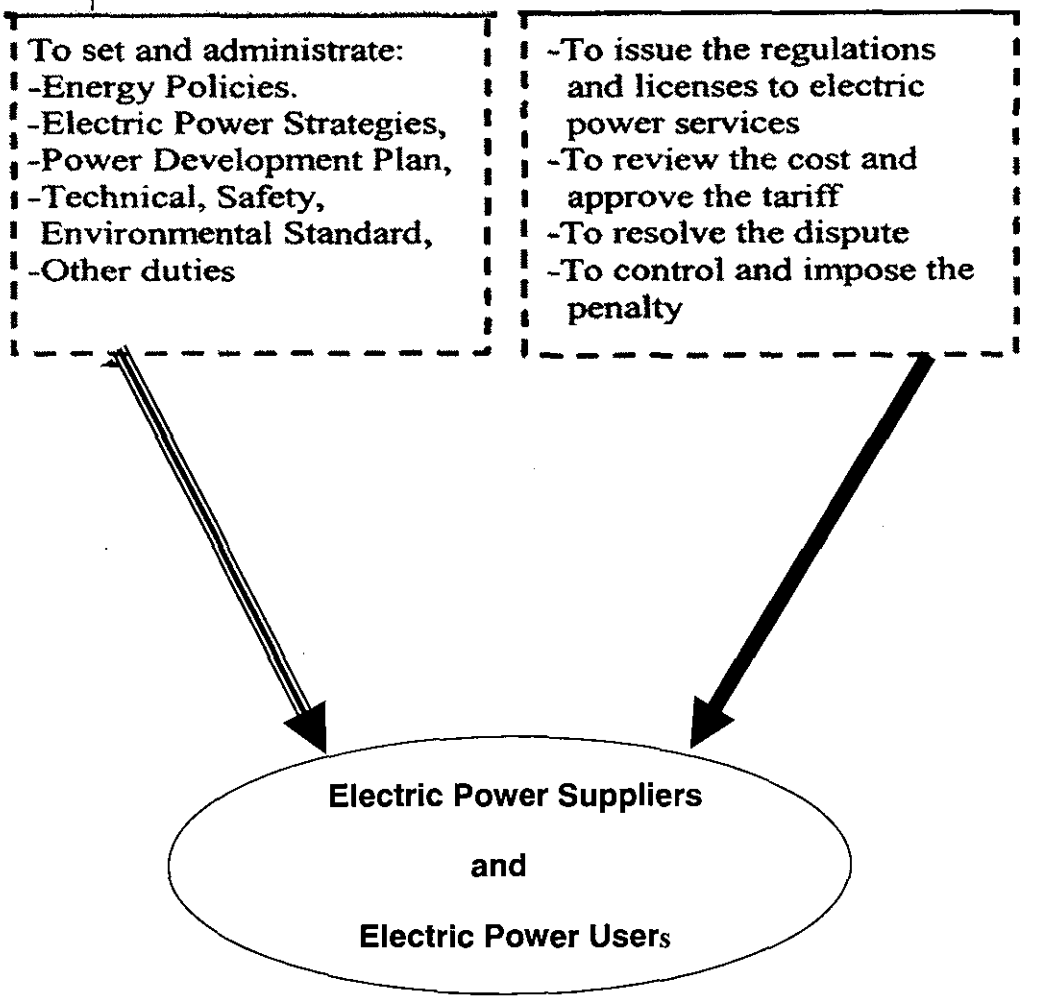
Due to the severely damage on the system by years of war and neglect, the power system of Cambodia with 80 per cent of the country consumption has been concentrated in Phnom Penh. A large amount of the demand has been still supplied from large and small generators owned by large, medium and small consumers. Cambodia's electricity supplies, at present, comprise 23 small isolated power systems and a major power grid in Phnom Penh owned by EDC.

Currently, 15 per cent of the households in Cambodia have access to electricity and the per capita energy consumption is 45 kWh per annum. It is the lowest ratio among East Asian Countries.

Remarks:	Revisions	
Source: EDC Annual Report 2002		
	17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-11
			Responsibility	
			MIME/EAC	

Title Responsibility of MIME and EAC in Power Sector



Remarks:	Revisions	
Source: Leaflet of EAC.		
	17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-12
			Electric Power Services	
Title	Powers and Duties of EAC			

Article 7 of Electricity Law provides to the Authority the following powers and duties:

(a) To issue, revise, suspend, revoke or deny the licenses for the supply of electricity services as provided in article 29 of this Law;
(b) To approve tariff rates and charges and terms and conditions of electric power services of licensees, except where EAC consider those rates or charges and terms and conditions are established pursuant to a competitive, market-based process;
(c) To order to implement guidance procedures and standards for investment programs by licensees;
(d) To review the financial activities and corporate organization structure of licensees to the extent that these activities and organization directly affect the operation of the power sector and the efficiency of electricity supply;
(e) To approve and enforce the performance standards for licensees;
(f) To evaluate and resolve consumer complaints and contract disputes involving licensees, to the extent that the complaints and disputes relate to the violation of the conditions of license;
(g) To approve and enforce a uniform system of accounts for all licensees;
(h) To prepare and publish reports of power sector and relevant information received from licensees for the benefit of the Government and the public interest;
(i) To prescribe fees applicable to licensees;
(j) To determine the procedures for informing the public about affairs within its duties, in order to ensure that EAC complies with the principle of transparency as set forth in Article 3 of this law;
(k) To issue rules and regulations and to make appropriate orders, and to issue temporary and permanent injunction for electric power services;
(1) To impose monetary penalty, disconnect power supply, suspend or revoke the license for the violations of this Law, standards and regulations of the EAC;
(m) To require the electric power services and the customers to obey the rules relating to the national energy security, economic, environment and other Government policies;
(n) To perform any other function incidental or consequential to any of the duties as describes above; and

(o) To establish the terms and conditions of employment of the officers or employees including expert/advisors of EAC.

Remarks	Revisions	
	30/10/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-13
			Electric Power Services	
			Type of Licenses	
Title	Type of Licenses for Electricity Services in Cambodia			

The Licenses under empowerment of EAC as stipulated in Article 7(a) of the Electricity Law is as follows:

1. Generation License
   - Generating Electricity for Sale
   - Validity is generally for expected useful life of the facilities, except the period designated in the Power Purchase Agreement (PPA)
   - The license can be revoked under the Law.
2. Transmission License
   - National Transmission License
     - # To be issued to the state power transmission company
     - # For delivering the electricity to the distribution companies and the bulk power companies
     - # Validity is indefinite term, subject to revocation under the Law
   - Special Purpose Transmission License
     - # For the special purpose and ensure the public interest
     - # Validity is indefinite term, or limited to the useful life of the particular transmission facilities
3. Dispatch License
   - For facilitating the delivery and receiving the electricity from the generation, transmission and distribution systems
4. Distribution License
   - To provide the electricity distribution services in a determined contiguous territory
   - Validity is indefinite term, subject to revocation under the Law
5. Bulk Sale License
   - To buy the electricity from any generation Licensees or from the power system of neighboring countries for sale to Distribution Licensees or to the large customers in one connected power system
6. Retail License
   - Sale of Electricity to consumers by a subcontract agreement with the existing Licensees
7. Subcontract License
   - Supply electricity services under the subcontract agreement with the existing Licensees
8. Consolidate License
   - A License may be combination of some or all types of licenses stated in the Law.
   - In issuing, EAC shall consider long term planning and the objectives of Government policy to reduce long run marginal cost through out Cambodia.

Remarks	Revisions	
	30/10/03	Original

Category	General		Power Sector in Cambodia	Document No. PS14-1
			Electric Power Services	
			Suppliers	
Title	License of Electricity Services in Cambodia (1/3)			

Consolidate Licenses

1. Electricity du Cambodge (EDC), license No. 001L, revision 1 issued on Aug 18, 2003.
2. Hour Pheng, license No. 006 L, issued on April 01, 2002.
3. Chilbo Industrial (Cambodia) Co., LTD, license No 012 L, issued on August 09, 2002.
4. Mak Thorn, license No 013 L, issued on September 06, 2002.
5. Srey Sokhom, license No 015 L, issued on November 22, 2002.
6. Ke Kuyhuoy, license No 016 L, issued on November 22, 2002.
7. Bun Liv, license No 017 L, issued on November 29,2002.
8. Ky Sophear, license No 018 L, issued on November 29, 2002.
9. Te Kok Eng, license No 019 L, issued on December 12,2002.
10. Chhou Lay, license No 020 L, issued on December 30, 2002.
11. Nov Sokha, license No 021 L, issued on December 30, 2002.
12. Kong Phat, license No 022 L, issued on February 11, 2003.
13. Khun Sambo, license No 023 L, issued on February 11, 2003.
14. Chang Bunnaret, license No 026 L, issued on Mar 12, 2003.
15. Kuy Suor, license No 027 L, issued on Mar 12, 2003.
16. Samreth Sothy, license No 028 L, issued on Mar 12, 2003.
17. Sok Thy, license No 029 L, issued on Mar 12, 2003.
18. Ly Buthy, license No 030 L, issued on Mar 13, 2003.
19. Chan Thon, license No 031 L, issued on Mar 13, 2003.
20. Nhen Kong, license No 032 L, issued on Mar 13, 2003.
21. Chhuor Nguon, license No 033 L, issued on Apr 09, 2003.
22. Toem Touch, license No 034 L, issued on Apr 09, 2003.

Remarks	Refer to http://www.eac.gov.kh As of 17 December 2003	Revisions	
		17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS14-2
			Electric Power Services	
			Suppliers	
Title	License of Electricity Services in Cambodia (2/3)			

Consolidate Licenses

23. *Chhuor Phoeut, license No 035 L, issued Apr 09, 2003.*
24. Pauch Kim, license No 036 L, issued on Apr 09, 2003.
25. KRy Bunthong, license No 037 L, issued on May 20, 2003.
26. Khut Bunpech, license No 038 L, issued on May 20, 2003.
27. KimChandara, license No 039 L, issued on May 20, 2003.
28. Mak Heat, license No 040 L, issued on May 26, 2003.
29. Ty Sokorn, license No 041 L, issued on May 26, 2003.
30. Mrs. Muy Kuan, license No 042 L, issued on May 26, 2003.
31. Lay Se, license No 043 L, issued on July 01, 2003.
32. Mrs. Tong Kimsok, license No 044 L, issued on July 01, 2003.
33. Keo Dara, license No 045 L, issued on Aug 18, 2003.
34. Seng Sokun, license No 046 L, issued on Aug 18, 2003.
35. Mom Dara, license No 047 L, issued on Aug 18, 2003.
36. Chhom Sophay, license No 048 L, issued on Aug 18, 2003.
37. Mrs. Khiev Nareth, license No 049 L, issued on Aug 18, 2003.
38. Long Nget, license No 053 L, issued on Sep 09, 2003.
39. Mrs. Ouch Por, license No 054 L, issued on Sep 09, 2003.

Remarks:	Refer to http://www.eac.gov.kh As of 17 December 2003	Revisions	
		17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS14-3
			Electric Power System	
			Suppliers	
Title	License of Electricity Services in Cambodia (3/3)			

Generation Licenses

1. GTS, license No. 004 L, issued on March 29, 2002.
2. JUPPITER, license No. 003 L, revision 2 issued on Aug 18, 2003.
3. CETIC, license No. 007 L, issued on April 05, 2002.
4. CUPL, license No. 002 L, license issued on February 01, 2002.
5. CHEA SOPHA, license No.005 L, issued on April 01, 2002.
6. WAN LONG, license No. 010L, issued on May 27, 2002.
7. Global Power System PTE LTD, license No 024 L, issued on February 11, 2003.
8. Santepheap Cambodia Investment, license No 025 L, issued on Mar 12, 2003.

Distribution Licenses

1. FRANASIE IMPORT EXPORT Co., LTD. license No. 008 L, issued on April 10, 2002.
2. MSP, license No. 009 L, issued on May 27, 2002.
3. Anco Brothers Co., LTD, license No 011 L, issued on August 09, 2002.
4. Duty Free Shop Co., LTD, license No 014 L, issued on November 22, 2002.
5. Reeco Company, license No 050 L, issued on Sep 09, 2003.
6. Sovanny Electricity Development Co., Ltd, license No 051 L, issued on Sep 09, 2003.
7. Nareth Electricity Development Co., Ltd, license No 052 L, issued on Sep 09, 2003.

Remarks:	Refer to http://www.eac.gov.kh As of 17 December 2003	Revisions	
		17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-15
			Electric Power Services	
			Consumers	
Title	Category of Consumers in Cambodia			

1. Small Consumer

- Consumers supplied power at single phase and low voltage (220V)
- An Application for New Supply to small consumer premises, where public LV network exists, shall be shall be filled at least 15 working days before the expected date on which supply is required.

2. Medium Consumer

- Consumers supplied power at three phase and low voltage (380V)
- An Application for New Supply of power to medium consumer premises shall be shall be filled at least 15 working days before the expected date on which supply is required.

3. Big Consumer

- Consumers supplied power at medium voltages (above 380V and up to 22kV)
- An Application for New Supply of power to a Big Consumer should be submitted well in advance to allow the supplier time to arrange for required power. The power supply shall be allowed only if the power is available. The consumer shall pay the cost of network extension and/or up gradation as per quotation given by the supplier and agreed by the applicant, to allow the supplier to start the work.

4. Bulk Consumer

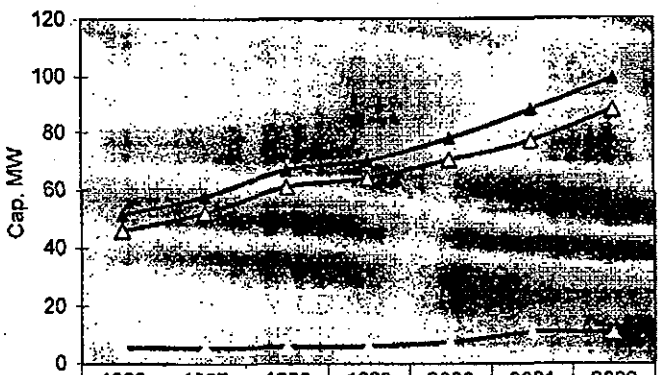
- Consumers supplied power at high voltage (above 22kV)
- For an Application for New Supply to a Bulk Consumer, the conditions are similar to the Big Consumer stated above.

Remarks: Refer to "Regulation on General Conditions of Supply of Electricity in the Kingdom of Cambodia"	Revisions	
	30/10/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-16
			Electric Power System	
			EDC	
Title	Annual Peak Demand in Phnom Penh			

Breakdown of Yearly Peak Power Demand, MW

EDC	1997	1998	1999	2000	2001	2002
PHN's	52.00	61.00	64.00	70.30	77.60	88
SHV's	2.36	2.34	2.85	3.00	3.50	3.50
SRP's	1.74	2.12	2.00	2.60	3.10	3.10
KGC's	1.44	1.43	1.25	1.35	1.40	1.40
TKO's	-	-	-	0.50	0.54	0.54
BBG's	-	-	-	-	2.54	2.54



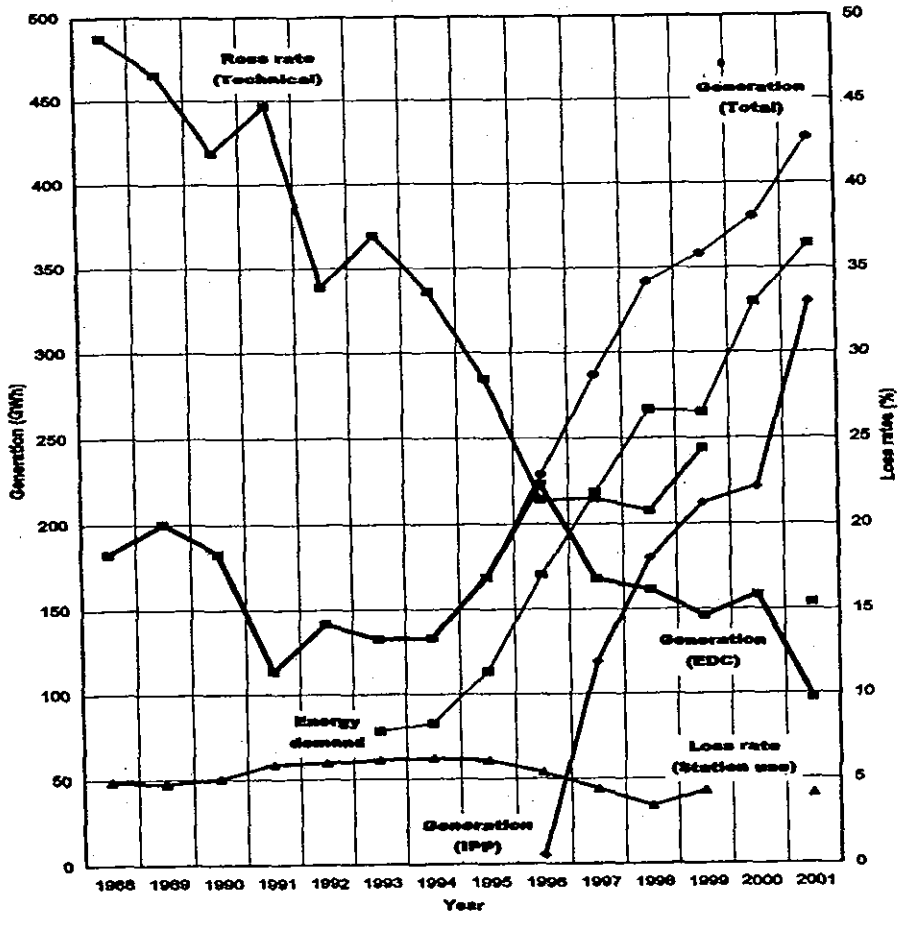
	1996	1997	1998	1999	2000	2001	2002
PHN's, Peak, MW	46	52	61	64	70.3	77	88
PRV's, Peak, MW	5.49	5.54	5.89	6.10	7.45	11.04	11.04
EDC Peak, MW	51.49	57.54	66.89	70.10	77.75	88.04	99.04

Remarks:

Source: EDC Annual Report 2002

Revisions	
17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-17
			Electric Power System	
			EDC	
Title	Annual Energy Generation in Phnom Penh			



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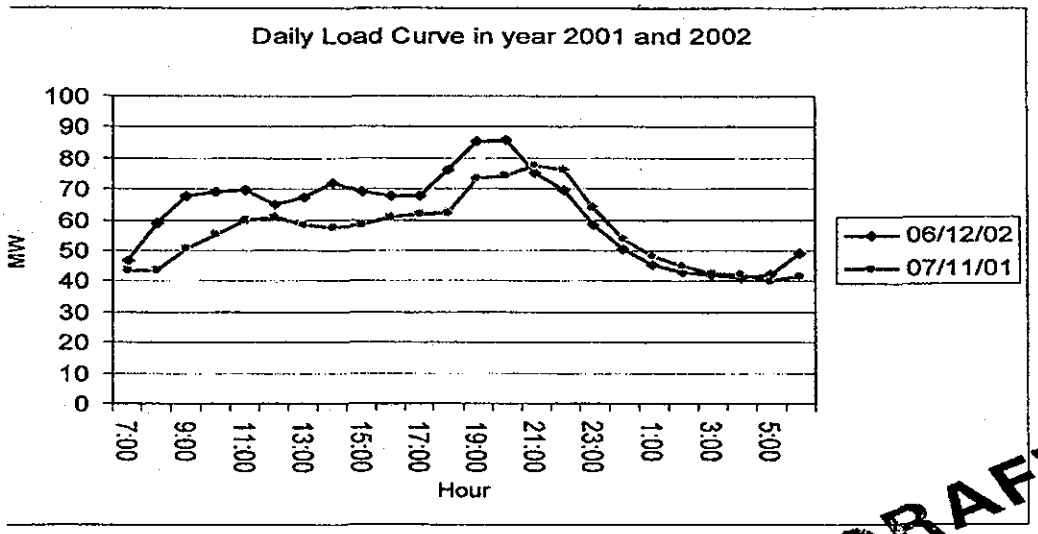
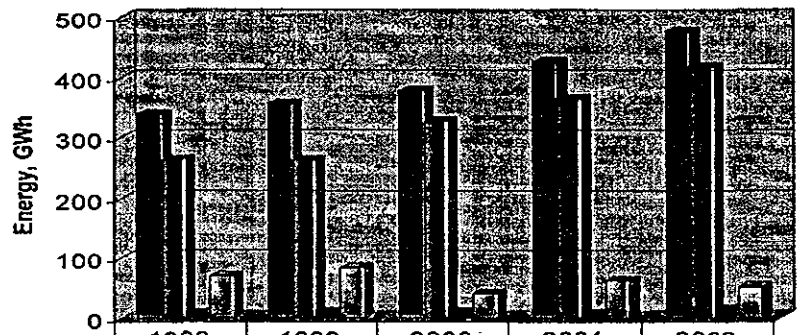
Remarks: Source: EDC

Revisions	
17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-18
			Electric Power System	
			EDC	
Title	Typical Load Curves in Phnom Penh			



Breakdown of PHN's Generation, Energy Billed & System Losses



	1998	1999	2000	2001	2002
Production, GWh	341.53	358.22	379.99	426.97	477.574
Billed, GWh	265.74	264.22	329.26	364.15	418.088
Own Con., GWh	6.63	9.25	9.99	5.98	14.9
Losses, GWh	69.16	84.75	40.74	62.821	52.09

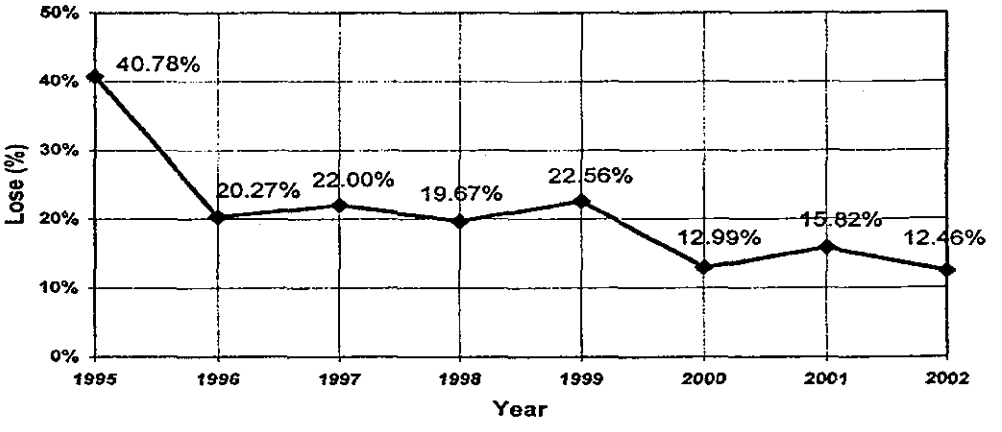
Remarks: Source: EDC Annual Report 2002

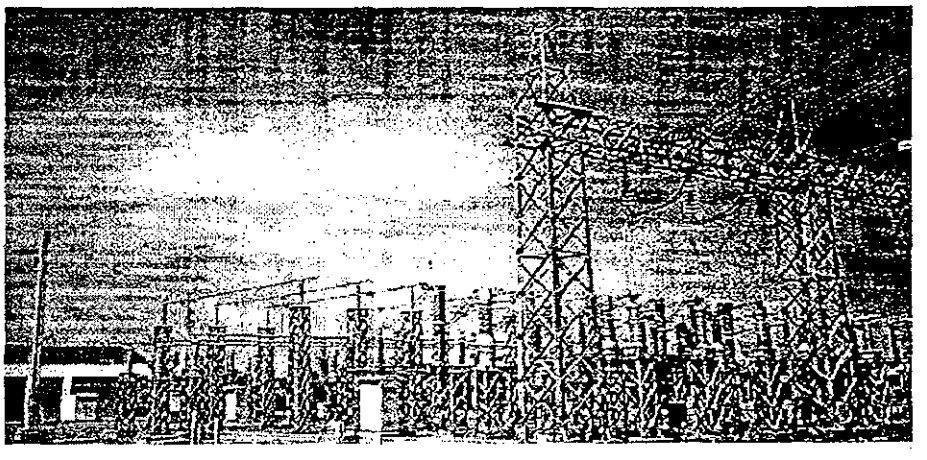
Revisions	
17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-19
			Electric Power System	
			EDC	
Title	Power System Loss in Phnom Penh			

Breakdown of System Losses ~~and~~ in PHN's

Power Lose in PHN's System



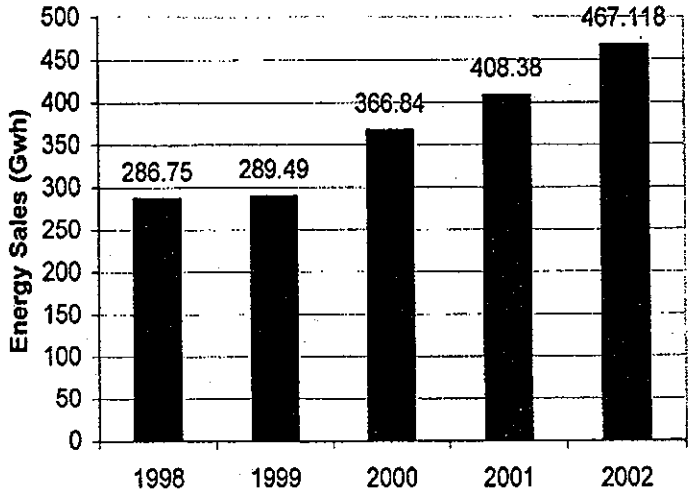


Grid Substation No.2, 115/22 kV

Remarks:	Source: EDC Annual Report 2002	Revisions	
		17/12/03	Original

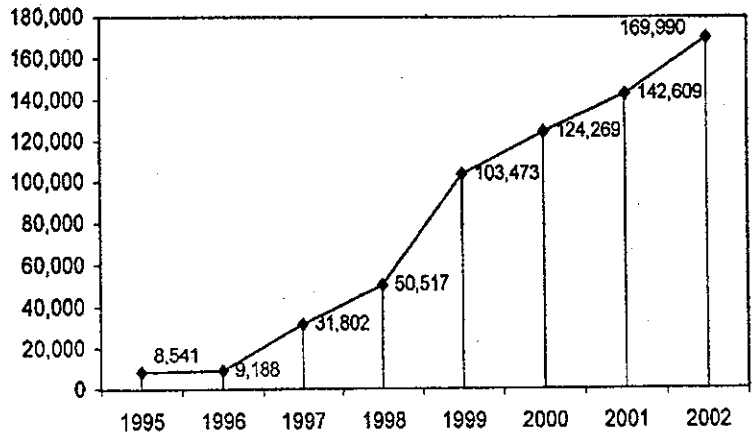
Category	General		Power Sector in Cambodia	Document No. PS-20
			Electric Power System	
			EDC	
Title	Remarkable Activities of EDC			

Energy sales in 1998-2002



For the year 2002, EDC's sales increased to 468GWh, which is 13% more than the previous year. Electrical losses are now around 14% in Phnom Penh system, compared with up to 41% in 1995. EDC's customer has increased from about 31,802 in 1997 to 169,990 in 2002. (See chart below).

EDC's Customers in 1995-2002

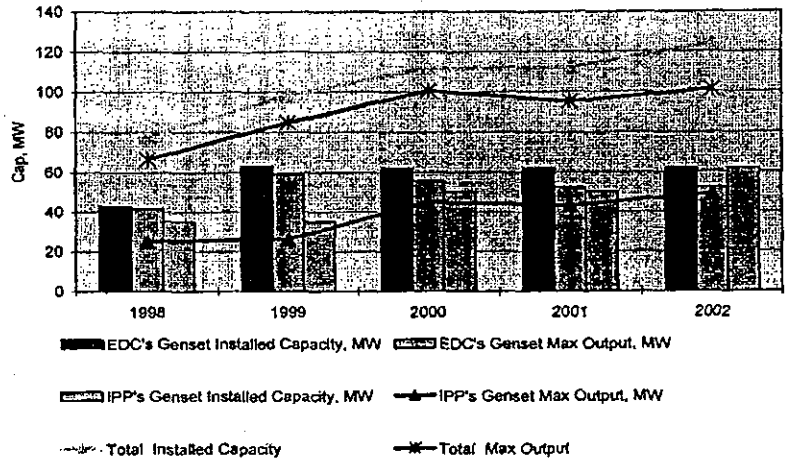


Remarks: Source: EDC Annual Report 2002

Revisions	
17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-21
			Electric Power System	
			Whole Cambodia	
Title	EDC's Power Generating Facilities			

Installed Capacity and the Possible Output



EDC's Installed Capacity and Maximum Output, MW

Year		2002	2001	2000	1999	1998
PHN's,	Installed Capacity	123.00	112.00	112.00	98.20	77.80
	Max Output	104.0	95.10	100.50	85.00	66.60
EDC's	Installed Capacity	62.00	62.00	62.00	63.20	42.80
	Max Output	53.00	52.10	55.50	59.00	41.60
IPP's-I	Installed Capacity	35.00	35.00	35.00	35.00	35.00
	Max Output	28.00	28.00	30.00	26.00	25.00
Jupiter	Installed Capacity	15.00	15.00	15.00	-	-
	Max Output	15.00	15.00	15.00	-	-
CETIC	Installed Capacity	11.00				
	Max Output	8.00				
SHV's	Installed Capacity	10.39	10.39	10.00	10.00	10.56
	Max Output	8.28	8.28	7.80	7.80	8.94
SRP's	Installed Capacity	14.62	14.62	4.04	4.04	2.96
	Max Output	5.91	5.91	2.80	2.80	2.40
EDC's	Installed Capacity	8.70	8.70	2.50	2.50	2.96
	Max Output	1.49	1.49	1.35	1.35	2.40
Rented Gen.	Installed Capacity	5.92	5.92	1.54	1.54	-
	Max Output	4.42	4.42	1.45	1.45	-
KGC's (Private Gen.)	Installed Capacity	3.59	3.59	2.03	2.03	3.30
	Max Output	2.90	2.90	1.66	1.66	1.44
TKO (Rented Gen.)	Installed Capacity	0.90	0.90	1.12	-	-
	Max Output	0.90	0.90	0.90	-	-
BBG's	Installed Capacity	6.85	6.85			
	Max Output	6	6.00			
Total	Installed Capacity	159.35	148.35	129.20	114.63	94.62
	Max Output	127.99	119.09	113.66	97.26	79.38
	Percentage[c], %	80.32%	80.27%	87.98%	85.11%	83.89%

[c] the ratio of maximum output to installed capacity

DRAFT

Remarks: Source: EDC Annual Report 2002
(In the year of 2003, it is the same.)

Revisions	
17/12/03	Original

Category	General		Power Sector in Cambodia	Document No. PS-22
			Electric Power System	
			Whole Cambodia	

Title EDC Electricity Tariff (2003)

	Riels/kWh	US$/kWh
[Phnom Penh]		
Residential		
0-50kWh/month	350	0.09
51-100kWh/month	550	0.14
>100kWh/month	650	0.17
Industrial and Handicraft		
<45,000kWh/month	600	0.15
45,000-80,000kWh/month	550	0.14
80,000-130,000kWh/month	550	0.14
130,000kWh/month	500	0.13
Medium Voltage	480	0.12
Commercial & Service Sectors		
<45,000kWh/month	650	0.17
45,000-80,000kWh/month	600	0.15
80,000-130,000kWh/month	600	0.15
130,000kWh/month	500	0.13
Medium Voltage	480	0.12
Embassy, Foreigners' House, NGO, OI	800	0.20
Government Institutions	700	0.18
[Siem Reap]		
Overall Sectors		
<20,000kWh/month	850	0.217
20,000-50,000kWh/month	757	0.193
50,000-110,000kWh/month	690	0.176
>130,000kWh/month	635	0.162
[Sihanoukville]		
Residencial	500	0.13
Industrial & Handicraft		
<20,000kWh/month	686	0.175
20,000-50,000kWh/month	690	0.176
50,000-110,000kWh/month	568	0.145
>130,000kWh/month	529	0.135
Commercial		
<20,000kWh/month	764	0.195
20,000-50,000kWh/month	706	0.18
50,000-110,000kWh/month	643	0.164
>130,000kWh/month	588	0.15
Hotels, Houses for Foreigners		
<20,000kWh/month	784	0.20
20,000-50,000kWh/month	721	0.18
50,000-110,000kWh/month	666	0.17
>130,000kWh/month	627	0.16
[Kompong Cham]		
Overall Sectors	850	0.22
[Takeo]		
Overall Sectors	900	0.23
[Battambang]		
Overall Sectors	960	0.245

Remarks: US$1.0 = Riel 3,920.

Revisions	
30/10/03	Original

Category	General		Power Development Plan (PDP)	Document No. PDP-1
Title	Power Sector Development Policy			

The Royal Government of Cambodia formulated an energy sector development policy in October 1994, which aims at:

1. To provide an adequate supply of energy throughout Cambodia at reasonable and affordable price,

2. To ensure reliability and secure electricity supply at reasonable and affordable prices, which facilitate investment in Cambodia and development of the national economy,

3. To encourage exploration and environmentally and socially acceptable development of energy resources needed for supply to all sectors of the Cambodian economy,

4. To encourage efficient use of energy and to minimize environmental effects resulting from energy supply and use.

The power sector development in Cambodia shall be in accordance with the energy sector development policy as stated above.

Remarks: Source: EDC Annual Report 2002	Revisions	
	17/12/03	Original

Category	General		Power Development Plan (PDP)	Document No. PDP-2
Title	Power Demand Forecasting (2003)			

1. According to the Master Plan of the Royal Government, electricity demand is expected to face a significant increase for the next 12 years.

2. Electricity generation requirement in Cambodia is likely to grow from 273MW and 1,036GWh in year 2004 to 746MW and 2,634GWh in year 2016. The majority of this growth will occur in Phnom Penh.

3. The following Table depicts the expected power and energy output for Cambodia. To meet the future demand, the Royal Government has developed a Generation and the National Transmission System Master Plan.

Year	2004	2006	2008	2010	2012	2014	2016
Power, MW	273	331	404	477	558	651	746
Energy, GWh	1036	1215	1454	1700	1968	2292	2634

Source: EDC/Corporate Planning and Projects Department.

Remarks: Source: EDC Annual Report 2002	Revisions	
	17/12/03	Original

Category	General		Power Development Plan (PDP)	Document No. PDP-3
Title	Power Generating Master Plan (2003)			

Power Generating Master Plan has been developed on the following criteria:

1. Base thermal generation will be located in Sihanoukville due to considerations of an independent access to imported oil, by reducing the amount of oil transportation through the Mekong River. The feasibility study of this power plant have been made by JICA and completed in 2001 with the capacity of 2 x 90MW.

2. Peak thermal generation in Phnom Penh.

3. Small and medium size diesel units for base and peak load generation in the provincial towns and cities.

4. Expanded hydropower development based initially on smaller size hydro easily accessible such as Kirirom, Prek Thnot, Kamchay and subsequently mid size hydropower projects Stung Atay, Middle Stung Russei Chrum and Battambang. The feasibility studies of Kamchay hydropower plant have been made with the capacity of 140MW by the Grant from Canadian Government.

Remarks: Source: EDC Annual Report 2002	Revisions	
	17/12/03	Original

Category	General		Power Development Plan (PDP)	Document No. PDP-4
Title	Power Transmission Master Plan (2003)			

The transmission master plan has been developed taking into account the following strategies to achieve Cambodia's energy sector objectives.

1. Reduce reliance on imported oil for energy generation (diversification of energy resources).
2. Reduce reliance on the transport of oil to Phnom Penh for power generation.
3. Reduce reliance on Vietnamese controlled oil transport to Phnom Penh.
4. Increase operational efficiency of the system (minimize losses).
5. Encourage least cost development of provincial load centers by a cost effective mix of the grid expansion and local private generation.
6. Increase competition in power generation by providing access to competitively priced external sources of energy from Vietnam, Thailand or Laos PDR.
7. Maintain reliability of power supply at the level required and financially supported by customers.
8. Facilitate export or energy

Remarks: Source: EDC Annual Report 2002	Revisions	
	17/12/03	Original

Category	General		Power Development Plan (PDP)	Document No. PDP-5
Title	Power Development Master Plan (1999 to 2016):			

1. Based on the Criteria for the Power Generation and Transmission Master Plan which have been stated in the previous Documents (Nos. PDP-3 and PDP-4), Power Development Master Plan have been developed and the outlines are as shown below:

2. The total investment for 18-year planning period is estimated around US$1.5 Billion. The initial five years would require US$ 400Million. To over come with this plan, the Government offers financial concession scheme for private sector investment.

3. The investment plan focuses on the development of National Generation and Transmission Grid, Provincial Supplies Rehabilitation Program, and Rural Electrification Strategy and Implementation Plan.

National Power Station & Transmission Program - 1999 to 2016
Cambodia Power Sector Strategy
(Hydro with Gas Turbine and Trade Option)

Power Stations					Transmission		
Year	Capacity (MW)	Location	Investment $M-1997	GWh Estimated	Year	Transmission Lines & New Consuming	Capital Costs T/L & Centers
2001	60 CCGT	Phnom Penh	72.8	773	2001	IPP2-GS1-GS3 in Phnom Penh	2.9
2002	29 Hydro	Kirrirom &	36.6	871	2002	Kirrirom-Phnom Penh	19.9
2002		Trade				Thailand-Banteay Meanchey	7
2003	Trade	Vietnam		1065	2004	Takeo-Vietnam (import/export)	6.9
						In East Phnom Penh-Kampong Cham	19.7
2004	90 SCGT	Sihanoukville	70.8	967	2003	Sihanoukville-Takhmau-Phnom Penh (import)	
2005	90 CCGT	Sihanoukville	81.8	1181	2005	Sihanoukville	4.5
2006				1284	2006		
2007				1396	2007	GS1 to North Phnom Penh	6.3
2008	47-127 Hydro	Kamchay	61.9	1517	2008	Kamchay-Kampot	6.9
						Banteay Meanchey-Siem Reap	17.4
2009				1658	2009	Battambang-Banteay Meanchey	9.2
2010				1802	2010		
2011	60 Hydro	Battambang 1&2	122.9	2073	2011	Battambang 1&2- Battambang In Phnom Penh (South)	11.8
2012	110 Hydro	Stung Atay	179.9	2252	2012	Stung Atay-Pursat	75.6
2013	Trade	Vietnam		2439	2013	In Phnom Penh (west)	14.1
2014	90 SCGT	Sihanoukville	69.7	2646	2014	Sihanoukville	3
2015				2843	2015	In Phnom Penh (Central)	18.6
2016	125 Hydro	Mid S.R.C.[1]	315.9	3073	2016	Mid S.R.C. - Stung Atay	12.7
						Kampong Chnang connected	6.2
						Battambang-Pursat	19.7
TOTAL	695		1012.3				363.5

Remarks : Source: EDC Annual Report 2002

Revisions	
17/12/03	Original

Category	General		Power Development Plan (PDP)	Document No. PDP-6
			Methodology	
Title	Study of Power Demand (Demand Forecast)			

1. The Demand Forecast is one of an important study to prepare the Power Development Plan (PDP).

2. However, there is no correct method on the demand forecast since it is difficult to foresee the matters in the future. Just like a forecast of the national economy in a country, many economists studied the forecast with Computers using various data concerned, but everybody got their results of the forecast in different figures. Nobody can get the same results in the forecast of the national economy, much less get the same results in the demand forecast which is considered a function of the economy.

3. Historical Trend Method is one of the extrapolation using relation between historical trend of Annual Energy Consumption. Plotting figures on a graph of Annual Energy Consumption in vertical axis vs. Years in horizontal axis using the existing records, and get figures of the demand in the future by extrapolation of the graph.

This method could be also used for the forecast of the energy consumption by category. Accumulation of the demand of each category could be obtained the gross demand in the future. However, the energy demand in the future obtained by the accumulating method will be higher than the forecast by the Macroscopic Method.

However, these methods could not be used in case that the Annual Energy Consumptions are historically falling down for some reasons.

4. Extrapolation by using relation between Annual Energy Consumption per Capita vs. GDP per Capita. This method is used for Macroscopic Demand Forecast in a whole country. This method may be suitable for obtaining gross demand in the future.

5. If it is difficult to obtain any tendency by a graph, Target Method could be used. For example, it is estimate the present annual energy consumption per consumer in a certain city, town, or village, then to obtain the annual energy consumption of the various cities, towns, and villages based on these figures as the target. Accumulation of the demand of the cities, towns and villages makes the total demand in a whole country.

6. Since the Energy Demand in the future may be limited by the amount of the investment to the power development, it is necessary to estimate the total annual investment amount and to compare the amount to the National Budget of the year during preparation of PDP. In the study of PDP, several cases of Power Demand Scenario should be considered.

Remarks:	Revisions	
	17/12/03	Original

Category	General		Power Development Plan (PDP)	Document No. PDP-7
			Methodology	
Title	Study of Power Development Plan (PDP)			

(Step 1)

Preparation of the Demand (Required kWh of each year)

(Step 2)

Obtaining the maximum kW of each year taking the load factor into consideration

Maximum kW = Annual kWh/(24x365xLoad-factor) ---------P1
Where; Load factor (p.u.)

(Step 3)

Contingency as a biggest unit in Maintenance ----------P2

(Step 4)

Contingency as a second biggest unit in fault ----------P3

(Step 5)

Contingency as a Redundancy (10% of P1)----------P4
(Accidental delay of the scheduled additional unit, and unexpected load increase)

(Step 6)

Required total kW = P1 + P2 + P3 + P4

(Attention to be made)

1. Unexpected demand increase by new customers owned private generators
2. Unexpected delay of IPP
3. Sudden retirement of the old power plant, due to lack of the budget for repairing
4. Delay of the expected loan for the power development
5. Delay of the power project due to environmental opposition
6. Delay on the construction of the related transmission lines
7. Expansion of the distribution lines,
8. Economic recession and etc.

Remarks	Revisions	
	03/11/03	Original

Category	General		Electric Power Project	Document No. PP-1
			Life of Project	

Title Project Cycle

From the Preparation of the Power Project to the Retirement of the power plant, the following procedures will be traced:

(Step 1) Planning (Preparation of the Power Project)

- Feasibility Study (Proof of the Project in Technically & Financially viable and Socially acceptable)
- Preparation of the finance (Soft Loan)
- Definite Design of the Project (Follow to the Technical Standards)
- Preparation of Bid Documents (Follow to the Technical Standards and Bank's Guidelines)
- Bidding (ICB, LCB, or Negotiation basis?)
- Bid Evaluation (Follow to the Bid Evaluation Guidelines)
- Contract (Guaranteed Period, Penalty, Liquidated Damage, etc.)

(Step 2) Construction of the Power Project

- Approval of the Shop Drawings (Follow to the Contract?)
- Shop Tests (Witness tests, or Checking the test records)
- Construction of the Facilities at the sites
- Installation of the Power Facilities
- Inspection during the Installation
- Tests during the construction
- Acceptance tests of the Plant and Civil Engineering Facilities (Should be in accordance with the Contract.)

(Step 3) Operation of the Power Plant

- Commissioning the Plant
- Final Acceptance Tests at the end of the Guaranteed Period
- Operation of the Plant
- Periodical Maintenance of the Plant
- Daily and Periodical Inspection of the Plant
- Overhaul of the Plant

(Step 4) Retirement of the Power Plant

- Plan of the Retirement Schedule
- Dismantling the Facilities
- Leveling the Project Area
- Taking Environmental Aspects and Safety into consideration
- Taking Social Aspects into consideration

Remarks:

A Feasibility Report is often called a Bankable Report when the report is used for evaluation of the project by Financial Institutes including banks.

Revisions	
31/10/03	Original

Category	General		Electric Power Project	Document No. PP-2
			Feasibility Study	
Title	Feasibility Study of Power Project (1) Thermal Power Project			

(1) Availability of Fuel (Amount of Fuel, Calories of Fuel, Amount of Fuel Required, Transportation, etc.), Transmission Lines to the Load Center, Jetty, Stockyards of Fuel, Road Conditions for Transportation of the Fuel and Machinery including security, etc. and Other Data for Design of the Project and Project Implementation Planning
(2) Environmental Aspects (Environmental Law & Regulations, Emission of Harmful Gases and Particles, Generation of Noise, Discharge of Hot Water, etc.)
(3) Engineering Aspects (Demand Forecast, Role of the Thermal Power Plant in the Power System, Scale of Development, Site Selection, Preliminary Design, Cost Estimates, Construction Method and Schedule, etc.)
(4) Relation to the Energy Policy of the Government
(5) Economical Viability (Project Cost, Fuel Cost, O&M Cost, Service Life, Discount Rate, EIRR, etc.)
(6) Financial Viability (Project Cost, Source of Funds (Self-Resources, Loan Amount, or Grant), Availability of Financing, Interest Rate, Repayment Schedule, FIRR, Cost of Energy, etc.)

Remarks	Revisions	
	31/10/03	Original

Category	General		Electric Power Project	Document No. PP-3
			Feasibility Study	
Title	Feasibility Study of Power Project (2) Hydropower Project			

In the study of the feasibility study for the Hydropower Project, the following matters have to be considered:

(1) Availability of Meteorological Data, Hydrological Data, Record of River-flow Gauging Stations, Topographic Maps and Study of Geological Conditions for Basic Planning. Availability of Local Materials of Civil Engineering Facilities, and Road for Transportation of Heavy Machineries, Jetty, Stockyards of the machinery and construction materials, Transmission Lines, etc. for Design and Project Implementation Planning.

(2) Environmental Aspects (Environmental Law & Regulations, Generation of Noise and Vibration during Construction and Operation of the Plants, Expected Discharge of Large Amount of Water for Regular Operation of the Plant and Emergency Water Discharge during Monsoon Period, Oil Leakage, etc.)

(3) Engineering Aspects (Demand Forecast, Role of the Hydropower Plant in the Power System, Scale of Development, Site Selection, Preliminary Design, Cost Estimates, Construction Method and Scheduling, etc.)

(4) Relation to the Energy Policy of the Government

(5) Economical Viability (Project Cost, O&M Cost, Service Life, Discount Rate, EIRR, etc.)

(6) Financial Viability (Project Cost, Source of Funds (Self-Resources, Loan Amount), Availability of Financing, Interest Rate, Repayment Schedule, FIRR, Cost of Energy, etc.)

Remarks	Revisions	
	31/10/03	Original

Category	General		Electric Power Project	Document No. PP-4
			Feasibility Study	
Title	Feasibility Study of Power Project (3) Renewable Energy			

(1) Availability of Energy Resources (Wind Flow, Sun Shine, or Bio-mass, etc.), Transportation of Fuel (Amount of Required Fuel, Cost of Fuel, Stockyards, Roads, etc.)
(2) Environmental Aspects (Environmental Law & Regulations, Emission of Noise, Production of Particles and Harmful Gases, Fermentation of Fuel, Discharge of Hot Water, etc.)
(3) Engineering Aspects (Demand Forecast, Availability of Energy Resources, Scale of Development, Site Selection, Preliminary Design, Cost Estimates, Construction Method and Schedule, etc.)
(4) Relation to the Energy Policy of the Government
(5) Special Subsidy for Renewable Energy Project or for Rural Electrification
(6) Economical Viability (Project Cost, Fuel Cost, O&M Cost, Service Life, Discount Rate, EIRR, etc.)
(7) Financial Viability (Project Cost, Source of Fund (Self-Resources, Loan Amount), Availability of Financing, Interest Rate, Repayment Schedule, FIRR, Cost of Energy, etc.)

Remarks	Revisions	
	31/10/03	Original

Category	General		Electric Power Project	Document No. PP-5
			Feasibility Study	
Title	Alternative Study of Power Project			

1. The Purpose of the Electric Power Project is for Supply Electricity to the Consumers, therefore, various alternatives are considered other than the designated power project for the feasibility study.

2. In the feasibility study, it should be considered some realistic projects which could achieve the similar results of the designated project. Then, the comparison study with alternatives shall be made on amount of the investment, unit generating cost (US$/kWh), schedule of the construction, year of the Commissioning, economical and financial viabilities, and other issues to be faced during proceeding the projects.

3. An alternative project of the Generating Project is no only Generating Projects, but also Power Transmission Project.

4. For Heating or Refrigeration, Gas is sometimes an alternative of the Electricity.

Remarks	Revisions	
	31/10/03	Original

Category	General		Project Management for Power Project	Document No. ES-1
			Engineering Consultants	
Title	Role of Consultants (Engineering Services)			

The most of Financial Institutes, such as ADB, WB, KfW, JBIC, are required to use consultants for their financed Projects in the most of developing countries.

The followings are major the items to be made by Engineering Consultants:

(1) *Feasibility Study of the Project*
(2) Definite Study of the Project
(3) Preparation of the Bid Documents
(4) Bid Evaluation including the Bid Evaluation Criteria
(5) Contract Negotiation
(6) Project Administration (Checking and Approval of the Shop Drawings, Control of the Construction Schedules, Coordination among contractors, *Preparation of Progress Report, etc.)*
(7) Daily Supervision of the Project (Monitoring the Progress of the Works, Solving the issues to be happened during construction, etc.)
(8) Attendance at the Shop Tests (Check the Machinery whether they are in accordance with the Contracts, etc.)
(9) Performing the Provisional Acceptance Tests after completion of the Project, and Preparation of the Record for issuing the Provisional *Acceptance Certificate, etc.*

(Note 1) Some times, the shop test may be separately asked to an inspection company which is specialized in the tests, such as "Lloyd" in U.K.

(Note 2) 5% to 10% of the Project Cost will be for the Engineering Fee, and *!0% of the Project Cost is considered for the Contingency.*

Remarks:	JBIC: http://www.jbic.go.jp ADB: http://www.adb.org WB: http://www.	Revisions	
		03/11/03	Original

Category	General		Project Management for Power Project Engineering Consultants	Document No. ES-2
Title	Selection Procedure of Consultants			

According to the Guidelines for Selection of the Consultants prepared by a Financial Institutes, the selection procedures are as follows;

(1) Preparation of "Long List of Consultants"
(The "Long List" means a list of the consultants registered in the designated fields. The First step for preparation of the Short List.)

(2) Preparation of "Short List of Consultants"
(The "Short List" means a list scrutinized from the "Long List" for the Invitation of the Proposals, or prior to the calling proposal, the Consultants would be asked their intention to submit the proposal for the Consultants by Advertisement in the newspaper.)

(3) Preparation of the Invitation Document for the Consultants
(Scope of Services, Terms of References, Conditions of the Contract are included in.)

(4) Call for the Proposal from the Consultants
(In case there is a short list, the invitation documents will be directly sent to the consultants in the list. In case, there is no short list, the advertisement will be made in a newspaper.)

(5) Preparation of the Evaluation Criteria for Selection of the Consultants
(To avoid the possible trouble after submission of the proposals, the evaluation criteria should be prepared in advance.)

(6) Evaluation of the Proposals from Consultants
(The evaluation of the Proposals should be made strictly in accordance with the evaluation criteria. In principle, the selection of the consultants will not be made the lowest price of the proposal. Regardless the price, the proposal who submitted the most suitable for the requirement will be awarded the contract. However, in case that the proposed price amount is far higher than the budget, some price negotiation might be made to reduce the amount.)

(7) Clarification of the proposals and the Contract
(In case there are some ambiguities in the proposal, the clarification will be made, but this is not negotiation.)

The International Financial Institutes are used to be selected the Consultants in the "Short List" taking Regional Distribution of the Consultants into account.

In case of the Soft Loan financed by a developed country, sometimes, the Consultants should be selected only from her country.

Remarks	Revisions	
	03/11/03	Original

Category	General		Project Management for Power Project	Document No. ES-3
			Procurement	
			Bidding	
Title	Procurement of Goods and Services (ICB and LCB)			

In principle, the procurement of goods and services shall be made by competitive bidding procedures taking fair and transparency into consideration.

The bidding will be "International Competitive Bidding (ICB)" for imported goods and services, and "Local Competitive Bidding (LCB)" for Civil Engineering Works.

The Bidders shall be qualified in the following conditions:

(1) Sufficient Experiences to offer the similar goods and services

(2) Sufficient Financial Resources for the firm

(3) Submission of the required amount of the Bank Guarantee

(4) No experience in default

(5) Should be the firm in a Member country (This requirement will be made by the International Financial Institutes, such as ADB, WB.

(6) The bidder shall be followed to the Contract if awarded.

Remarks	Revisions	
	17/12/03	Original

Category	General		Project Management for Power Project	Document No. ES-4
			Procurement	
			Bidding	
Title	Purpose and Contents of Invitation to Bid			

1. The invitation to Bid normally takes the form of a letter, or advertisement in the news papers, inviting interested bidders to bid for the tender. It should describe briefly the nature of the goods or the scope of the services being called for and bidders who are eligible to bid. It should also give information on the closing date of the tender, the place where bidding documents can be obtained and the fee chargeable for such documents.

2. The purpose of the Letter of Invitation to Bid is to supply such information as is necessary to enable potential bidders to judge for themselves whether they should pursue the matter any further.

Remarks	Revisions	
	17/12/03	Original

Category	General		Project Management for Power Project	Document No. ES-5
			Procurement	
			Bidding	
Title	Purpose and Contents of Instructions to Bidders			

1. *Purpose*

This is to be intended to acquaint intending bidders with the nature and scope of the tender and should provide all information which will be of assistance to bidders in preparing their bids. It would naturally vary in contents and complexity from contract to contract but should ensure that intending bidders are quite clear about the requirements of the purchaser.

2. Contents

The contents of the Instruction to Bidders are generally as follows:

1) Project Description
2) *Source of Procurement*
3) Qualifications of Bidders
4) Submission of Bids
5) Extension of Bidding Periods
6) Period of Bid Validity
7) Scope of Bids
8) Alternative Bids
9) *Currency of Bid*
10) Criteria for Bid Evaluation
11) Rejection of Bids
12) Award of Contract

Remarks	Revisions	
	17/12/03	Original

Category	General		Project Management for Power Project	Document No. ES-6
			Procurement	
			Bidding	
Title	Type of Contract			

There are many types of the Contract for the Power Project.

1. Supply only Contract

The contract is to supply goods only. The delivery of the goods is Ex-factory, FOB (Free on Board), or at the site, depend on the contract.

2. Supply plus Supervision of Erection Contract

The contract is to supply goods to the site, and to supervision of the erection works to be done by other people

3. Supply and Installation Contract

The contract is to supply goods to the site, and to install the goods ready for operation.

4. Civil Work Contract

The contract is for civil works.

5. Turnkey Contract

The contract is usually for plants, such as power plant. The contractor is responsible to supply the goods and materials for the plant and to install the plant completely ready for operation, including the commissioning test. The construction schedule of the plant is often delayed due to the delay of a part of the contract. The merit of turnkey contract is easy to keep the construction schedule on time because all responsibility until completion belong to the contractor.

6. Semi-turnkey Contract

The contract is usually a part of the plant, such as substation, fuel-treatment system, water-treatment system. The contractor is responsible to supply parts and materials for the facilities and to install and to deliver them with a completed condition ready for operation.

Remarks	Revisions	
	17/12/03	Original

Category	General		Project Management for Power Project	Document No. ES-7
			Procurement	
			Bidding	
Title	Treating Alternative Bids			

1. If the purchaser, who is called the Borrower by the Bank or Financial Institutes, considers that there are other specifications which could meet the performance requirements and at the same time offer the possibility of lower costs, then the purchaser may submit alternative bids either as:

   1) a single bid which does not conform to the specifications provided but meets the performance prescribed or the objectives of the specifications, or

   2) in special cases, to request bidders to submit two bids, one of which conforms strictly with the specifications and the other which need not conform, but which meet the objectives of the specifications. Bidders, however, cannot be obliged to submit an alternative bid.

2. Where alternative bids are acceptable, invitation for bids should specify the conditions governing such bids. The methodology of bid evaluation and comparison for alternative bids should be clearly specifies in the bid documents. Very often, although no alternative bids are specifically called for their own initiative alternative bids in addition to their original bids. In such case, bid comparison should be between original bids only to determine the lowest evaluated bidder. If the alternative bids of the lowest evaluated bidder is considered more advantageous than its original bid, such an alternative bid may be accepted.

Remarks: Extract fro Handbook on the practice of ADB	Revisions	
	17/12/03	Original

Category	General		Project Management for Power Project	Document No. ES-8
			Procurement	
			Contract	
Title	Letter of Intent (L/I)			

1. After the contract negotiation, successful bidder requires some kind of a formal confirmation that the contract will be awarded to him so that he may proceed to prepare for the undertaking of the contract and to take all necessary steps to comply with the requirements of the contract. This formal confirmation usually takes the form of a "Letter of Intent" issues by the purchaser to the successful bidder.

2. The Letter of Intent should make reference to the bid submitted by the bidder and any modifications agreed to through clarifications, subsequent bid meetings or correspondence. It should state the intention of the purchaser to award the contract to the bidder concerned and should give specific instructions to the bidder to take the next step of the necessary actions, for example, the submission of performance bond as a precondition for the contract to be formally executed and the taking out of the required insurance policy before the start of the work on site.

3. An acknowledge of receipt of the Letter of Intent should be required from the successful bidder and a copy should be sent to the Bank for information. The Letter of Intent by necessity would be brief and can only be regarded as an interim document, by no means a substitute for a proper contract document. Finalization of the contract document should be pursued for execution as soon as possible.

Remarks: Extract fro Handbook on the practice of ADB	Revisions	
	17/12/03	Original

Category	General		Project Management for Power Project	Document No. ES-9
			Procurement	
			Contract	
Title	Elements of a Contract Document			

1. The contract is the formal document, signed by the Purchaser and the successful bidder by which the successful bidder agrees to perform the work, or provide the equipment and materials described in the bid for the amount set forth therein. It details the terms and conditions of the contract and defines the right and obligations of the contracting parties. Therefore, the contract should incorporate all relevant terms and conditions included in the bidding documents *and such other documents necessary to make a complete contract in all aspects.*

2. The following items would normally comprise the contract document:

   1) Form of Agreement
   2) Performance Bond
   3) General Conditions of Contract
   4) *Special Conditions of Contract*
   5) Specifications
   6) Bill of Quantities
   7) Schedule of Prices (as finally agreed upon between the bidder and the purchaser)

Remarks: Extract fro Handbook on the practice of ADB	Revisions	
	17/12/03	Original

Category	General		Project Management for Power Project	Document No. ES-10
			Procurement	
			Contract	
Title	Items on Some Contract Provisions			

The following items are normally incorporated in the contract documents. These are stipulated in the Special Conditions of Contract as a part of the contract document.

1) Definitions
2) Powers and Duties of Engineer
   - Engineer normally acts on behalf of the purchaser in administering the contract and superintending the work at site.
   - The purchaser may wish to reserve the decision on certain major matters to itself. If such is the case, those matters that require the specific approval of the purchase should be clearly defined.
3) Language and Law
4) Detailed Schedule of Program
5) Time of Completion
6) Insurance
7) Transportation
8) Use of Local Labor and Materials
9) Construction Plant
10) Certification of Payment
11) Liquidated Damages and Bonus
12) Maintenance and Defects
13) Settlement of Disputes
14) Changes in Costs and Legislation
15) Taxation and Custom Duties

Remarks: Extract fro Handbook on the practice of ADB	Revisions	
	17/12/03	Original

Category	General		Project Management for Power Project	Document No. ES-11
			Project Management	
			Project Manager	
Title	The Project Manager			

1. Functions and Responsibilities of a Project Manager

As the person responsible for implementing and completing a project on time, within budget and in accordance with technical performance requirements, the Project Manager will have full responsibility for the following:

1) Project Planning:

2) Project Coordination:

3) Project Staffing & Training: Recruiting

4) Project Implementation:

5) Project Management Control and Reporting:

6) Project Interfacing or linkages:

7) Conflict Management:

8) Change Management:

9) Project Turn-over and Commissioning:

10) *Project Financial Management*:

11) Compliance with Terms of Loan Agreement:

2. Qualities of a Good Project Manager

A good Project Manager should possess as many of the following personal qualities as possible: strong human relation skills; strong leadership skills; sense of fairness; the ability to compromise and to arbitrate personal concerns; successful experience in managing similar projects; a project-oriented outlook; good technical knowledge of project management principles, tools and techniques; a strong personal interest in managing projects; the ability to concentrate on the overall picture and to delegate responsibilities; the ability to keep informed and to exercise effective control by asking the "right" questions; and a willingness to face risks; make decisions, and take responsibility for decisions. The Project Manager should also be aggressive, honest, unafraid of confrontation, mature, energetic, an effective communicator, intelligent, discerning, dependable, loyal, and, last but not least, healthy enough to perform the duties and meet the challenges of the position.

Remarks: Extract from "Handbook on Management of Project Implementation" by ADB	Revisions	
	17/12/03	Original

JICA

GUIDEBOOK
FOR
POWER ENGINEERS

English Edition

VOL. No.2
THERMAL POWER

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MINISTRY OF INDUSTRY, MINES AND ENERGY
ELECTRICITY AUTHORITY OF CAMBODIA
ELECTRICITE DU CAMBODGE

GUIDEBOOK FOR POWER ENGINEERS

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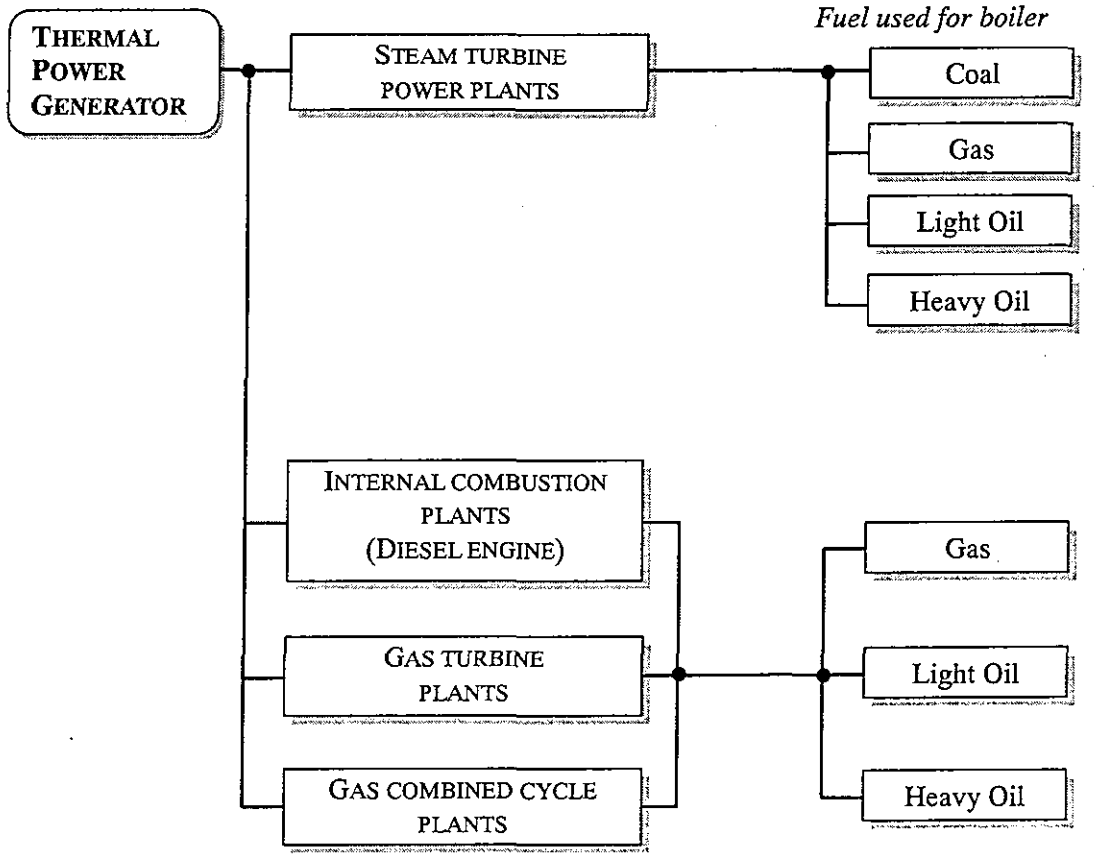
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.BO1-1
	Paragraph	2	Generating Facilities (Thermal Power)	
	Clause			
Title	Outline of Thermal Power Station (1)			

Thermal power Generator

Thermal power plants convert heat to work and then often to electrical energy through some form of energy-conversion cycles.
The classification of the thermal power generation is as follows;



Remarks	Revisions	
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Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.BO1-2
	Paragraph	2	Generating Facilities(Thermal Power)	
	Clause			
Title	Outline of Thermal Power Station (2)			

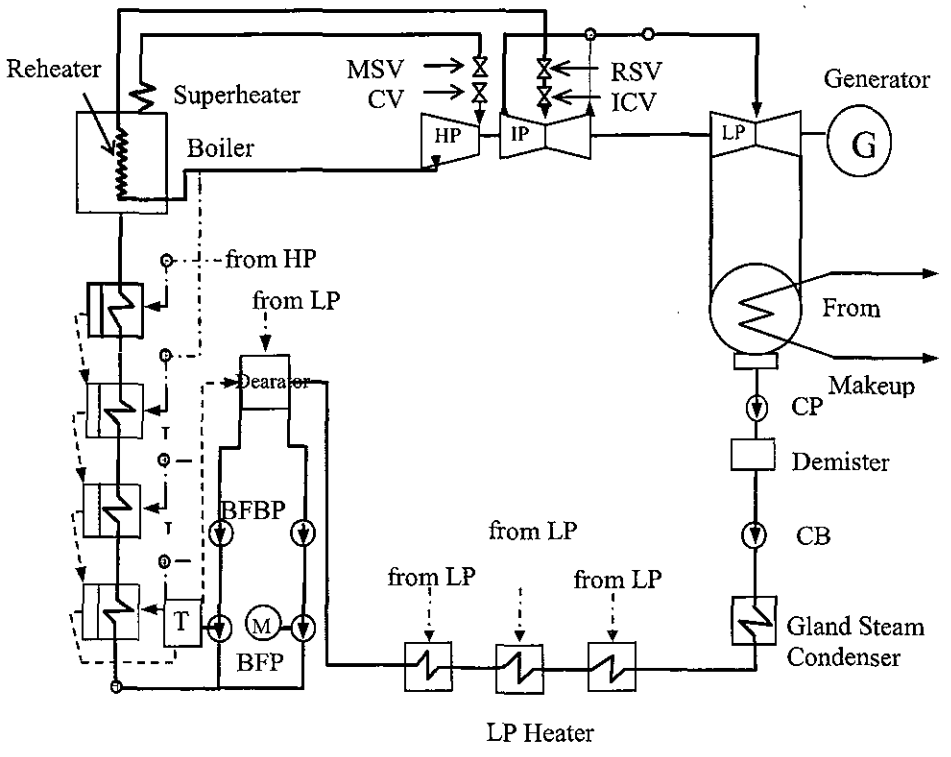
Widely thermal power generation system using coal, oil and gas. Thermal power station roughly consists of following 3 factors such as boiler, turbine and generator.

The flow of steam is as follows,

Makeup water□ condensate water pump □ Low Pressure heater□ Dearator □ Boiler feed pump□ High Pressure-heater□ Economizer □ Boiler□ Super-heater□ High Pressure-turbine□ Re-heater□ Intermediate pressure turbine □ Low pressure turbine □ condenser.

The fuel and combustion exhaust gas flow is as follows,

Fuel □ Tank □ Boiler □ Air Preheater □ ESP(Electric Statistic Precipitator) □ Chimney.



Remarks	Revisions	
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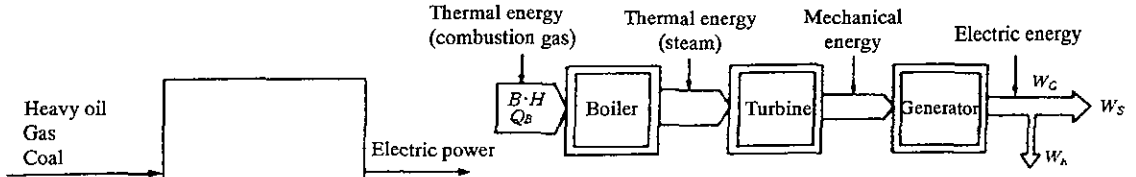
Category				Document No.BO2-1
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	2	Generating Facilities (Thermal)	
	Clause			
Title	General Description of Thermal Power Station (1)			

A thermal power station (steam power station) is a facility where the combustion energy of a fossil fuel is converted into electric energy.

A thermal power station consists of three blocks: boiler, turbine, and generator. Each of these blocks handles a specific energy state to meet Fleming's right-hand rule.



B : Amount of fuel input into the boiler [kg, kl, or Nm^3]
H : Calorific value of the fuel [kJ]
Q_B : Quantity of heat input into the boiler [kJ]
W_G : Generated electric energy [kWh]
Wh : Station electric energy [kWh]
W_S : Transmitted electric energy [kWh]

Energy conversion

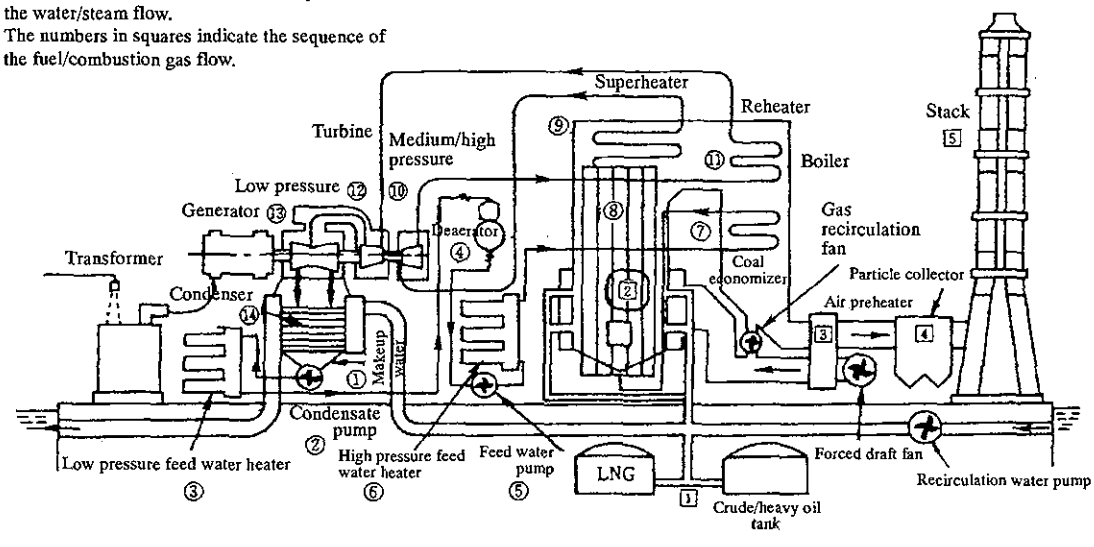
Different blocks for energy conversion

In the mid 1950s, the most common unit capacity was 60 MW. The recent rapid progress of thermal power generation technologies has made it possible to construct generators of high thermal efficiency that produce 125, 175, 265, 350, 600, and 1000 MW. Centralized global operation control based on automatic control systems and protection and security systems including computerized equipment to ensure high efficiency and safe operation are being applied to thermal power stations. Moreover, efforts are being made to contribute to environmental protection with contamination-proof devices. Figure shows typical components of a thermal power station.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.BO2-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	2	Generating Facilities (Thermal)	
	Clause			
Title	General Description of Thermal Power Station (2)			

○ The numbers in circles indicate the sequence of the water/steam flow.
□ The numbers in squares indicate the sequence of the fuel/combustion gas flow.



Components of a steam power station

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.BO3-1
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	2	Generating Facilities (Thermal)	
	Clause			
Title	Thermodynamics and Heat Cycle (1)			

Thermal power generation is based on the heat cycle: heated water changes into steam that contains great energy and, when the surrounding heat is shut, returns to the aqueous state and emits great energy, expanding in a limited space. Several fundamentals of thermodynamics should be known.

1. Fundamentals of Thermodynamics

(1) Units for temperature

Three units are used to characterize the degree of thermal state of a system:

1) °C (degrees Celsius): this unit is generally used in Europe and many countries including Japan. Temperatures in Japanese thermal power stations are indicated in °C;

2) °F (degrees Fahrenheit): this unit is generally used in the United States and the United Kingdom. In Japan, this unit was sometimes used for temperatures in thermal power stations imported from the United States. The conversion between °F and °C is carried out with the formula: $t\,[°F] = \frac{9}{5}t\ \ [°C] + 32$;

3) °K (degrees Kelvin) or K (Kelvin): This is the unit for absolute temperatures (thermodynamic temperature) in the international system of units (SI). The conversion between °K and °C is carried out with the formula: $T\,[°K] = t\,[°C] + 273$. This unit is not used in thermal power stations.

(2) Units for pressure

Three units are used to characterize the degree of pressure in the components of a thermal power station:

1) kgf/cm^2: unit for atmospheric pressure of fluids such as steam, oil and water. Atmospheric pressure ("atm") is a force [kgf] applied to a surface of 1 square centimeter. 1 kgf/cm^2 = 98066.5 Pa ≒ 0.098 MPa;

2) mmHg: this unit is used to characterize the degree of vacuum in the tube of a condenser as the height of a mercury column. 1 atm (standard atmospheric pressure) corresponds to a height of a 760-mm mercury column at 0°C. 1 mmHg = 133.322 Pa;

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Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.BO3-2
	Paragraph	2	Generating Facilities (Thermal)	
	Clause			
Title	Thermodynamics and Heat Cycle (2)			

3) mmAq: this unit is used to characterize the degree of pressure in boiler furnace drafts as the height of a water column. 1 atm corresponds to a height of a 10336-mm water column. 1 mmAq = 9.8 Pa

In the SI system of units, Pa is used for this quantity. 1 Pa = 1 N/m^2

(3) Unit for quantity of heat

Joule (J) is used for representing the quantity of heat of a steam. The relationship with the previously used unit (cal) is: 1 cal = 4.186 J.

(4) First law of thermodynamics

Heat and work are energy. Heat is equal to work. They vary with each other.

1) Quantity of heat Q [J] and work W [J]

In the SI system, both the quantity of heat Q and work W are represented in joules (J).

$$Q\,[J] = W\,[J] \quad \text{..... (1-1)}$$

The work of electricity is represented in kWh. 1 kWh can be rewritten as follows:

$$1\ kWh = 1\,[kW] \times 3600\,[s] = 3600\,[kJ] \quad \text{..... (1-2)}$$

Values in joules (J) are used in the calculation of the change of steam's quantity of heat into a work (torque or turning force) in the turbine. Formula (1-2) is very important for calculating the gross thermal efficiency of a thermal power station.

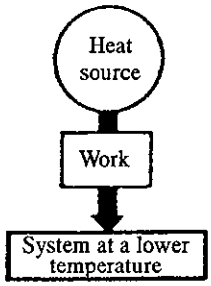
(5) Second law of thermodynamics

When the heat in a system is transferred to another system that has a higher temperature, another energy is consumed. The second law of thermodynamics represents this relationship.

This property is applied to the air-conditioning system for a central control room or computer room.

Remarks	Revisions	
	2003/Nov	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.BO3-3
	Paragraph	2	Generating Facilities (Thermal)	
	Clause			
Title	Thermodynamics and Heat Cycle (3)			



A system cooler than the heat source is required for changing the heat energy of a heat source into work.

Scheme of the second law of thermodynamics

(6) Enthalpy and entropy

1) Enthalpy *i*

Enthalpy *i* is the quantity of heat that water or steam has and is expressed in kcal/kg. Enthalpy is important in the thermal calculations for a power station.

$$i = u + Pv \text{ [J/kg]} \quad \text{..... (1-3)}$$

where u: internal energy [J/kg]
P: pressure [Pa]
v: volume (specific volume) of the system [m^3/kg]

2) Entropy *s*

Entropy *s* is represented in J/K. The quantity of heat dQ [J] that a system acquires at the absolute temperature T [K] divided by the absolute temperature is referred to as increment of entropy ds [J/K].

$$ds = \frac{dQ}{T} \text{ [J/K]} \quad \text{.....(1-4)}$$

When 1 kg of steam being heated changes from state 1 to state 2, keeping its equilibrated conditions,

$$s_2 - s_1 = \int_1^2 \frac{dQ}{T}, s_2 = s_1 + \int_1^2 \frac{dQ}{T} \text{ [J/K]} \quad \text{.....(1-5)}$$

Entropy *s* is a property of a system that has been defined virtually for thermodynamic calculations to indicate the states of steam and is very useful in understanding the heat cycle in the *T-s* diagram.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.BO3-4
	Paragraph	2	Generating Facilities (Thermal)	
	Clause			
Title	Thermodynamics and Heat Cycle (4)			

(7) Properties of steam

The steam that is generated in the boiler and performs work in the turbine has several properties:

1) Saturated steam and superheated steam

Water being heated will increase its temperature under the atmospheric pressure and will finally reach its boiling point of 100°C. At the boiling point, the temperature stops rising, and the heat supplied is consumed for evaporation of the water. At this stage, a latent heat of 2260 kJ is required per kg of water. The boiling point of water varies with the pressure. As the pressure rises, the boiling point rises.

This boiling point is referred to as saturation temperature for the pressure and the pressure is referred to as **saturation pressure** for the boiling point. At this state of water, the steam is called **saturated steam** for the pressure.

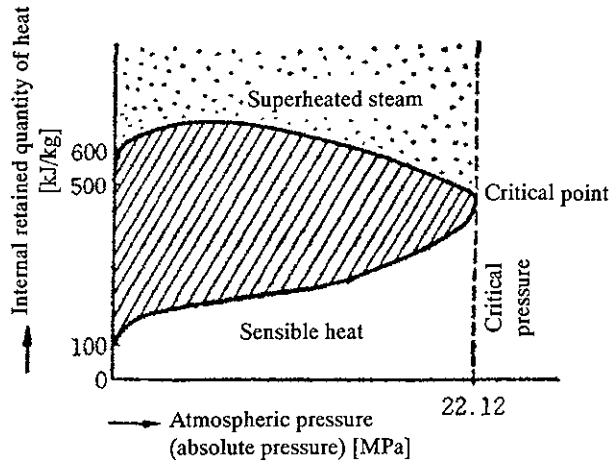
As the pressure rises, the latent heat decreases. When a pressure of 22.12 MPa is reached at 374.1°C, the latent heat is null. At this state, water immediately changes into steam. This state is the **critical point**, the temperature is the **critical temperature**, and the pressure is the **critical pressure**.

Saturated steam is referred to differently depending on the presence of liquid water content: that which contains liquid water content is **wet saturated steam** and that which does not contain it is **dry saturated steam.**

If dry steam is further heated, the temperature of the steam rises in direct proportion to the quantity of heat provided under a given pressure. Steam that has a temperature higher than the saturation temperature is referred to as **superheated steam.** The **degree of superheat** is the difference between the saturation temperature and the retained quantity of heat. As the degree of superheat rises, the superheated steam approaches the perfect gas properties. Shows the retained quantity of heat in relation to the pressure.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.BO3-5
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	2	Generating Facilities (Thermal)	
	Clause			
Title	Thermodynamics and Heat Cycle (5)			



Retained quantity of heat in water in relation to atmospheric pressure

Remarks	Revisions	
	2003/Nov.	Original

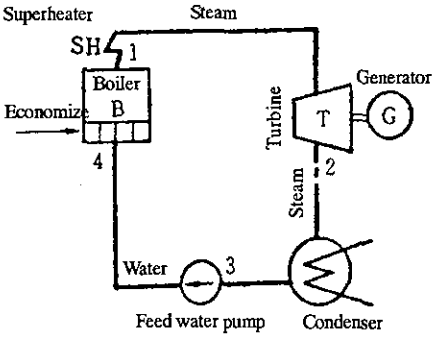
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.BO4-1
	Paragraph	2	Generating Facilities (Thermal)	
	Clause			
Title	Types of Heat Cycle in Thermal Power Stations (1)			

Types of Heat Cycle in Thermal Power Stations

(1) Rankine cycle

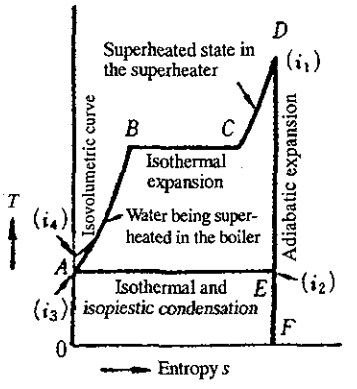
This is a basic heat cycle in a thermal power station. A line chart of the system (a) and the *T-s* diagram (b).

1) Heat cycle efficiency in *T-s* diagram



(a) Rankine cycle system

Superheater : device which changes saturated steam into superheated steam.
Economizer : device which heats the feed water with waste heat from the boiler.
Evaporation tube : tube which absorbs the heat from the furnace and generates steam.
Condenser : device which cools the steam having performed work in the turbine to change it into water.



(b) Rankine cycle diagram

Rankine cycle

In the diagram (b), the line A-B represents the process in which water is superheated in the economizer and evaporation tubes (Isovolumetric change), the line B-C the process in which water evaporates in the evaporation tubes (isothermal expansion), the line C-D the superheated state in the superheater, the line D-E the process in which the steam in the evaporation turbine changes into a mechanical force (adiabatic expansion), and the line E-A the process in which steam is cooled with cooling water in the condenser and changes into water (isothermal and isopiestic condensation). In this diagram, the total quantity of heat received is represented by the area formed by 0ABCDF. The part of the quantity of heat which was changed into mechanical energy in the turbine is represented by the area formed by ABCDE. Therefore, the part of the quantity of heat which was taken by the cooling water is represented by the area formed by OAEF. Hence, the theoretical heat cycle efficiency η_p of the cycle is:

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.BO4-2
	Paragraph	2	Generating Facilities (Thermal)	
	Clause			
Title	Types of Heat Cycle in Thermal Power Stations (2)			

$$\eta_p = \frac{\text{Area ABCDE}}{\text{Area 0 ABCDEF}}$$

2) Heat cycle efficiency η_k in the rankine cycle system

In (a), the mechanical energy Qi into which steam was changed in the turbine is

$$Qi = i_1 - i_2 \text{ [kJ/kg]} \quad \text{(1-6)}$$

The energy Q_0 supplied to 1 kg of water in the boiler is

$$Q_0 = i_1 - i_4 \text{ [kJ/kg]} \quad \text{(1-7)}$$

The energy Q_p consumed for feeding 1 kg of water with the feed water pump is

$$Q_p = i_4 - i_3 \text{ [kJ/kg]} \quad \text{(1-8)}$$

Therefore, the theoretical heat cycle efficiency η_k is

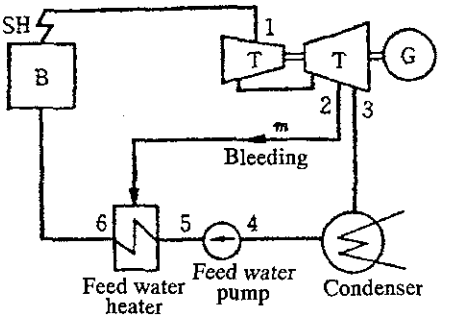
$$\eta_k = \frac{Q}{Q_0} = \frac{Q_i - Q_p}{Q_0} = \frac{(i_1 - i_2) - (i_4 - i_3)}{(i_1 - i_4)} \quad \text{(1-9)}$$

(2) Regeneration cycle

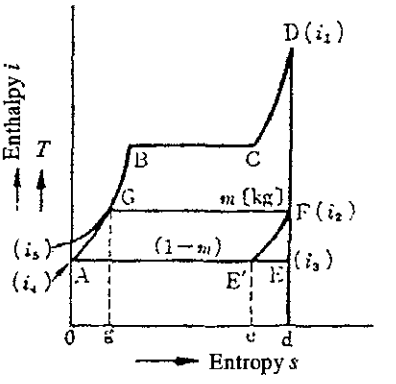
A sudden adiabatic expansion occurs from D to E in the turbine. This increases the portion of the quantity of heat in the discharged steam at the point E which is carried away by the cooling water in the condenser. This portion is heat loss. This loss in the condenser can be reduced by extracting a part of the expanding steam from the turbine, sending it to the feed water heater, heating the feed water to return it to the aqueous state, and feeding the resulting water to the boiler (a). (b) shows a *T-s* diagram for a regeneration cycle. Extracting m kg of steam at the point F will reduce the generated energy to FEE' and the heat loss EdeE' in the condenser as well. The heat efficiency increases with the number of bleeding stages. At the last bleeding stages, the increase rate for the heat efficiency becomes less steep, increasing the equipment costs. **Usually seven to nine bleeding stages are used for a large-scale turbine.**

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.BO4-3
	Paragraph	2	Generating Facilities (Thermal)	
	Clause			
Title	Types of Heat Cycle in Thermal Power Stations (3)			



(a) Line chart of regeneration cycle system



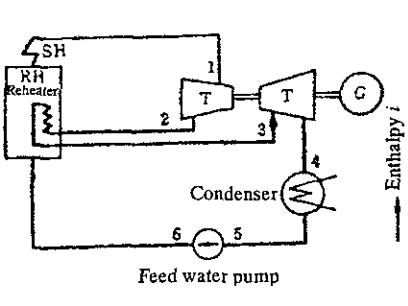
(b) Graphic chart of regeneration cycle

Regeneration cycle

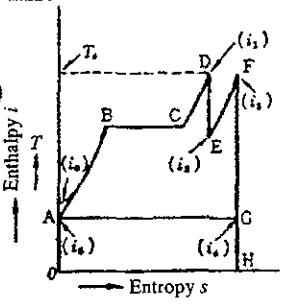
(3) Reheating cycle

Rapid adiabatic expansion of high-pressure steam in the turbine will increase the steam's liquid water content and decrease the turbine's efficiency. Therefore, steam's liquid water content must be limited to 7 or 8%. (a) shows the characteristics of the reheating cycle. After adiabatic expansion in the high-pressure turbine, the steam is returned to the boiler and is sent to the reheater where it is superheated at a suitable temperature. And then, the steam is returned to the turbine where adiabatic expansion occurs to reduce the steam's liquid water content.

(b) shows a *T-s* diagram of the reheating cycle.



(a) Line chart of reheating cycle system



(b) *T-s* diagram for reheating cycle

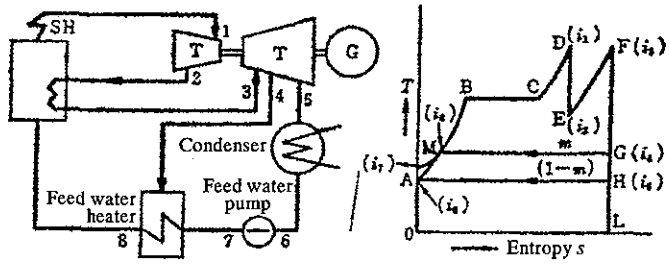
Reheating cycle

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.BO4-4
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	2	Generating Facilities (Thermal)	
	Clause			
Title	Types of Heat Cycle in Thermal Power Stations (4)			

(3) Reheating/regeneration cycle

Today, industrial thermal power stations use a **reheating/regeneration cycle** (a). This cycle has two advantages: the regeneration cycle achieves thermal improvements and the reheating cycle reduces the loss of steam due to wear in the turbine. (a) shows a line chart of system and (b) shows *T-s* diagram.



(a) Line chart of reheating/regeneration cycle system (b) *T-s* diagram for reheating/regeneration cycle

Reheating/regeneration cycle

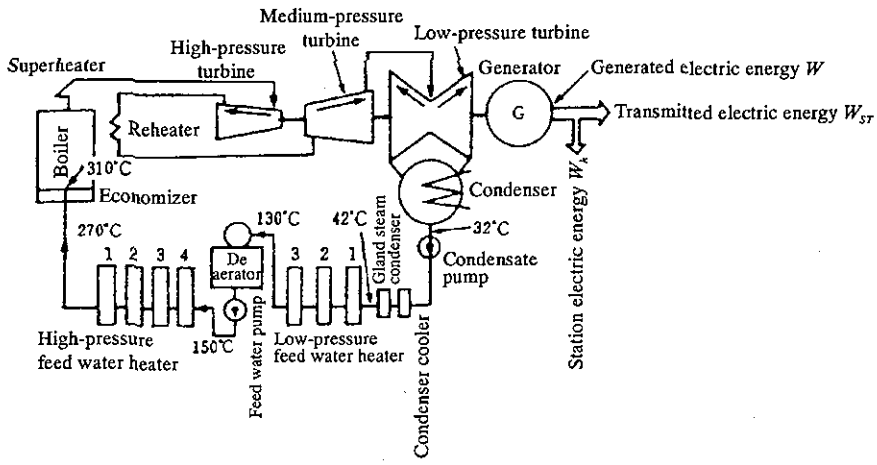
Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.BO5-1
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	2	Generating Facilities (Thermal)	
	Clause			
Title	Flows of Water and Steam (1)			

Shows a water and steam line for a power generation unit that produces an output of 350 MW. Water and steam flow in the direction indicated by arrows. At the condenser's outlet, the pressure for the water of 2.9 kPa and 32°C is raised in the condensate pump, and the water passes through the condensate cooler and the gland steam condenser, absorbing heat. At this stage, the water has a temperature of 42°C. Downstream, the water further passes through a three-stage low-pressure feed water heater to have a temperature of 130°C and enters the deaerator where it is purged of air. And then, the pressure for the water of 150°C and 19.6 MPa is raised by the feed water pump up to the boiler pressure, and the water passes through a four-stage high-pressure water feeder to have a temperature of 270°C. The water flows into the economizer in the boiler, absorbing the temperature of the flue gas to obtain a temperature of 310°C, and enters the upper steam drum. The water in this steam drum flows through the main downcomer into the lower water drum. The water in this water drum flows up through the evaporation tubes, changing into a staturated steam, and returns to the steam drum. The saturated steam is divided by the solid/liquid separation equipment into two parts: water and steam. The water is conducted to the main downcomer and the steam enters a steam dryer where it is dried. The dry steam is led to the primary, secondary and tertiary heater successively to become a steam of 556°C and 16.6 MPa and enters the high-pressure turbine. During adiabatic expansion, the steam produces a torque, being cooled down to 480°C under 4 MPa. The steam is returned to the boiler and passes through the primary and secondary reheater, being superheated up to 538°C under 4 MPa, and is returned to the turbine. During adiabatic expansion in the medium- and low-pressure segment, the steam provides a torque, being cooled down to 33°C, and flows through a low-pressure exhaust chamber into the condenser where it is cooled by cooling water to return to the aqueous state and repeat the entire circulation in the direction indicated by arrows. Loss of water due to leakage is compensated for by the makeup water line. In general, 3 or 4% of the water is lost during a single cycle of circulation.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.BO5-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	2	Generating Facilities (Thermal)	
	Clause			
Title	Flows of Water and Steam (2)			



Water and steam line

Remarks	Revisions	
	2003/Nov.	Original

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