カンボジア国
鉱業エネルギー省(MME)
カンボジア電力庁(EAC)

カンボジア国
電力経済・計画アドバイザー業務
(IPP 審査能力強化のための研修)
【有償勘定技術支援】

業務完了報告書

2022 年 6 月

独立行政法人
国際協力機構 (JICA)

中国電力株式会社

社基
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22-080

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略語集

略語	説明
C/P	Counter Part
EAC	Electricity Authority of Cambodia（カンボジア電力庁）
EDC	Electricité du Cambodge（カンボジア電力公社）
LNG	Liquefied Natural Gas（液化天然ガス）
IPP	Independent Power Producer（独立系発電事業者）
JICA	Japan International Cooperation Agency（国際協力機構）
MEF	Ministry of Economy and Finance（経済財務省）
MME	Ministry of Mines and Energy（鉱業エネルギー省）
MP	Master Plan
OJT	On the Job Training
PPA	Power Purchase Agreement（電力購入契約）
WG	Working Group

サマリー

IPP 事業の審査は電力政策や電源計画等を所管する MME が総括し、国内で唯一発電・送電（国家系統）・配電の統合ライセンスを持つカンボジア電力公社（EDC）、電気事業関連のライセンス発行や料金認可等を担当する独立規制機関たるカンボジア電力庁（EAC）等から構成される委員会が担っている。委員会では、各機関が政府計画と発電所運用計画の整合性、提案料金の適切性、環境社会配慮に関する検討結果の適切性等の観点から審査をしてきている。しかしながら、各機関では、他国の事例や前例等を参考にしつつ審査を実施していることから、審査結果の一貫性や信頼度に問題が発生する懸念が生じている。

IPP 提案書の審査を担当する委員会の構成要員である MME 及び EAC に対し、IPP の事業審査に係る研修及び参照文書の整備等を行うことにより、IPP による事業計画提案に対する審査能力向上を図り、もってカンボジア電力セクターの安定的な電力開発に寄与するものである。

WG1 審査体制

カンボジア電力セクターでは、様々な課題に直面する都度、MME、EDC、EAC 等が集まって協議する慣習となっており、IPP 審査体制もこれを踏襲している。しかし実際の役割は、組織された委員会メンバーの能力によって都度変更しており、各組織の役割が明文化されている訳ではない。このことから、IPP 審査体制に対する提言や、審査におけるチェックリストを作成することとした。

a) チェックリストの作成

カンボジアの IPP 審査体制では、各組織の役割が委員会メンバーの能力で都度変更され、また審査する項目を規定したものが無いことから、様々なプロジェクトが審査される度に審査内容が変わってしまう恐れがある。必要な審査が毎回実施され、安定した電力供給が担保されるよう、IPP 審査で確認する必要のある項目をまとめたチェックリストを作成することとした。

b) IPP 審査体制に対する提言

組織単位ではなく個人名で任命された委員が、協議により IPP 審査を実施している現状では、任命された委員の能力によって審査品質にばらつきが出ることが想定される。審査品質を一定にしつつ、責任を持った審査を行うため、業務をルーチンワーク化し、審査を効率的でシステマチックに実施できるよう、以下のとおり提言を取りまとめた

a.審査品質を一定に保ち、審査の公平性を確保するため、IPP 審査のチェックリストを作成し、審査項目を明確化させる。このチェックリストは、MME が主体となり、定期的に見直す場を設ける。

b.組織に責任を持たせて審査を行うために、チェックリストの項目毎に責任部署を決める

c.各部署は、割り当てられたチェックリストの項目に関し、社内研修などの人材育成を継続的に実施し、審査品質の向上に努める。例えば、毎年各職員の能力を把握し、この把握結果に基づく研修を実施することを推奨する。研修は、本プロジェクトの C/P が中心となって実施することを期待する。

d.本プロジェクトで作成した研修に関する技術資料は、MME 及び EAC の誰もが参照できるように保存されていることから、今後もこのようなしくみを使って情報共有を行うことを推奨する。

c) 情報の共有

カンボジアでは、組織で技術力を保有するという感覚が希薄であるのか、過去の研修資料などについては、参加した担当者が個人的に所有するだけで、それを共有するという思想が無い。そのため、本プロジェクトでは作成した資料を Google Drive を使って共有化し、C/P であれば誰でもアクセスできるようにした。また、Web で実施した研修動画を録画し、You Tube にて共有した。

WG2 IPP 事業評価手法

審査時に参照する資料として、WG1 で作成したチェックリストの項目に対し審査項目をどのように確認すべきかを記載した資料を作成し、それに基づく研修を実施した。

研修資料の作成にあたっては、共通項目、LNG 火力、水力及び太陽光発電について下記の方針で研修資料を作成した。

a) 共通項目

共通項目の内、レベルの低い系統連系に関して研修資料を作成した。今回、研修対象者が MME 及び EAC 職員であることから、技術的検討方法ではなく IPP 審査時に審査する項目の内容や、確認すべき情報が何かという点を重視した。審査の基準となるカンボジア国の技術基準及びグリッドコードでの記載内容を紹介しながら、各項目の内容を理解できるように配慮した。

b) LNG 火力発電

LNG 火力発電については、全体的にレベルが低いこと、またカンボジア国内での経験がないことから、LNG に関する知識の習得を目的とした燃料のハンドリングや機械設備といった石炭火力と LNG 火力の違いについての研修資料と、その知識を踏まえて実際の審査が出来るように各審査項目が何を表しているのか、その項目で何を確認すべきかについての資料を作成した。各資料は、図や写真を用いて理解しやすいように配慮して作成した。

c) 水力発電

水力発電については、カンボジア国内での経験があることから、特にレベルの低い項目に対しての研修を行うこととし、資料を作成した。水力に関してはカンボジア国の技術基準があることから、審査時には技術基準の要求事項を満たしているかの観点が必要である。技術基準の項目からどのような点を審査すべきか、日本での場合も示しながら説明する資料とした。

d) 太陽光発電

太陽光発電については、チェックリストの項目全般に対する研修を行うこととし、資料を作成した。特にレベルの低い自然災害リスクに関する項目については、災害事例の写真や、日本

における台風進路や落雷分布といった資料を用いて、対策の必要性やどのような資料を確認する必要があるか分かりやすい資料となるよう配慮した。

WG3 需要想定

ここ数年の経済成長による電力需要の急増や、コロナの影響による需要の減などにより、需要が大きく変わってきているため、MME は需要想定の更新頻度を高める必要性を認識しており、Departemet of Energy Development を需要想定の担当部署として、今後は 2 年毎に需要想定を更新する目標を定めている。しかし、これまでカンボジア側で需要想定を実施してこなかったことから、実際に需要想定が出来る担当者が育っていない。2019 年に中国電力が実施した MP 改定における需要想定は、カンボジア側ニーズを満たす Simple-E を使って実施した。Simple-E はエクセルのアドインであることから、エクセルが動く PC 上で使用でき、また、データと相関関数が明示されていることから想定の過程がブラックボックスとなっておらず、需要想定の諸元と想定結果の関係性を理解しやすい。

以上のことから、Simple-E を使った需要想定研修を実施した。

WG4 財務／料金分析

MME への聞き取り結果から、財務・料金分析能力が十分でないため、前例を参照・踏襲する傾向があり、IPP から提案された電力購入契約（PPA）の内容が妥当であるかの判断が的確にできていないことが分かっている。例えば、発電所毎に「立地」「技術内容」「コスト構造」などが異なるが、これらが同じであることはほとんどあり得ず、前例を参照したとしても、当該審査発電所との違いをどのように評価するのかに苦慮している。財務・料金分析ができないと、IPP との PPA 交渉を有利に進めることができない。そのため、財務・料金分析の能力向上を目的に研修を実施した。

第1章 事業の概要

1.1 事業の背景

カンボジアは近年、目覚ましい経済成長を遂げ、増加する海外直接投資と多様化する産業という変化と共に、国内開発を進めてきた。これらの開発に不可欠なのが電力であり、カンボジアの電力需要は 2010 年からの 10 年間で約 5 倍、年平均約 19%の割合で増加している。

国内電力需要の 7 割を占める首都プノンペンでは、拡大する電力需要に対し電力供給設備の整備が追い付いておらず、電力の安定供給が最大の課題となっており、JICA は円借款事業で変電所の新・増設、送配電網拡張や送変電設備の適切な運用・維持管理を支援している。

また、上記設備の開発効果維持・向上のため「電力経済・計画アドバイザー」を 2016 年度から鉱業エネルギー省（Ministry of Mines and Energy。以下、「MME」という。）に派遣し（2022 年 6 月現在 3 人目派遣中)、電力需給バランスの確保や送配電設備の増強も含め系統容量の継続的確保に資する助言を行っている。

急増する電力需要への対応が重要な課題となる中、カンボジアでは発電事業（水力、石炭火力等）の大部分は独立系発電事業者（Independent Power Producer。以下、「IPP」という。）に頼っている。これら事業者の発電設備は、政府に対する事業者からの提案を元に事業化検討が行われるケースが多いため、技術面並びに買電料金を含む財務面での適切性を確保し計画通りに開発、運転されるためには、政府関係機関が事業提案段階で適切な審査をし、必要に応じて計画を変更した上で承認する必要がある。

IPP 事業の審査は電力政策や電源計画等を所管する MME が総括し、国内で唯一発電・送電（国家系統)・配電の統合ライセンスを持つカンボジア電力公社（Electricite du Cambodge。以下、「EDC」という。)、電気事業関連のライセンス発行や料金認可等を担当する独立規制機関たるカンボジア電力庁（Electricity Authority of Cambodia。以下、「EAC」という。）等から構成される委員会が担っている。委員会では、各機関が政府計画と発電所運用計画の整合性、提案料金の適切性、環境社会配慮に関する検討結果の適切性等の観点から審査をしてきている。しかしながら、各機関では、他国の事例や前例等を参考にしつつ審査を実施していることから、審査結果の一貫性や信頼度に問題が発生する懸念が生じている。

本研修は、上記事案の重要性に鑑み、要望内容の中から優先度の高い項目を選択した上で、現在派遣中の電力経済・計画アドバイザーの活動の一環として実施された。

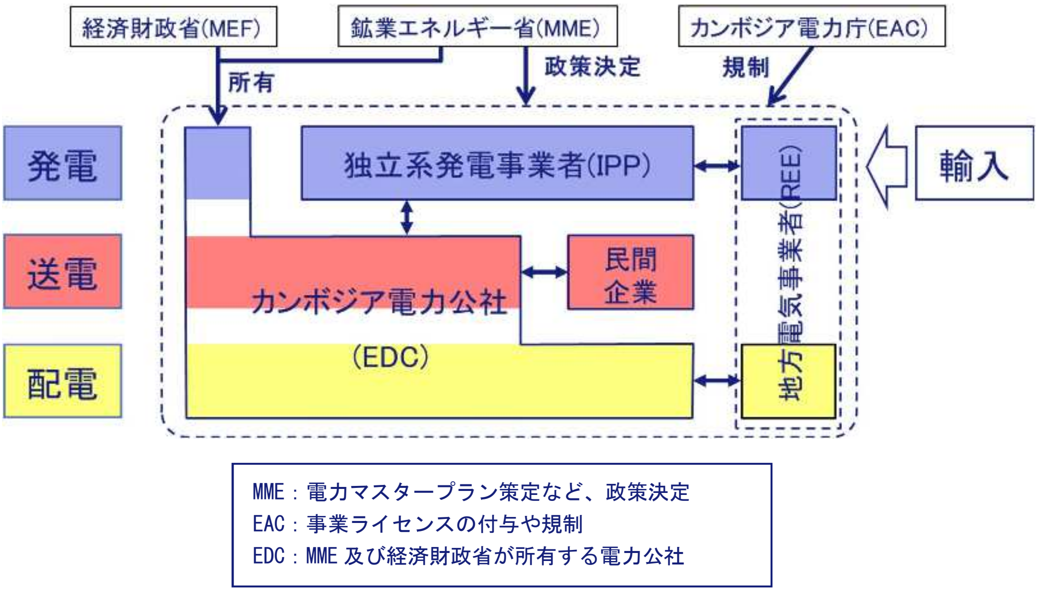
1.2 事業の目的

IPP 提案書の審査を担当する委員会の構成要員である MME、EDC 及び EAC に対し、IPP の事業審査に係る研修及び参照文書の整備等を行うことにより、IPP による事業計画提案に対する MME、EDC 及び EAC の審査能力向上を図り、もってカンボジア電力セクターの安定的な電力開発に寄与するものである。

第2章　活動内容

2.1　C/P の構成

カンボジア電力セクターは図 2-1 の構成となっている。



出典：EAC Annual Report などから中国電力作成

図 2-1 カンボジア電力セクターの構成

本研修では、IPP 審査で中心的な役割を果たす MME、EAC 及び EDC の全てがカウンターパート（C/P）として名を連ねることを想定していたものの、EDC が C/P となることに難色を示した。コンサルタント側からレターを出すなどの調整を試みたが、EDC を C/P として迎えることができなかった。このため、MME 及び EAC を対象に C/P を選定した。

2.2　キックオフミーティング

2021 年 10 月 20 日に本プロジェクトのキックオフミーティングを Web 会議で実施。MME の Heng Kunleang 総局長に対し、プロジェクトの概要を説明し、了解を得た。（添付資料３）

図 2-2 キックオフミーティング

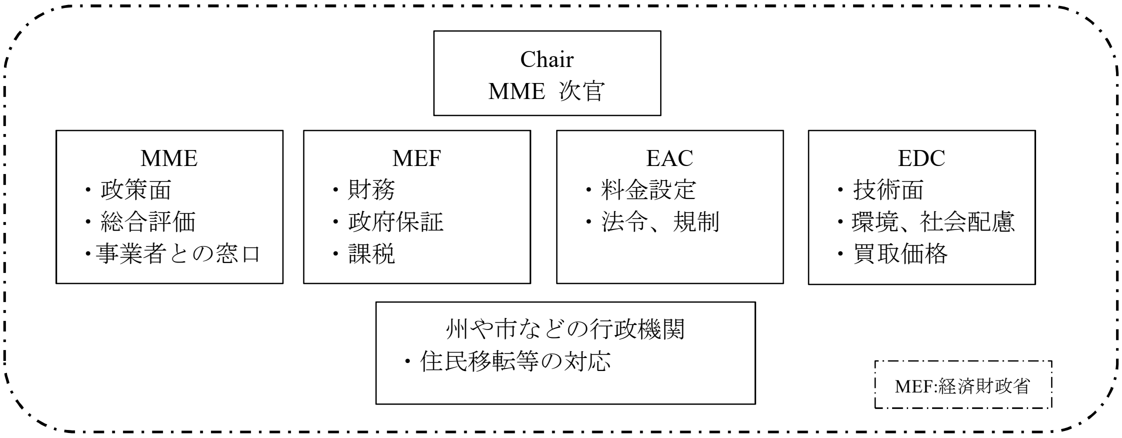
また、2021 年 12 月 7 日には、C/P とのキックオフミーティングを Web 会議で実施した（添付資料４）。

図 2-3 C/P とのキックオフミーティング

2.3 WG1 審査体制

カンボジアでは、2019 年の電力不足時に緊急的に導入した 400MW のディーゼル発電所を除き、主な水力及び火力発電所は IPP により開発されている。これに加え、近年、大規模太陽光発電所も 10MW を皮切りに IPP により開発されている。

IPP 審査は、その都度委員会を組織して行っており、体制と役割は基本的には図 2-4 の通りである。審査に当たっては、近隣国の事例を参考にしたり、外部コンサルタントを使ったりと、可能な限り審査精度を高める努力を行っている。



出典：MME への聞き取りから中国電力作成

図 2-4 IPP 審査体制と役割

カンボジア電力セクターでは、様々な課題に直面する都度、MME、EDC、EAC 等が集まって協議する慣習となっており、IPP 審査体制もこれを踏襲している。しかし実際の役割は、組織された委員会メンバーの能力によって都度変更しており、各組織の役割が明文化されている訳ではない。このことから、IPP 審査体制に対する提言や、審査におけるチェックリストを作成することとした。

2.3.1 チェックリストの作成

カンボジアの IPP 審査体制では、各組織の役割が委員会メンバーの能力で都度変更され、また審査する項目を規定したものが無いことから、様々なプロジェクトが審査される度に審査内容が変わってしまう恐れがある。必要な審査が毎回実施され、安定した電力供給が担保されるよう、IPP 審査で確認する必要のある項目をまとめたチェックリストを作成することとした。

本プロジェクトでは、石炭火力及び風力発電所については対象とせず、LNG 火力、水力及び太陽光発電所を対象とすることとした。理由は、カンボジアでは石炭火力発電所の新規開発をしない方向性が出されたことと、風力発電所は有望地点が限られており開発がほとんど進んでいないことによる。

チェックリストは、当初カンボジア国の実態に則した資料とする為にカンボジア国の FS 資料を元に作成するよう考えていたが、カンボジア国側から情報を得ることが出来なかったことから、公開されている他国の FS 資料や JICA の水力開発ガイドマニュアル等を参考として LNG 火力、水力及び太陽光発電所に関する審査項目を作成した。各審査項目に対しては、プロジェクト毎に審査内容が変わらないよう、着目すべき点を併せて記載した。

2.3.2 IPP 審査体制に対する提言

(1) 現状把握

カンボジアで近年運転開始した IPP 発電所は表 2-1 のとおりであり、水力発電所、石炭火力発電所及び太陽光発電所に関する IPP 審査をそれぞれ複数件経験してきている。

表 2-1 近年運転を開始した IPP 発電所

発電所名	種類	出力[MW]	運開年
Kamchay	水力	194	2011
Atay	水力	120	2013
Tatay	水力	246	2014
Russei Chrum	水力	338	2015
Lower Sesan 2	水力	400	2017
CEL	石炭火力	100	2014
CEL2	石炭火力	135	2019
CIIDG	石炭火力	405	2016
Sunseap	太陽光	10	2017
Schneitec (Kampong Speu)	太陽光	80	2019
Schneitec (Pursat)	太陽光	60	2021
Schneitec (Kampong Chhnang)	太陽光	60	2020

出典：EAC Anuual Report や現地での報道などから中国電力作成

しかし、組織ではなく個人名で選定された審査委員が、協議の上審査を行っていた。人材育成の観点では、近年では年間 1～2 件程度 IPP 審査が行われる程度であり、かつ、発電所も水力・火力・太陽光と種類があることから、若手人材の IPP 審査技術の向上を OJT だけで実現させるのは不十分であることが分かった。加えて、これまで各種ドナーが様々な研修をカンボジア電力セクターに対して実施してきているが、その研修資料は参加者個人で所有されおり、知識の共有や技術継承などが行われる素地が薄いことが確認できた。

(2) 基本計画

審査を効率よく、かつ、システマチックに行うための方法として、

・本プロジェクトの WG2 で作成する IPP 審査チェックリストを利用する
・技術資料を共有化する仕組みをつくる
・個々人の技術力を把握する
・本プロジェクトで育成されたトレーナーにより、継続して教育を実施する

ことを基本計画とした。

(3) 提言

組織単位ではなく個人名で任命された委員が、協議により IPP 審査を実施している現状では、任命された委員の能力によって審査品質にばらつきが出ることが想定される。審査品質を一定にしつつ、責任を持った審査を行うため、業務をルーチンワーク化し、審査を効率的でシステマチックに実施できるよう、以下のとおり提言を取りまとめた（添付資料 6）。これについて 2022 年 5 月 11 日に、Heng Kunleang 総局長に説明し、了解を得た。

a.審査品質を一定に保ち、審査の公平性を確保するため、IPP 審査のチェックリストを作成し、審査項目を明確化させる。このチェックリストは、MME が主体となり、定期的に見直す場を設ける。
b.組織に責任を持たせて審査を行うために、チェックリストの項目毎に責任部署を決める
c.各部署は、割り当てられたチェックリストの項目に関し、社内研修などの人材育成を継続的に実施し、審査品質の向上に努める。例えば、毎年各職員の能力を把握し、この把握結果に基づく研修を実施することを推奨する。研修は、本プロジェクトの C/P が中心となって実施することを期待する。
d.本プロジェクトで作成した研修に関する技術資料は、MME 及び EAC の誰もが参照できるように保存されていることから、今後もこのようなしくみを使って情報共有を行うことを推奨する。

2.3.3 情報の共有

カンボジアでは、組織で技術力を保有するという感覚が希薄であるのか、過去の研修資料などについては、参加した担当者が個人的に所有するだけで、それを共有するという思想が無い。そのため、本プロジェクトでは作成した資料を Google Drive を使って共有化し、C/P であれば誰でもアクセスできるようにした。また、Web で実施した研修動画を録画し、You Tube にて共有した。

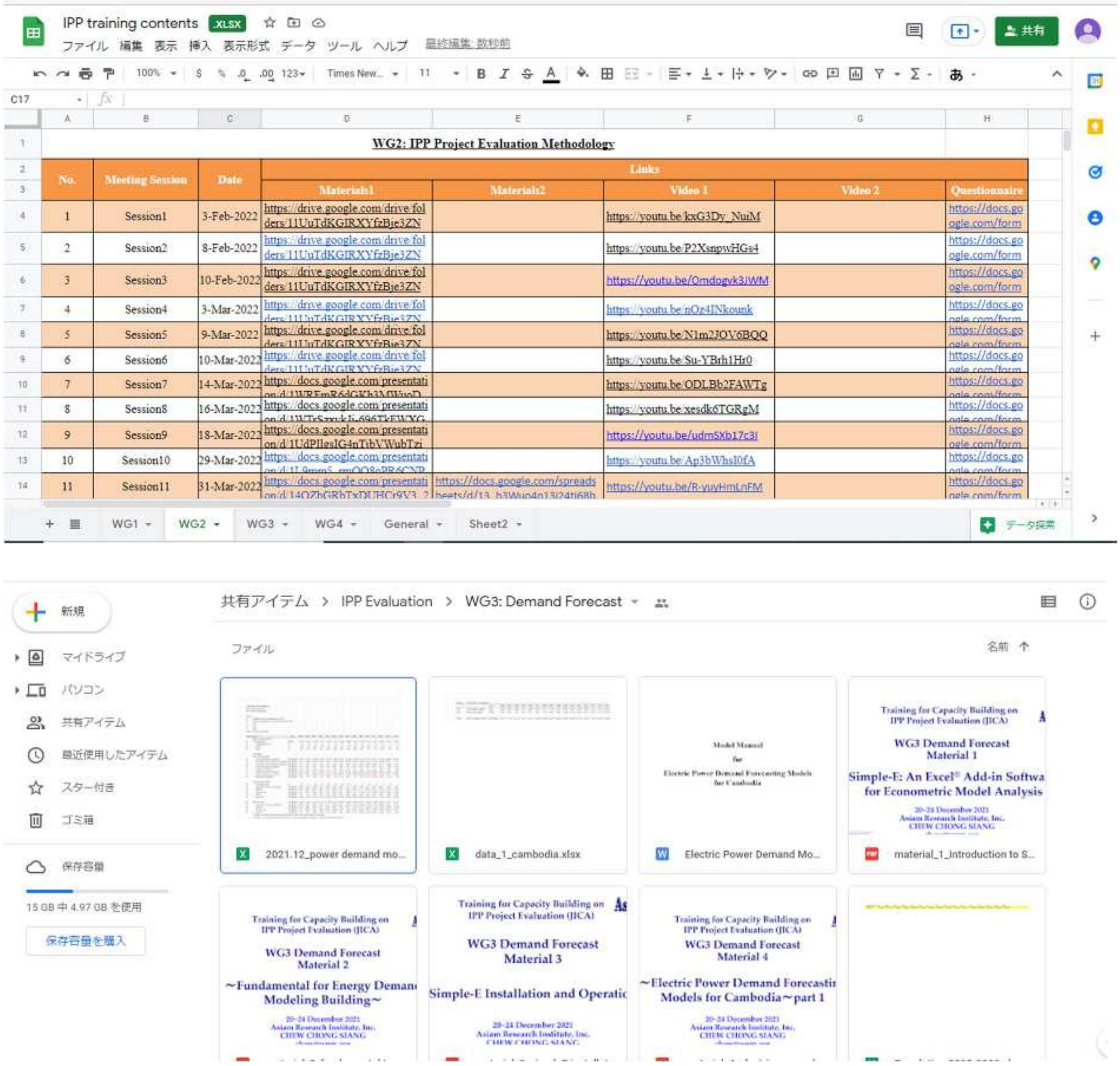


図 2-5 情報の共有化(Google Drive の画面コピー例)

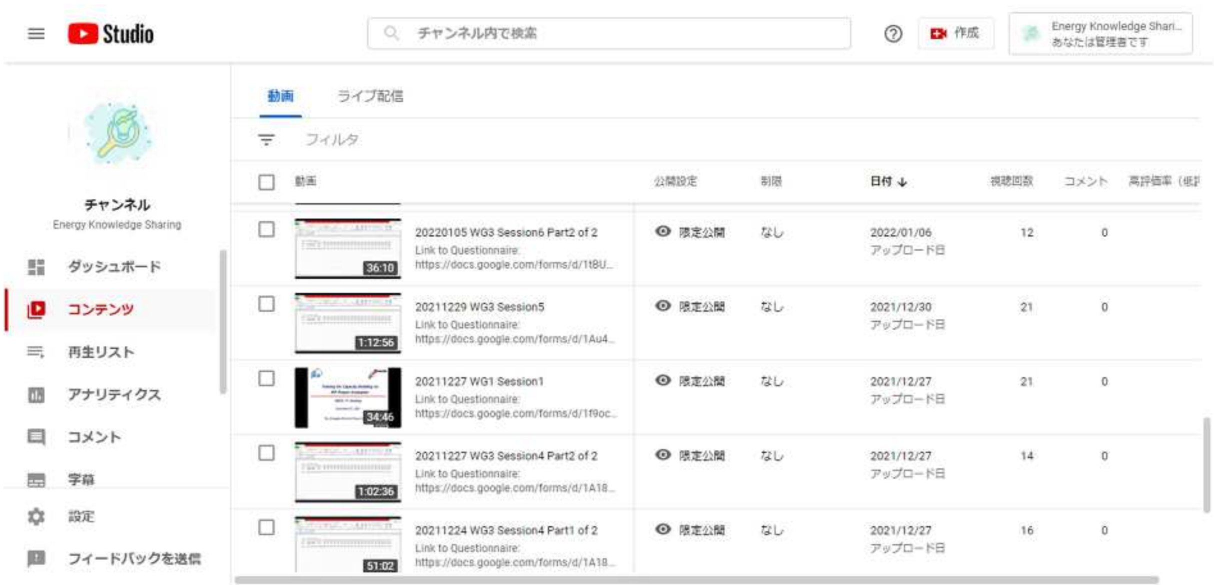


図 2-6 情報の共有化(YouTube チャンネルの画面コピー例)

2.4 WG2 IPP 事業評価手法

審査時に参照する資料として、WG1 で作成したチェックリストの項目に対し審査項目をどのように確認すべきかを記載した資料を作成し、それに基づく研修を実施した。

IPP_Feasibility Study Check List(LNG Thermal)

Evaluation item	Specific elements	Department in charge of evaluation		Pass	Fail
		MME	EAC		
1.Fuel Supply					
1.1 Fuel Source	To enable stable supply, check the financial status and fuel supply experience of the fuel supplier. To make sure that the fuel supply contract period matches the IPP project period.	Thermal & Combustion Energy			
1.2 LNG Quality	Confirm Gas calorific value, Gas property, Environmental impact component (nitrogen, sulfur, etc.) Confirm the fuel is suitable for the GT specifications. Confirm the consistency between the amount of exhaust gas components and local environmental regulations	Thermal & Combustion Energy			
1.3 Fuel Handling Facility	-				
1.3.1 Transport Distance	Calculate the LNG consumption at the power plant and confirm that the required amount can be procured by LNG carriers considering the distance to power station, the number and the capacity of carriers	Thermal & Combustion Energy			
1.3.2 Unloading Place and LNG Jetty of Power Plant	Confirm feasibility of pier docking of LNG carriers considering vessel size, water depth of jetty.	Thermal & Combustion Energy			
2.Power Plant Site					
2.1 Conditions of Plant Site	-				
2.1.1 Location	Confirm the distance to transmission lines, the rivers as water source, access roads, obstacles such as unexploded ordnance	Thermal & Combustion Energy			
2.1.2 Natural Conditions of Site	Confirm that annual temperature, coastal wave height, sea water temperature, tidal level, Hydrologic regime and wind condition near the site for the past several decade and site height are collected	Thermal & Combustion Energy			
2.2 Traffic	Confirm availability of air transportation method, sea transportation method, land transportation method, maximum transportable amount.	Thermal & Combustion Energy			
2.3 Engineering Geology	-				
2.3.1 Earthquake	Confirm that earthquake record (e.g. time and scale), existence of active fault and seismic region coefficient around the site are collected	Thermal & Combustion Energy			
2.3.2 Topography	Confirm that topographic data of the site is collected. Confirm that rainfall data around the site are collected and rainfall characteristic of the site is understood.	Thermal & Combustion Energy			
	Confirm that geological survey result near the site by boring survey are collected Confirm that geological condition including geological classification, N-value, depth				

図 2-7 審査時参照資料(抜粋)

2.4.1 能力把握･研修項目の決定

IPP 審査能力強化のための研修を実施するにあたり、限られた期間でカンボジア国の IPP 審査能力を効率的に向上させるため、能力が不足しており研修を実施すべき項目を絞り込む必要があった。これについては、まず現状のカンボジア国における IPP 審査能力を把握するため、C/P 全員に WG1 で作成したチェックリスト（ドラフト版）の各項目について研修前のレベル（１～５のスコア）を付けてもらった。スコアの基準については下表の通り。

表 2-2 能力把握基準

スコア	レベル
1	チェックリストの項目が全く理解できない
2	チェックリストのうち、１つが理解できる
3	チェックリストのうち、半分が理解できる
4	チェックリストのうち、75%が理解できる
5	チェックリストのうち、全てが理解できる。

Evaluation item	Specific elements	average
Purpose of FS Check List	**This list is a compilation of items that should be checked in order to review Feasibility studies fairly and appropriately. Please check each evaluation item with points of interest.**	
1.Power System		
1.1 Situation of Power System	Validity of conditions and results of power flow study	2.37
1.2 Necessity of Power Plant based on power development mast	Type of generator, Capacity, Commercial Operation Date	2.79
1.3 Connection to Power System		
1.3.1 Specification	Voltage, Power factor, Operating frequency range of power generation facilities, etc., Frequency adjustment function※1, Neutral point grounding equipment・Electromagnetic induction hazard・Protection device	2.00
1.3.2 Impact on Power system	Necessity of power system extension (if overloaded), Voltage fluctuation※2, Power plant output [kW, MW] fluctuation※2, Power quality※2, System stability, Automatic load limiter and power generation suppression(only if required)	1.89
1.3.3 Countermeasures for accidents	Short-circuit and ground-fault currents, Fault Ride Through function※7	1.79
1.3.4 Control and communication requirements	Telephone equipment for security of electric facilities, Power Feed Information Transmission Equipment	2.11
2.Transmission Line		
2.1 Transmission line	Interconnection point with power system, Voltage, Route(Over head or under ground), Structures, Wire type, Necessity of Low-loss wire, Number of Circuits, Things crossing transmission lines(e.g. river, railroad, etc.), Matching of power generator and transmission line capacity	2.11
3.License & Permission		
3.1 Land acquisition	Land acquisition, Land use permit conditions, Usable period	1.83
3.2 Construction permission and power generation license	Government permission (the start of construction work and power generation, etc.)	2.11
4.Legal Requirements		
4.1 Related laws and regulations	e.g. Energy Saving, Regulation of vibration and noise at site boundaries and around equipment, etc.	2.17
4.2 Environmental preservation	e.g. Discharge of Pollutants, Environmental Protection, Soil and Water Conservation, etc.	2.05
4.3 Social and Environmental Impact Assessment	Residents, rare animals, remains, etc. at the installation site	2.00
4.4 Health and safety	Occupational health, Labour safety	2.32
5.Power Off-Take		
5.1 Power Off-Take of the project	Power purchase (power generation amount, price, reception point, Commercial Operation Date, etc.)	2.32
5.2 Power Evacuation Options in case of trouble	Penalty conditions in case of trouble	2.11
5.3 Project development schedule and plan	Construction schedule, Construction organization(including ability of EPC), Technical risks(Reflection status of the latest knowledge on power plant components), etc.	3.05
6.Financial analysis		
6.1 Financing cost	Financing costs in project development	1.84
6.2 Financial analysis	IRR, Sensitivity analysis	1.63
6.2.1 Capital expenditures (CAPEX)	EPC cost of power plant and transmission line, Financing cost, Tax, and other related expenses	2.05
6.2.2 Operation and maintenance expenditures (OPEX)	Operation and Mentenance cost after Commercial Operation Date	1.95
6.2.3 Tariff	Confirmation of Tariff (including power generation cost) consideration of CAPEX, OPEX, Power generation amount, Profit, etc.	2.47
7.Risk Analysis		
7.1 Completion risk	Probability of Cost overrun, Commercial Operation Date delay, etc.	1.74
7.2 Operational and Management risk	Reliability of operation / management system	1.79
7.3 Financial risk	Financial arrangements, Repayment, Fluctuation of exchange rate, Bankruptcy, etc.	1.79

図 2-8 能力把握結果(共通項目)

C/P の能力把握結果は以下のとおり。

a) LNG 火力発電

LNG 火力発電では最も能力の高い人でもレベル３としている項目が多いことから、前提となる知識を含め、全般に対して能力向上を図る必要があると判断した。

b) 水力発電

水力発電についてはカンボジア国内での経験があることから、広範な項目について全て研修するのではなく、特にレベルが低い項目に重点を置くこととし、具体的には地震・水文・気象関係調査、ダム設計、水路設計、電気設備設計に関して研修することとした。

c) 太陽光発電

太陽光発電については水力と同様にカンボジア国内での経験があり、能力の高い人もいるが、自然災害や PCS・保護装置・維持管理の部分でレベルが低かった。太陽光発電は火力発電や水力発電に比べて設備が少なく、審査項目も少ないことから、レベルの低い項目のみを研修するより全般的に研修を行う方がカンボジア国の能力向上に資すると判断した。

d) 共通項目

系統連系や法規制等、各プロジェクトに共通する項目については、特に能力の低い項目

の内、WG4 で研修を実施する財務・料金分析を除いた系統連系に関する項目について、能力向上が必要と判断した。

2.4.2 研修資料の作成、整理

研修資料の作成にあたっては、共通項目、LNG 火力、水力及び太陽光発電について下記の方針で研修資料を作成した。

a) LNG 火力発電

LNG 火力発電については、全体的にレベルが低いこと、またカンボジア国内での経験がないことから、LNG に関する知識の習得を目的とした燃料のハンドリングや機械設備といった石炭火力と LNG 火力の違いについての研修資料と、その知識を踏まえて実際の審査が出来るように各審査項目が何を表しているのか、その項目で何を確認すべきかについての資料を作成した。各資料は、図や写真を用いて理解しやすいように配慮して作成した。

b) 水力発電

水力発電については、カンボジア国内での経験があることから、特にレベルの低い項目に対しての研修を行うこととし、資料を作成した。水力に関してはカンボジア国の技術基準があることから、審査時には技術基準の要求事項を満たしているかの観点が必要である。技術基準の項目からどのような点を審査すべきか、日本での場合も示しながら説明する資料とした。

c) 太陽光発電

太陽光発電については、チェックリストの項目全般に対する研修を行うこととし、資料を作成した。特にレベルの低い自然災害リスクに関する項目については、災害事例の写真や、日本における台風進路や落雷分布といった資料を用いて、対策の必要性やどのような資料を確認する必要があるか分かりやすい資料となるよう配慮した。

d) 共通項目

共通項目の内、レベルの低い系統連系に関して研修資料を作成した。今回、研修対象者が MME 及び EAC 職員であることから、技術的検討方法ではなく IPP 審査時に審査する項目の内容や、確認すべき情報が何かという点を重視した。審査の基準となるカンボジア国の技術基準及びグリッドコードでの記載内容を紹介しながら、各項目の内容を理解できるように配慮した。

2.4.3 研修の実施、フォロー

新型コロナウィルス感染症の影響により、カンボジア国への渡航が出来ない状況が続いたため、研修は Web 会議ツール（Zoom）を利用し遠隔で実施した。WG2 では IPP 審査手法に関する広範な内容について研修することから、研修頻度を C/P の業務に配慮し 2 月から 5 月にかけて週 2 回程度のペースで実施した。各研修ではいつでも質問可能とし、質問の都度疑問点の解消に努めた。また、研修後でもアンケートによる質問を受け付け、リアルタイムでの研修参加が出来なかった

者でも疑問の解消が出来るように配慮した。

2.5 WG3 需要想定

電力マスタープラン（MP）で使用する中長期的な需要想定は、2006 年に世界銀行の支援で韓国電力が、2013 年と 2019 年には中国電力が実施しているが、いずれも MP を作成するコンサルタント任せとなっていた。しかし、MME への聞き取りによると、ここ数年の経済成長による電力需要の急増や、コロナの影響による需要の減などにより、需要が大きく変わってきているため、需要想定の更新頻度を高める必要性を認識しており、MME の Departemet of Energy Development を需要想定の担当部署として、今後は 2 年毎に需要想定を更新する目標を定めている。しかし、これまでカンボジア側で需要想定を実施してこなかったことから、実際に需要想定が出来る担当者が育っていない。

2019 年に中国電力が実施した MP 改定における需要想定は、カンボジア側ニーズを満たす Simple-E を使って実施した。Simple-E はエクセルのアドインであることから、エクセルが動く PC 上で使用でき、また、データと相関関数が明示されていることから想定の過程がブラックボックスとなっておらず、需要想定の諸元と想定結果の関係性を理解しやすい。

以上のことから、Simple-E を使った需要想定研修を実施した。

2.5.1 研修資料の作成、整理

(1) Simple-E

Simple-E は、計量経済学的シミュレーションツールから発展した統合シミュレーションシステムである。同ツールは、データ準備をはじめ、モデル構築、シミュレーション（予測）までモデリングプロセス全体を支援している。回帰モデルによる推定と予測シミュレーションの自動化により、シームレスな運用が可能である。

Simple-E は、マイクロソフト社のエクセル（Excel）のアドインアプリケーションとして制作されいる。表計算ソフト・エクセルのネイティブな機能と、他のウィンドウズ・アプリケーションとのオープンなインターフェースの利点を活かしている。同時に、データ入力、モデリング、テスト、予測・シミュレーションの各プロセスを統合することができ、新たなプログラミングは必要ない。その上、グラフィカルで視覚的な操作により、Simple-E は簡単に使用・学習することができるように作成されている。ユーザーは、ウィンドウズ内の他のデータ及びプログラム・インターフェースとの完全な透明性及び互換性という利点を活かし、モデリングとシミュレーションという最も困難なタスクに集中することができる。

エクセルの関数機能を統合・制御し、通常の最小二乗（OLS）、自己回帰、非線形などの様々な推計オプションを提供している。連立方程式はフォワードルッキング（Forward Looking）モデルを含む連立方程式で、回帰モデルや定義方程式など様々な形式の方程式が利用できる。各時系列変数またはそのモデルは、ワークシートの 1 行に割り当てられ、各期間または各変数のケースは、ワークシートの 1 列に割り当てられる。

Simple-E は、「1.Data」、「2.Model」、「3.Simulation」の 3 つのシートから構成される。これらのシートは連動しており、モデル構築にはこの 3 つシートが必須である。モデル構築は、データ入力からシミュレーションまで、1）モデルのチェック（Model Check）、2）モデルの解答（Model Solve）、3）シミュレーション（Simulation）の 3 つの工程がある。下図はその基本

的な考え方と、各プロセスと 3 つのシートとの関係を示している。ユーザーは「1.Data」シートにデータを、「2.Model」シートにモデルの仕様を入力する必要がある。データ入力とモデル指定が終わると、Simple-E はモデルのチェックとシミュレーションの処理を行う。

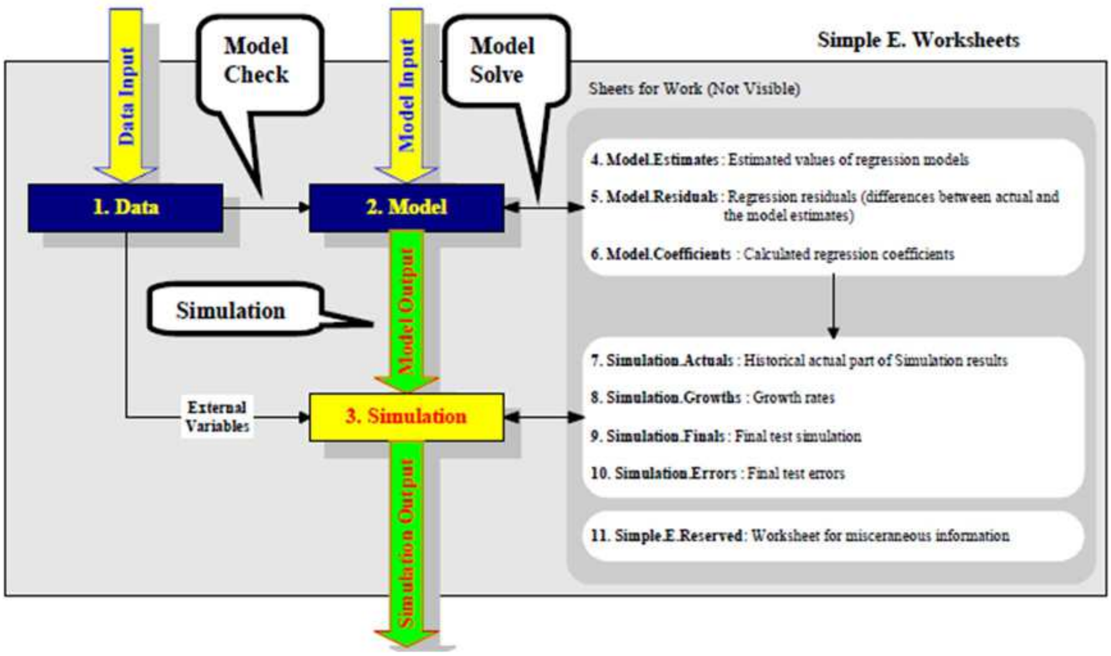


図 2-9 Simple-E の基本的な考え方と各プロセスのフロー図

(2) 資料作成・データ収集と整理

今回の研修は、モデル構築に関する理論的な学習を含み、研修参加者が実際のモデル構築ができるようになることを目指している。そのため、資料作成にはカンボジア政府が公式に発表したマクロ経済に関する統計（アジア開発銀行データベース）及び EDC と EAC が発表した電力部門に関する統計を使用した。しかし、資料作成及びデータ収集には下記の課題が存在する。

- カンボジアの統計データの整備は進んでいるものの、需要モデルに必要なデータが一部欠けている。例えば、電力価格や顧客数について、EAC は関連データを収集するものの、時系列で整理されていない。
- 部門ごとのデータが少ないため、部門別の電力需要分析を深めることができない。
- 地方（各州）に関する統計データの整備が進んでいないため、各地域別の電力需要分析が困難である。

上記の制約は、短期的に解消できないため、今回の電力需要モデルの構築は、マクロ的な視点で行うこととした。研修で構築するモデルには、今後の需要モデル構築のプラットフォームとして、拡張性のある仕組みを導入する。これにより、カンボジアの統計データ整備が進むに従って、モデル予測精度の向上が期待できる。

2.5.2 研修及びトレーナー育成

(1) 研修内容

トレーナー育成の研修は、コンピュータによる実習を実施し、実用化と研修を通じた電力需

要モデル構築の手法を技術移転した。具体的にはそれぞれが有機的に連動しているマクロ経済モデル、電力需要予測モデル及び地方電力需要モデルの 3 つのテーマごとにエクセル（Simple-E のアドイン）の表計算上にて演習を行った。マクロ経済モデルではエネルギー（電力）と経済活動との関連を定式化する手法である回帰分析など計量経済における最も重要な部分についての理論を学ぶと共に、近隣諸国を例とし、経済と電力需給の関係の定式化の演習を行った。

トレーナー育成研修の資料作成は、主にモデル構築の基礎理論、ソフトの操作と電力需要モデル構築に焦点を当てている。これらの目的を達成するために、カンボジアの実際の統計データを用い、参加者全員が各自のパソコンで、モデル構築を最初から最後まで各ステップの説明を受けながら、モデルを完成させる全過程が体験できる流れである。具体的な内容と資料は以下の通りである。

・Simple-E ソフトの仕組みについて（添付資料 8-1 を参照）
・エネルギー需要モデルの基礎（添付資料 8-2 を参照）
・Simple-E ソフトの操作（添付資料 8-3 を参照）
・電力需要モデル構築（添付資料 8-4 を参照）

上述したように、実際の自国のデータを用いて自らパソコン上に電力需要モデルを構築し、それぞれ各自でその成果を確認しつつ学べるよう配慮した研修プログラムに沿って実施した。最終的なモデル構築の結果は、電子ファイル（エクセル表形式）として各研修参加者のパソコンに残り、今後各自の仕事の必要性に応じてモデルの更新、修正、拡張などでこれを再利用することができる。

(2) トレーナー育成研修実施日程

研修は 2021 年 12 月 20 日（月）～2022 年 1 月 5 日（水）期間の内 6 日間、下表に示したスケジュールで実施した。

表 2-3 トレーナー育成研修実施日程

セッション	日付	研修内容
1	2021 年 12 月 20 日(月)	Simple-E ソフトの仕組みについて （資料 添付資料 8-1）
2	2021 年 12 月 22 日(水)	Simple-E ソフトの操作 （資料 添付資料 8-3）
3	2021 年 12 月 23 日(木)	エネルギー需要モデルの基礎 （資料 添付資料 8-2）
4	2021 年 12 月 24 日(金)	エネルギー需要モデルの基礎 （資料 添付資料 8-2）
5	2021 年 12 月 29 日(水)	電力需要モデル構築 （資料 添付資料 8-4）
6	2022 年 1 月 5 日（水）	電力需要モデル構築 （資料 添付資料 8-4）

(3) 研修参加者

WG3 のトレーナー育成研修参加者は C/P 全員（合計 19 名）である。その内 3 名を、トレー

ナーとして育成した。

(4) 感想

今回、初めて Web 会議形式で電力需要モデル構築の研修を実施した。Web 会議の最大のメリットは、時間の節約である。インストラクター（講師）と参加者は、物理的に移動する必要がなく、移動にかかっている時間を大幅に削減することができる。Web 会議形式はまた始まったばかりで、通信速度や操作不慣れなど改善すべきところは多くあるが、いずれも克服できる問題である。

2.5.3 トレーナーによる研修の実施、フォロー

(1) トレーナーによる研修内容

トレーナーによる研修は、対象 3 名のトレーナーを中心として、将来的にカンボジアの関係機関（MME、EAC、EDC）のスタッフへ電力需要想定に関する分析ツール及び手法を普及させていくことを目的としている。この研修を通して、電力需要想定に関する分析ツール及び関連技術が C/P の組織内部で持続的に展開していくことが出来るように支援した。プロジェクトが短期間で 4 名のトレーナーに説明資料を作成させることが難しいため、今回はトレーナー育成研修で使用した講義資料を使った二次教育を実施することとした。具体的な各トレーナーの研修実施内容は次の通りである。

セッション 1

分析ツールの Simple-E ソフトのインストールを中心に説明を行った。

セッション 2

講師は Simple-E の操作を中心に講義した。具体的には、実践的に各自のパソコンで練習問題に取り組んだ。この研修では、Simple-E ツールを使った回帰分析やシミュレーション分析などの手法及び操作方法と共に、統計学に関する基本的な検定方法及びポイント教えた。

セッション 3

このセッションでは、電力需要モデルの構築方法に焦点をあてた講義を行った。具体的には、電力需要モデルの構造の説明と、電力需要とマクロ経済の動向を関数式化し、回帰分析を行なった。

セッション 4

セッション 4 は、電力需要モデルを使い、シミュレーション分析に基づいて需要予測を実施した。講義では、電力需要予測だけではなくモデルの応用についても説明した。

(2) トレーナーによる研修実施

トレーナー4 名、研修受講者 6 名が参加し、2022 年 3 月 21 日（月）～2022 年 3 月 22 日（火）の 2 日間で実施した。研修スケジュールは下表のとおり。

表 2-4 トレーナーによる研修実施日程

日付	セッション	研修内容
2022 年 3 月 21 日（月）	1	Simple-E ソフトの導入 （資料 添付資料 8-3）
	2	Simple-E ソフトの操作 （資料 添付資料 8-2、添付資料 8-3）
2022 年 3 月 22 日（火）	3	電力需要モデルの基礎 （資料 添付資料 8-4）
	4	電力需要モデルの応用 （資料 添付資料 8-1、添付資料 8-5）

セッション 1

セッション 2

セッション 3

セッション 4

図 2-10 トレーナーによる研修の実施風景

(3) 課題

今回のトレーナーによる研修は、C/P に対して初めての試みだった。この経験から具体的には下記の課題が見られた。

- 初めてこの分野に参加するメンバーがほとんどであるため十分な経験を持っておらず、トレーナーによって持っている電力需要モデル構築のスキルに大きな差がある。
- 研修の受講者がパソコンを使い、実際に操作する時間が少なかった。このため、参加者

は需要予測モデルの概念には触れることができたが、実際に電力需要モデルを操作するまでには至っていない。

- 需要予測はエネルギー分野の知識だけではなく、統計学及び経済学の基本的な基礎知識が求められる。この二つ分野の基礎は今回の研修では軽くしか触れておらず、今後の課題として対応する必要がある。

(4) 評価

トレーナーによる研修は、初めての二次教育としてはとても良い感触であった。今までの支援では支援側が一方的に電力需要予測を作る方式であったが、C/P が自力で分析し需要予測を行うことが出来るように支援する方法に変わった。このような支援は、電力需要予測のノウハウや技術移転においてより持続性を持ち、今後の発展性が期待できる。一方、トレーナーの実務としての経験不足は現実問題としてあるので、本プロジェクト完了後も継続的に支援する必要がある。

2.5.4 需要想定 OJT の実施

(1) OJT 研修内容

OJT 研修は、C/P が実際に電力需要モデルをできるように支援することを目標とした。OJT 研修の実施によって、Simple-E による電力需要モデル技術が定着し、C/P の自信を高められることが期待できる。また、トレーナー育成研修で習得し、構築したモデルをプラットフォームとして、その更新、修正、拡張などの応用に重点を置き、研修を実施し、実際のモデル構築時に直面する問題や特徴などを解説し、その対応する方法を提示した。

研修資料は、モデル分析の応用に焦点を当て、実際に電力需要予測を行う時に注意すべき点について作成した。具体的には以下の 4 点について資料にまとめた。

・モデルの構造及び方法論（資料 添付資料 8-6 を参照）
・電力需要分析（資料 添付資料 8-7 を参照）
・モデル評価（資料 添付資料 8-8 を参照）
・予測（資料 添付資料 8-8 を参照）

(2) OJT 研修実施日程

OJT 研修は、参加者の日程調整の制約があるため、2022 年 2 月 16 日（水）と 2022 年 2 月 28 日（月）の 2 日間で実施することとなった。2 月 18 日（金）は、2 月 16 日（水）に参加できなかった 2 名のトレーナーのために、同じ内容で再実施した。

表 2-5 OJT 研修実施日程

セッション	日付	研修内容
1	2022 年 2 月 16 日（水）	モデルの構造及び方法論 （資料 添付資料 8-6）
2	2022 年 2 月 18 日（金）	モデルの構造及び方法論（再実施） （資料 添付資料 8-6）
3	2022 年 2 月 28 日（月）	電力需要分析、モデル評価、予測 （資料 添付資料 8-7、添付資料 8-8）

(3) 研修参加者

WG3 の OJT 研修参加者は C/P 全員（合計 19 名）である。その内 4 名のトレーナーは、Web 会議へのリアルタイムでの参加を必須とした。

(4) 課題

トレーナー育成研修と共通している課題は、こちらには再掲載しないが、OJT 研修の部分について、以下の課題が挙げられる。

- 参加者の多くは各自の業務で忙しく、研修する時間の調整が困難で、3 日間（その内、1 日が同じ内容で再実施）の日程での実施となった
- 実際の電力需要予測を参加者と一緒に最新のデータで行う予定で、参加者にデータの更新を事前にお願いしたが、最新データが提供されなかったため、こちらで集めた 2000 年から 2018 年までのデータベースで演習を行った。
- 今後の電力需要モデルの修正、拡張に新たなデータ（変数）の収集が必要である。電力需要予測に必要な統計データの整備は、体系的に構築することを推奨する。データベースの整備は計量分析のパフォーマンスを向上するのに不可欠である。データ収集は、集まった数値の確認、整理、記載、計算などのプロセスで行われる。このプロセスの中で多くの情報を読み取る必要がある。

(5) 評価

研修参加者に対して、カンボジアの統計データに基づいてゼロから電力需要モデルを構築し、最後は需要予測結果が出てくるまで一緒に作業し、完成させた。研修参加者に対しては今後も継続的にフォローアップができる仕組みを用意し、関連分析手法が定着するまでの支援が必要であると考える。実際のエネルギー需要モデル分析はさらに複雑であり、より広範囲な知識が求められる。今回の研修に使用した分析手法及びモデル構造は、発展途上国において統計データの整備が進んでいない状態に対して開発したものである。これをきっかけとしてエネルギー需要モデルが導入され、政策方針を決める際の一つの指標として参考とされることを願う。

2.6 WG4 財務／料金分析

MME への聞き取り結果から、財務・料金分析能力が十分でないため、前例を参照・踏襲する傾向があり、IPP から提案された電力購入契約（Power Purchase Agreement。以下、「PPA」という。）の内容が妥当であるかの判断が的確にできていないことが分かっている。例えば、発電所毎に「立地」「技術内容」「コスト構造」などが異なるが、これらが同じであることはほとんどあり得ず、前例を参照したとしても、当該審査発電所との違いをどのように評価するのかに苦慮している。

財務・料金分析ができないと、IPP との PPA 交渉を有利に進めることができない。そのため、財務・料金分析の能力向上を目的に研修を実施した。

2.6.1 研修資料の作成、整理

これまでに Feasibility Study の提案書（FS 提案書）を見たことがない人でも、FS 提案書に出てくる商務的な内容についての概要が理解できるようになることを目的に研修資料を作成した。具

体的には、収益性、収入、タリフ（Tariff、ここでは電力料金の意）の構造、ファイナンス（コーポレートファイナンス、プロジェクトファイナンス）等を研修資料に織り込んだ。また、タリフの水準が妥当かの判断は、各プロジェクトのリスクプロファイルに左右されること、カンボジアでは現時点で事業者が PPA を前提とした FS 提案書を提出してくると想定されるため、収入やタリフ構造の前提となる PPA で一般的に定められる主な項目も説明資料に織り込んだ。

作成にあたり、事業者がどのような立場で Feasibility Study を行おうと考えるかといった視点を理解してもらうため、事業者の考える投資基準（ハードルレート）の考えや、MME の立場が、安定的に事業が継続することを期待するレンダーと近い部分もあるため、レンダーの視点も紹介することとした。更に財務的な分析の観点として、財務諸表等の数字を使用した収益性分析、生産性分析、安全性分析、成長性分析などのコンセプトも研修資料に織り込んだ。

2.6.2 研修及びトレーナー育成

新型コロナの影響もあり現地に行くことができなかったため、Web 会議（Zoom）による研修を 2021 年 12 月末から 2022 年 1 月にかけて、週 1～2 回、合計 5 回実施した。

研修時には、民間企業が考える具体的なハードルレートの水準（数字）や、財務健全性を懸念すべきと考える比率、日本企業の場合の水準などについて質問が出るなど、リモートでの研修にもかかわらず、積極的な質問を受けた。なお、授業中に受けた質問については、質問後の授業において追加資料で説明するなどしてフォローアップを実施した。

2.6.3 トレーナーによる研修の実施、フォロー

トレーナー候補者の研修内容理解度の把握と、トレーナーとしての能力把握を目的とし、トレーナーとなる予定である 3 名による若手職員への研修を下記日程で実施した。

表 2-6 トレーナーによる研修実施日程

セッション	日付
1	2022 年 3 月 24 日（木）※
2	2022 年 3 月 24 日（木）※
3	2022 年 3 月 29 日（火）

※3 月 24 日は午前・午後に分けて実施した。

セッション 1

セッション 2

セッション 3

図 2-11 トレーナーによる研修の実施風景

研修中には、トレーナー役の C/P から Off taker や Escrow 等の用語に関する確認はあったが、自身が受講して学んだ内容については適切な研修が出来ていた。また、プロジェクトファイナンスや BOT 等について、研修に参加した若手職員やほかの職員と議論する等、より理解を深めようとする姿勢が窺えた。なお、トレーナーによる研修の実施で新たに出た質問などがあれば提出してもらうよう要請したが、その後追加質問等は出ていない。

2.6.4 評価

C/P にとり財務/料金分析は、当初、馴染みが薄い部分もあるように感じられたが、積極的な質問等を通じて、様々な指標や分析手法の考え方についての基礎部分を習得できた。しかしながら、今回の研修により基本的な考え方やコンセプトは理解したものの、実務遂行にあたっては、どういった数値や条件であれば「良い」または「悪い」と判断すればよいのか、といった客観的で分かり易い基準についての質問も出たことから、今後の対応として、足元のカンボジアにおける経済状況やビジネス上の慣行等を踏まえた具体的な数字や条件を調査・分析し、判断基準の目安として共有することも有益と考えられる。

2.7 その他

2.7.1 トレーナー認定

カリキュラムを全て実行した 6 名に対し、JICA カンボジア事務所長のサインが入ったトレーナーとしての認定証を授与した。

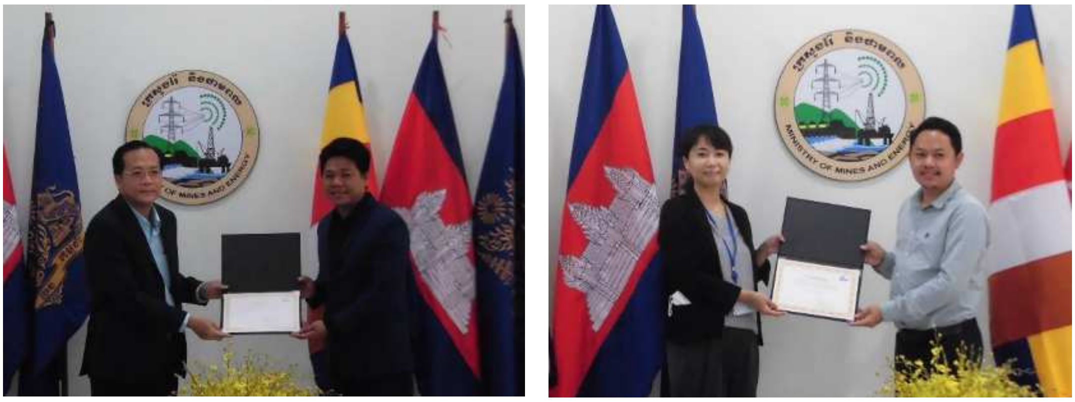


図 2-12 認定式の写真

図 2-13 認定証の写真

2.7.2 機材調達

当初、需要想定ソフト Simple-E は 10 ライセンスを調達することとなっていたが、C/P 数の増加に伴い 15 ライセンスに変更して調達を実施した。2022 年 2 月 2 日に、JICA 電力経済・計画アドバイザー（写真右）から、MME Heng Kunleang 総局長（写真左）に対して、機材のハンドオーバーを実施した。

図 2-14 ハンドオーバー

2.7.3 広報

a) FACEBOOK 第一回

2022 年 1 月 18 日に、JICA カンボジア事務所の FACEBOOK において、プロジェクトの開始に関してのお知らせを実施した。

9:22

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16時間前 ·

[វគ្គបណ្តុះបណ្តាលកសាងសមត្ថភាពលើការវាយតម្លៃគម្រោងអ្នកផលិតថាមពលអគ្គិសនីឯករាជ្យ/ Training on Capacity Building for Independent Power Producers (IPP) Project Evaluation]

គម្រោងផលិតថាមពលអគ្គិសនីជាច្រើននៅប្រទេសកម្ពុជាពឹងផ្អែកទៅលើ អ្នកផលិតថាមពលអគ្គិសនីឯករាជ្យ (IPP)។ ដើម្បីធានាថាសំណើរគម្រោងរបស់អ្នកផលិតថាមពលអគ្គិសនីឯករាជ្យមានភាពត្រឹមត្រូវ ហើយរោងចក្រអគ្គិសនីផ្សេងៗត្រូវបានដាក់ឲ្យដំណើរការបានតាមផែនការនោះ ក្រសួងក៏ដូចជាស្ថាប័នពាក់ព័ន្ធផ្សេងៗ ចាំបាច់ត្រូវធ្វើការវាយតម្លៃគម្រោង IPP ទាំងនោះឲ្យបានត្រឹមត្រូវផងដែរ។ ដូចនេះ ចៃកាបានចាប់ផ្តើមគម្រោងបណ្តុះបណ្តាលមួយ ដែលមានគោលបំណងចូលរួមចំណែកលើកកម្ពស់ស្ថេរភាពនៃការផ្គត់ផ្គង់ថាមពលនៅកម្ពុជាតាមរយៈការធ្វើឲ្យប្រសើរឡើងនៃសមត្ថភាពវាយតម្លៃគម្រោង IPP របស់មន្ត្រីនៅក្រសួងរ៉ែ និងថាមពល និងស្ថាប័នពាក់ព័ន្ធនានាដែលចូលរួមក្នុងការវាយតម្លៃគម្រោង។ វគ្គបណ្តុះបណ្តាលត្រូវបានធ្វើឡើងដោយផ្តោតសំខាន់ទៅលើផ្នែកបច្ចេកទេសនៃរោងចក្រផលិតអគ្គិសនី ការព្យាករណ៍តម្រូវការថាមពលអគ្គិសនី ព្រមទាំងការវិភាគលើតម្លៃ និងហិរញ្ញវត្ថុ។ ការបណ្តុះបណ្តាលនេះបានចាប់ផ្តើមឡើងនៅថ្ងៃទី ២០ ខែធ្នូ ឆ្នាំ២០២១ តាមរយៈវីដេអូពីចម្ងាយ ដោយមានសិក្ខាកាមប្រមាណជា ២០នាក់ចូលរួម។ នៅក្នុងពេលបណ្តុះបណ្តាល ពួកគេបានលើកជាសំណួរ និងរួមគ្នាពិភាក្សាដោះស្រាយបញ្ហា និងភាពស្រពិចស្រពិលផ្សេងៗ។ នេះសបញ្ជាក់ពីការប្តេជ្ញាចិត្តខ្ពស់ក្នុងការអភិវឌ្ឍសមត្ថភាពរបស់ពួកគេតាមរយៈគម្រោងនេះ។

ក្រៅពីការផ្តល់នូវវគ្គបណ្តុះបណ្តាលនេះ ចៃកាក៏បានចូលរួមសហការយ៉ាងសកម្មជាមួយរាជរដ្ឋាភិបាលកម្ពុជាក្នុងវិស័យថាមពល ដើម្បីឲ្យវិស័យនេះមានការអភិវឌ្ឍជាលំដាប់។ គម្រោងចៃកាដែលកំពុងអនុវត្តសព្វថ្ងៃមានដូចជា គម្រោងពង្រីកប្រព័ន្ធបញ្ជូន និងចែកចាយអគ្គិសនីនៅទីក្រុងភ្នំពេញ ជំហានទី១ និងទី២ (កម្ចីហិរញ្ញប្បទានសហប្រតិបត្តិការអភិវឌ្ឍផ្លូវការ) កិច្ចសហប្រតិបត្តិការបច្ចេកទេសលើគម្រោងកែលម្អការគ្រប់គ្រង និងប្រតិបត្តិការបណ្តាញថាមពលអគ្គិសនី ព្រមទាំងមានការបញ្ជូនទីប្រឹក្សាផ្នែកផែនការ និងសេដ្ឋកិច្ចថាមពល (អ្នកជំនាញការចៃកា) ទៅកាន់ក្រសួងរ៉ែ និងថាមពលផងដែរ។

Most of the power generation projects in Cambodia rely on independent power producers (IPP). In order to ensure appropriateness of proposals by IPP and to develop and operate power plants as planned, ministries and/or governmental agencies need to conduct appropriate evaluation of IPP projects.
Therefore, JICA launched a training project in Cambodian power sector, which aims to contribute to the stable power supply by improving the IPP evaluation capacity of the Ministry of Mines and Energy and other organizations involved in the evaluation of IPP project. In this project, the training will be conducted on technical aspects of power plants, electricity demand forecast, and tariff and financial analysis. The training started on December 20, 2021 via WEB conference and about 20 people participated. The participants showed a positive attitude toward the training by asking questions and resolving doubts through discussions whenever necessary. It reflects their willingness to improve their capability through this training project.

Besides this training project, JICA has also been cooperating with the Royal Government of Cambodia in continuously developing Cambodia's energy sector through various projects in ODA Loan and Technical Cooperation schemes. The on-going projects include the Phnom Penh Transmission Line and Distribution System Expansion Project Phase 1 and 2 (ODA Loan), the Technical Cooperation Project for Enhancement of Operation and Management of Cambodian Transmission System, as well as dispatching the Power Economic and Planning Adviser (JICA Expert) to the Ministry of Mines and Energy.

Credited: Mr. Kurisu Yosuke (Training Support of IPP Training) & Industrial Development Section, JICA Cambodia Office.

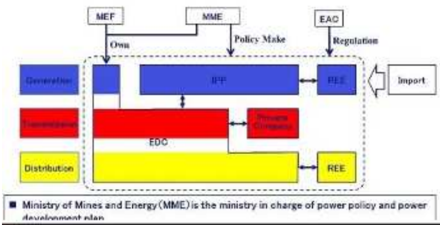


図 2-15 FACEBOOK（1 回目投稿）

b) FACEBOOK 第二回

2022 年 4 月 12 日に、JICA カンボジア事務所の FACEBOOK において、本プロジェクトで実施しているトレーナー役の育成についての記事を投稿した。


JICA Cambodia Office - JICA カンボジア事務所
4月12日 10:44

[... / Training on Capacity Building for Independent Power Producers (IPP) Project Evaluation]

Most of the power generation projects in Cambodia rely on Independent Power Producers (IPP). In order to ensure appropriateness of proposals by IPP and to develop and operate power plants as planned, ministries and/or governmental agencies need to conduct appropriate evaluation of IPP projects. Therefore, back in December 2021, JICA launched a training project, which aims to contribute to the stable power supply by improving the IPP evaluation capacity of the Ministry of Mines and Energy and other organizations involved in the evaluation of IPP projects.

The trainees whose capacities have been developed through this project are also expected to become trainers in the future. In March this year, the trainees provided training to young staff members on the contents such as electricity demand forecast and electricity tariff structure, which they learned through this project. This training was a good opportunity for them to reconfirm what they had learned by teaching themselves and to be aware of their roles as trainers.

Besides this training project, JICA has also been cooperating with the Royal Government of Cambodia in continuously developing Cambodia's energy sector through various projects in ODA Loan and Technical Cooperation schemes. The on-going projects include the Phnom Penh Transmission Line and Distribution System Expansion Project Phase 1 and 2 (ODA Loan), Technical Cooperation Project for Enhancement of Operation and Management of Cambodian Transmission System, as well as dispatching the Power Economic and Planning Adviser (JICA Expert) to the Ministry of Mines and Energy.

Credited: Mr. Kurisu Yosuke (Training Support of IPP Training) & Industrial Development Section, JICA Cambodia Office.

図 2-16 FACEBOOK(2 回目投稿)

第3章　事業実施運営上の工夫・教訓・今後の課題（業務実施方法、運営体制等）

3.1　情報の共有、遠隔での研修実施

（工夫）

2.3.3 で述べた通り、カンボジア国では研修資料等の情報を共有する意識が希薄であることから、本プロジェクトでの C/P 全員への研修資料の共有が課題であった。また、カンボジア側より C/P 全員が全ての研修に参加できるよう配慮を求められたことと、新型コロナウィルス感染症の影響で長期に渡り現地渡航できない状況が続いたことから、研修実施方法についても工夫が必要であった。

研修資料については、GoogleDrive で共有することとした。これにより、各 C/P はいつでも研修資料を参照したり自身の PC への取り込むことが可能となった。研修実施方法については、Web 会議ツールである Zoom を活用することとした。Zoom では、Web 会議をレコーディングすることが出来る。録画したデータは YouTube へアップロードし、URL を知っている者であれば誰でも視聴できるように設定した。これにより、研修当日に参加できなかった場合でも後日同様の研修を受けられるように配慮すると共に、GoogleForm を使用した研修受講後のアンケートで追加の質問も受け付けた。

これら研修資料、研修模様のレコーディングデータ及びアンケートは、研修前後で C/P へリンクを連絡すると共に、これら URL をまとめた資料を作成し、これについても C/P と共有した。研修資料については研修の前に共有し、C/P が事前に内容を確認できるように配慮した。

今回、カウンターパートの人数が 19 名であり、全員のスケジュールを調整することは非常に困難であったことから、全員に対して研修受講を可能とする YouTube の活用は、プロジェクトを進める上で不可欠であり、C/P にとっても繰り返し視聴が可能で研修内容の振り返りに活用できることから、有用であったと思う。

（教訓）

Web 会議ツールは Zoom 以外にも主要なものとして Teams や Meets 等があるが、C/P 側が対応可能である必要がある。今回、都合により Teams で研修を実施しようとした際に参加できない C/P がおり、開催日を変更するということがあった。遠隔での業務実施を行う場合には、最初の時点で使用する Web 会議ツールについて共通認識を図っておくべきであった。

（今後の課題）

・遠隔での研修では、パソコン画面を眺めることにより疲労が生じることから、研修時間の長さに配慮し、一回 2～3 時間程度で行う必要がある。
・現地で研修実施をする場合には参加者への直接指導ができ、こちらから個別のレベル差をフォローする、場合によっては参加者間で自国言語によりお互いにフォローし合うこともよくあるが、遠隔ではこれらは困難である。
・参加者の出欠管理や参加者の勉強意欲の読み取りが困難である。
・通信状況によって、参加者と共有している画面にタイムラグが生じる場合がある。

今回のプロジェクトを通じてこれらの課題を認識しているが、通信環境の改善、VR 技術や Web 会議ツールの発展等により、今後改善されていくものと思う。

3.2 C/P の選定

（教訓）

IPP 審査で中心的な役割を果たす MME、EAC 及び EDC の全てが C/P として名を連ねることを想定していたものの、EDC が C/P となることに難色を示した。コンサルタント側からレターを出すなどの調整を試みたが、EDC を C/P として迎えることができなかった。EDC としては MME からのレターが必要、他方、MME は EDC へのレターは出さないという溝があり、これが最後まで埋まることが無く、非常に残念な結果となった。プロジェクト組成段階で、要請を出した MME 以外に、EDC 及び EAC の参加も見込まれていたことから、今後は早い段階で EDC や EAC に情報提供する必要があると感じた。

（工夫）

EDC 職員への研修資料の提供は EDC から許可をされたため、前述の GoogleDrive による資料の共有を実施した。

第4章 今後の取り組み

本プロジェクト終了後、以下の取り組みについて実施することを推奨する。

4.1 認定トレーナーによる定期的な研修

本プロジェクトで技術移転した後、実際に IPP 審査でその能力を活用する必要がある。しかし、IPP 審査は、IPP 事業者からの申請がキックとなることから、審査時期が近いうちにあるとは限らない。そのため、本プロジェクトの成果を維持するために、本プロジェクトで認定したトレーナーにより、定期的に研修を行うことを推奨する。

また、トレーナーを中心としたメンバーで周辺国を訪問し、IPP 審査に関する第三国研修を実施することで、さらに理解が深まるため、これについて MME へ派遣された JICA 個別専門家がサポートすることも有用である。

4.2 審査マニュアルなどの見直し

今回作成した審査マニュアルなどについて、Heng Kunleang 総局長から「今後カンボジア側で資料を見直してより良いものにしたい」との発言があった。そのため、IPP 審査毎に、審査マニュアルの見直しを実施することを推奨する。見直し作業を行う過程で、新たに技術的にカンボジアで不足している事項があれば、MME 派遣の JICA 個別専門家の予算で修正作業を実施することや、本プロジェクトのフォローアッププロジェクトを実施すれば、MME の予算不足による先送りもなく、適切な時期に見直しがなされると思料する。

また、本プロジェクトでは、「ガス火力」「太陽光」「水力」「系統連系」の研修を実施したが、当面風力 IPP が予定されていないことから、風力の研修は実施していない。このように、実施していない分野の審査マニュアルの作成も今後必要となる。

第5章 添付資料

添付資料１　業務フローチャート
添付資料２　専門家派遣実績（要員計画）
添付資料３　キックオフミーティング資料
添付資料４　C/P とのキックオフミーティング資料

【WG１】審査体制
添付資料５　審査マニュアル（チェックリスト）
添付資料６　提言

【WG２】IPP 事業評価手法
添付資料７－１　LNG 火力研修テキスト１
添付資料７－２　LNG 火力研修テキスト２
添付資料７－３　LNG 火力研修テキスト３
添付資料７－４　水力研修テキスト１
添付資料７－５　水力研修テキスト２
添付資料７－６　水力研修テキスト３
添付資料７－７　水力研修テキスト４
添付資料７－８　水力研修テキスト５
添付資料７－９　太陽光研修テキスト１
添付資料７－１０　系統連系研修テキスト１
添付資料７－１１　水力参考資料
添付資料７－１２　太陽光参考資料

【WG３】需要想定
添付資料８－１　需要想定テキスト１
添付資料８－２　需要想定テキスト２
添付資料８－３　需要想定テキスト３
添付資料８－４　需要想定テキスト４
添付資料８－５　需要想定テキスト５
添付資料８－６　需要想定ＯＪＴテキスト１
添付資料８－７　需要想定ＯＪＴテキスト２
添付資料８－８　需要想定ＯＪＴテキスト３
添付資料８－９　需要想定マニュアル

【WG４】財務／料金分析
添付資料９－１　財務料金分析テキスト１
添付資料９－２　財務料金分析テキスト２
添付資料９－３　財務料金分析テキスト３

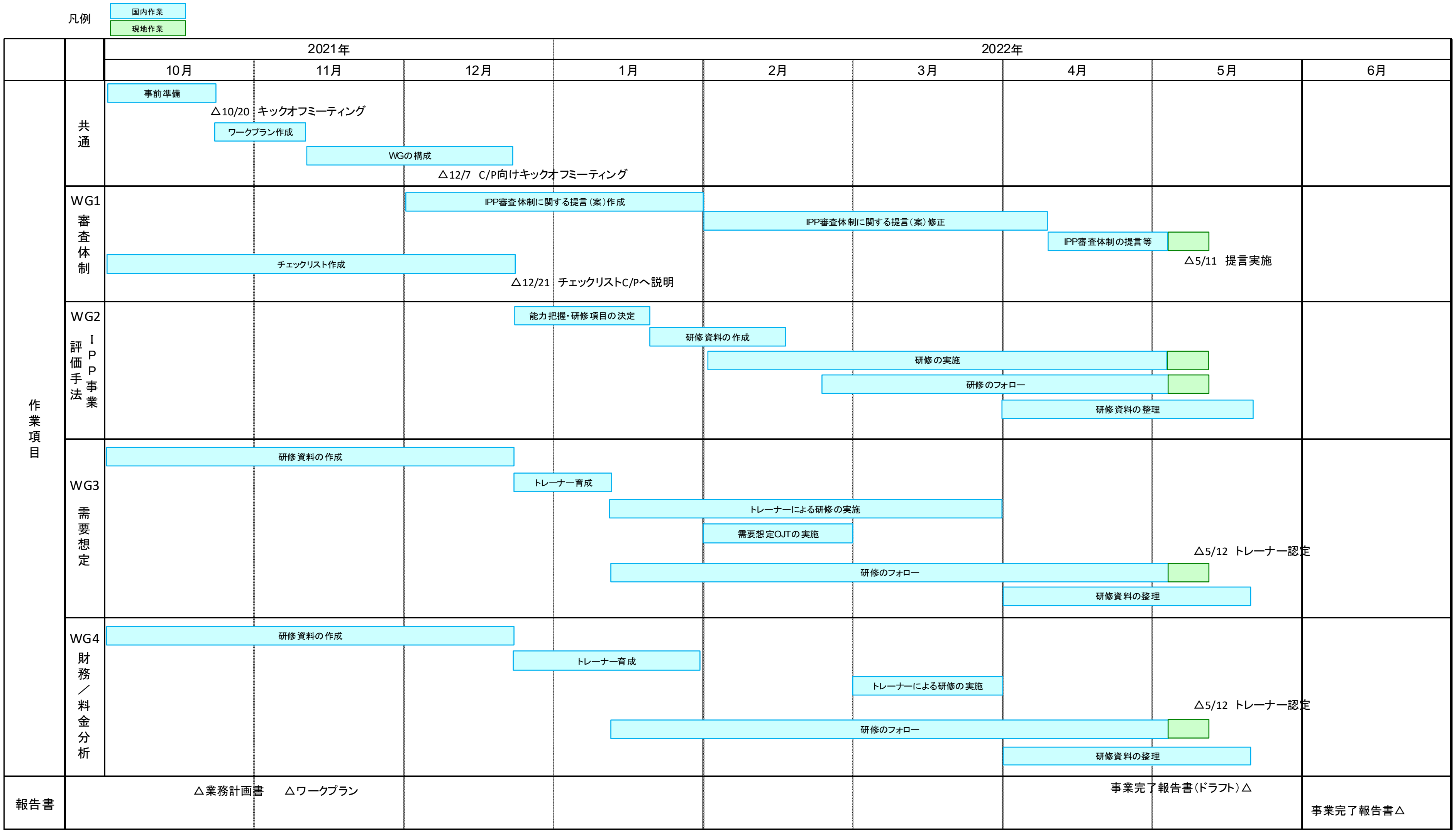
添付資料９－４　財務料金分析テキスト４

添付資料９－５　財務料金分析テキスト５

添付資料９－６　財務料金分析補足資料

添付資料

添付資料1 業務フローチャート



添付資料2　専門家派遣実績(要員計画)

要 員 計 画

区分	担当業務	氏名	所属先	格付	2021 10	11	12	2022 1	2	3	4	5	6	人・月 計 現地	国内
現地業務	業務主任/発電計画	廣瀬 匡一	中国電力株式会社	2								(0.20)		0.20	
	需要想定	Chew Chong Siang	中国電力株式会社 （補強:エイジアム研究所）	3										0.00	
	財務分析	藤原 健	中国電力株式会社	3										0.00	
	料金分析	見儀 茂	中国電力株式会社	3										0.00	
	系統連系	中西 康一	中国電力株式会社	3										0.00	
	研修補助	栗栖 庸輔	中国電力株式会社	5								(0.20)		0.20	
													現地業務小計	0.40	
国内作業	業務主任/発電計画	廣瀬 匡一	中国電力株式会社	2											3.54
	需要想定	Chew Chong Siang	中国電力株式会社 （補強:エイジアム研究所）	3											3.38
	財務分析	藤原 健	中国電力株式会社	3											1.76
	料金分析	見儀 茂	中国電力株式会社	3											1.36
	系統連系	中西 康一	中国電力株式会社	3											0.70
	研修補助	栗栖 庸輔	中国電力株式会社	5											1.99
													国内作業小計		12.73
		報告書等提出時期			△業務計画書	△ワークプラン						事業完了報告書(ドラフト)△	事業完了報告書△		
													合　計	13.13	

凡例　現地業務　国内間欠作業

Training for Capacity Building on IPP Project Evaluation

Kick-off Meeting

October 20th, 2021

The Chugoku Electric Power Co., Inc.

Energia

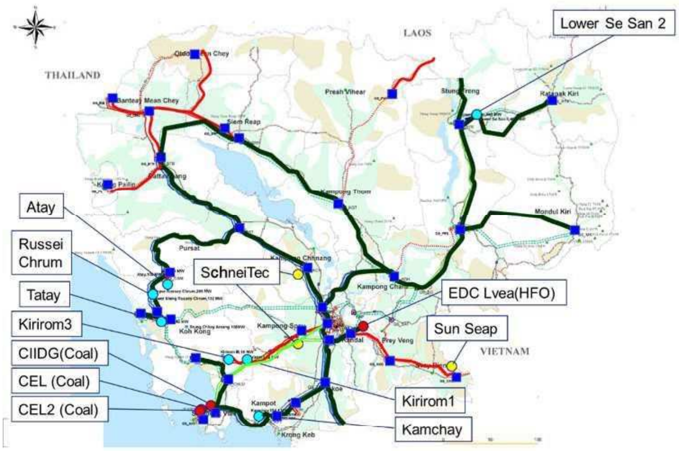
1. JICA Team

Position	Name	Company	Picture
Project Manager / Generation Planning	Mr. HIROSE Masakazu	Chugoku EPCO	
Demand Forecast	Dr. CHEW Chong Siang	Asiam Research Institute	
Financial & Tariff Analysis	Mr. FUJIWARA Takeshi	Chugoku EPCO	
	Mr. KENGI Shigeru	Chugoku EPCO	
Training Support	Mr. KURISU Yosuke	Chugoku EPCO	

2. Background & Purpose of the Project

- ■Electricity consumption has grown rapidly in order to support Cambodia's development.
- ■For reliable power development, it is necessary to improve IPP project evaluation skill for managing generation development.

Power System (10 years ago)



Power System (Present)

3. Outline of the Project

■The Project will be conducted by Four Working Groups (WGs)

Recommendation

WG1: Evaluation System

- Making checklist of IPP evaluation.
- Clarification of demarcation and necessary abilities for IPP evaluation. (Recommendation)

Training

WG2: IPP Project Evaluation Methodology

- Counter Part (C/P) Training.

WG3: Demand Forecast

- Training of trainers.
- Training by trainers.
- On the Job Training (OJT).

WG4: Financial & Tariff Analysis

- Training of trainers.
- Training by trainers.

3. Outline of the Project

- ■Project Term: From October 2021 to April 2022.
- ■Training will be conducted from Japan. Training in Cambodia depends on COVID-19 situation.

	Oct	Nov	Dec	Jan	Feb	Mar
WG1: Evaluation System	Making check list	Draft recommendation		Finalization of recommendation		
WG2: IPP Project Evaluation Methodology		C/P training				
WG3: Demand Forecast	Training of trainers	Training by trainers			OJT	
WG4: Financial & Tariff Analysis	Training of trainers			Training by trainers		

4. (WG1) Evaluation System

- ■Making checklist for IPP project evaluation to ensure the quality of evaluation.
- ■Discussion in order to improve IPP project evaluation system will be conducted.
- ■JICA team will make proposals and/or recommendations.

Present Situation	Basic Policy
- A committee is organized each time IPP project evaluation is conducted. - The division of roles is decided according to the abilities of the organized committee members, and the roles of each organization are not stated clearly.	- Clarify the division of roles of each organization in the evaluation system, the knowledge that each organization should possess, and the human resources that should be trained. - Make a checklist for IPP evaluation to ensure the quality of evaluation, and training based on the checklist.

4. (WG1) Evaluation System

Purpose	- Clarification of demarcation & necessary abilities for IPP project evaluation.
Output	- Check list for IPP project evaluation - Recommendations about IPP project evaluation
Activity	- Making check list - Discussion

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Data collection	■						
1-2. Making check list (Japanese Side)	■						
2-1. Making draft recommendation		■					
2-2. Discussion about draft recommendation			■				
3-1. Revision of draft recommendation				■	■		
3-2. Finalization of recommendation					■	■	

Energia

5. (WG2) IPP Project Evaluation Methodology

- ■ **Training about IPP project evaluation methodology will be conducted, especially methodology of Feasibility Study about Gas fired, hydro, solar power plant.**
- ■ **Training focuses on what Cambodia power sector does not know.**

1. Submission of official letter for Pre-FS
2. Issue Letter of Permission (LOP) to give permission to implement Pre-FS
3. Implementation of Pre-FS
4. Approval of Pre-FS Report
5. Signing of MOU
6. Implementation of FS
7. Approval of FS Report
8. MME reports FS to the Cabinet of Prime Minister (=Council of Ministers)
9. Selection of Concessionaire
10. Contract of PPA, Submission of LA (Lease Agreement) and/or IA (Implementation Agreement)
11. Deliberation of National Assembly and Senate
12. Sign of PPA, LA and IA

IPP project procedure

Energia

5. (WG2) IPP Project Evaluation Methodology

Purpose	- Improvement of IPP project evaluation knowledge except Demand Forecast and Financial & Tariff Analysis
Output	- Training materials
Activity	- Training for WG2

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Discussion to grasp the ability of C/P							
1-2. Making training materials (Japanese Side)							
1-3. C/P training							

6. (WG3) Demand Forecast

- **Trainers will be developed. (Training of trainers)**
- **After that, training by trainers will be conducted.**
- **Finally, actual demand forecast as OJT by using Simple-E will be conducted.**

1. Demand forecast method (analysis flow, energy balance table, predictive model, data collection and analysis method etc)
2. Demand forecast accuracy verification method (GDP correlation, sensitivity analysis, predicted value / actual value / similar country comparison, etc.)
3. Sectoral analysis method (industry / consumer, energy conservation effect, etc.)
4. Demand forecast examples among ASEAN countries
5. How to use Simple-E

Training Contents (Tentative)

1. Data collection
2. Update / correction of forecast model
3. Implementation and verification of demand forecast

OJT Contents (Tentative)

6. (WG3) Demand Forecast

Purpose	- MME becomes to be able to conduct Demand Forecast
Output	- Training materials
Activity	- Training of trainers - Training by trainers - On the Job training (Actual Demand Forecast)

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Making training materials (Japanese Side)	■						
1-2. Training of trainers		■					
2-1. C/P conducts training for young engineers (Training by trainers)			■	■	■		
3-1. On the Job Training					■	■	
3-2. Certify as trainer						▲	

7. (WG4) Financial & Tariff Analysis

■Trainers will be developed. (Training of trainers)
■After that, training by trainers will be conducted.

1. Estimated project cost
    a. Profit and Loss Index (type of profit and loss index, discounted cash flow (DCF), internal rate of return (IRR), Hurdle rate)
    b. Financial system (type of finance, points of confirmation about corporate finance and project finance, loan scheme, etc.)

2. Electricity tariff structure
    a. Overview of Power Purchase Agreement (PPA)
        - Risk sharing (Power plant construction and operation, force majeure, change in law, Termination)
        - Payment condition (Local currency and dollar denominated, convertible policy)
    b. Tariff structure (capacity payment, energy payment etc.)

3. Others
    a. Investment structure etc.

Training Contents (Tentative)

7. (WG4) Financial & Tariff Analysis

Purpose	- Improvement of Financial & Tariff Analysis Skill
Output	- Training materials
Activity	- Training of trainers - Training by trainers

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Making training materials (Japanese Side)	■	■	■				
1-2. Training of trainers		■	■	■			
2-1. C/P conducts training for young engineers (Training by trainers)				■	■	■	
3-1. Certify as trainer						▲	

8. Request

■**Please decide person in charge, counter part and contact person for each WG.**

■**Consideration of gender balance is necessary. In other words, it is encouraged for female engineers to join WG.**

WG	Cambodian Side	Japanese Side
WG1: Evaluation System		Mr. HIROSE Masakazu
WG2: IPP Project Evaluation Methodology	**Please decide below for each WG**	Mr. KURISU Yosuke
WG3: Demand Forecast	**- Person in charge** **- Counter Part**	Dr. CHEW Chong Siang
WG4: Financial & Tariff Analysis	**- Contact Person**	Mr. FUJIWARA Takeshi Mr. KENGI Shigeru

Training for Capacity Building on IPP Project Evaluation

Kick-off Meeting for Counter Part (C/P)

December 16, 2021

The Chugoku Electric Power Co., Inc.

1. Background & Purpose of the Project

- ■Electricity consumption has grown rapidly in order to support Cambodia's development.
- ■For reliable power development, it is necessary to improve IPP project evaluation skill for managing generation development.

Power System (10 years ago)

Power System (Present)

2. JICA Team

Position	Name / E-mail	Company	Picture
Project Manager / Generation Planning	Mr. HIROSE Masakazu	Chugoku EPCO	
Demand Forecast	Dr. CHEW Chong Siang	Asiam Research Institute	
Financial & Tariff Analysis	Mr. FUJIWARA Takeshi	Chugoku EPCO	
	Mr. KENGI Shigeru	Chugoku EPCO	
Training Support	Mr. KURISU Yosuke	Chugoku EPCO	

3. Counter Part List (MME)

Name	Position	E-mail
Not disclosed due to personal information	Deputy Director, Energy Development	Not disclosed due to personal information
	Deputy Director, Energy Development	
	Deputy Director, Energy Development	
	Chief of Energy Statistics, Energy Development	
	Chief of Investment Procedure, Energy Development	
	Deputy Chief, Energy Development	
	Energy Development	
	Deputy Director, Thermal and Combustion Energy	
	Deputy Chief, Thermal and Combustion Energy	
	Chief, Hydroelectricity	
	Officer, Hydroelectricity	
	Deputy Chief, Technique and Energy Business Policy	
	Deputy Chief, Technique and Energy Business Policy	
	Deputy Chief, Renewable and Other Energy	
	Deputy Chief, Renewable and Other Energy	

3. Counter Part List (EAC)

Name	Position	E-mail
Not disclosed due to personal information	Chief of Monitoring and Data Collection Section of Generation Office, EAC	Not disclosed due to personal information
	Chief of Regulation and License Section of Transmission and Sub-Transmission Office, EAC	
	Chief Transmission and Sub-Transmission Office, EAC	
	Chief of Policy and Generation License Section of Generation Office	

4. WG List

Please choose "Thermal", "Hydro", "Solar", "Demand Forecast", "Financial & Tariff"

Name	WG1	WG2	WG3	WG4	Related Work
Not disclosed due to personal information	○	○	◎	○	
	○	○	○	○	
	○	○	○	○	
	○	○	◎	○	
	○	○	◎	○	
	○	○	○	○	
	○	○	○	◎	
	○	○	○	◎	Thermal
	○	○	○	○	Thermal
	○	○	○	○	Hydro
	○	○	○	○	Hydro
	○	○	○	◎	
	○	○	○	○	
	○	○	○	○	Solar
	○	○	○	○	Solar
	○	○	○	○	
	○	○	○	○	
	○	○	◎	○	
	○	○	○	◎	

◎: Person who will to be a trainer needs to conduct training for young engineer.

5. Outline of the Project

■The Project will be conducted by Four Working Groups (WGs)

Recommendation

WG1: Evaluation System

- Making checklist of IPP evaluation.
- Clarification of demarcation and necessary abilities for IPP evaluation. (Recommendation)

Training

WG2: IPP Project Evaluation Methodology

- Counter Part (C/P) Training.

WG3: Demand Forecast

- Training of trainers.
- Training by trainers.
- On the Job Training (OJT).

WG4: Financial & Tariff Analysis

- Training of trainers.
- Training by trainers.

5. Outline of the Project (WG2)

■WG2 is comprehensive technical training for Feasibility Study.
■We will select and concentrate contents about training.

	Contents
1	Overview
2	Power System Study
3	Fuel Supply and Transportation
4	Conditions of Plant Site
5	Project Proposal
6	Transmission Line
7	Environmental and Social Impact Analysis
8	Comprehensive Utilization
9	Labour Safety
10	Occupational Health
11	Resource Utilization
12	Energy Saving
13	Manpower Allocation
14	Required Conditions for Construction and Progress Schedule & Construction Period
15	Risk Analysis
16	Conclusions and Suggestions
17	Main Technical Indexes
18	Investment Estimation & Economic Evaluation

Example of FS Contents

5. Outline of the Project (Schedule)

■Project Term: From October 2021 to April 2022.
■Training will be conducted using Zoom. Training in Cambodia depends on COVID-19 situation.

	Oct	Nov	Dec	Jan	Feb	Mar
WG1: Evaluation System	■	■	Making check list / Draft recommendation	Draft recommendation	Finalization of recommendation	Finalization of recommendation
WG2: IPP Project Evaluation Methodology			C/P training	C/P training	C/P training	C/P training
WG3: Demand Forecast			Training of trainers	Training by trainers	Training by trainers	OJT
WG4: Financial & Tariff Analysis			Training of trainers	Training of trainers	Training by trainers	Training by trainers

6. (WG1) Evaluation System

Purpose	- Clarification of demarcation & necessary abilities for IPP project evaluation.
Output	- Check list for IPP project evaluation - Recommendations about IPP project evaluation
Activity	- Making check list - Discussion

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Making check list (Japanese Side)	■	■					
2-1. Data collection for recommendation			■				
2-2. Making draft recommendation				■			
2-3. Discussion about draft recommendation					■		
2-4. Revision of draft recommendation					■		
2-5. Finalization of recommendation						■	

7. (WG2) IPP Project Evaluation Methodology

Purpose	- Improvement of IPP project evaluation knowledge except Demand Forecast and Financial & Tariff Analysis
Output	- Training materials
Activity	- Training for WG2

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Discussion to select training contents			■				
1-2. Making training materials (Japanese Side)			■	■	■		
1-3. C/P training			■	■	■	■	

8. (WG3) Demand Forecast

Purpose	- MME becomes to be able to conduct Demand Forecast
Output	- Training materials
Activity	- Training of trainers - Training by trainers - On the Job training (Actual Demand Forecast)

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Making training materials (Japanese Side)	■	■					
1-2. Training of trainers			■				
2-1. C/P conducts training for young engineers (Training by trainers)				■	■		
3-1. On the Job Training					■	■	
3-2. Certify as trainer						▲	

9. (WG4) Financial & Tariff Analysis

Purpose	- Improvement of Financial & Tariff Analysis Skill
Output	- Training materials
Activity	- Training of trainers - Training by trainers

Items	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1-1. Making training materials (Japanese Side)							
1-2. Training of trainers							
2-1. C/P conducts training for young engineers (Training by trainers)							
3-1. Certify as trainer						▲	

10. Information Sharing

■**Documents are shared by Google Drive.**
■**Training will be shared by You Tube.**

✓**All documents (training schedule, material, link for You Tube etc.) are shared by Google Drive. The link for Google Drive will be shared by Mr. Watakabe, JICA expert for MME, and/or his project staff, Ms. Sovannavy Kheng.**

✓**All trainings will be conducted and recorded by Zoom, and updated to You Tube. Therefore, C/Ps who could not attend the training can study to see You Tube.**

Reference

(WG1) Evaluation System

- **Making checklist for IPP project evaluation to ensure the quality of evaluation.**
- **Discussion in order to improve IPP project evaluation system will be conducted.**
- **JICA team will make proposals and/or recommendations.**

Present Situation	Basic Policy
- A committee is organized each time IPP project evaluation is conducted. - The division of roles is decided according to the abilities of the organized committee members, and the roles of each organization are not stated clearly.	- Clarify the division of roles of each organization in the evaluation system, the knowledge that each organization should possess, and the human resources that should be trained. - Make a checklist for IPP evaluation to ensure the quality of evaluation, and training based on the checklist.

(WG2) IPP Project Evaluation Methodology

■Training about IPP project evaluation methodology will be conducted, especially methodology of Feasibility Study about Gas fired, hydro, solar power plant.
■Training focuses on what Cambodia power sector does not know.

1. Submission of official letter for Pre-FS
2. Issue Letter of Permission (LOP) to give permission to implement Pre-FS
3. Implementation of Pre-FS
4. Approval of Pre-FS Report
5. Signing of MOU
6. Implementation of FS
7. Approval of FS Report
8. MME reports FS to the Cabinet of Prime Minister (=Council of Ministers)
9. Selection of Concessionaire
10. Contract of PPA, Submission of LA (Lease Agreement) and/or IA (Implementation Agreement)
11. Deliberation of National Assembly and Senate
12. Sign of PPA, LA and IA

IPP project procedure

(WG3) Demand Forecast

■Trainers will be developed. (Training of trainers)
■After that, training by trainers will be conducted.
■Finally, actual demand forecast as OJT by using Simple-E will be conducted.

1. Demand forecast method (analysis flow, energy balance table, predictive model, data collection and analysis method etc)
2. Demand forecast accuracy verification method (GDP correlation, sensitivity analysis, predicted value / actual value / similar country comparison, etc.)
3. Sectoral analysis method (industry / consumer, energy conservation effect, etc.)
4. Demand forecast examples among ASEAN countries
5. How to use Simple-E

Training Contents (Tentative)

1. Data collection
2. Update / correction of forecast model
3. Implementation and verification of demand forecast

OJT Contents (Tentative)

(WG4) Financial & Tariff Analysis

■Trainers will be developed. (Training of trainers)
■After that, training by trainers will be conducted.

1. Estimated project cost
   a. Profit and Loss Index (type of profit and loss index, discounted cash flow (DCF), internal rate of return (IRR), Hurdle rate)
   b. Financial system (type of finance, points of confirmation about corporate finance and project finance, loan scheme, etc.)

2. Electricity tariff structure
   a. Overview of Power Purchase Agreement (PPA)
      - Risk sharing (Power plant construction and operation, force majeure, change in law, Termination)
      - Payment condition (Local currency and dollar denominated, convertible policy)
   b. Tariff structure (capacity payment, energy payment etc.)

3. Others
   a. Investment structure etc.

Training Contents (Tentative)

IPP_Feasibility Study Check List(Common)

Evaluation item	Specific elements	Department in charge of evaluation: MME	Department in charge of evaluation: EAC	Pass	Fail
Purpose of FS Check List	**This list is a compilation of items that should be checked in order to review Feasibility studies fairly and appropriately. Please check each evaluation item with points of interest.**				
1.Power System					
1.1 Situation of Power System	The conditions of power flow study should be the largest power flow time such as daytime peak, lighting peak, and other possible conditions after the planned year of interconnection.	Energy Development			
1.2 Necessity of Power Plant based on power development master plan	Confirm generator type, capacity, commercial operation date.	Energy Development			
1.3 Connection to Power System					
1.3.1 Specification	・System Frequency shall be nominally 50 Hz. System Voltage at the Connection Point will normally remain within the operating range. Operation range: 230kV:207kV～245kV, 115kV:103.5kV～123kV, 22kV:19.8kV～24kV ・Generating Units must be capable of supplying rated Active Power output at any point between the limits 0.85 power factor lagging and 0.95 power factor leading. ・Generating Units shall be capable of continuous operation in the frequency range of 47.5 to 52 Hz and shall be capable of operation for a period of 20 seconds in the frequency range of 47 to 47.5 Hz. ・Generating Units shall be capable of operation at all times under the control of a governor control system or frequency control device. ・The higher voltage windings of the Generating Unit transformer connecting a Generating Unit to the CTS at voltages of 115 kV and above shall be star connected with the star point earthed. ・Main transformer and shunt reactor shall be equipped with devices to automatically shutdown when over current or internal fault occurs. ・Power capacitor shall be equipped with devices to automatically shutdown when over current or over voltage or internal fault occurs. ・On medium-voltage lines, an over current circuit breaker shall be installed at the outgoing point and on the primary side of a transformer. A ground fault breaker that breaks circuit automatically when an earth fault happens in the lines shall be installed at an outgoing point. Surge arresters shall be installed at the places of lines such as a)A lead-out of overhead line, and b)The connecting point of overhead medium-voltage lines with a main transformer. ・Maximum time for fault clearance by primary protection shall be as follows: 230kV 100ms, 115kV 140ms. ・230 kV lines shall have following protective devices : Primary Protection - Current differential protection relay in conjunction with optical fiber communication from the transmission line. Back up Protection - Three or more zone distance protection with phase fault and earth fault measuring elements and with permissive inter trip for accelerating tripping at remote end in case of zone-2 fault. Reclosing provision shall be high speed first shot for single phase and three phase re-closing and further delayed multiple shot three phase re-closing. ・115 kV lines shall have following protective devices : Three or more zone static distance protection with permissive inter-trip for accelerating tripping at remote end in case of a zone-2 fault shall be provided as primary protection. The backup protection will be directional three poles over current and earth fault protection. ・22 kV lines shall have following protective devices : a minimum of over-current and earth fault protection at connection point. For parallel feeders or ring feeders, directional time lag over-current and earth fault relays. For Other feeers, non-directional time lag over-current and earth fault relay with suitable settings to obtain discrimination between adjacent relay stations. For long feeders, the relay with a high set instantaneous element.	Energy Development			
1.3.2 Impact on Power system	・For the power flow calculation results, the power flow of each transmission and distribution line shall not exceed the capacity of the line. ・Generating Unit shall be equiped a continuously-acting fast-response automatic excitation control system. The control system shall be included power system stabilizing equipment if required by the NTL. Generating Units shall be capable of contributing to frequency and voltage control by modulation of Active Power and Reactive Power supplied to the CTS. ・On-load tap changing facilities shall be equiped by Generating Unit transformer for dispatch of Reactive Power. The Reactive Power output at the Generating Unit terminals under steady state conditions and at rated Active Power should be fully available within the range ±5% of nominal grid system voltage at the Connection Point. ・The maximum total levels of harmonic voltage distortion and the total demand distortion of the current on CTS at a Connection Point shall be under the amounts specified in GridCode 3.3.1 c. ・The results of transient stability studies, voltage stabilities studies and steady state oscillatory stability studies shall be stable. ・Generating units shall be capable of curtailing output to balance supply and demand. (For solar power plants and wind power plants, If needed, in Japan)	Energy Development			
1.3.3 Countermeasures for accidents	The short circuit current level at a point on the CTS calculated by short circuit studies shall be below the levels stated below: 40 kA on the 230kV system, 31.5 kA on the 115kV system, 12.5 kA on the 22kV system.	Energy Development			
1.3.4 Control and communication requirements	The power plant shall be provided necessary communication equipment to monitor the operating status and to transmit commands.	Energy Development			
2.Transmission Line					
2.1 Transmission line	・Interconnection point shall be the bus line of a switchyard, substation or power plant or, If it is lower cost, existing transmission line . ・In the case of underground transmission lines, there shall be a reason(e.g. No land for a steel tower exists in the city) for using underground lines. The transmission line shall avoid areas with legal restrictions. ・Conformity with technical standards.(e.g. SREPTS Article 31, 40) ・In the case of a single line, generation curtailment during transmission line maintenance work shall be taken into account. ・In the case of crossing large rivers, railroads, existing power lines, etc., the method of crossing shall be considered. ・Transmission line capacity shall be greater than power plant generation capacity. The type of wire shall be inexpensive, taking into account construction and O&M costs, transmission losses, and service life.	Energy Development			
3.License & Permission					
3.1 Land acquisition	Land must be available (owned or leased) or expected to be available by the start of construction. The duration of the power generation project does not exceed the duration of land use. The use of the land for the power generation project is not restricted.	Energy Development			
3.2 Construction permission and power generation lic	Confirm power generation license and construction permit.	Energy Development	Regulation and License		
4.Legal Requirements					
4.1 Related laws and regulations	e.g. Energy Saving, Regulation of vibration and noise at site boundaries and around equipment, etc. Conform to Cambodian laws and regulations	Energy Development			
4.2 Environmental preservation	e.g. Discharge of Pollutants, Environmental Protection, Soil and Water Conservation, etc. Conform to Cambodian laws and regulations	Energy Development			
4.3 Social and Environmental Impact Assessment	Residents, rare animals, remains, etc. at the installation site Conform to Cambodian laws and regulations	Energy Development			
4.4 Health and safety	Occupational health, Labour safety Conform to Cambodian laws and regulations	Energy Development			
5.Power Off-Take					
5.1 Power Off-Take of the project	Confirm that the off-take assumptions are reasonable (e.g. Off-take period and the amount of power generation, etc.)	Energy Development			
5.2 Power Evacuation Options in case of trouble	During construction : Confirm who is supposed to bear the responsibility of compensation for loss in the event of construction delays and whether the patry in charge (i.e. EPC contractor and Sponsor company) that will bear the responsibility is sufficiently creditworthy. During operation : Make sure that who and how responsibility will be taken in the event of equipment failure and/or underperformance is well organized.	Energy Development			
5.3 Project development schedule and plan	Confirm that the construction schedule is reasonable, that the EPC contractor has extensive construction experience, that it is financially sound, that sufficient contingency is included in the project cost, and that the technology is proven.	Energy Development			
6.Financial analysis					
6.1 Financing cost	Confirm that financial terms and conditions commonly assumed in the similar projects (e.g. interest rate, loan amount and term) are included in the financial model.	Energy Development	Policy and Generation License		
6.2 Financial analysis	Confirm that the plan is based on reasonable assumptions primarily in the following aspects and that the business is stable and sustainable.				
6.2.1 Capital expenditures (CAPEX)	Make sure that the appropriate CAPEX amount is assumed and included in the financial model.	Energy Development	Policy and Generation License		
6.2.2 Operation and maintenance expenditures (O	Make sure that the appropriate O&M costs are assumed and included in the financial model.	Energy Development	Policy and Generation License		
6.2.3 Tariff	Make sure that proper electricity tariff, based on an appropriate profitability, is assumed and included in the financial model.	Energy Development	Policy and Generation License		
7.Risk Analysis					
7.1 Completion risk	The construction cost shall include contingency for possible risks, and the EPC contractor must have a proven track record.	Energy Development			
7.2 Operational and Management risk	The sponsor shall be able to support the operation, or plan to have an operator with a proven track record. The sponsor shall have a plan to anticipate possible risks that may occur during the operation and take countermeasures against them.	Energy Development			
7.3 Financial risk	The finance provider should be creditworthy. The cash flow model shall be able to sustain repayment against possible accidents, exchange rate fluctuations, etc.	Energy Development			

IPP_Feasibility Study Check List(LNG Thermal)

Evaluation item	Specific elements	Department in charge of evaluation		Pass	Fail
		MME	EAC		
1.Fuel Supply					
1.1 Fuel Source	To enable stable supply, check the financial status and fuel supply experience of the fuel supplier. To make sure that the fuel supply contract period matches the IPP project period.	Thermal & Combustion Energy			
1.2 LNG Quality	Confirm Gas calorific value, Gas property, Environmental impact component (nitrogen, sulfur, etc.) Confirm the fuel is suitable for the GT specifications. Confirm the consistency between the amount of exhaust gas components and local environmental regulations	Thermal & Combustion Energy			
1.3 Fuel Handling Facility	-				
1.3.1 Transport Distance	Calculate the LNG consumption at the power plant and confirm that the required amount can be procured by LNG carriers considering the distance to power station, the number and the capacity of carriers	Thermal & Combustion Energy			
1.3.2 Unloading Place and LNG Jetty of Power Plant	Confirm feasibility of pier docking of LNG carriers considering vessel size, water depth of jetty.	Thermal & Combustion Energy			
2.Power Plant Site					
2.1 Conditions of Plant Site	-				
2.1.1 Location	Confirm the distance to transmission lines, the rivers as water source, access roads, obstacles such as unexploded ordnance	Thermal & Combustion Energy			
2.1.2 Natural Conditions of Site	Not disclosed due to containing confidential data	Thermal & Combustion Energy			
2.2 Traffic	Confirm availability of air transportation method, sea transportation method, land transportation method, maximum transportable amount.	Thermal & Combustion Energy			
2.3 Engineering Geology	-				
2.3.1 Earthquake	Not disclosed due to containing confidential data	Thermal & Combustion Energy			
2.3.2 Topography		Thermal & Combustion Energy			
2.3.3 Geotechnical Foundation Distribution Features		Thermal & Combustion Energy			
2.3.4 Natural phenomenon		Thermal & Combustion Energy			
3.Proposal of Project	-				
3.1 Overall Planning of Whole Plant	Confirm appropriateness of equipment layout				
3.1.1 Water Source for Power Plant and Cooling Mode	Confirm feasibility of construction for water intake facilities in the case of sea water cooling, temperature difference between intake water and discharged water	Thermal & Combustion Energy			
3.1.2 Plant Access Road	Confirm that access roads around the project site are designed to allow heavy duty trucks to pass (e.g. load capacity, road width and etc.). If necessary, Confirm that additional expenses for improvement and/or expansion of access roads put on a budget	Thermal & Combustion Energy			
3.1.3 Construction Area	Confirm area of storage for construction material is enough	Thermal & Combustion Energy			
3.1.4 Living Area	Confirm accommodation for personnel for both construction and O&M	Thermal & Combustion Energy			
3.1.5 Work area for periodic inspection	Confirm working area and accessibility for equipment are enough when periodic inspection	Thermal & Combustion Energy			
3.1.6 Crane for periodic inspection	Confirm the crane for periodic inspection to be installed	Thermal & Combustion Energy			
3.1.7 Mobile crane approach route (for inspection of each equipment)	Confirm the mobile crane access route for work	Thermal & Combustion Energy			
3.1.8 Flood Protection	Not disclosed due to containing confidential data	Thermal & Combustion Energy			
3.1.9 Planning of Transportation and Roads	Confirm stable procurement and supply method of fuel, chemicals, consumables, etc.	Thermal & Combustion Energy			
3.1.10 Civil Engineering Structure	Not disclosed due to containing confidential data	Thermal & Combustion Energy			
3.2 Capacity of Unit	Confirm consistency between power development plan, PPA and plant net output capacity.				
3.2.1 estimated performance curve	Confirm consistency between power development plan, PPA and plant net output capacity taking performance degradation into account.	Thermal & Combustion Energy			
3.2.2 Power generation range	Confirm capability of Minimum Load and Rated Load.	Thermal & Combustion Energy			
3.2.3 Load demand response	Confirm capability of Dispatch ramp rate and Reactive Power Capability.	Thermal & Combustion Energy			
3.2.4 Unsteady operation	Confirm capability such as House Load Operation, Runback and Gas turbine independent operation when steam turbine is unavailable.	Thermal & Combustion Energy			
3.2.5 Auxiliary power ratio	Confirm rationality of auxiliary power consumption rate	Thermal & Combustion Energy			
3.2.6 Electric power supply plan	Confirm consistency with PPA on e.g. Period of power plant operation, availability factor and capacity factor.	Thermal & Combustion Energy			
3.3 Main Technical Specification of BTG	Confirm manufacturer delivery record, competency, consistency with unit capacity				
3.3.1 Selective catalytic reduction(SCR) system, Flue gas desulphurisation(FGD) system, CO oxidation system	Confirm capability of such treatment facilities is capable of treating exhaust gas as to comply such regulation and fuel property	Thermal & Combustion Energy			
3.3.2 Emergency generator	Confirm capacity of emergency generator to operate the plant in case of black out	Thermal & Combustion Energy			
3.3.3 Start-up Bioler	Capacity to provide enough amount of steam required for start-up.	Thermal & Combustion Energy			
3.3.4 Heat recovery steam generator(HRSG),Material design of heat exchanger tube	Confirm heat resistance and corrosion resistance against sulfidation of heat exchanger panel materials, and countermeasures against flow-accelerated corrosion	Thermal & Combustion Energy			
3.3.5 Main Steam, Reheat Steam and Turbine Bypass System	Confirm capacity of turbine bypass valve to enable CTG to continue operation in case of STG trip if independent operation of CTG is required	Thermal & Combustion Energy			
3.3.6 Feed Water System	Confirm feedwater chemical control is accomplished through packaged chemical injection units	Thermal & Combustion Energy			
3.3.7 Extraction Steam System	To confirm Extraction Steam System is incorporated as to make efficiency high if it is thermal power station.	Thermal & Combustion Energy			
3.3.8 Condensed Water System	Confirm consistency with unit capacity	Thermal & Combustion Energy			
3.3.9 Heater Draining System	To confirm Extraction Steam System is incorporated as to make efficiency high if it is thermal power station.	Thermal & Combustion Energy			
3.3.10 Vacuum-pumping System for Steam Condenser	Confirm redundancy of vacuum pump and Capacity of vacuum pump to hold condenser vacuum	Thermal & Combustion Energy			
3.3.11 Circulating Water System	Confirm redundancy of pump and consistency with unit capacity	Thermal & Combustion Energy			
3.3.12 Closed Circulating Cooling Water System	Confirm redundancy of pump and consistency with unit capacity	Thermal & Combustion Energy			
3.3.13 Auxiliary Steam System	Confirm Capacity to provide enough amount of steam required for start-up.	Thermal & Combustion Energy			
3.3.14 Main Electrical Wiring	Confirm wiring within desks and panels shall be supported on trays and shall be segregated according to voltage level	Thermal & Combustion Energy			
3.3.15 Power System	PSS(Power System Stabilizer) is generally required by Grid System Operator/PPA. Confirm consistency of them.	Thermal & Combustion Energy			
3.3.16 Auxiliary Power Ratio	Confirm rationality of auxiliary power consumption rate.	Thermal & Combustion Energy			
3.4 LNG handling facility	-				
3.4.1 LNG unloading system	Confirm manufacturer delivery record, competency, consistency with unit capacity, auxiliary equipment redundancy, thermal durability Confirm the LNG carrier and the loading arm match. Confirm that the specifications are compatible with the emergency shutdown system.	Thermal & Combustion Energy			
3.4.2 LNG storage system	Confirm manufacturer delivery record, competency, consistency with unit capacity, auxiliary equipment redundancy, thermal durability Confirm the heat insulation and capacity to resist pressure of the tank. Confirm the fire extinguishing system in case of fire. Make sure it complies with your country's regulations.	Thermal & Combustion Energy			
3.4.3 LNG vaporization system	Confirm manufacturer delivery record, competency, consistency with unit capacity, auxiliary equipment redundancy, thermal durability Make sure that the seawater temperature is taken into consideration as it affect efficiency of vaporization system.	Thermal & Combustion Energy			
3.4.4 Boil off gas system	Confirm manufacturer delivery record, competency, consistency with unit capacity, auxiliary equipment redundancy Confirm that its capacity is enough considering the amount of gas generated much at the receiving of LNG.	Thermal & Combustion Energy			
3.4.5 LNG tank capacity (fuel)	Consistency with unit capacity Check the capacity of the LNG tank is sufficient for stable operation, taking LNG receiving plan into consideration .	Thermal & Combustion Energy			
3.4.6 LAG tank capacity (ammonia for SCR system)	Confirm spill prevention measures from ammonia tank (e.g. installation of ammonia detector, double-walled tank) Consistency between consumption and capacity of ammonia tank	Thermal & Combustion Energy			
3.4.7 Preparation for handling of light LNG	Confirm that measures are taken to prevent the rollover phenomenon of the LNG tank such as receiving procedure of LNG, density detection system. Confirm the pump is compatible with light LNG and the capacity to feed the required amount.	Thermal & Combustion Energy			

Evaluation item	Specific elements	MME	EAC	Pass	Fail
3.5 Balance of Plant	-				
3.5.1 Water Source and Water Quality	Confirm accessibility to water source, quality and amount comply with requirement of unit	Thermal & Combustion Energy			
3.5.2 Boiler Make-up Water Treatment System	Confirm if water quality comply with requirement of unit	Thermal & Combustion Energy			
3.5.3 Chemical Dosing System	Confirm chemical dosing system enable water purity to pass the requirement of HRSG and ST	Thermal & Combustion Energy			
3.5.4 On-Line Water and Steam Sampling and Analysis System	Confirm monitoring item covers required water quality	Thermal & Combustion Energy			
3.5.5 Circulating Cooling Water Treatment System	Confirm if water quality comply with requirement of unit	Thermal & Combustion Energy			
3.5.6 Central Industrial Waste Water Treatment	Confirm waste water treated comply regulation in your country	Thermal & Combustion Energy			
3.5.7 Oil Treatment System	Confirm waste water treated comply regulation in your country	Thermal & Combustion Energy			
3.6 On-site monitoring system	-				
3.6.1 Continuous Emission Monitoring System	Confirm CEMS monitor flue gas as per regulation in your country	Thermal & Combustion Energy			
3.6.2 Closed Circuit Television System	Confirm covered area is enough in terms of security	Thermal & Combustion Energy			
3.6.3 Fire Alarm System	Confirm covered area is enough in terms of security	Thermal & Combustion Energy			
3.6.4 Entrance Guard System and Patrolling System	Check conformity with regulation in your country	Thermal & Combustion Energy			
3.7 Safety measures	-				
3.7.1 Fire protection plan, quantitative risk assessment for LNG	Confirm the measures to be taken in the event of a fire or gas leak. Confirm it comply with regulation in your country	Thermal & Combustion Energy			
3.7.2 Countermeasures for handling light LNG	Confirm that measures are taken to prevent the rollover phenomenon of the LNG tank such as receiving procedure and density detection system	Thermal & Combustion Energy			
3.7.3 Firefighting facilities	Confirm the fire fighting system comply with regulation in your country	Thermal & Combustion Energy			
4.Labour Safety	Confirm contractor comply with regulation in terms of safety	Thermal & Combustion Energy			

IPP_Feasibility Study Check List(Hydro)

Evaluation item	Specific elements	Department in charge of evaluation		Pass	Fail
		MME	EAC		
1.Survey Plan for Hydroelectric Power Plant					
1.1 Selection of the Type	・ N/A	Hydroelectricity			
1.2 Location Survey	・ N/A	Hydroelectricity			
1.3 Traffic	・ A survey of the general transportation conditions (transportation method, transportation routes and transportation capacity) in the vicinity of the construction area and a survey of the power supply for the construction (capacity of existing transmission lines) shall have been conducted. ・ Existing transportation facilities/method shall be checked, and expansion plan of existing transportation facilities or new construction of transportation facilities shall be considered if necessary.	Hydroelectricity			
1.4 Topographic, Geological Survey					
1.4.1 Topographic Survey	・ In addition to the main civil engineering structures such as dams, waterways, power plants, etc., and reservoir areas, a topographic map should be prepared with a certain amount of leeway to cover construction roads, material extraction sites, and sites for temporary facilities. ・ A cross-sectional survey of the river at the point of the outlet should be conducted and a discharge rating curve (H-Q curve) should be prepared.	Hydroelectricity			
1.4.2 Geological Survey	(Common) ・ Appropriate geological investigations, permeability tests, and strength tests shall be conducted for the ground at the proposed location and around the reservoir, depending on the size of the dam and reservoir capacity. ・ The possibility of landslides around the reservoir must be considered. In particular, narrow ridges and potential landslide areas should be investigated in detail. ・ No geological serious problems that may affect the feasibility of the project should be identified. ・ In the case of collecting aggregate for concrete or filling materials for fill dams, the distribution of materials in the area where the materials are to be collected, the amount of material that can be collected, and the physical and mechanical properties of the collected materials should be investigated. (For Concrete dam) ・ The required performance of the foundation of the concrete dam shall be determined by in-situ testing.	Hydroelectricity			
1.4.3 Earthquake	・ Seismic studies have been conducted and the seismic loads assumed at the proposed site have been appropriately set.	Hydroelectricity			
1.5 Hydrology Survey	(For the study of power generation plans) ・ Accuracy and duration of river flow data, which will serve as the basis for the study of the power generation plan, shall be sufficient. If sufficient flow data is not available, the river flow shall be calculated by an appropriate method. ・ The flow data used in the power generation planning shall be daily flow data in the study a run-of-river type, and monthly flow data in the study of a reservoir type. ・ In the case of a reservoir type, studies and analyses related to evaporation shall have been conducted. (For the study of the design flood) ・ Design flood shall be established in a manner appropriate to the size of the dam or reservoir. ・ Design flood are appropriately set based on adequate and appropriate hydro-meteorological investigations and analyses. (For the study of sediment volume) ・ Analysis of sediment volume has been conducted, and the estimated sediment volume and its impact on power generation has been properly calculated and evaluated.	Hydroelectricity			
1.6 Enegy Generation Calculation					
1.6.1 Energy Generation of Run-of-river type	・ The calculation method of maximum output and electric energy shall be appropriate.	Hydroelectricity			
1.6.2 Energy Generation of Reservoir type	・ The calculation method of maximum output and electric energy shall be appropriate. ・ In the case of a reservoir type, the reservoir operation (rule curve) shall be efficient, taking into account the changes in flow during the wet and dry seasons. ・ The power generation operation must meet the power demand of the grid.	Hydroelectricity			
2.Basic Design of Each Structures					
2.1 Intake facilities					
2.1.1 Weir/D	(Common) ・ Necessary freeboard (margin height) shall be secured according to the type of dam, presence or absence of flood discharge facilities, and wave height in the reservoir. ・ The reservoir should not adversely affect the surrounding ground. ・ There is no risk of flooding of houses, etc. in the upstream area due to the rise in water level caused by the construction of the dam and sand deposition. If there is a risk of flooding, appropriate measures shall be taken. ・ The dam water level (such as N.H.W.L., F.W.L., and L.W.L.) and the height of the non-overflow portion of the dam body shall be set appropriately. ・ The anticipated loads (including earthquake inertia forces) to be considered in the design of the dam shall be appropriately calculated. ・ The dam foundation shall have the necessary shear strength and shall not cause significant settlement, cracking, slip failure, erosion, etc. ・ Appropriate measures (grouting, drainage systems, etc.) shall be implemented in the dam foundation to prevent increased uplift pressure and significant leakage and seepage failures. ・ The reservoir does not cause harmful leaks or landslides that could damage settled are, farms, roads, etc. Water leakage prevention and/or landslide prevention measures shall be taken as necessary. ・ The reservoir is not expected to cause deterioration of water quality in or downstream of the reservoir, such as cold water and turbid water problems. If deterioration of water quality in or downstream of the reservoir is expected, appropriate measures such as removal and purification of pollutants around the reservoir and/or mitigation measure must be planned in accordance with the EIA report. ・ When installing a facility that discharges the amount of water necessary for water utilization or environmental preservation into a reduced water flow area, the facility must be capable of discharging the necessary amount of water and must be stable against vibration during partial discharge. (For concrete gravity dam) ・ The structural stability of the concrete gravity dam shall be ensured. ・ The dam and its foundation (including the dam foundation rock and the contact surface between the dam and the bedrock) must be watertight and strong enough to support the anticipated loads. (For fill dam) ・ The main body of the fill dam shall be designed to be safe against failure due to slips and seepage. ・ The fill material (impervious material, semi-permeable material, permeable material) shall have the specified mechanical properties. ・ The dam foundation (including the dam foundation bedrock and the contact surface between the dam body and the bedrock) must have the specified performance and be safe against failure caused by sliding, slipping, or seepage flow. ・ The technical requirements applicable to each dam type (uniform type, zoned type, and surface impervious type) must be satisfied.	Hydroelectricity			
2.1.2 Discharge equipment	(Common) ・ Flood discharges facilities capable of safely and reliably discharging design flood and lower flows shall be installed. ・ The flood discharge does not affect the stability of the dam. ・ The discharge water from the dam must be adequately reduced so that it does not adversely affect the dam itself or the downstream areas. ・ Appropriate measures are taken to ensure that water is discharged as necessary for water use and conservation of the river environment in the downstream areas of the dam or water intake. ・ Discharge facilities for water utilization, flood control, and water management must be constructed so that they will not be rendered unusable by sedimentation or other causes. (For fill dam) ・ The dam body must not be planned to have a flood discharge or a channel that would cause cracks in the interior of the dam. ・ No spillway is planned to be installed in the dam body.	Hydroelectricity			
2.1.3 Intake	・ The Intake shall be safe against collapse of the surrounding mountain slope, soil and rocks. ・ The channel must be able to properly take water from rivers, reservoir, regulating reservoir. ・ The structure and location shall be such that sediment, debris, dust, etc. cannot flow in. ・ The structure must be safe against anticipated loads. ・ Sluice gates or watertight panels are to be installed to allow for inspection and repair of the waterway. ・ If the water intake is connected to a pressure conduit, conduit, or hydraulic steel pipe, it must be located and structured to prevent air from entering the waterway, and must be capable of taking water at any water level within the range of the water depth to be used.	Hydroelectricity			
2.1.4 Settling basin	・ The structure shall be capable of settling suspended sand that may cause damage to downstream channels and turbines, and shall allow for easy flow of settled and deposited sediment. ・ The structure must be safe against collapse of surrounding mountain slope, soil and rocks. ・ Stable against anticipated loads.	Hydroelectricity			

Evaluation item	Specific elements	MME	EAC	Pass	Fail
2.2 Headrace facilities					
2.2.1 Headrace (water way)	(Common) ・ The waterway shall not be damaged by flooding or landslides. ・ Construction of the waterway shall not cause leakage, landslides, or other adverse effects. In the event of water leakage from within the channel, it must not affect the surrounding ground or structures. ・ Necessary countermeasures shall be taken when passing through areas with weak geological conditions. ・ The waterway shall be safe against anticipated loads. ・ In case of possible settlement of the surrounding area (due to water leakage from the channel), lining or other measures shall be provided. ・ The channel must be able to safely and reliably control the designed flow rate and be stable against expected hydraulic phenomena. ・ Sediment deposited in the channel shall not cause damage to downstream channels or turbines. (For open channel) ・ There should be no danger of landslides near the waterway route. (For culvert channel) ・ The structure must be safe against external pressure (groundwater pressure, earth pressure, grouting pressure, etc.). (For pressure type (conduit type)) ・ The structure shall be safe against external pressure (ground pressure, earth pressure, grouting pressure, etc.) and internal pressure (hydrostatic pressure, water hammer pressure, surging pressure, etc.). ・ The headrace shall be installed below the hydraulic gradient line of the lowest water level in the intake system and the surge tank.	Hydroelectricity			
2.2.2 Head tank/Surge tank	(Common) ・ Be safe for the anticipated loads. (For head tank) ・ The capacity must be sufficient to prevent air from entering the hydraulic iron pipe during normal operation and load surges. ・ It must have a spillway that can safely discharge the maximum amount of water used in the event of a full load shutdown. However, this does not apply if the facilities are capable of safely discharging water by a method other than a spillway. ・ The water level rise at the time of overflow from the head tank must not adversely affect the upstream channel/culvert. ・ The discharge of excess water shall not adversely affect the surrounding facilities or rivers. ・ It must be designed to prevent dust and floating sand from flowing into the penstock, and must be capable of easily discharging accumulated sand. ・ It must have the necessary surface area to mitigate the effects of water surface fluctuations and wave action during normal operation. (For surge tank) ・ The structure shall be such that water level fluctuations in the surge tank do not increase and equilibrium is achieved in a short period of time (damping condition). ・ The water level in the surge tank (up-surge) shall not overflow at the time of full load shutdown. However, this does not apply if facilities are installed to safely divert surplus water (full-load shutdown condition). ・ The water level in the surge tank (down-surge) shall not fall below the top of the waterway and hydraulic iron pipe during a half-load surge (half-load surge condition).	Hydroelectricity			
2.2.3 Head tank Spillway	・ It shall be stable under the anticipated loads. ・ The structure shall be designed to prevent slides and to prevent water tightness. ・ An energy dissipater shall be installed at the end of the channel to ensure safe discharge of water. ・ When excess water is discharged directly into a river, the structure must prevent excessive scouring of the river bed. ・ In the case of a pipeline, ventilation holes shall be installed at bends.	Hydroelectricity			
2.2.4 Penstock	(Common) ・ The penstock shall be safe under the anticipated loads for each type of penstocks (exposed type, bedrock embedded type, and soil embedded types). The thickness of the penstock shall be set in consideration of the required load. ・ The top of the penstock shall be set lower than the hydraulic gradient line when the water level in the head tank or surge tank is at its lowest. ・ The penstock must be safe and stable against vibration, buckling, and corrosion. ・ The hydraulic pipes must not cause serious leakage. (For exposed type) ・ The route shall be planned to be unaffected by natural disasters such as landslides. ・ In the case of an exposed pipe, anchor blocks and concrete saddles shall be installed to support the penstock. Anchor blocks and concrete saddles shall be stable under the anticipated loads. ・ Concrete saddles shall be able to move smoothly according to the expansion and contraction of the water hydraulic pipe. (For embedded type) ・ It shall be planned on a route with sufficient soil cover and good geological quality.	Hydroelectricity			
2.3 Powerhouse					
2.3.1 Types of Powerhouse	・ N/A	Hydroelectricity			
2.3.2 Location of Powerhouse	・ No damage from flooding or landslides.	Hydroelectricity			
2.3.3 Design of Powerhouse	・ The power plant building shall be stable against expected loads. ・ Structures around the turbine shall be stable against vibration. ・ Space for overhaul and repair of water turbines, generators, etc. shall be provided in the powerhouse.	Hydroelectricity			
2.4 Tailrace	・ Layout and structure shall be such that it will not be damaged by river water or drifted riverbed. ・ Be safe under the anticipated loads. ・ Leakage from tailrace shall not affect the surrounding ground and structures. ・ If collapse of tailrace occur, it will not have a significant adverse effect on the downstream area. ・ If settlement of the surrounding area (due to leakage from tailrace) is anticipated, lining or other measures shall be provided.	Hydroelectricity			
3.Basic design of hydroelectric equipments					
3.1 Water turbine-related facilities					
3.1.1 Design of water turbine	・The items necessary for water turbine design shall be selected. ・The materials such as river flow conditions shall be calcurated appropriately. ・The number and type of turbines shall be selected according to the efective head and the amount of water used. ・The turbine output shall be calculated in consideration of the turbine efficiency. ・The optimum water turbine suction height shall be set.	Hydroelectricity			
3.1.2 Selection of inlet valve	・The inlet valve shall be selected according to the capacity of the power plant. ・An inlet valve or other device shall be installed to shut off incoming water.	Hydroelectricity			
3.1.3 Design of appurtenant equipment	・The appurtenant equipment shall be designed in consideration of the size and operation of the power plant.	Hydroelectricity			
3.2 Generator-related facilities					
3.2.1 Design of generator	・The type of generator and installation method shall be selected according to the scale of the power plant. ・The generator output, rated power factor, and generator capacity shall be appropriate. ・The generator voltage shall be selected to match the generator capacity.	Hydroelectricity			
3.2.2 Design of exciter	・The exciter shall be selected according to the power plant operation method and generator capacity. ・The exciter shall equip necessary functions.	Hydroelectricity			
3.3 Main circuit-related facilities					
3.3.1 Main circuit connection system	・The main circuit configuration and power plant layout shall be according to the importance of the power plant.	Hydroelectricity			
3.3.2 Composition of electric equipments	・The capacity of the transformer shall be consistent with the rated capacity of the generator. ・Does the house transformer capacity match the capacity of the power consumption in the power plant. ・An appropriate circuit breaker shall be selected. ・Water turbines, generators and other protective devices shall be properly selected.	Hydroelectricity			
3.3.3 operation・control・protective device	・The operation control method shall be selected according to the type of the power plant.	Hydroelectricity			
3.3.4 DC power supply system	・The capacity of the DC power supply system required for control shall be available.	Hydroelectricity			
3.4 Other equipments					
3.4.1 Design of crane	・The rated load, lifting height, and movable range of the crane shall be appropriate.	Hydroelectricity			
3.4.2 Design of ground wire	・The design value of grounding resistance shall be less than or equal to the target value.	Hydroelectricity			
3.4.3 Design of emergency power supply system	・An emergency power generation facility with an installed capacity according to the operation shall be installed.	Hydroelectricity			

IPP_Feasibility Study Check List (PV)

Evaluation item	Specific elements	Department in charge of evaluation		Pass	Fail
		MME	EAC		
1.Site Assessment					
1.1 Site Location	The site location is appropriate for PV installation? (Compared to the case of flat and plane land, it is necessary to consider the influence when it is on slope in the mountains, or sea breeze close to the sea, etc.)	Renewable & Other Energy			
1.2 Site Boundary	Are not there any private houses and/or factories around the site location? (It should be avoid the influence of shade from the building. Also, if it is close to a residential area, it is necessary to check whether there is a complaint due to the reflection of the panel. And if it is close to the factory, it is necessary to check whether the contaminated dusts comes in.)	Renewable & Other Energy			
1.3 Site Connectivity	Is easy road access to the site location? (It is necessary to confirm the access conditions to carry in and out of sand soil to the site, and such as transportation of equipment under the construction, also operation and maintenance is ease or not.)	Renewable & Other Energy			
1.4 Geography	Is the ground condition suitable for PV installation? (Because the basic design changes depending on whether the ground condition is hard or soft, it is necessary to check the ground conditions before construction.)	Renewable & Other Energy			
1.5 Natural disaster risks					
1.5.1 Seismic	Is a low probability of an earthquake? (It is necessary to confirm whether the risk of equipment damage due to the occurrence of an earthquake in the area is evaluated as based on the data of the Cambodia Meteorological Agency and various documents. Or are there any appropriate countermeasures taken?)	Renewable & Other Energy			
1.5.2 Flood hazard	Is a low probability of flood disasters and landslides such as in the mountains? (It is necessary to confirm whether the risk of equipment damage due to heavy rain disasters or landslides in the area is evaluated as based on Cambodia Meteorological Agency data and various documents. Or are there any appropriate countermeasures taken?)	Renewable & Other Energy			
1.5.3 Cyclone	Is a low probability that the cyclone will adverse affect the equipment? (It is necessary to confirm whether the risk of equipment damage due to cyclone storms, etc. in the area is evaluated as based on Cambodia Meteorological Agency data and various documents. Or are there any appropriate countermeasures taken?)	Renewable & Other Energy			
1.5.4 Lightning	Is low probability that the equipment will be affected by a lightning strike? (It is necessary to confirm whether the risk of equipment damage due to lightning strikes in the area is evaluated as based on Cambodia Meteorological Agency data and various documents. Or are there any appropriate countermeasures taken?)	Renewable & Other Energy			
2.PV System					
2.1 Facility Structure	Is the equipment design appropriate such as single diagram? (It is necessary to confirm that the single diagram, device configuration, and various device specifications are properly designed or not.)	Renewable & Other Energy			
2.2 Foundation	Is the foundation design appropriate depending on the ground conditions? (It is necessary to confirm whether the foundation is properly designed according to the ground conditions, and how the ground soil improvement if necessary.)	Renewable & Other Energy			
2.3 Frame structure	Is the mount frame design appropriate depending on the weather conditions? (It is necessary to confirm that the mount frame is properly designed, such as the panel will not fly away when a cyclone storm coming.)	Renewable & Other Energy			
2.4 Solar PV module	Is appropriate the module manufacturer that has much delivered record in other projects, and appropriate the proposed equipment performance and warranty period? (It is necessary to confirm whether the module manufacturer has a lot of experience, and whether the proposed equipment performance and warranty period are appropriate or not.)	Renewable & Other Energy			
2.5 PCS	Is appropriate PCS manufacturer that has much delivered record in other projects, and the proposed device performance? (It is necessary to confirm whether the module manufacturer has a lot of experience, and whether the proposed equipment performance is appropriate or not.)	Renewable & Other Energy			
2.6 Tilt angle optimisation	Is appropriate panel angle depending on the illuminance conditions? (It is necessary to confirm whether an panel angle is appropriate according to the illuminance conditions or not.)	Renewable & Other Energy			
2.7 DC / AC ratio for optimal plant configuration	If it is PV panel overloaded, the whole design is appropriate? (It is necessary to confirm whether the proposed overload design is appropriate or not.)	Renewable & Other Energy			
2.8 DC Cabling	Are appropriate cable laying design for each string to the CB hub and PCS specification? (It is necessary to confirm whether the cable laying design from the PV panel to each CB and PCS are appropriate or not.)	Renewable & Other Energy			
2.9 AC Cabling, Voltage transformer ,Grid interconnection	Are appropriate design for the AC equipment, transformer, and circuit breaker? (It is necessary to confirm whether AC equipment, transformer, and circuit breaker design are appropriate or not.)	Renewable & Other Energy			
2.10 Facility protection device	Are appropriate design and specifications for the protective system in the event of a ground fault, short circuit, or lightning strike? (It is necessary to confirm whether protection system is appropriate or not, when ground faults, short circuits, lightning surges during lightning strikes, etc. are occurred.)	Renewable & Other Energy			
2.11 Monitoring and Control Equipment	Are appropriate design for the specifications of remote monitoring / control system such as SCADA? (It is necessary to confirm whether the remote monitoring / control device design is appropriate or not.)	Renewable & Other Energy			
2.12 Boundary wall and fencing	Are appropriate desigin for the equipment boundaries? (It is necessary to confirm whether the design has been made and proposed to prevent electric shock due to the invasion of humans and/or animals, and also equipment damage, etc.)	Renewable & Other Energy			
2.13 O&M	Are appropriate design for the operation and maintenance plan such as checking the power generation, PV panels and mounts, peripheral facility, and weed treatment? (It is necessary to confirm whether the operation / maintenance plan is appropriate or not.)	Renewable & Other Energy			
3.Energy Assessment					
3.1 Evaluation of site	Are appropriate illuminance conditions at the PV installation site? (It is necessary to confirm whether the appropriate illuminance conditions and whether it is not shaded by trees or building.)	Renewable & Other Energy			
3.2 Calculation of solar PV system energy yield	Is appropriate power generation forecast according to the equipment conditions such as illuminance conditions and panel / PCS performance? (It is necessary to confirm whether the appropriate power generation in consideration of illuminance conditions, and including panel / PCS degradation, transmission / transformation loss, etc.)	Renewable & Other Energy			
3.3 Evaluation of results of Curtailment	Is appropriate power output evaluation according to the energy demand, capacity of the transmission, power tidal current, etc.? (If curtailment occurs, it is necessary to confirm whether the power output evaluation is appropriate or not.)	Renewable & Other Energy			

Training for Capacity Building on IPP Project Evaluation

(WG1)

May, 2022

The Chugoku Electric Power Co., Inc.

Current Situation

- **Cambodia power sector has conducted IPP evaluations so far, and has a certain amount of experience and knowledge.**
- **However, there are some issues in ensuring the quality of evaluations and human resource development.**

Experience	・More than ten IPP evaluation experiences in hydro, coal and solar power plants.
Evaluation system & method	・Pre-FS and FS work flows are Page 8. ・Although there are a wide variety of IPP evaluation items, there is no manual for ensuring quality. ・The evaluation is conducted by consultation by the evaluation committee selected each time.
Human Resource Development	・ IPP evaluations are conducted once or twice a year. Therefore, only OJT is not enough to develop human resources about young engineers. ・ Materials related to past IPP projects and past training are not shared. It is difficult for Cambodia power sector to spread the technology to young engineers.

Basic Policy

Evaluation system / Evaluation method

Measures to carry out the evaluation efficiently and systematically will be recommended.

Basic Policy

- **Utilization of IPP evaluation checklist made by WG2**
- **Sharing of technical materials with anyone**

Human Resource Development

Measures to develop human resources involved in evaluation work will be recommended.

Basic Policy

- **Understanding each person's ability**
- **Implementation of continuous education by trainers**

Recommendation

In the current situation where the IPP evaluation committee members appointed by individual names, not as organization carry out IPP evaluations through discussions, it is expected that the evaluation quality will vary depending on the abilities of the appointed members. In order to keep the evaluation quality constant and to take responsibility for the evaluation, we propose the following recommendations so that the evaluation can be made into routine work and can be carried out efficiently and systematically.

(1) In order to keep the evaluation quality constant and ensure the fairness of the evaluation, a checklist for the IPP evaluation will be created and the evaluation items will be clarified. This checklist will be reviewed regularly by MME.

(2) In order to make the organization responsible for the evaluation, determine the responsible organization and/or department for each item in the checklist.

(3) Each organization and/or department will continue to develop human resources such as in-house training for checklist, and strive to improve the evaluation quality. For example, it is recommended to grasp the abilities of each staff member every year and conduct training based on the results of this grasp. It is expected that the training will be conducted mainly by the C/P of this project.

(4) Since the technical materials related to the training created in this project are stored so that anyone in MME and EAC can refer to them, we recommend to continue to share information.

WG2: IPP Project Evaluation Methodology
-Thermal power plant-
1st Class : :Basics of Gas Turbine Combined Cycle

The Chugoku Electric Power Co., Inc.

中国電力株式会社
THE CHUGOKU ELECTRIC POWER CO.,INC

Contents

1. Fuel property and power generation system
2. Fuel supply and operation plan
3. Comparison of alternatives for power generation type and specifications
4. Construction plan
5. O&M plan

Contents

1.1 Fuel Property of LNG

	Coal	LNG
Transport	- Marine transport (conveyer, coal unloader etc.)	- Marine transport (LNG carrier) (pipe, pump etc.)
Storage	- Coal yard - Silo	- LNG storage tank
Environmental effect	- NOx, SOx, Coal Ash - High CO_2 Emissions	- NOx - Low CO_2 Emissions
Others	- Low calorific value - Cheaper than LNG	- High calorific value - More expensive than Coal

-162 ˚C liquid

LNG is a liquid obtained by cooling natural gas to -162 ˚C and is colorless and transparent.

1/600 volume of gas

The volume in the liquid state is 1/600 of that in the gas state.

(Liquefied for mass transportation and storage)

Clean energy

LNG is clean energy when compared to other fossil fuels.

The amount of CO_2 generated is small, and SOx and soot are not generated.

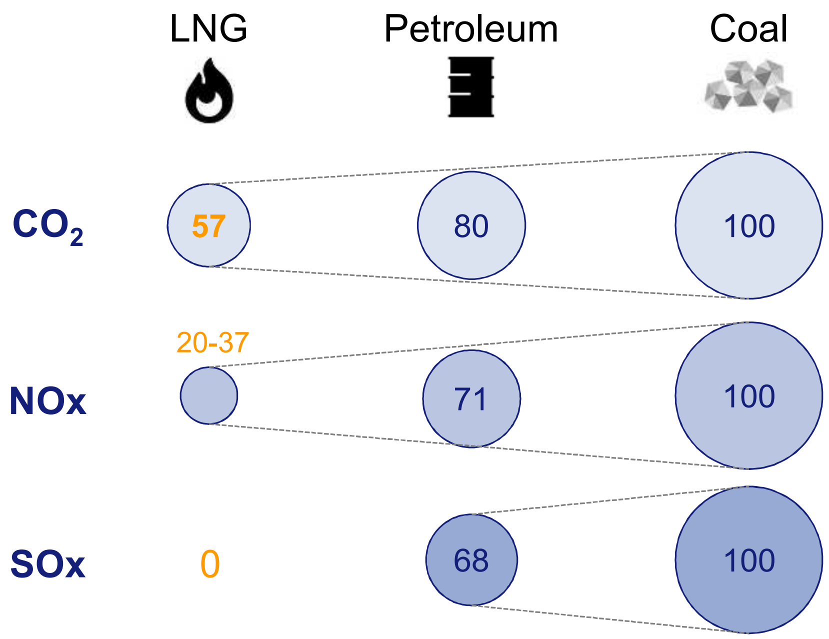
High calorific value

LNG has a high calorific value per unit weight.

Calorific value by fuel

LNG	LPG	Coal	Crude oil
13,068 kcal/kg	11,963 kcal/kg	6,231 kcal/kg	9,139 kcal/L

Comparison of exhaust gas

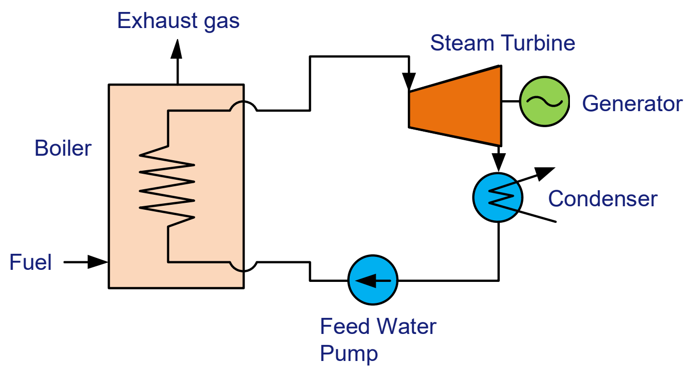


- LNG produces a small amount of carbon dioxide, which is one of the greenhouse gases.
- The amount of NOx generated, which is a cause of air pollution, is also small.
- Sulfur is removed during liquefaction, so SOx is not generated.

Data source "Osaka Gas Renewal Report 2017"
https://www.osakagas.co.jp/company/ir/library/ar/pdf/2017/67-68.pdf

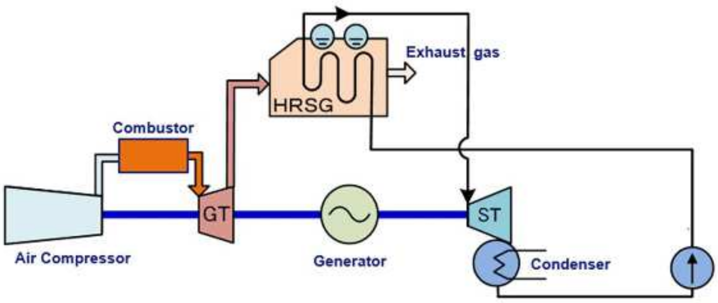
Difference between “Conventional” and “Combined cycle” power generation

Conventional

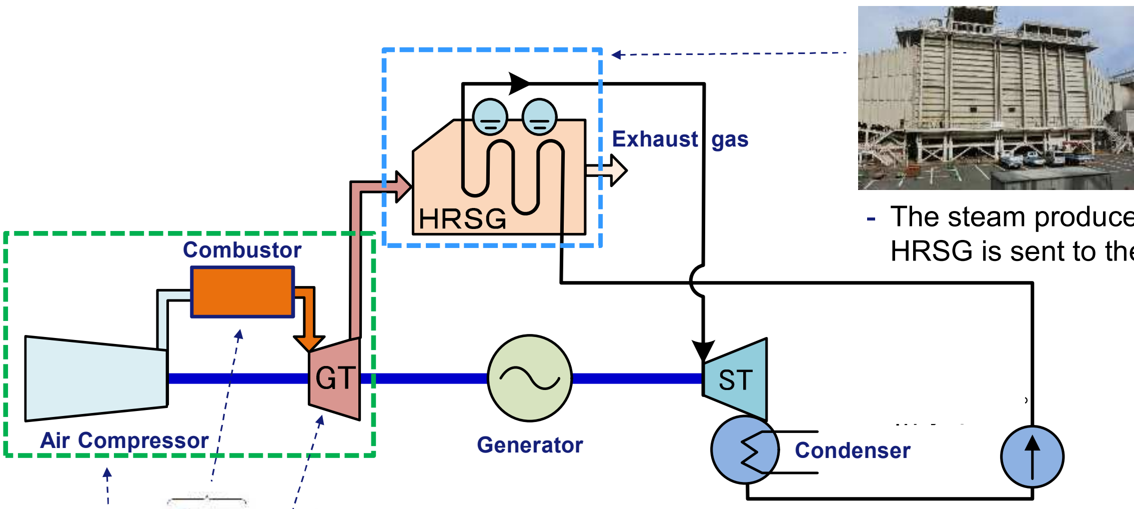


GTCC

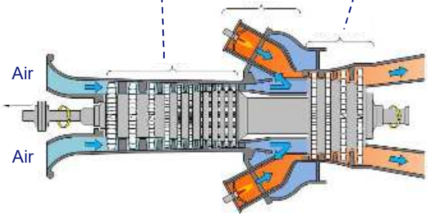
HRSG : Heat Recovery Steam Generator



- Generating by a gas turbine using combustion gas.
- Steam is generated by HRSG using the exhaust gas of Gas Turbine, and this steam is used to turn the steam turbine to generate electricity.



- The steam produced by the HRSG is sent to the turbine.

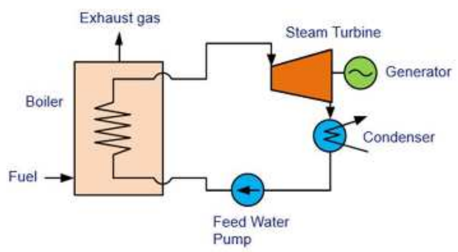


- Air is compressed by air compressor, mixed with fuel and burned.
- The combustion gas expands in the gas turbine and rotates the gas turbine rotor.

1.2 Power generation system

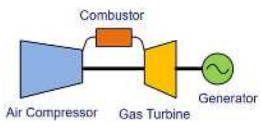
Thermal efficiency

Conventional



45%

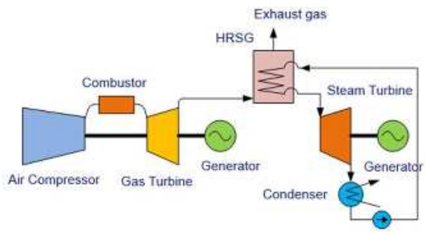
Gas turbine



40%

- With the single gas turbine operation, the exhaust loss is large and the efficiency is about 40%.

GTCC



60%

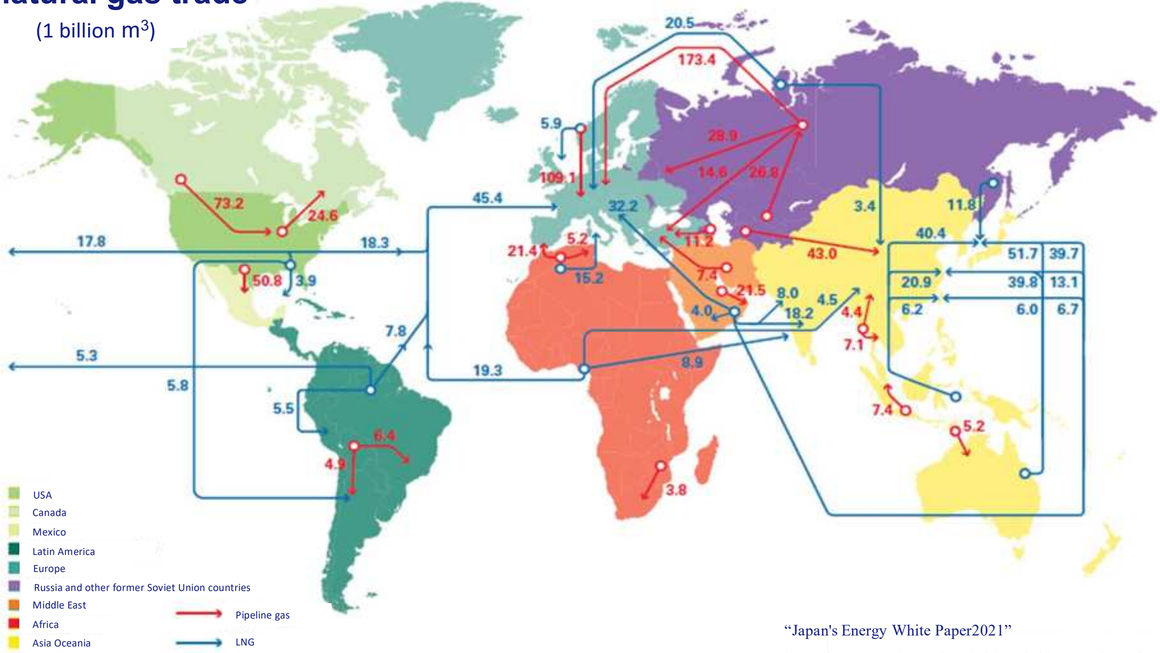
- High efficiency is achieved by recovering the energy of the exhaust gas with a steam turbine.

Contents

Energia

World natural gas trade

(1 billion m^3)

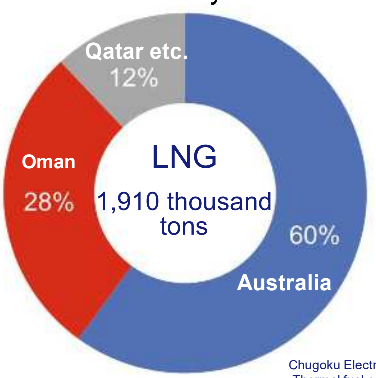


"Japan's Energy White Paper2021"
https://www.enecho.meti.go.jp/about/whitepaper/2021/html/2-2-2.html

Energia

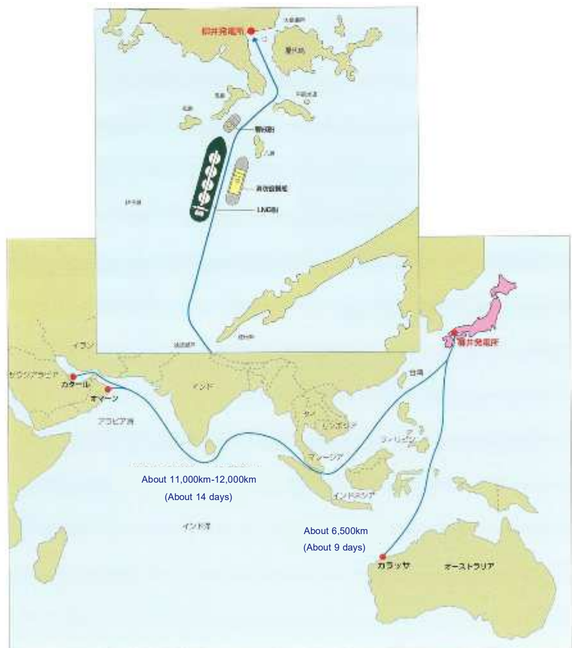
LNG import of "Chugoku Electric Power"

- We procure LNG mainly from Australia, the Middle East and other countries under long-term contracts.
- We procure additional LNG as required, and are working to expand the variety of country for LNG procurement in order to ensure stable procurement and economic efficiency in the future.



Chugoku Electric Power Co., Inc.
Thermal fuel consumption 2018

LNG import route

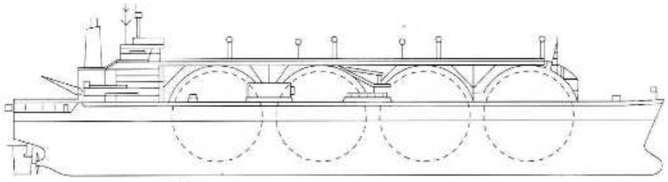


Energia

LNG carrier

One way 6,500km（9days）

Australia



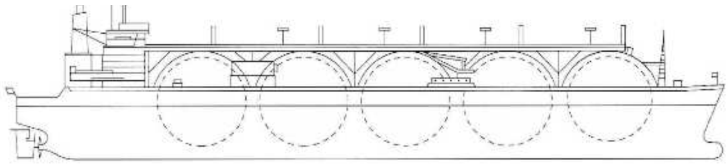
Capacity: 125,000m^3

Length: about 272m

Width: about 47m

Qatar

One way 12,000km（14days）



Capacity: 135,000m^3

Length: about 298m

Width: about 46m

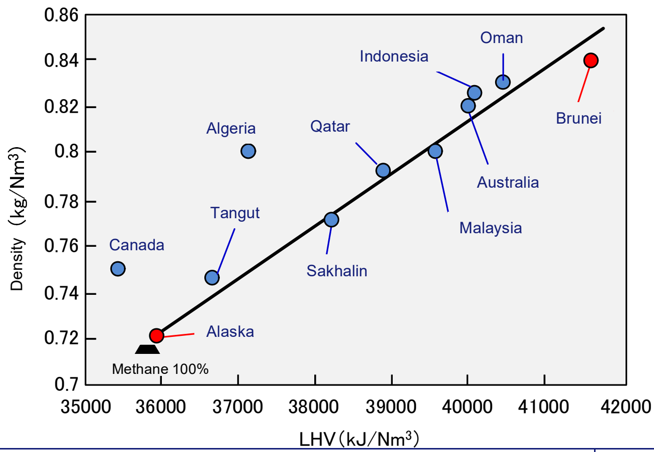
2. Fuel supply and Operation plan

LNG property

- Natural gas is mainly composed of methane (CH_4), and its proportion varies depending on where the natural gas is produced.
- Since the calorific value differs depending on the component ratio, it affects the combustion of the gas turbine. Manufacturers set the range of calorific value that can be burned by the combustor.

Composition of natural gas (Example) (volume %)

	Methane	Ethane	Propane	Butane	Nitrogen
Alaska	99.8	0.1	-	-	0.1
Sakhalin	92.8	3.9	1.7	0.8	-
Brunei	88.8	5.6	3.7	1.8	0.1
Indonesia	87.7	6.9	3.1	1.8	0.4
Qatar	89.9	6.6	2.3	0.4	0.2
Australia	87.5	8.3	3.3	0.4	0.1
Malaysia	91.6	4.1	2.7	1.4	0.1
Canada	91.9	2.0	0.9	0.3	4.9
Abu Dhabi	75.1	23.1	1.7	0.1	-
Algeria	83.7	6.8	2.1	0.8	5.8



2. Fuel supply and Operation plan

■ **Yanai Power Plant** (LNG)

Approval Output: 1,539MW

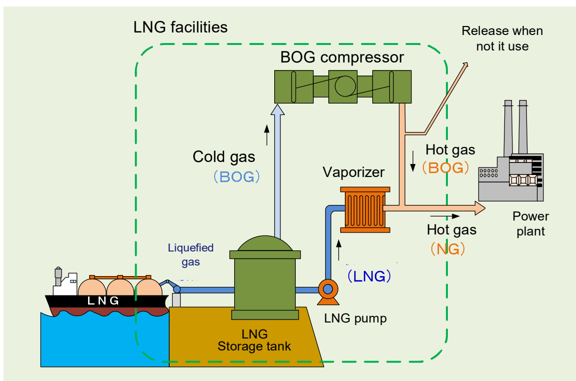
- Unit 1 Series 139MW×6 units
- Unit 2 Series 198MW×4 units

Site area (The area of green space)		About 500,000㎡ (About 120,000㎡ 24%)
Annual results		
Main fuel		LNG
LNG receiving amount		1,514,000 t
Number of LNG carriers / year		25 ships
(Tank lorry)	shipment	64,000 t
(Pipe line)	shipment	170,000 t

2. Fuel supply and Operation plan

LNG facilities

- In Japan, many gas turbine power plants import LNG from overseas.
- LNG is a liquid and has characteristics such as ultra-low temperature. Therefore, gas turbine power plants are equipped with LNG receiving facilities that are different from coal-fired power plants.



➤ **Confirmation**

Confirm manufacturer delivery record, competency, consistency with unit capacity, auxiliary equipment redundancy, thermal durability.

2. Fuel supply and Operation plan

LNG unloading facility

- LNG carriers are so large that there is a jetty where large LNG carrier can arrive.
- The LNG carrier is connected by a large loading arm and from which LNG is received on the land side.

➢ **Confirmation**

- Confirm the LNG carrier and the loading arm match.
- Confirm that the specifications are compatible with the emergency shutdown system.

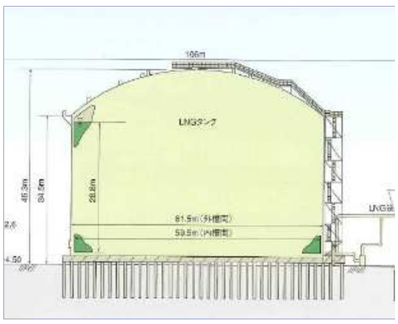
2. Fuel supply and Operation plan

LNG storage tank

- Since liquefied natural gas is extremely cold, the tank has a double wall (double shell), and the part in contact with the liquid is made of a material that can withstand low temperatures. Steel plates and concrete for heat insulation are used on the outside.

➢ **Confirmation**

- Check the capacity of the LNG tank is sufficient for stable operation, taking LNG receiving plan into consideration.



(Yanai Power Plant)
Six LNG tanks, each capacity is 80,000kl.

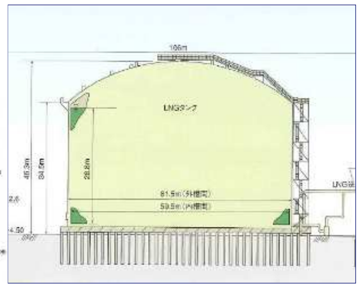
2. Fuel supply and Operation plan

LNG storage tank

✓ **Example of LNG tank operation**

In consideration of risks such as ship delays, secure the minimum amount of fuel required for operation.

- As a risk of delay of LNG carriers due to bad weather, etc., secure average daily consumption x 3 days.
- As a risk of delay in ship allocation from the time of planning, secure average daily consumption x 2 days.

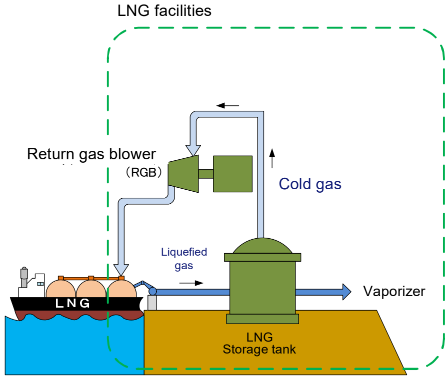


(Yanai Power Plant)
Six LNG tanks, each capacity is 80,000kl.

2. Fuel supply and Operation plan

Return gas blower

- When receiving LNG from an LNG transport ship, the pressure in the transport ship tank drops, so the BOG (Boil Off Gas) generated in the storage tank is returned to the LNG transport ship and the pressure in the transport ship tank is adjusted.
- The facility that returns this BOG to the transport ship is the Return Gas Blower (RGB).

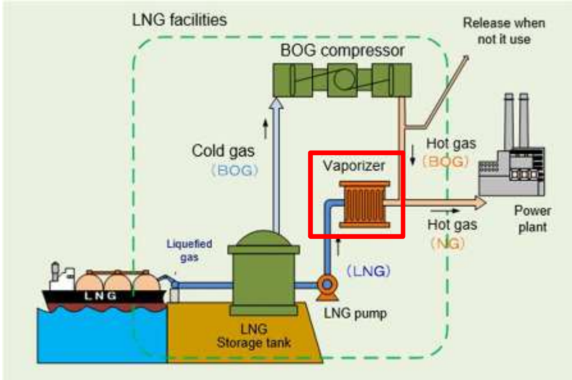


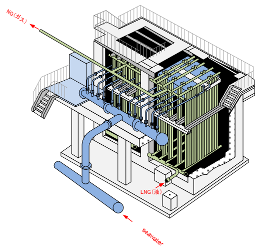
Vaporizer

- The vaporizer commonly used is an open rack vaporizer (ORV).
- LNG passes through a heat transfer tube, and the outer surface of the heat transfer tube is heated with seawater.
- The heated gas is called hot gas and is sent to the gas turbine as fuel for power generation.

Confirmation

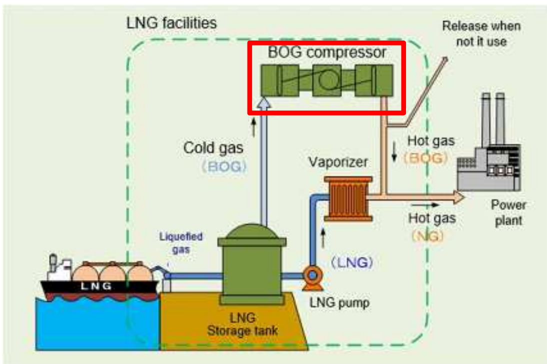
- Confirm the seawater temperature is taken into consideration as it affect efficiency of vaporization system.





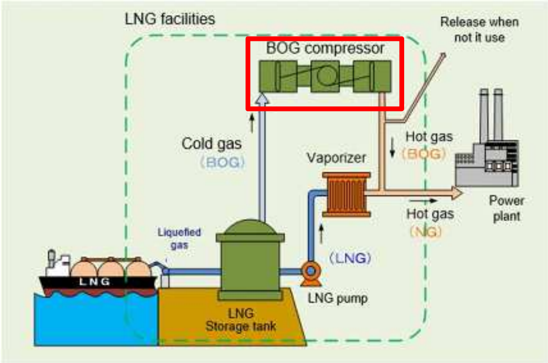
BOG(Boil Off Gas) compressor

- A part of LNG is naturally vaporized and gasified during the receiving or storage. This gas is called BOG (BOG: Boil Off Gas).
- The component of the BOG is methane(CH_4). This is because methane has the lowest boiling point and is vaporized first.
- BOG stays in the upper part of the LNG storage tank and raises the tank internal pressure, so it is necessary to extract the BOG. BOG generated inside the tank has a low temperature (about -160 to -140 ˚C) and is called cold gas. BOG is boosted by a BOG compressor and then mixed with hot gas (NG) and supplied to the gas turbine.



BOG(Boil Off Gas) compressor

- In particular, during LNG is received, BOG is often generated from the tank. Ultra-low temperature gas (BOG) is generated 3 to 4 times as much as in normal times.
- When BOG is generated, the tank internal pressure rises, so the BOG is extracted by the BOG compressor and the tank internal pressure is automatically adjusted.
- For effective utilization of BOG, compressed natural gas is utilized as fuel at the gas turbine.



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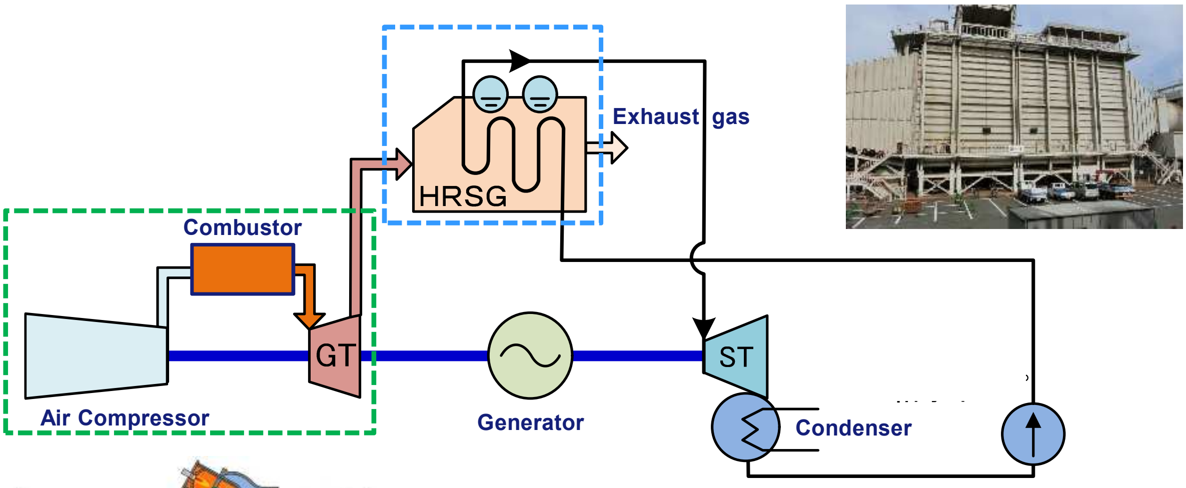
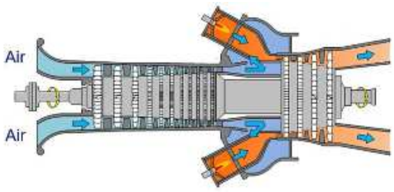




Features of Gas Turbine Combined Cycle

High efficiency

- Since the steam turbine recovers the waste heat of the gas turbine to generate electricity, it has high thermal efficiency.
- The latest GTCC is more than 60% efficient.

Short startup time

- At a coal-fired power plant, it takes several hours to generate steam, but at a GTCC power plant, the startup time is fast and it can be started in about 40 to 80 minutes(Hot starting).

High load change rate

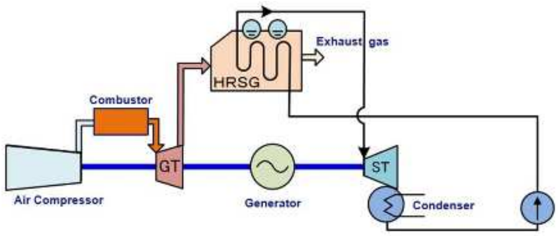
- The load change rate is higher than that of coal-fired power.

Effect of atmospheric temperature

- The maximum output is affected by the outside air temperature. If the outside temperature is high, the maximum output may drop and it may not be possible to generate electricity up to the rated output.

Small impact of inspection

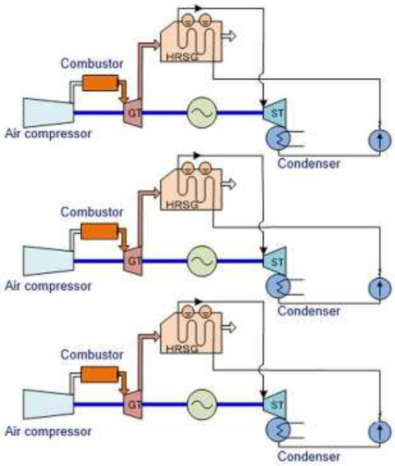
- By installing multiple combined units, it is possible to reduce the amount of reduction in plant load during periodic inspections and accidents.



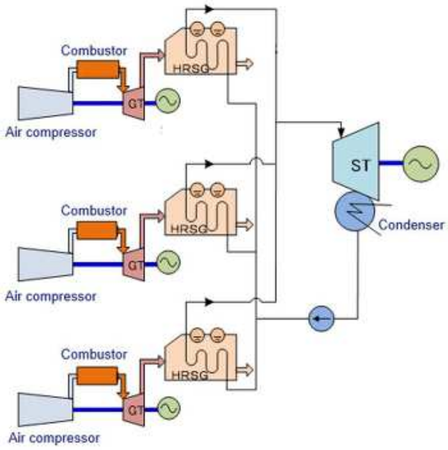
There are two types of equipment combinations:

- "Single-shaft type" in which one steam turbine and one gas turbine are directly connected to the same shaft,
- "Multiple-shaft type" in which a plurality of gas turbines are combined for one steam turbine.

Single-shaft type

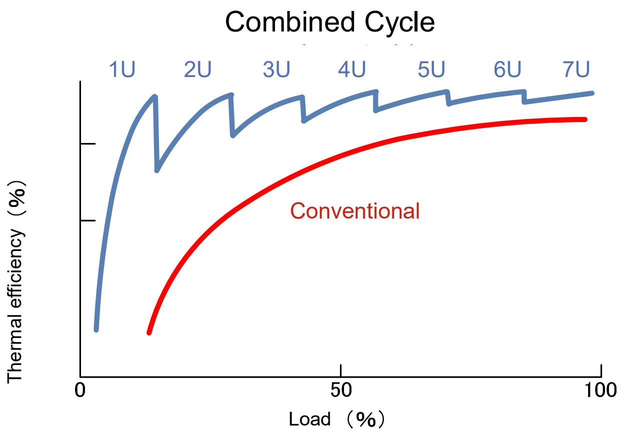


Multiple-shaft type



Combination of multiple units

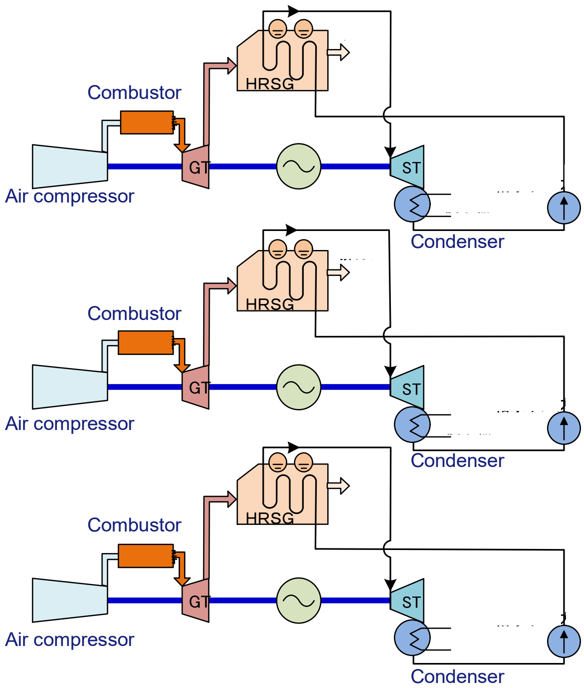
- In typical combined cycle, several medium or small capacity units are installed and the total capacity is configured as a large-capacity.
- This is because the thermal efficiency of the gas turbine at the partial load is very low compared to the thermal efficiency at the rated load.



➤ High efficiency is achieved in a wide output range by increasing or decreasing the output according to the number of operating units.

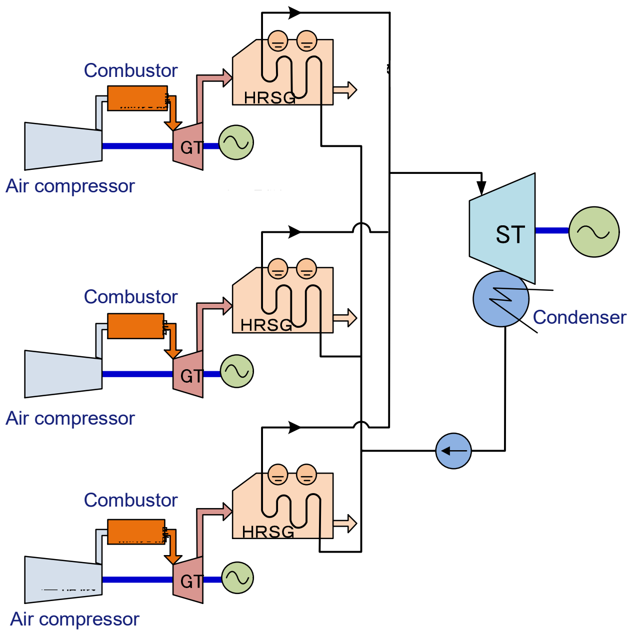
Single-shaft type

- Small capacity steam turbine
- Less efficiency reduction at partial load
- Start up in a short time
- Short outage period during periodic inspection



Multiple-shaft type

- Large capacity steam turbine
- High thermal efficiency at rated load. (For base load)
- Long power generation outage period (during periodic inspection)



Contents

4. Construction plan

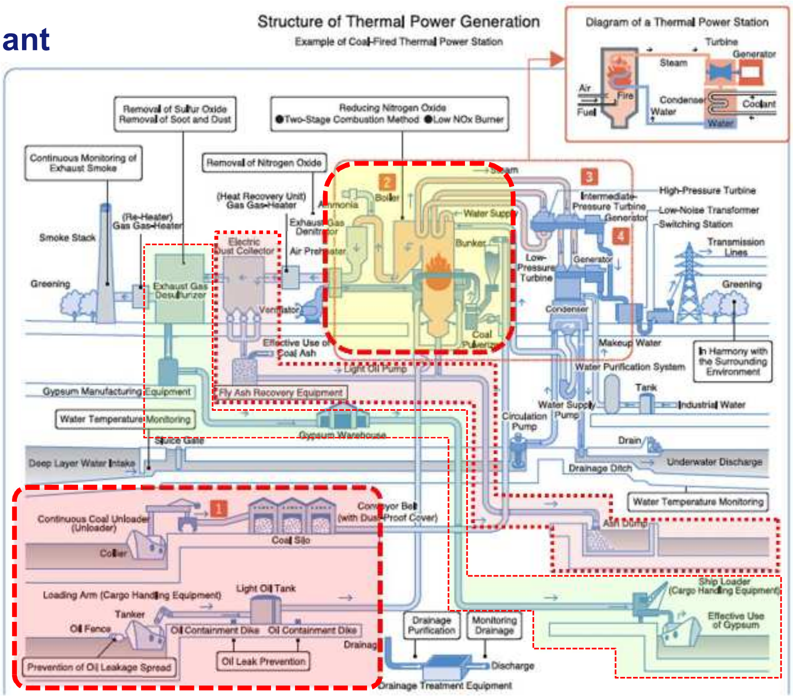
Difference from conventional power plant

- LNG receiving facilities



- Gas turbine and HRSG


- Exhaust Gas Desulfurizer
  - Desulfurizer is not installed because LNG does not contain sulfur
- Electric Dust Collector
  - Electric Dust Collector is not installed because no soot is generated.



“COMPANY PROFILE 2021-2022” https://www.energia.co.jp/e/corp/pr/pamph.html

Difference from conventional power plant

	Coal fired	GTCC
Turbine	✓ Steam turbine	✓ Gas turbine , Steam turbine
Boiler	✓ Boiler	✓ HRSG
Storage	✓ Coal yard / Silo coal receiving facilities	✓ LNG tank LNG receiving facilities
Denitrification equipment	✓	✓
Desulfurization equipment	✓	-
Electric dust collector	✓	-

"COMPANY PROFILE 2021-2022" https://www.energia.co.jp/e/corp/pr/pamph.html

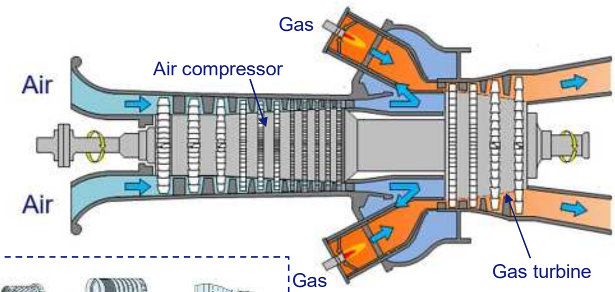
Contents

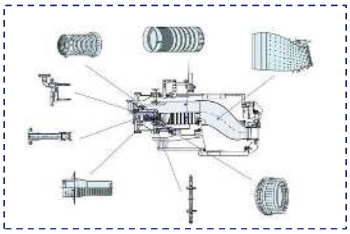
Hot parts

- The parts of gas turbine heated by high temperature combustion gas are called Hot Parts.
- Since it is used under high temperature condition, it is especially necessary to do appropriate periodical inspection and maintenance.


1-stage blade

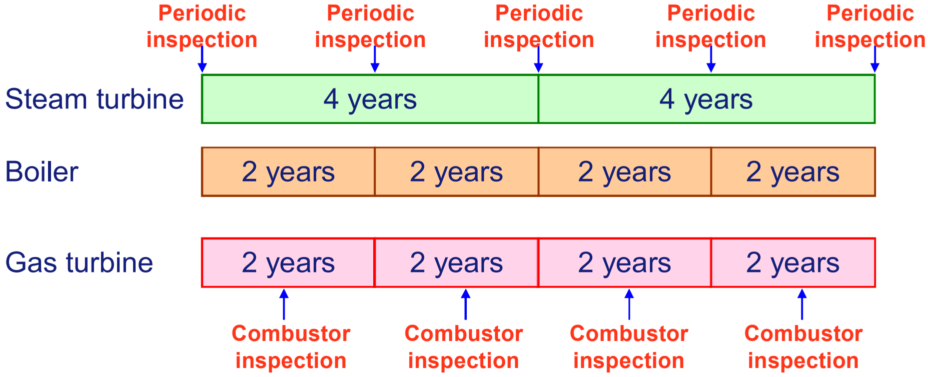

1-stage nozzle





Inspection cycle

- In Japan, steam turbines need to be inspected every four years, and boilers need to be inspected every two years in line with Japanese regulation. On the other hand, periodical inspection for gas turbines for power station is not obligation according to Japanese regulation, but it is inspected every two years in several power station for stable operation. In addition, the combustors are inspected every year.
- This is because the materials of gas turbines and combustors operating in high temperature environments cannot withstand use for more than a year or two.

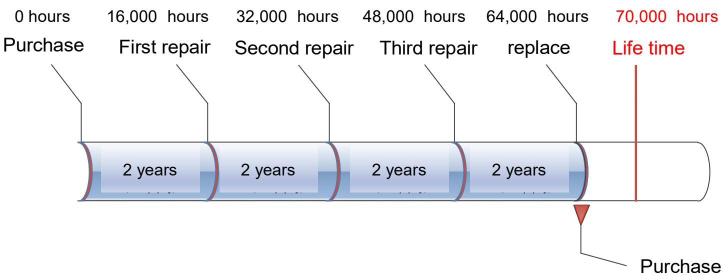


5. O&M plan

Hot parts life cycle example

<u>Gas turbine nozzle</u>

Lifetime: 70,000 hours



- Repair standards and replacement standards are set by the manufacturer.
- Maintenance plan is made considering not only manufacturer's standard but also actual condition.

➢ LTSA (Long Term Service Agreement)

Recently, LTSA are also available.
Manufacturer is responsible for repairing or replacing hot parts over a long period.

5. O&M plan

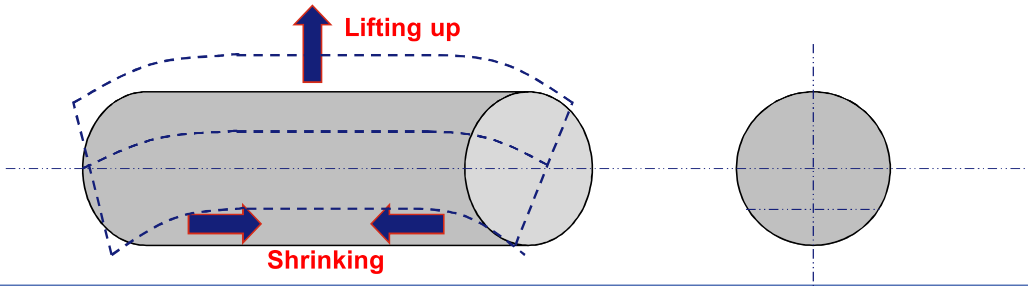
Point to be noted when receiving LNG

- It is necessary to cool-down when you receive LNG as its temperature is quite low.
- Cool-down is conducted by pouring LNG gradually.
- If you pour LNG rapidly, LNG evaporate suddenly inside piping and damage piping.

Receiving pipe for LNG

Bowing phenomenon

- The Bowing phenomenon means that the pipe warps like a bow due to the temperature difference between the upper part and the lower part of the pipe.
- As a result, the piping is damaged or leakage from the flange occurs.

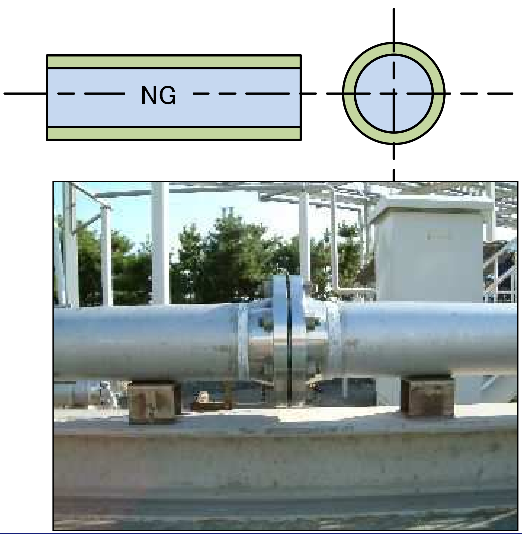


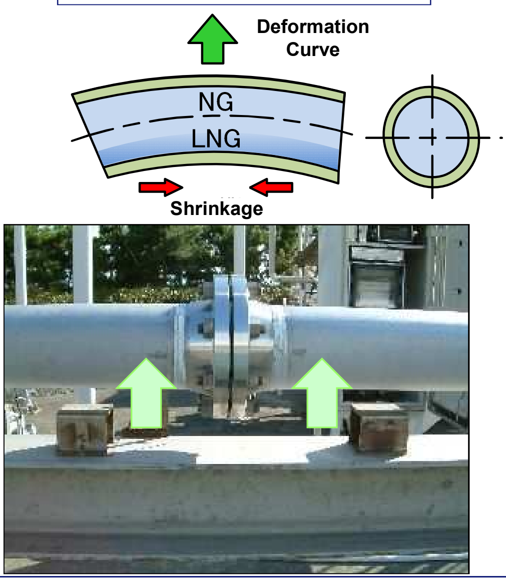
- **Occurs when piping is rapidly cooled from ordinary temperature with LNG. It is necessary to cool-down gradually.**
- **Occurs when the LNG piping is left with a low liquid level. It is necessary to purge LNG not to leave it inside piping.**

Bowing phenomenon

Before

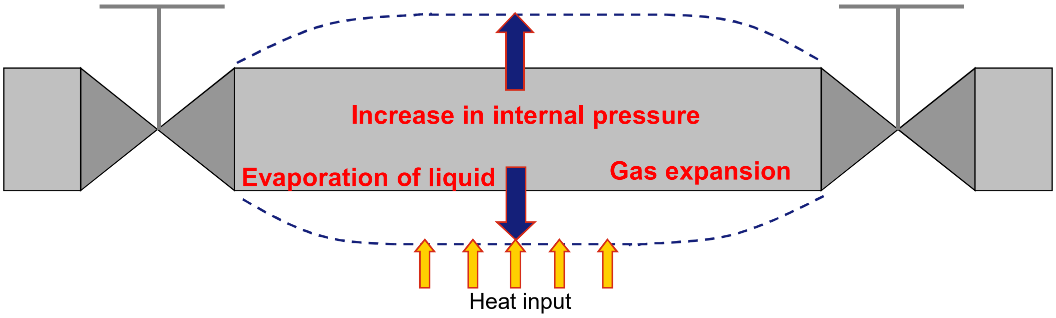
After





Liquid seal

- In case LNG is confined in the pipe by isolation, the internal liquid can be gasified (about 600 times the volume) due to heat input from the outside, and the internal pressure rises. As a result, leakage from the flange of the valve seat and deformation or breakage of the piping occur.

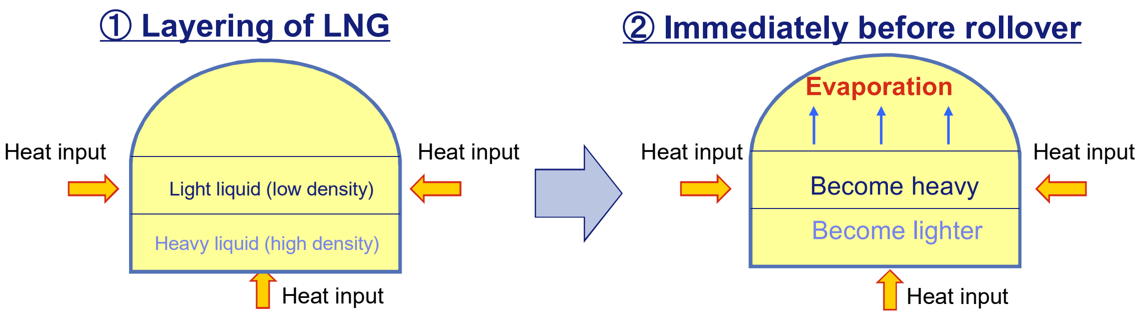


Cause of liquid seal

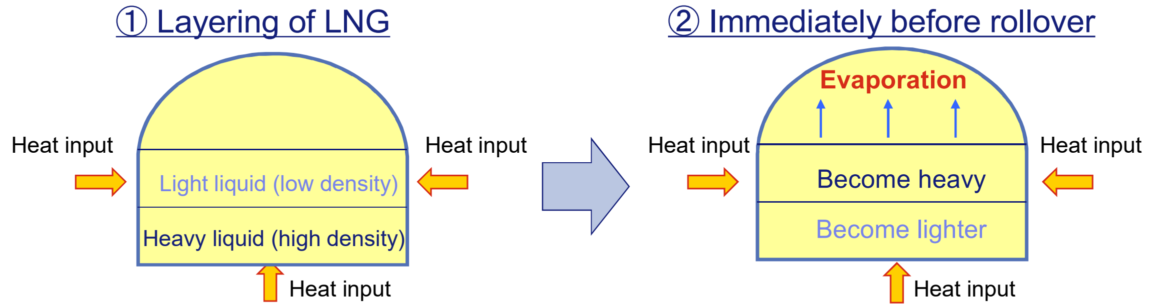
- **When the liquid is not drained at the time of isolation.**
  It is necessary to purge with N2 completely.
- **When the valve is accidentally closed. Operator needs to take care it.**

Rollover phenomenon

- Since LNG is composed of multi-component hydrocarbons, when LNG with different components is stored in the same storage tank, it can be layered if the mixture is insufficient.
- If it is stored for a long time as it is with layered condition, it will be mixed suddenly due to the composition change by evaporation caused by heat input from outside, and BOG will be generated abnormally.



Rollover phenomenon

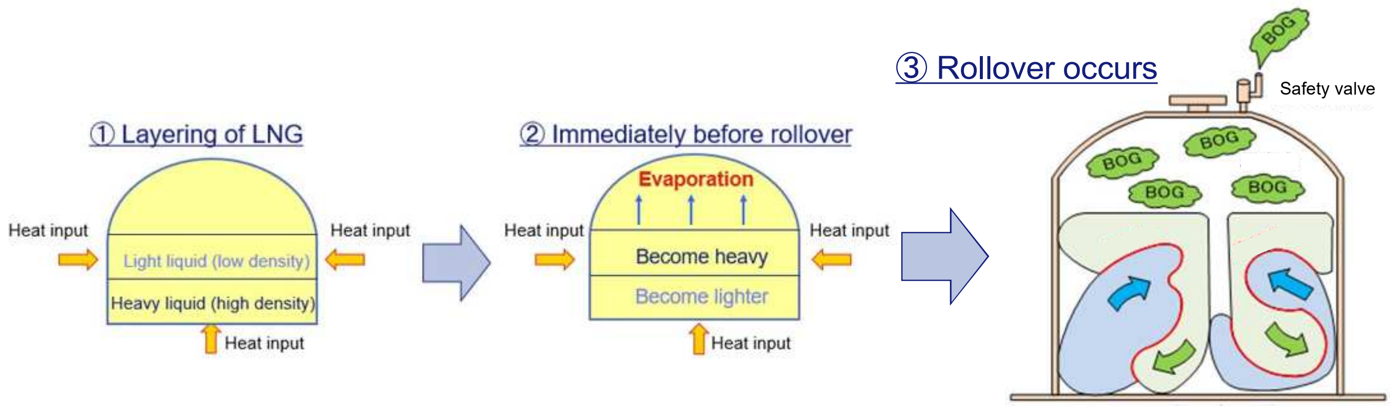


① LNG with different compositions / densities form two layers
- Upper layer : Light LNG (low density)
- Lower layer : Heavy LNG (high density)

② Density difference between LNG layers is reduced
- Upper layer : BOG generation is promoted by heat input, and it becomes heavier and denser.
- Lower layer : Liquid temperature rises and density decreases due to heat input

Rollover phenomenon

③ Rollover occurs
The difference in density between LNG layers becomes the same, and the two layers are mixed within a short time. At this time, the heat energy stored in the lower layer is rapidly released as BOG.



Countermeasures for rollover

- ✓ **Analysis of LNG to be mixed**

  Confirmation of composition, temperature, and liquid density of the liquid to be mixed

- ✓ **Operational measures**

  Installation of receiving nozzles from the top and bottom
  Tank selection at the time of LNG receiving

- ✓ **Detection of rollover**

  Monitoring Temperature difference and density difference in the height direction in the tank

- ✓ **Countermeasure to prevent Two-layer separation**

  Transfer to another tank and mixing with other tank liquids
  Liquid circulation in own tank

WG2: IPP Project Evaluation Methodology
-Thermal power plant-
2nd Class : Supplemental Explanation on Check list

The Chugoku Electric Power Co., Inc.

中国電力株式会社
THE CHUGOKU ELECTRIC POWER CO.,INC

Contents

1. Fuel Supply
2. Power Plant Site
3. Proposal of Project
4. Labor Safety

Contents

1. Fuel Supply

1.1 Fuel Source

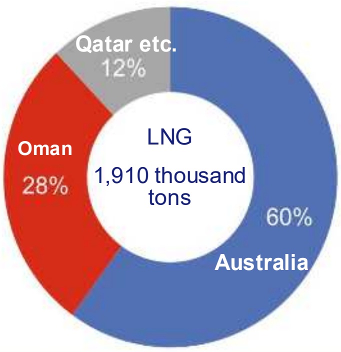
✓ **Check Point**

To enable stable procurement, check the financial status and fuel supply experience of the fuel supplier.

To make sure that the fuel supply contract period matches the IPP project period.

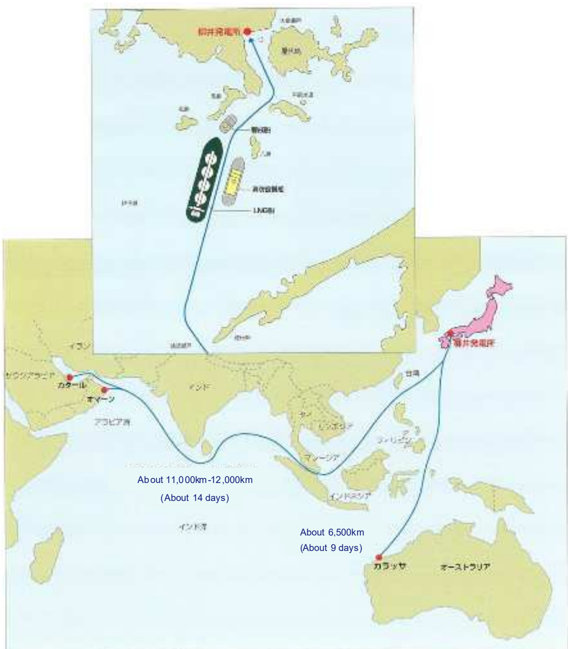
✓ **Reference**

Chugoku procures LNG mainly from Australia, the Middle East and other countries under long-term contracts



Chugoku Electric Power Co., Inc.
Thermal fuel consumption 2018

LNG import route (CEPCO)



1.2 LNG Quality

✓ **Description**

- Natural gas is mainly composed of methane (CH4), and its proportion varies depending on country of origin
- Since the calorific value differs depending on the component ratio, it affects the combustion of the gas turbine.

✓ **Check Points**

- Gas calorific value, Gas property, Environmental impact property such as nitrogen and sulfur
- The consistency between the concentration of exhaust gas and local environmental regulations
- The fuel is suitable for the Gas Turbine specifications.

Composition of natural gas (Example) (volume %)

	Methane	Ethane	Propane	Butane	Nitrogen
Alaska	99.8	0.1	-	-	0.1
Sakhalin	92.8	3.9	1.7	0.8	-
Brunei	88.8	5.6	3.7	1.8	0.1
Indonesia	87.7	6.9	3.1	1.8	0.4
Qatar	89.9	6.6	2.3	0.4	0.2
Australia	87.5	8.3	3.3	0.4	0.1
Malaysia	91.6	4.1	2.7	1.4	0.1
Canada	91.9	2.0	0.9	0.3	4.9
Abu Dhabi	75.1	23.1	1.7	0.1	-
Algeria	83.7	6.8	2.1	0.8	5.8

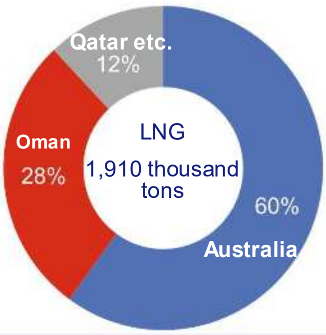
1.3 Fuel Handling Facility

1.3.1 Transport Distance

✓ **Check Point**

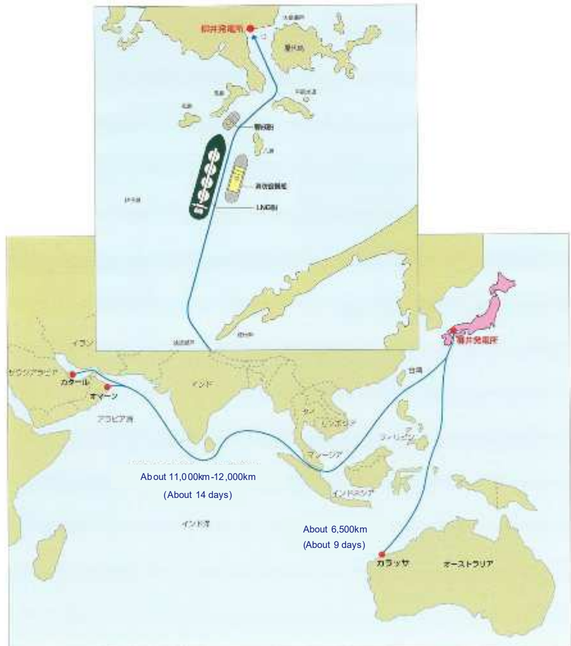
Confirm if the required amount can be procured by LNG carriers considering:

- LNG consumption at the power plant
- The distance to power station
- The number and the capacity of LNG carriers.



Chugoku Electric Power Co., Inc.
Thermal fuel consumption 2018

LNG import route (CEPCO)

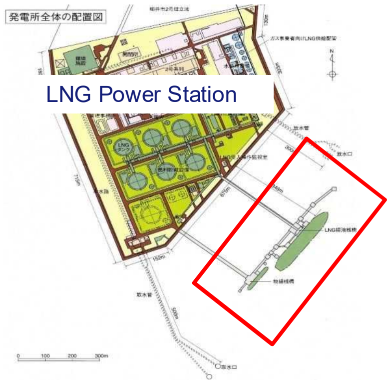


1. Fuel Supply

1.3.2 Unloading Place and LNG Jetty of Power Plant

✓ Check Points

Confirm feasibility of pier docking of LNG carriers considering vessel size, water depth of jetty.



Contents

2. Power Plant Site

2.1.1 Location

✓ **Check Points**

To confirm following points:

- Feasibility of pier docking of LNG carriers
- The distance to transmission lines
- The distance to rivers as water source
- Access roads
- Recirculation of thermal discharge
- Securing fresh water
- Obstacles such as unexploded ordnance and mines

2. Power Plant Site

2.2 Traffic

✓ **Check Points**

To confirm following points:

- Air transportation method
- Sea transportation method
- Land transportation method
- Maximum transportable amount

Contents

3. Proposal of Project

3.1.1 Water Source for Power Plant and Cooling Mode

✓ **Check Points**

To confirm feasibility of water intake work, effect of thermal discharge

IPP needs to procure cooling-water to cool-down equipment for operation from sea/river. It is necessary to confirm if power plant can access such water source. The temperature of cooling water after heat exchange rise and return back to sea/river. You need to confirm if thermal impact is acceptable environmentally.

3.1.3 Construction Area

✓ **Check Points**

To confirm area of storage for construction material is enough

Contractor uses a lot of equipment/parts during construction. So storage space for such material is necessary.

3.1.4 Living Area

✓ **Check Points**

To confirm if accommodation for personnel for both construction and Operation & Maintenance is considered

3.1.5 Work area for periodic inspection

✓ **Check Point**

To confirm working area and accessibility for equipment are enough when periodic inspection

3.1.6 Crane for periodic inspection

✓ **Check Point**

To confirm the crane for periodic inspection to be installed

3.1.7 Mobile crane approach route for inspection of each equipment

✓ **Check Points**

Confirm the mobile crane access route for work

3.1.9 Planning of Transportation and Roads

✓ **Check points**

To confirm stable procurement and supply method of fuel, chemicals, consumables.

Contents

■3.2.1 estimated performance curve

✓ **Description**

It is known that plant efficiency shall drop gradually due to performance degradation. As a result of the degradation, IPP might not generate rated output in the future.

IPP should take such degradation into account so that IPP can generate rated output to satisfy requirement of PPA even in a few decades.

✓ **Check Point**

Confirm consistency between PPA and plant net output capacity taking performance degradation into account.

3.2.2 Power generation range
3.2.3 Load demand response
3.2.4 Unsteady operation

IPP shall comply with requirements by Grid System Operator and Power Purchase Agreement ("PPA"). You need to confirm if proposal comply with them.

✓ **3.2.2 Power generation range**

✓ **Check Point**

You need to confirm if following item of proposal comply with PPA.

✓**Minimum Load**

Minimum Load is the lowest possible output (MW) for stable and continuous operation under fully automatic control. IPP shall be capable of being dispatched at the Minimum Load whenever required by the Grid System Operator. Minimum Load of GTCC is basically around 15%.

✓**Rated Load**

IPP might not generate rated load due to aging performance degradation in a few decades. It is necessary to confirm performance degradation assumption.

✓ **3.2.3 Load demand response**

✓ **Check Point**

You need to confirm if IPP has capability on following items as per PPA/requirement by Grid

✓ **Dispatch Ramp Rate**

IPP shall be capable of meeting dispatch ramp rate requirements. Dispatch ramp rate for GTCC is basically around 10%/min

✓ **Reactive Power Capability**

e.g. IPP shall be capable of supplying full load at any point between 0.85 power factor lagging and 0.95 power factor leading at the generator terminals.

3.2.4 Unsteady operation

✓ **Check items**

Even in case of trouble, IPP have to continue stable operation as much as possible. Grid System Operator/PPA requires IPP to keep stable operation even in the event of trouble. You need to confirm if IPP has following capability as per PPA/requirement by Grid. e.g.:

✓ **House Load Operation**

The occurrence of certain faults or disturbance incidents in the grid system leading to tripping of the associated high-voltage circuit breaker (HVCB) may result in the disconnection of generating units from the grid system. In the event of such disconnection, IPP have to keep operation supplying the house load without trip.

✓ **Runback**

IPP shall keep steady operation even in case one of the duty running machines trip. When duty running machine trip, output decrease rapidly and automatically to continue operation.

✓ **Gas turbine independent operation when steam turbine operation is unavailable**

Capability to continue operation with only gas turbine when steam turbine get unavailable

3.2.5 Auxiliary power ratio

✓To confirm rationality of auxiliary power consumption rate. Generally, it is around 2.3%.

$$\text{Auxiliary power consumption rate} = \frac{\text{Auxiliary Power consumption(MW)}}{\text{Gross output(MW)}}$$

3.2.6 Electric power supply plan

✓To confirm if following item fits with PPA

- Period of power plant operation : e.g. 25 years
- Availability Factor: e.g. 85%

$$\text{Availability} = \frac{\text{Available Hour (hr)}}{\text{Period Hour (hr)}}$$

- Capacity Factor : e.g. 80%

$$\text{Capacity factor} = \frac{\text{Actual Generration (MWh)}}{\text{Maximum Generation(MWh)}}$$

Reference: IEEE Std 762™-2006

Contents

✓ **Common Check Points**

- To make sure competency of manufacturer by checking delivery record and past trouble record

3.3.1 Selective catalytic reduction(SCR) system, Flue gas desulphurization (FGD) system

✓ **System Description**
- SCR is the equipment that removes NOx from the flue gas
- FGD is the equipment that removes SOx from the flue gas

SCR

✓ **IPP shall comply with environmental regulation such as;**
- NOx
- SOx
- CO

✓ **Check Points**
- Such treatment facility is capable of treating flue gas to comply such regulation
- Environmental regulation in your country
- Fuel property

As LNG is almost SOx-free fuel, FGD is basically not necessary. However, you need to confirm property of fuel just in case.

3.3.2 Emergency generator

✓ **System Description**

In case of black out of power station, the emergency diesel generator supply power to operate the plant.

✓ **Check Points**
- Capacity of emergency generator

The emergency diesel generator should be capable of operating the plant for safety shutdown including essential load requirements in blackout condition. The emergency diesel generator set is basically composed of 2 sets of generators as redundancy and have some capacity margins to the total load requirements.

Emergency generator

3.3.3 Start-up Boiler (Auxiliary Boiler)

✓**System Description**

Start-up boiler is required for following purpose during start-up of the power station:

- To supply gland steam at steam turbine when start-up of power station to build up the vacuum in the condenser
- For warming-up and deaeration of feedwater at feedwater tank

✓ **Check Points**

capacity to provide enough amount of steam required for start-up.

3.3 Main Technical Specification of BTG

3.3.4 Heat recovery steam generator(HRSG), Material design of heat exchanger tube

✓**System Description**

The heat recovery steam generator (HRSG) is the equipment that utilize exhaust gas from a combustion turbine and produces steam rotating steam turbine. A heat recovery steam generator is used in a combined-cycle power station.

✓ **Check Points**

To confirm heat resistance and corrosion resistance against sulfidation of heat exchanger panel materials, and countermeasures against flow-accelerated corrosion

HRSG

Tubes inside HRSG

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Energia

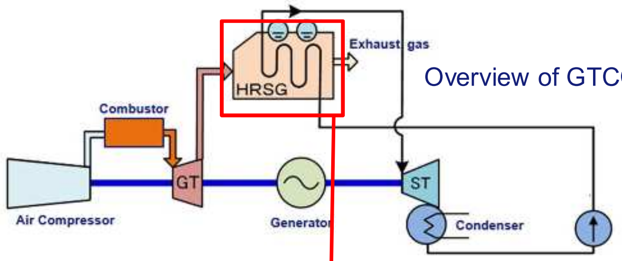
3.3 Main Technical Specification of BTG

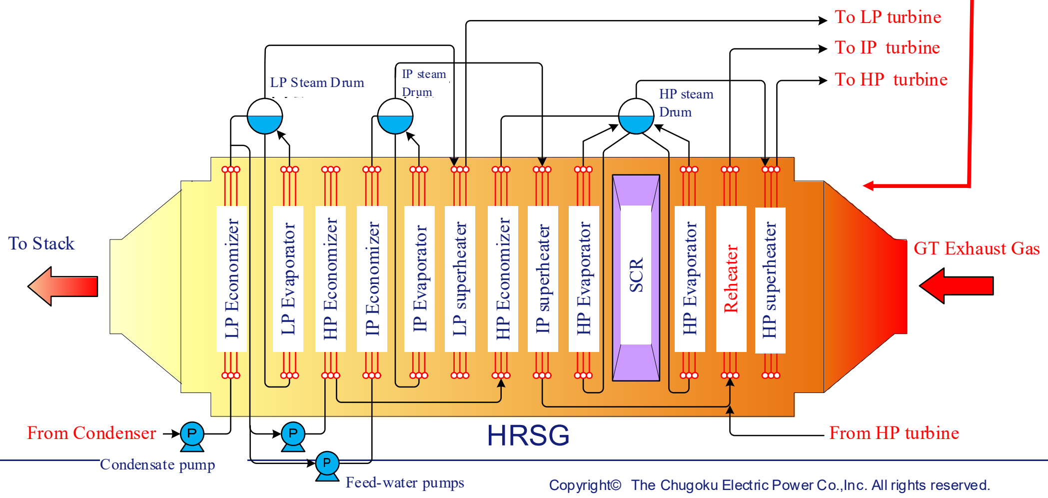
3.3.5 Main Steam, Reheat Steam and Turbine Bypass System

✓ **System Description**

- **Main steam/Reheat steam**

  The main steam system transports steam from HRSG to ST. Exhaust steam from the HP turbine (cold reheat) come back to HRSG and go through the reheater. Steam from the reheater is conveyed to the IP turbine. The steam for LP turbine come from the LP superheaters.





Energia

3.3 Main Technical Specification of BTG

3.3.5 Main Steam, Reheat Steam and Turbine Bypass System

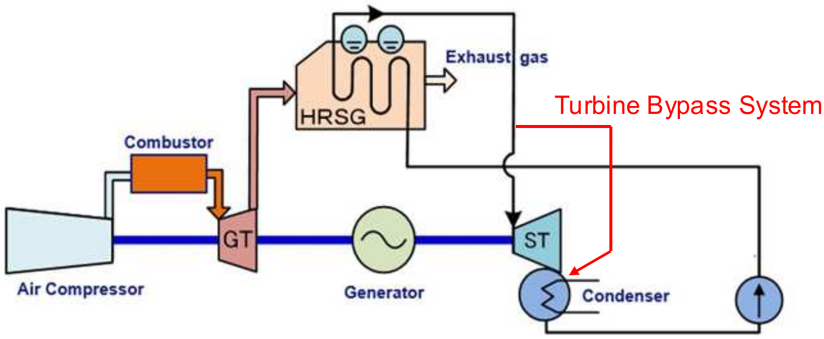
✓ **System Description**

- **Turbine Bypass system**

  The turbine bypass system accommodates the steam generated in the HRSG during CTG startup before STG admission, to ensure that steam temperature matches the STG metal temperatures during any type of startup event. In addition to that, turbine bypass system enables the CTG to continue operation at full load even in the case of STG trip. The system will divert 100 percent of the HP, re-heater steam and LP steam flow at rated pressure to the condenser.

✓ **Check points**

Capacity of turbine bypass system to enable CTG to continue operation in case of STG trip if independent operation of CTG is required



Energia

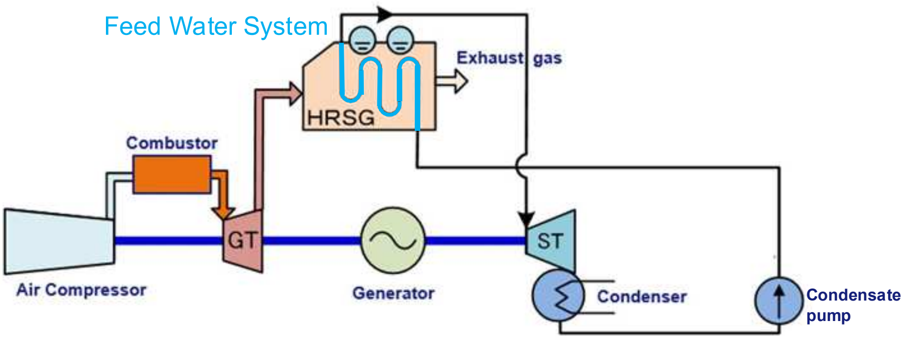
3.3.6 Feed Water System

✓ **System Description**

Feedwater system supply heated, deaerated feedwater to the HP and IP economizer in the HRSG.

✓ **Check Points**

- Consistency with capacity
- Feedwater chemical control is accomplished through packaged chemical injection units



3.3.7 Extraction Steam System
3.3.9 Heater Draining System

System for Thermal Power Station

✓ **System Description**

Steam is extracted from the steam turbine at various stages and used to heat the condensate and feedwater through various heaters. This results in higher cycle efficiency, as the temperature of condensate and feedwater is increased, also, reducing the amount of energy loss by turbine exhaust steam in the Condenser. Steam utilized at heater become drain and go to condenser.

✓ **Check Points**

To confirm Extraction Steam System is incorporated as to make efficiency high if it is thermal power station.

3.3 Main Technical Specification of BTG

3.3.8 Condensed Water System

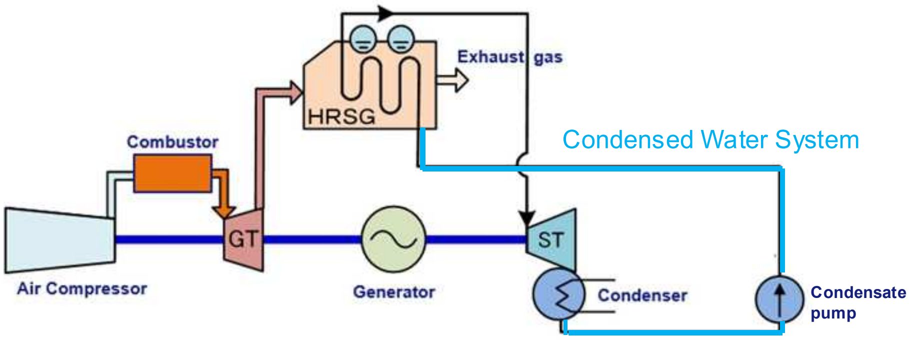
✓ **System Description**

Condensate system removes condensed LP turbine exhaust steam and other process drains from the condenser and pump the condensate water to the LP economizer section of the HRSG.

The condensate system includes the condenser, condensate pumps, gland steam condenser, valves and controls necessary for system operation and protection.

✓ **Check Point**

- Consistency with capacity



Energia

3.3 Main Technical Specification of BTG

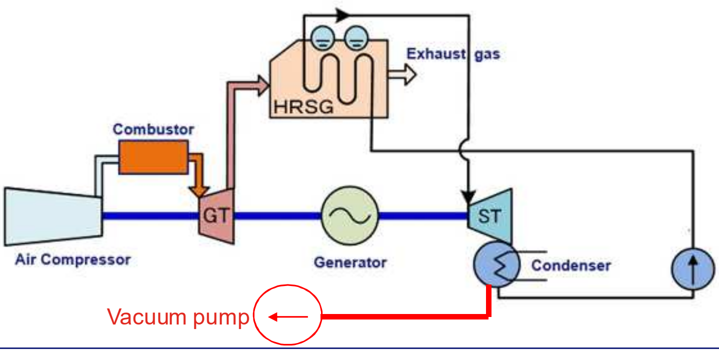
3.3.10 Vacuum-pumping System for Steam Condenser

✓ **System Description**

The condenser includes an air removal system consisting of two vacuum pumps to hold condenser vacuum. Each pump capable of holding condenser vacuum during operation.

✓ **Check Points**

- Redundancy of vacuum pump
- Capacity of vacuum pump to hold condenser vacuum



Energia

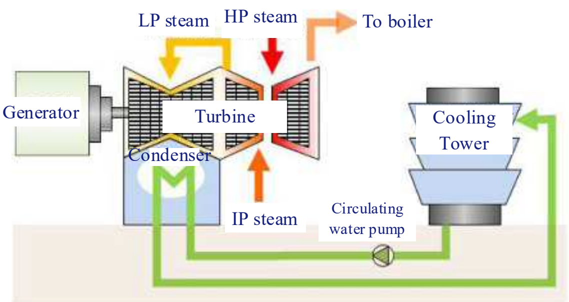
3.3.11 Circulating Water System

✓ **System Description**

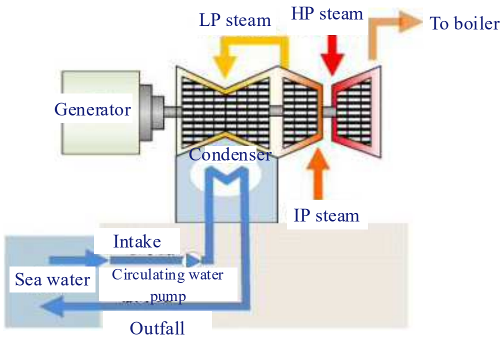
Circulating water system provide a continuous supply of circulating water to the facility.
Recirculating type of system use a cooling tower as the heat sink. Components of the heat sink system includes the cooling tower, circulating water pumps, surface condenser, and closed cooling water heat exchangers. For 1,000MW class power station, Seawater cooling is preferable because heat efficiency is better than cooling tower.

✓ **Check Point**

- Redundancy of pump
- Consistency with capacity



Power plant at inland
Cooling tower cooling



Power plant along the coast
Seawater cooling

3.3.12 Closed Circulating Cooling Water(CCCW) System

✓ **System Description**

The CCCW system provide closed cooling water to water-cooled components. The CCCW system uses plate and frame heat exchangers as the heatsink. Equipment requiring water cooling includes:

- STGs/CTGs
  - Lubricating oil coolers
  - Hydraulic coolers
  - Generator hydrogen coolers

✓ **Check points**

- Redundancy of CCW pumps
- Consistency with capacity

3.3.13 Auxiliary Steam System

✓ **System Description**

The Purpose of Auxiliary Steam System is to provide auxiliary steam to various equipment, from Auxiliary Steam Header. It shall be used to provide dry superheated steam to the following consumers:

- Pre-warming of main Steam Turbine before start up.
- Turbine gland steam seal during start-up till the turbine self-sealing system is in operation.
- Deaerator & Feedwater Tank initial heating.

✓ **Check Points**

Capacity to provide enough amount of steam required for start-up.

3.3 Main Technical Specification of BTG

3.3.14 Main Electrical Wiring

✓ **System Description**

Electricity is supplied with each equipment thorough electrical wiring. Its thickness differ subject to voltage.

✓ **Check Points**

- Wiring within desks and panels shall be supported on trays and shall be segregated according to voltage level.
- Wiring carrying AC and D.C. voltage shall also be segregated.
- All desks, panels, cubicles and racks shall be factory-wired with regard to the internal connections.

3.3.15 Power System

✓ **System Description**

The Excitation control system with Power System Stabilizer (PSS) is required for constant terminal voltage control of the Unit in responding to deviations in interconnection voltage, without instability over the entire operating range of the Unit.

✓ **Check Point**

If PSS is required by Grid System Operator/PPA. Confirm consistency of them.

3.3 Main Technical Specification of BTG

3.3.16 Auxiliary Power Ratio

Same as 3.2.5

✓**Check Point**

To confirm rationality of auxiliary power consumption rate. Generally, it is around 2.3% for 1,000MW power class unit.

$$\text{Auxiliary power consumption rate} = \frac{\text{Auxiliary Power consumption(MW)}}{\text{Gross output(MW)}}$$

Contents

3.4 LNG handling facility

3.4.1 LNG unloading system

✓ System Description

Operator receive LNG with loading arm from LNG carrier.

✓ Check Points

- Confirm the LNG carrier and the loading arm match.
- Confirm the emergency shutdown system is equipped.

  Emergency shutdown system enable separate between LNG carrier and loading arm immediately in case of emergency trouble such as fire.

3.4 LNG handling facility

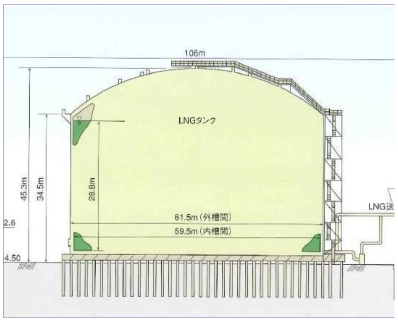
3.4.2 LNG storage system
3.4.5 LNG tank capacity(fuel)

✓ **System Description**

Since liquefied natural gas is extremely cold, the tank has a double wall (double shell), and the parts in contact with the liquid is made of a material that can withstand low temperatures. Steel plates and concrete are used on the outside.

✓ **Check Points**

- Check the capacity of the LNG tank is sufficient for stable operation, taking LNG receiving plan into consideration. You need to consider the risk of delay of receiving LNG due to bad weather and delay in ship allocation from the time of planning.
- Confirm the heat insulation and capacity to resist pressure of the tank, and the fire extinguishing system in case of fire.
- Make sure it complies with your country's regulations.

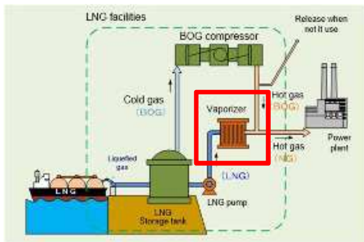


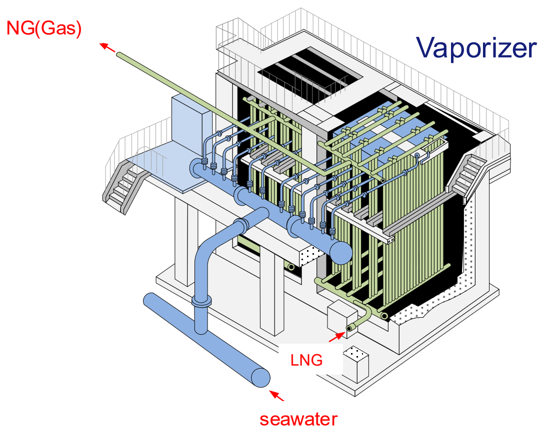
(Yanai Power Plant)
Six LNG tanks, each capacity is 80,000kl.

3.4 LNG handling facility

3.4.3 LNG vaporization system

- LNG passes through a heat transfer tube, and the outer surface of the heat transfer tube is heated with seawater.
- The heated gas is called hot gas and is sent to the gas turbine as fuel for power generation.





✓ **Check Point**

- Confirm the seawater temperature is taken into consideration as it affect efficiency of vaporization system.

3.4 LNG handling facility

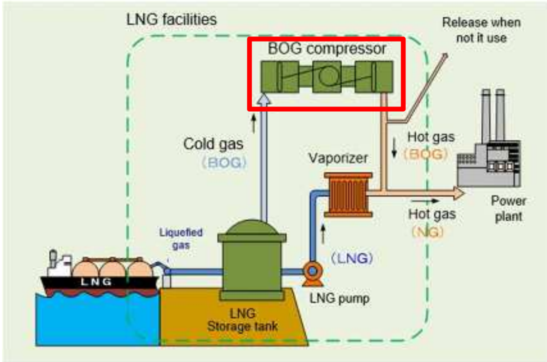
3.4.4 Boil off gas system

✓ **System Description**

- A part of LNG is naturally vaporized and gasified during the receiving or storage. This gas is called BOG (BOG: Boil Off Gas).
- The component of the BOG is methane(CH_4). This is because methane has the lowest boiling point and is vaporized first.
- BOG stays in the upper part of the LNG storage tank and raises the tank internal pressure, so it is necessary to extract the BOG. BOG generated inside the tank has a low temperature (about -160 to -140 ˚C) and is called cold gas. BOG is boosted by a BOG compressor and then mixed with hot gas (NG) and supplied to the gas turbine.

✓ **Check Point**

- Confirm that its capacity is enough considering the amount of gas generated much at the receiving of LNG.



3.4 LNG handling facility

3.4.6 LAG tank capacity（ammonia for SCR system）

✓ **System Description of Ammonia Storage**

An ammonia storage and delivery system is provided to store and deliver aqueous ammonia to the HRSG SCR for NOx reduction. Trucks deliver aqueous ammonia solution to the site. Aqueous ammonia is stored in storage tanks, and is pumped from the tanks by pumps to the HRSG.

✓ **System Description of SCR**

An SCR system is incorporated into the HRSGs for NOx control. Aqueous ammonia is vaporized using CTG exhaust gas as a heat source. The ammonia and CTG exhaust gas mixture is introduced to the flue gas. The ammonia and NOx pass through the catalyst, which converts the NOx to N2 and H2O vapor.

✓**Check Point**

- To confirm spill prevention measures from ammonia tank (e.g. installation of ammonia detector, double-walled tank)
- Consistency between consumption and capacity of ammonia tank

Ammonia tank

3.4 LNG handling facility

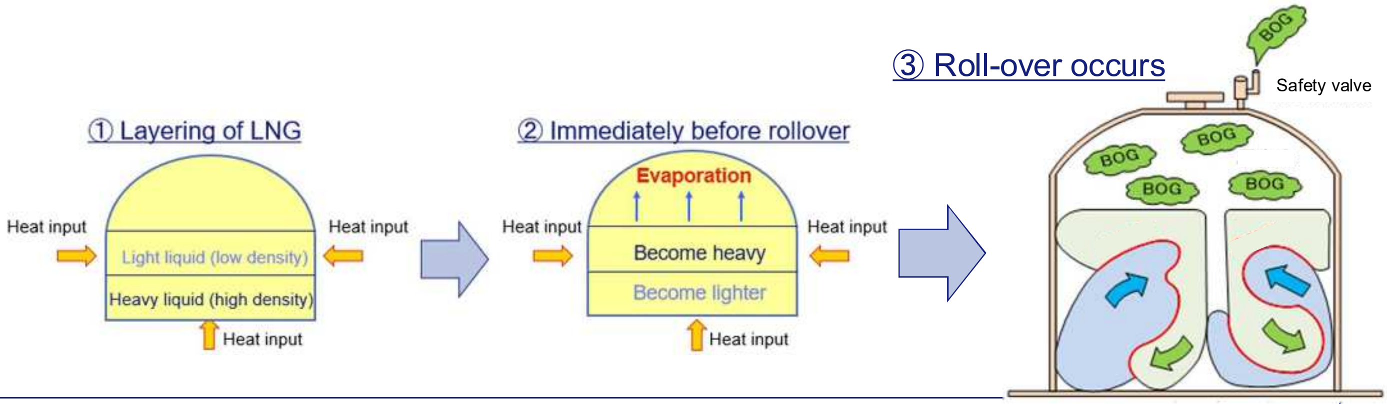
3.4.7 Preparation for handling of light LNG

✓ General Description

When operator store light and heavy LNG in one tank, operator need to handle carefully. If different type of LNG mixed in the tank, a lot of BOG (Boil off Gas) generate due to friction heat, which is called Rollover.

✓ Check Point

Confirm that measures are taken to prevent the rollover phenomenon of the LNG tank such as receiving procedure and density detection system



Contents

3.5.1 Water Source and Water Quality

✓ **System Description on Raw Water System**

Raw water is injected with sodium hypochlorite and treated in a pre-filter. The pre-filter act as a roughing filter to reduce the total suspended solids (TSS) concentration.

✓ **Check Points**

- Accessibility to water source such as availability of water pipeline
- To confirm if water quality and amount satisfy requirement of unit

3.5.2 Boiler Make-up Water Treatment System

✓ **System Description**

The water treatment system is generally the equipment that removes minerals and other impurities in the water, which is used in the condensate/feedwater system and the condenser and cooling water system.

✓ **Check Points**

To confirm if water quality comply with requirement of unit

3.5.3 Chemical Dosing System

✓ **System Description**

The function of the HRSG feedwater chemical injection system is to control steam cycle chemistry to minimize corrosion. For example, amine feed pumps inject ammonium hydroxide for pH control into the condensate pump discharge.

✓ **Check Point**

To confirm chemical dosing system enable water purity to satisfy the requirement of HRSG and ST

3.5.4 On-Line Water and Steam Sampling and Analysis System

✓**System Description**

Water treatment system has appropriate instruments for continuous analysis of water quality. Water quality input from these analyzers is sent to the DCS (Distributed Control System) for trending and report development so that operator can monitor the status at all times.

Example of analyzed items are following:

- Conductivity
- pH
- Dissolved oxygen

✓ **Check point**

To confirm monitoring item covers required water quality

3.5.5 Circulating Cooling Water Treatment System

✓ **System Description**

The function of the cooling tower chemical injection system is to inject chemical solutions into the cooling tower circulating water for chemistry control. The system include:

- Cooling tower pH control system
- Cooling tower chlorination system

✓ **Check Points**

To confirm if water quality satisfy requirement of unit

3.5.6 Central Industrial Waste Water Treatment
3.5.7 Oil Treatment System

✓ **System Description**

Plant wastewater is discharged to sea or river after treatment. It is monitored for compliance with effluent limitations before discharging. For example, IPP have to comply following parameters:

- PH
- Temperature
- Oil and grease
- Phosphorus

✓**Check Point**

To confirm waste water treated comply regulation in your country

Contents

3.6 On-site monitoring system

3.6.1 Continuous Emission Monitoring System (CEMS)

✓ **System Description**

The continuous emissions monitoring system is the equipment that monitors emissions. For example, CEMS monitors following concentration in flue gas:

- NOx
- SOx
- CO

✓ **Check point**

To confirm if CEMS cover all item required to monitor as per regulation in your country

3.6 On-site monitoring system

3.6.2 Closed Circuit Television System
3.6.4 Entrance Guard System and Patrolling System

✓ **System Description**

The Closed Circuit Television System(CCTV) system is for the process supervision for plant operation and the intrusion supervision.

✓ **Check Point**

To confirm covered area is enough in terms of security

CCTV

3.6 On-site monitoring system

3.6.3 Fire Alarm System

✓ **System Description**

The fire protection system is the equipment that detects, suppresses and extinguishes fires.

✓ **Check Point**

To check conformity with regulation in your country

Contents

Energia

3.7 Safety measures

3.7.1 Fire protection plan, quantitative risk assessment for LNG

✓ **General Description**

IPP shall submit the fire protection plan/strategy, which includes:

- Fire fighting system
- Detection system (Smoke detection, heat detection, gas detection, LNG spill detection)
- Fire scenario (affecting zone in case of leakage of LNG from tank)

✓ **Check Point**

To confirm it comply with regulation in your country

Energia

3.7 Safety measures

3.7.2 Countermeasures for handling light LNG

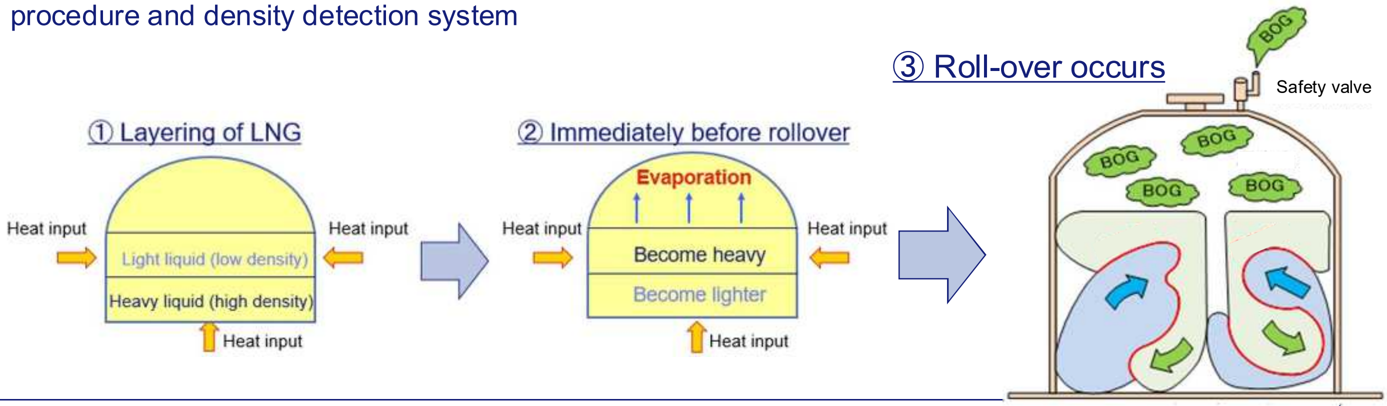
Same as 3.4.3

✓ **General Description**

When operator store 2 kind of LNG, light and heavy LNG in one tank, operator need to handle carefully. If different type of LNG form layer and mixed suddenly in the tank, a lot of BOG (Boil off Gas) generate due to friction heat, which is called Rollover.

✓ **Check Point**

Confirm that measures are taken to prevent the rollover phenomenon of the LNG tank such as receiving procedure and density detection system



3.7 Safety measures

3.7.3 Firefighting facilities

✓ **System Description**

Purpose of firefighting system is to protect the life safety and property from the hazards created by fire in this plant. For example, firefighting facility is consist of following facilities:

- Fire Water Storage Tank
- Fire Water Pump
- External Hydrant System
- Automatic Water Spray System
- Automatic Sprinkler System
- Fixed CO2 Fire Extinguishing System
- Portable Fire Extinguishers
- Fire Detection and Alarm System
- Smoke Exhaust System
- Anti-static

✓ **Check Point**

To check if the fire fighting system comply with regulation in your country

4. Labor Safety

✓ **Safety Personnel**

Contractor shall assign a full-time Project Site safety officer who shall be responsible for introducing, administering, and monitoring procedures to promote safe working conditions on the Project Site and compliance with Applicable Law.

Contractor shall furnish adequate numbers of trained, qualified, and experienced personnel and appropriate safety and other equipment in good condition, suitable for performance of the Work.

✓ **Check Point**

To confirm contractor comply with regulation in terms of safety