

モザンビーク共和国  
モザンビーク電力公社（EDM）

モザンビーク国  
火力発電所運営能力向上プロジェクト  
業務完了報告書

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独立行政法人  
国際協力機構（JICA）

東電設計株式会社

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## 添付資料

### ・キックオフ資料



- ・キックオフ議事録
- ・Clarification まとめ資料
- ・Online academy 資料
- ・契約管理能力強化資料
- ・財務管理能力強化資料
- ・現地調査議事録
- ・Work Shop 資料

#### 別冊

- ・O&M マニュアル
- ・HRD マニュアル

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## 略語表

|                    |                                                     |
|--------------------|-----------------------------------------------------|
| APUA               | African Power Utilities Association                 |
| BOT                | Boards of Trustees                                  |
| CTM                | Central Térmica de Maputo                           |
| EDM                | Electricidade de Mocambique, EP                     |
| EPC contractor     | Engineering Procurement and Construction Contractor |
| GTCC               | Gas Turbine Combined Cycle                          |
| HRD                | Human Resource Development                          |
| HRSG               | Heat Recovery Steam Generators                      |
| JICA               | Japan International Cooperation Agency              |
| KGRTC              | Kafue Gorge Regional Training Center                |
| LTSA               | Long-Term Service Agreement                         |
| manuals/procedures | Manuals/procedures/records/drawings                 |
| O&M                | Operation and Maintenance                           |
| PLC System         | Programmable Logic Controller System                |
| PMIS               | Plant Management Information System                 |
| RAM                | Responsibility Assignment Matrix                    |
| SADC               | Southern African Development Community              |
| TEPSCO             | Tokyo Electric Power Services Co., Ltd              |

# 1. プロジェクトの概要

## 1.1. プロジェクトの背景と目的

モザンビークでは、近年の順調な経済成長から全国的な電力需要の増加が見込まれており、人口約 120 万人を擁する首都マプト市を含む南部系統の電力需要も飛躍的に増加することが見込まれている。円借款事業「マプト・ガス複合式火力発電所整備事業」では、国産の天然ガスを燃料とする 106MW のガス複合式火力発電所（以下「マプト火力発電所」）の建設を支援した。マプト火力発電所は、モザンビーク電力公社（Electricidade de Mocambique, E. P.、以下「EDM」）自前で運営する初のガスタービン・コンバインドサイクル（Gas Turbine Combined Cycle、以下「GTCC」）発電所であり、円借款のコンサルティングサービスなどで運営および維持管理（Operation and Maintenance、以下「O&M」）の技術支援を実施し、2018 年 8 月に運開した。発電所の主たる機器が長期保守サービス（Long-Term Service Agreement、以下「LTSA」）の対象となっていることもあり、問題の発生に対しても適切な技術支援を受けられる状況にある。

しかし、大半の発電所従業員は過去に発電所の O&M に従事した経験がなく、発電所内の O&M についての人材育成体制を強化していく必要がある。特に O&M の経験を積むに従って、経験に応じた技術者階層と技術研修の整備が必要である。さらに EDM 自らが運転実績に基づいた O&M データの分析を行うことで、保守計画を最適化し、中長期的に保守・修繕費を漸減させていくことが事業収益性を高めていくうえで重要な課題となっている。この際、日本の電力会社の知見を活用しながら円借款事業で導入した発電所管理情報システム（Plant Management Information System、以下「PMIS」）を一層活用していくことに加えて、財務・契約・調達の各分野における管理能力の強化が求められる。

以上に鑑み、火力発電所運営能力向上プロジェクトでは、発電所の O&M に係る技術移転や組織体制、さらには人材育成体制を強化することにより、EDM による持続的かつ安全・効率的な発電所の O&M を実現し、円借款事業のさらなる効果発現の促進に寄与することを目的とする。

## 1.2. プロジェクトの基本情報

### 1.2.1. プロジェクトの基本方針

本プロジェクトは、EDM のマプト火力発電所組織による自立的・持続的かつ安全・効率的な O&M 能力の強化を目的とし、単に発電所技術者個人の技術能力強化を図るものではなく、①発電所組織として体系的に O&M を実施出来る仕組みの構築、②そのために不可欠な人材育成のためのプログラム構築の支援を本邦電力会社の知見・ノウハウも共有しながら実施する。

また、体系的な O&M の仕組み、人材育成プログラムとともに③本プロジェクト終了後も計画的・持続的に実施され、実施した結果の評価および改善が図られるように配慮する。

体系的な O&M の仕組み構築と人材育成プログラムの構築は自立的な O&M 能力強化に必要な両輪であり、並行して両方の仕組みを整備することで、発電所組織としての O&M 能力向上、発電所員個々人の O&M 能力向上が図られる。

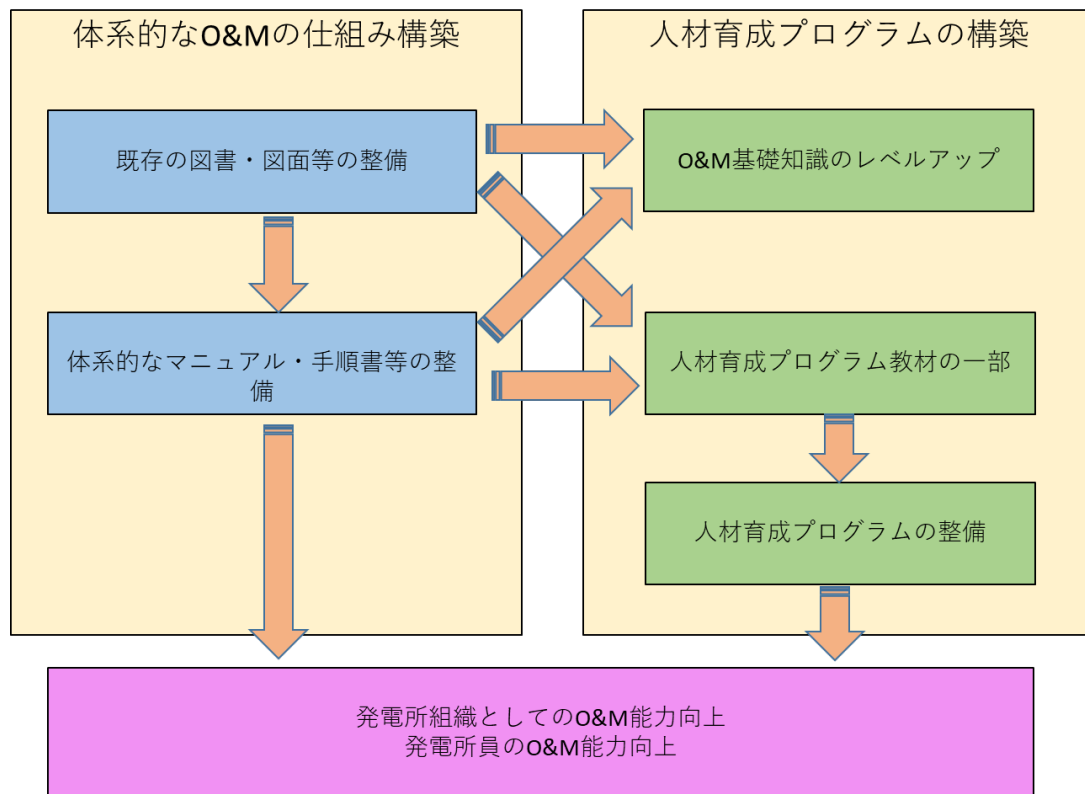


図 1.2-1 自立的な O&M 能力強化の両輪

#### (1) 体系的な O&M の仕組み構築

モザンビークは火力発電所が少ないのでマプト火力発電所の O&M 経験者は限られている。そのため、体系的な O&M の仕組みは無く、発電所建設中に設計調達建設請負者（Engineering Procurement and Construction Contractor 以下、EPC コントラクターとする）からの運転指導や研修で得た技能・知見をもとに単発的・断片的に O&M が実施されている。自立的な O&M 能力を強化するには体系的・組織的な O&M の仕組みが必要であ

り、仕組みの構築を支援していく。

## (2) 人材育成プログラムの構築

マプト火力発電所の熟練社員は限られており、ほとんどが新規採用の若手社員で構成されている。そのため、マプト火力発電所は自動運転やコンピューター化された O&M 管理システムなどが導入されているものの、その基礎となる技術、システムの応用・活用といった技術を数少ない熟練社員から若手社員へどう継承していくかが課題である。また、EDM の全社的な人材育成プログラムはあるものの、主に送配電技術者用に作成されたプログラムであり、火力発電技術者に必ずしも合致するものではないようである。

この現状を踏まえ、本プロジェクトではマプト火力発電所と協議を重ねながら、人材育成プログラムおよび研修プログラムなどの構築を、技術的側面のみならず、組織の規律などの側面も考慮し支援していく。

### 1.2.2. マプト火力発電所の現状と課題

#### (1) マプト火力発電所の概要

モザンビークの首都マプトから約 6 キロメートル南東に位置するマプト火力発電所構内にモザンビーク初のコンバインドサイクル火力発電所が、円借款事業にてわが国の企業連合が設計調達建設契約（EPC 契約）で建設し、2018 年商業運転を開始した。マプト火力発電所は日本企業との間で 6 年間の長期保守契約を締結し主要機器の維持管理を行っている。

マプト火力発電所は首都圏への電力の安定供給上、重要な位置にある。そのため、この発電所の確実な O&M が必要であり、加えて、この発電所の O&M の取り組みが、これから開発が進むモザンビークでの火力発電所 O&M のモデルとなることも予想される。発電所は出力 106MW、ガスタービン発電設備 2 基、排熱回収ボイラー 2 基および蒸気タービン 1 基を主要機器、燃料設備、給水・排水処理設備、配電設備およびその他周辺機器で構成されている。



図 1.2-2 マプト火力発電所（上空より）

(2) EDM 本社、マプト火力発電所の組織体制

EDM 本社は経営管理部門、企画部門、人事部門および発電・送電・配電などの運転管理部門などで組織され、マプト火力発電所を管理する発電部は運転管理部門に位置する。

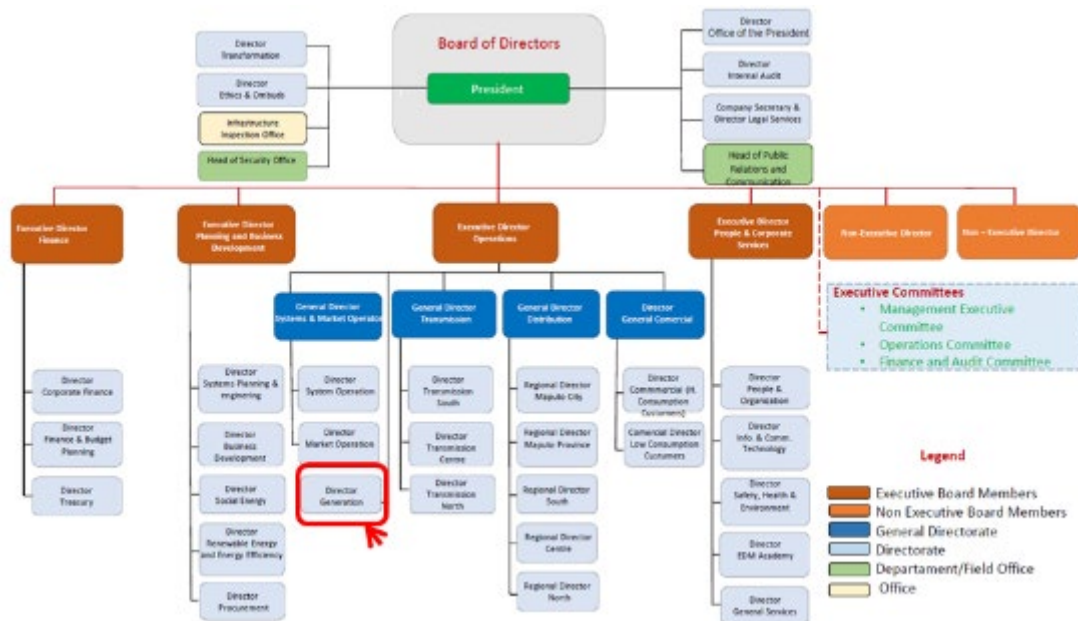


図 1.2-3 EDM 本社組織図

本社が策定した全社的な長期計画に基づき、マプト火力発電所では所長を責任者として運転グループ、保守グループと支援グループが協調しながら、発電所としての基本方針、年間の発電計画などを策定し、日常の O&M を実施している。発電所員の多くは建設開始に伴い 2017 年 3 月に採用された約 50 名の若手社員、営業運転後の 2019 年 3 月に新たに採用された約 15 名の若手社員のため、総勢約 70 名体制の中で発電所 O&M 経験がある熟練社員は限られている。





図 1.2-4 マプト火力発電所組織図

2021 年に EDM は組織の改編を実施している（図 1.2-5 参照）。しかしマプト火力発電所の役割に変更はない。

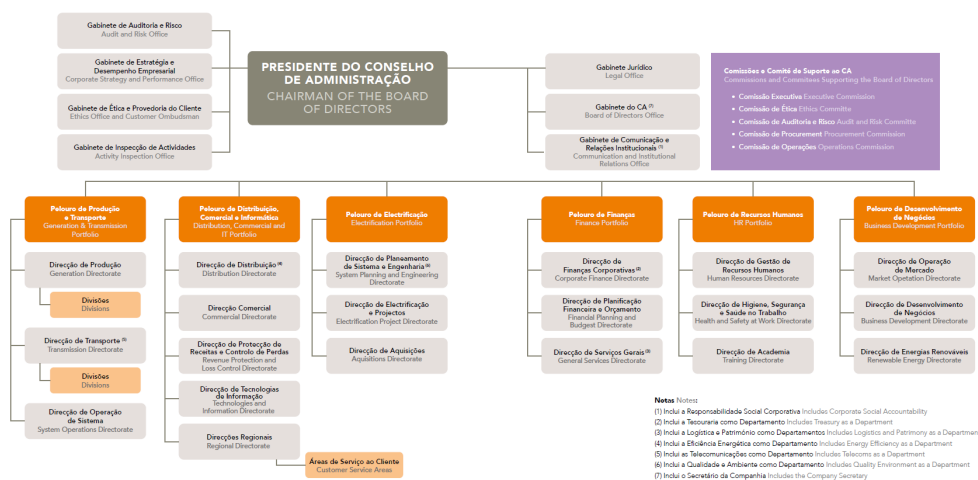


図 1.2-5 EDM 新本社組織図

### (3) マプト火力発電所の課題

#### ① 運転改善の必要性・保守強化の必要性

##### a. O&M 技術

円借款によるコンバインドサイクル発電設備建設以前は、発電所には電気エンジニア 1 名、機械エンジニア 2 名、運転員 1 名の計 4 名が常駐していたが、同発電所は電力ピーク対応用の軽油焚ガスタービン 3 台だけで運転実績は少なく、計画的な O&M は実施されていなかった。

したがって、コンバインドサイクル発電設備建設時に、O&M 体制構築と管理手法、所員の教育・訓練をほぼゼロからスタートしたような状況であった。

建設時に EPC コントラクターからの運転指導や研修で得た技能・知見をもとに、自らパトロールチェックシートを作成するなど、特に複雑な対応を必要としない通常運転操作などは実施出来るようになってきてはいるが、トラブル時の緊急運転保守対応、予防保全点検の計画的な実施などは EPC コントラクターからのサポートが現在も必要な状況である。

b. O&M 管理

ガスタービン、蒸気タービンおよび排熱回収ボイラーの主要機器は LTSA により日本の製造企業にて点検および運転支援が行われるが、ガス圧縮機などの周辺機器、変圧器など電気設備、計装制御設備、給水処理設備などの周辺設備は発電所員自らが運転保守管理しなければならない。

主要機器を LTSA で外注しても、多岐にわたる周辺機器や設備を適切・計画的に管理出来なければ、これら機器のトラブルにより発電停止や出力制限などが懸念される。

c. O&M の仕組み

火力発電所 O&M は EPC コントラクターから提出された O&M マニュアルだけでなく、運転と保守に直接関わる各業務、非常災害対応、トラブル対応、プラント性能管理、水質・薬品・潤滑油管理、発電所中長期計画、安全・環境管理、予算管理、法令遵守など多岐にわたる業務の全体像および各業務を把握したうえで、各業務の関連、各業務の責任所在などを明確にして進める必要がある。

② 人材育成体制強化の必要性

a. 現状の人材育成

既存円借款事業の中で EPC コントラクターにより熟練社員、若手社員一緒に机上研修と現場研修が実施されてきた。机上研修は主にコントラクターの各専門家が講師となりマプト火力発電所用に作成された研修資料をもとに日本と現場の会議室にて行われた。

しかし、会場スペースの問題、熟練社員の現場管理の多忙などから出席出来ない者が多かったうえ、テキストの共有化もされていないなど、研修内容が全員に浸透しているとは言えない。

既存の資料を有効活用するためにもこれらのテキストの整備・共有化を図ることも必要である。

b. 運転訓練シミュレーター研修

EPC コントラクターによりシミュレーター研修が実施されたが、現状あまり使われていないのが実情である。これまでのシミュレーター研修は EPC コントラクターによる単発的な研修であり、人材育成の中での位置づけ、若手社員と熟練社員での位置づけ、指導者のあり方などが明確にされていなかったことなどが原因と思われる。人材育成プログラムの中でシミュレーター研修の位置づけを明確にして効果的な研修が必要である。

③ 人材育成プログラム

上記のとおり、これまでは単発的な研修による人材育成だけであった。それでも発電所運転開始当初はモザンビーク初の最新鋭コンバインドサイクル発電設備ということもあり、発電所員は前向きに技術を吸収していたようだが、次第にモチベーションが下がり目標を見失っているようでもある。

システムだった人材育成プログラムの構築と発電所員のモチベーションが上がるような仕組みが必要である。

### 1.2.3. プロジェクト目標と期待される成果

#### (1) 目標

本プロジェクトは、ガスコンバインドサイクル発電のマプト火力発電所において、現在の EPC コントラクターに依存した O&M から脱却し、自立した発電所として安定・継続的な発電所運営が可能となるよう、体系的な O&M の仕組み、および、そのための人材育成強化に関する仕組みを構築する。

#### (2) 期待される成果

自立的・持続的かつ安全・効率的な O&M 能力の強化を目的として『体系的な O&M の仕組み構築』、『人材育成プログラムの構築』の整備を行い、下記の成果を得る。

##### ① 本プロジェクトによる最終成果

- 将来にわたって安定した発電所の運転、突発的な停止や出力抑制の防止により、マプト首都圏への安定した電力供給が行われる。
- O&M の全体・詳細を理解し、管理能力・技術力が向上する。
- 人材育成プログラムに基づいた研修が行われ、発電所技術者の技術力が向上する。

##### ② 本プロジェクトによる成果（プロジェクトにより整備される環境基盤）

###### a. 体系的な O&M がマプト火力発電所により実施される

- O&M 業務全体を網羅した O&M ガイドライン(仮称)に基づき、各発電所組織の責任と権限において運転や保守の各業務が実施される。
- O&M ガイドラインに基づく各マニュアル・手順などにより運転や保守の各業務が日常・中長期に渡り計画的に実施される。
- トラブル発生時などに適切な運転・補修対応が図られるよう、対応・報告手順などが整備される。
- 継続的な評価と改善が図られる仕組みが構築される。

###### b. マプト火力発電所にて人材育成プログラムが導入される(技術水準に応じた階層制度の構築・導入)

- 技術者に求められる育成水準（目標）に到達するための人材育成プログラムが策定される。
- 人材育成目標に到達するための研修プログラムが整備され、実施される。
- 業務品質に対する意識、モチベーション向上などを目的に技術者認定制度などが整備される。
- 継続的な評価と改善が図られる仕組みが構築される。

### 1.2.4. 実施期間

2020 年 8 月～2022 年 8 月（約 24 ヶ月）

### 1.2.5. 相手国側実施機関

モザンビーク電力公社（Electricidade de Moçambique, Empresa Publica : EDM）

### 1.2.6. 業務実施フロー

図 1.2-6 に業務全体の実施フローを示す。

① 第 1 ステージ：

- 発電所の現状を確認

② 第 2 ステージ：

- 既存の書類や記録を整理
- 体系的な O&M・人材育成プログラムのフレームワーク構築

③ 第 3 ステージ：

- 体系的な O&M・人材育成プログラムの構築

④ 第 4 ステージ：

- 体系的な O&M・人材育成プログラムの実施

⑤ 第 5 ステージ：

- 体系的な O&M・人材育成プログラムの評価・改善

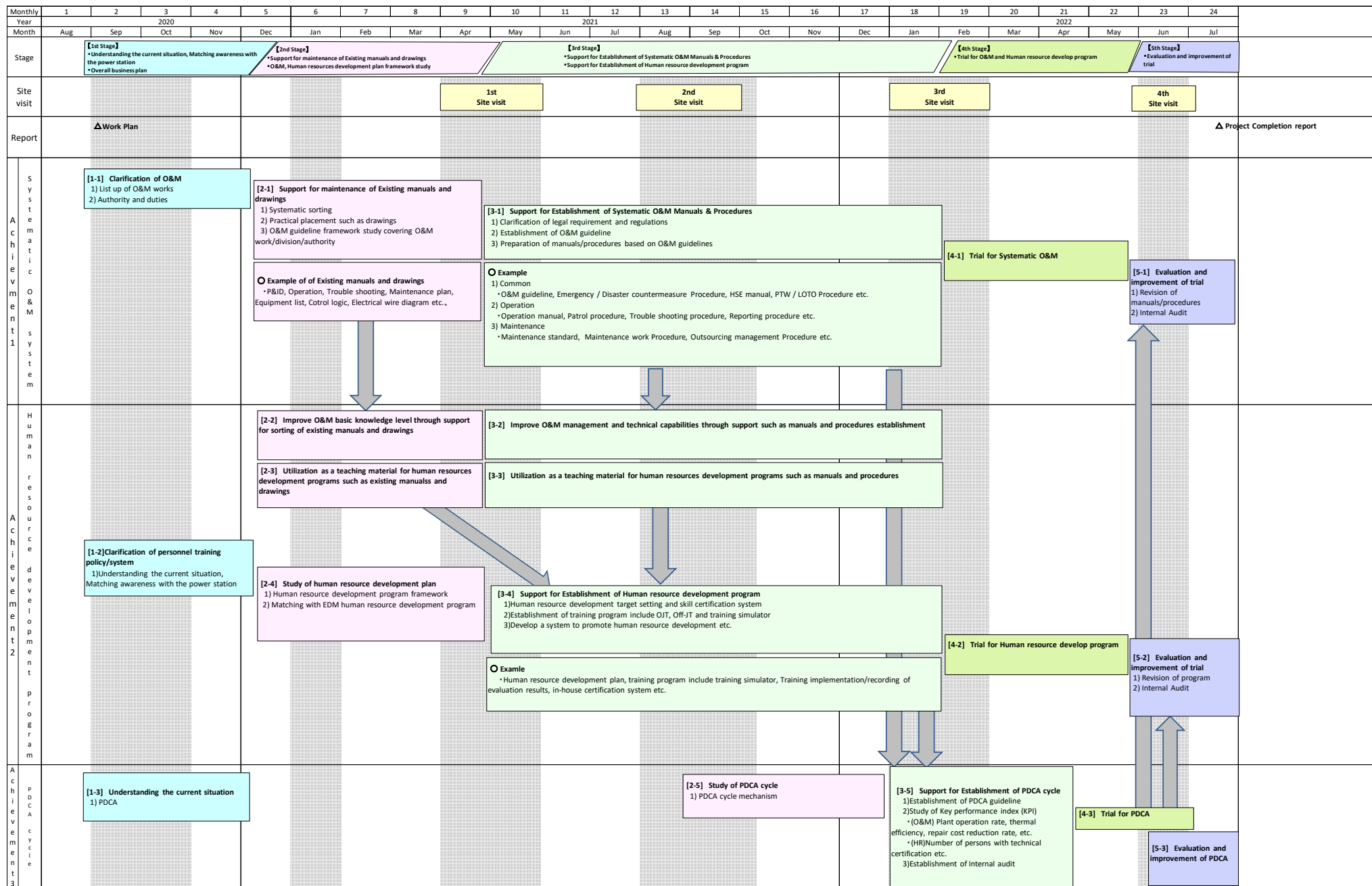


図 1.2-6 業務全体の実施フロー

## 2. 活動内容

### 2.1. キックオフミーティング

業務計画書の内容について 2020 年 9 月 16 日にキックオフミーティングを開催して、プロジェクトの実施体制や全体スケジュールについて EDM と専門家チームで確認した。新型コロナウイルス (COVID-19) の感染拡大に伴い、現地訪問出来ない状況であることから、EDM とのオンライン定例ミーティングを通して、EDM の発電所 O&M 体制、文書などの環境整備、実施能力、人材育成の考え方、人材育成の体系整備などについて、協議することを確認した。キックオフミーティングの協議内容を議事録として取り纏めた (添付 Appendix-1: Kick-off 資料、Appendix-2: Kick-off 議事録を参照)。



図 2.1-1 キックオフミーティング

### カウンターパートと業務従事者

表 2.2-1 にカウンターパートの担当と所属・役割を示す。Ms.Thandi が EDM 側の Project Leader となり具体的な業務を進める実務クラスの EDM 責任者となった。

表 2.2-1 カウンターパート

| 担当                                  | 所属・役割                                            |
|-------------------------------------|--------------------------------------------------|
| Mr. Neves Xavier<br>(Successor)     | EDM, Generation Director                         |
| Mr. Narendra Gulab<br>(Predecessor) |                                                  |
| Mr. Firmino Licumba                 | EDM, Generation Division Director - South Region |
| Mr. Lourenco Macau<br>(Successor)   | EDM, Maputo Plant Manager                        |
| Mr. Inacio Manuel<br>(Predecessor)  |                                                  |
| Ms. Thandi Tekwasse                 | EDM, HRD Project Coordinator・Project Leader      |

表 2.2-2 に業務従事者の担当と所属・役割を示す。

表 2.2-2 業務従事者

| 担当                                  | 所属・役割                                                                                 |
|-------------------------------------|---------------------------------------------------------------------------------------|
| Mr. Ono Masayoshi                   | TEPSCO, Chief of Operations /<br>Thermal power plant operation management A           |
| Mr. Aoki Masaho<br>(Successor)      | TEPSCO, Thermal power station maintenance (inspection/repair)                         |
| Mr. Takeda Shinobu<br>(Predecessor) |                                                                                       |
| Mr. Nemoto Hiroyuki                 | TEPSCO, Human resources development A /<br>Thermal power plant operation management B |
| Mr. Nakajima Takahiro               | TEPSCO, Thermal power plant operation simulation A                                    |
| Mr. Koto Taisuke<br>(Successor)     | TEPSCO, Thermal power plant operation simulation B /<br>Operation Coordinator         |
| Mr. Kawakami Naoki<br>(Predecessor) |                                                                                       |



### 2.3. EDM との定例ミーティング

新型コロナウイルス（COVID-19）の感染拡大に伴い、2020 年の業務開始当初は、現地訪問出来ない状況であることから、EDM とのオンライン定例ミーティングを通して、EDM の発電所 O&M 体制、文書などの環境整備、実施能力、人材育成の考え方、人材育成の体系整備などについて、本邦電力会社の知見・ノウハウを共有しながらキャパシティアセスメントを実施した。また、定例週間ミーティングのフォローアップとして毎週 TEPCO 内ミーティングも実施した。

#### 2.3.1. 第 1 回定例ミーティング（2020 年 10 月 6 日）

テーマ (O&M),(HRD)：発電所運営体制、業務分担

- 発電所の運営体制、各グループの役割、人事ローテーションなどについて本邦電力会社の方法を説明しながらマプト火力発電所の実施方法を確認した。  
なお、後日、EDM から本邦火力発電所の業務分担表を依頼されたため、参考として作成し提出した。



図 2.3-1 第 1 回定例ミーティング

#### 2.3.2. 第 2 回定例ミーティング（2020 年 10 月 13 日）

テーマ (O&M)：文書体系、文書と記録

- 日本での電気事業法に基づく保安規程の有無、文書体系や文書/記録の整備状況などについて、本邦電力会社の方法を説明しながらマプト火力発電所の実施方法を確認した。

テーマ (HRD)：従業員の採用計画、人材育成及び研修体系

- 従業員の採用方法や計画、人材育成、人事異動及び研修体系について、本邦電力会社の方法やマプト火力建設プロジェクト業務を通しての経験をもとにマプト火力発電所の実施方法を確認した。



図 2.3-2 第2回定例ミーティング

### 2.3.3. 第3回定例ミーティング（2020年10月20日）

テーマ (O&M)：発電設備保守計画と発電設備停止計画

- 日本での電気事業法に基づく定期点検の有無、保守計画の策定方法とその管理、給電指令所との発電設備の停止要求手順などについて、本邦電力会社の方法を説明しながらマプト火力発電所の実施方法を確認した。

テーマ (HRD)：技術認定制度

- 今回の人材育成計画の主要な技術認定制度について、本邦電力会社の制度及びマプト火力建設プロジェクト業務を通しての経験をもとに説明をした。
  - (a) マプト火力発電所より、現状の課題として採用時期に於ける従業員間のスキルギャップがマプト火力建設時に於ける採用者と発電所の運用開始後の採用者にあり、そのギャップ解消が課題であることが提起された。
  - (b) マプト火力発電所より国内研修及び外国研修に実施に関して、隣国の南アフリカ共和国での実施可能性を提案された。

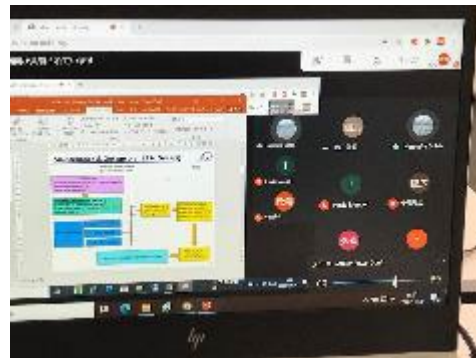


図 2.3-3 第3回定例ミーティング

### 2.3.4. 第4回定例ミーティング（2020年10月27日）

テーマ (O&M)：発電所の法的要求事項順守

- 電気事業法に限らずモザンビーク国の各法令や基準からの要求事項の把握状況、その保守基準などへの反映と管理方法などについて、本邦電力会社の方法を説明しな

がらマプト火力発電所の実施方法を確認した。

テーマ (HRD)：国内研修及び南アフリカ共和国や日本に於ける外国研修。

- 国内研修及び外国研修の実施に関して、Website より隣国の南アフリカ共和国で電気技術者に有意義で参加出来る研修（変圧器、遮断器及び電気保護リレーなど）があることを確認した。

なお、南アフリカ共和国に於ける技術研修の実施が今回の契約上、可能か、JICA に事前確認が必要と思われる。

- 日本に於ける研修は、今回の契約には、含まれないことを確認した。

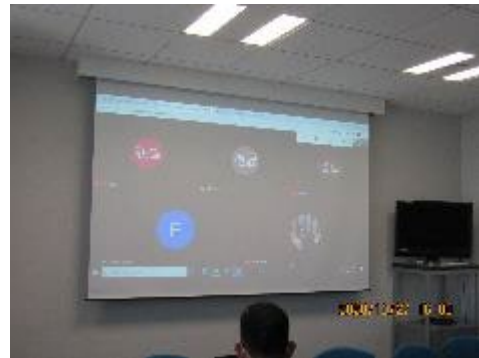


図 2.3-4 第4回定例ミーティング

### 2.3.5. 第5回定例ミーティング（2020年11月10日）

テーマ (O&M)：「発電所運営年間計画と実績管理」

- マプト火力発電所での年間計画策定、実績管理などについて、本邦電力会社の方法を説明しながらマプト火力発電所の実施方法を確認した。

テーマ (HRD)：専門技術研修対象機器と改良職業訓練センター構想

- マプト火力発電所の主要機器の基礎及び特別な技術研修について、対象機器リストに基づき確認した。なお、Website より南アフリカ共和国で制御技術者に有意義で参加出来る研修（PLC System = Programmable Logic Controller System）があることを確認した。
- Website より入手した改良職業訓練センターの概要（2018年6月 Website 掲載）について、その内容を確認した。

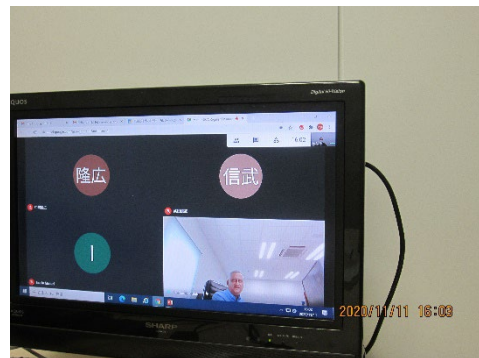
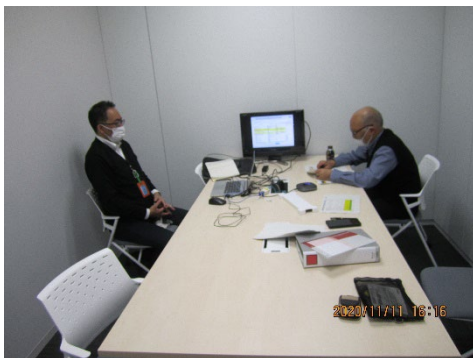


図 2.3-5 第5回定例ミーティング

#### 2.3.6. 第6回定例ミーティング（2020年11月17日）

テーマ (O&M)：作業安全対策（作業許可と作業隔離）

- マプト火力発電所での作業計画・実施にあたっての安全対策の実施状況などについて、本邦電力会社の方法を説明しながらマプト火力発電所の実施方法を確認した。

テーマ (HRD)：職業訓練センター改良計画と訓練内容

- Website より入手した資料：(1) 研修方針とロードマップ (2018年12月作成), (2) 改良職業訓練センター計画の概要 (2018年6月 Website 掲載)
- 及び EDM より受領した資料：(3) 改良職業訓練センター計画のスキル マネジメント プラン (2020年9月作成), (4) 学習プログラムの概要と対象者 (2016年12月作成) を基に内容確認が必要な項目を説明した。

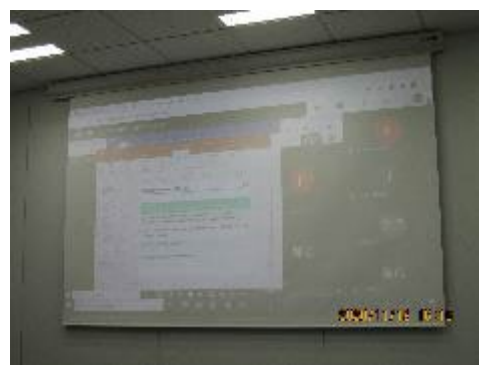


図 2.3-6 第6回定例ミーティング

#### 2.3.7. 第7回定例ミーティング（2020年11月24日）

テーマ (O&M)：非常災害対策、保安防災管理

- マプト火力発電所での非常災害体制および対応方法、保安防災に関する実施状況などについて、本邦電力会社の方法を説明しながらマプト火力発電所の実施方法を確認した。

テーマ (HRD)：従業員の採用計画、人材育成及び研修体系などの確認

- 従業員の採用計画、人材育成及び研修体系などについて、再確認した。





図 2.3-7 第7回定例ミーティング

### 2.3.8. 第8回定例ミーティング（2020年12月1日）

テーマ (O&M)：発電所保守業務

- マプト火力発電所での保守計画、実施、管理方法などについて、本邦電力会社の方法を説明しながらマプト火力発電所の実施方法を確認した。

テーマ (HRD)：職業訓練センターの改良計画の確認

- 第6回定例ミーティング時に実施した職業訓練センター改良計画と訓練内容に対する確認項目の再確認をしたが内容が多岐にわたるため、詳細は次回の現地出張時にEDMの関連部門に確認することにした。



図 2.3-8 第8回定例ミーティング

### 2.3.9. 第9回定例ミーティング（2020年12月8日）

テーマ (O&M)：発電所運転業務

- マプト火力発電所での運転業務、サポート業務、トラブル対応後の水平展開などについて、本邦電力会社の方法を説明しながらマプト火力発電所の実施方法を確認した。

テーマ (HRD)：国家試験や社内試験の合格者に対する社内表彰制度

- 国家試験や EDM 社内試験の合格者に対する表彰制度は、従業員の自己啓発やスキルアップに有意義のため導入を提案した。

これらの表彰制度が適用出来る国家試験などがあるか、次回の現地出張時に確認することにした。



図 2.3-9 第9回定例ミーティング

### 2.3.10. 第10回定例ミーティング（2020年12月15日）

テーマ：第1ステージ(Clarification)のまとめと今後の進め方

- これまで9回実施した定例ミーティングの総括と今後の進め方について確認した。

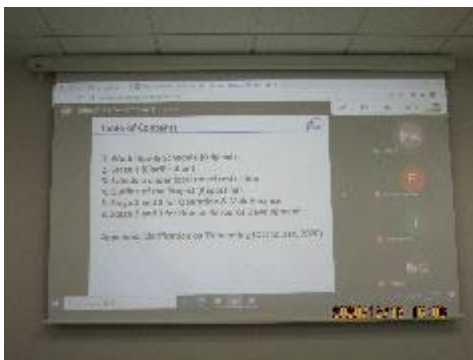


図 2.3-10 第10回定例ミーティング

### 2.3.11. 第11回定例ミーティング（2020年12月22日）

テーマ：第1ステージ(Clarification)のまとめと今後の進め方

- 前週に引き続き、定例ミーティングの総括と今後の進め方について確認した。



図 2.3-11 第11回定例ミーティング

### 2.3.12. 第 12 回定例ミーティング（2021 年 1 月 12 日）

テーマ：第 1 回中間報告書作成スケジュール及び再渡航

- 第 1 回中間報告書作成スケジュール確認並びに再渡航準備として現地感染対策状況を確認した。



図 2.3-12 第 12 回定例ミーティング

### 2.3.13. 第 13 回定例ミーティング（2021 年 1 月 26 日）

テーマ：今後のスケジュール並びに再渡航準備

- 今後のスケジュール確認並びに再渡航準備として現地感染対策状況を確認した。

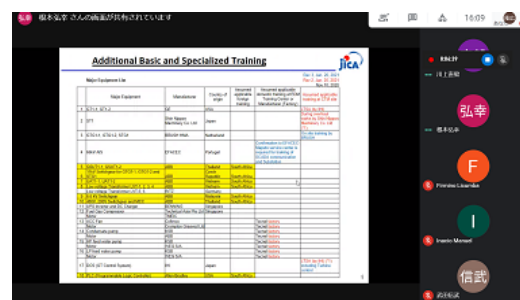


図 2.3-13 第 13 回定例ミーティング

体系的な O&M の仕組み構築、人材育成プログラムの構築の整備を行うため、EDM と 13 回の定例ミーティングを開催した。主に第 1 ステージのマプト火力発電所の現状把握（発電所の O&M 体制、文書などの環境整備、実施能力、人材育成の考え方、人材育成の体制整備など）を実施した。そのさい本邦電力会社の知見ノウハウを共有した。EDM と Clarification のまとめを確認した（添付資料 Appendix-3: Clarification on TV Meeting 参照）。

#### 2.3.14. 第14回定例ミーティング（2021年2月9日）

テーマ：第1回中間報告書及び再渡航

- 第1回中間報告書の説明・協議並びに再渡航準備として現地感染対策状況を確認した。EDMより専門家チームの現地入りが希望された。



図 2.3-14 第14回定例ミーティング

#### 2.3.15. 第15回定例ミーティング（2021年3月2日）

テーマ：O&M Guideline 及び Methodology for HRD Program

- O&M Guideline 及び Methodology for HRD Program を説明・確認した。

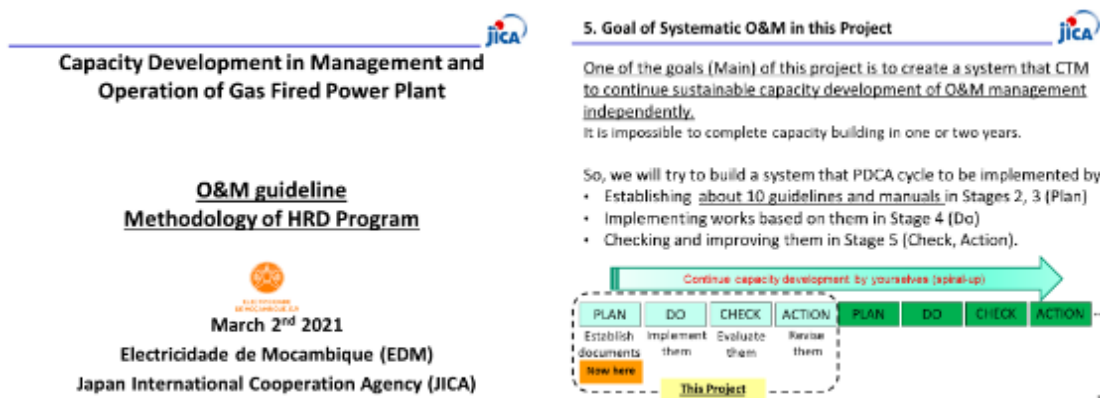


図 2.3-15 第15回定例ミーティング



### 2.3.16. 第16回定例ミーティング（2021年3月23日）

テーマ（O&M）：Emergency response manual

テーマ（HRD）：HRD Program

出席者：EDM (Mr. Firmino)

JICA team (Ono, Takeda, Nemoto, Nakajima, Kawakami)

- Emergency response manual について本邦電力会社の事例を説明しながら確認した。

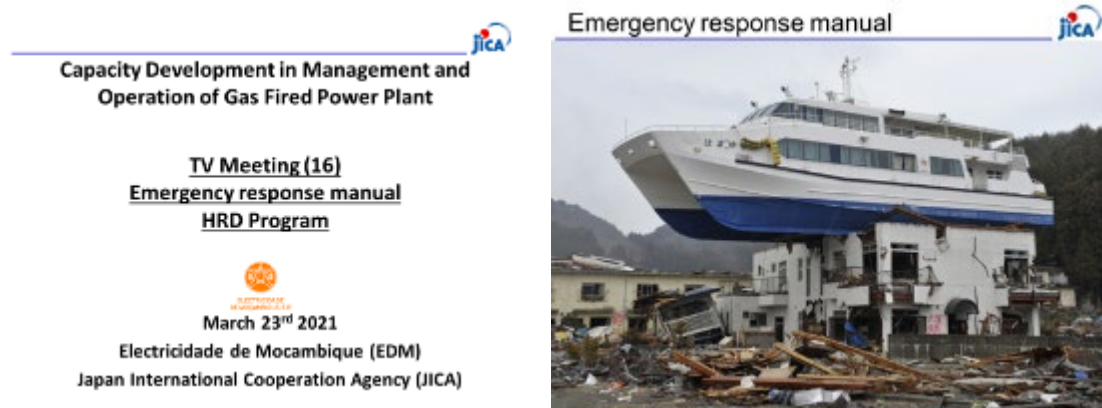


図 2.3-16 第16回定例ミーティング

### 2.3.17. 第17回定例ミーティング（2021年4月20日）

テーマ（O&M）(HRD)：マプト火力発電所訪問

出席者：EDM (Mr. Firmino, Mr. Inacio, Ms Thandi)

JICA team (Ono, Takeda, Nemoto, Nakajima, Kawakami)

- マプト火力発電所訪問スケジュールについて確認した。

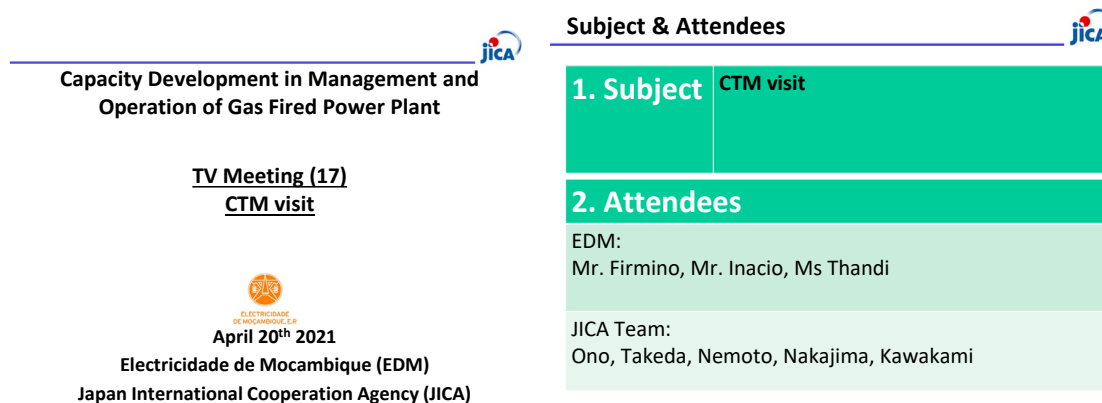


図 2.3-17 第17回定例ミーティング

### 2.3.18. 第 18 回定例ミーティング（2021 年 6 月 22 日）

テーマ (O&M)(HRD) : Next Trip Schedule, JICA Online Program

出席者 : EDM (Mr. Firmino, Ms Thandi)

JICA team (Ono, Takeda, Aoki, Nemoto, Nakajima, Kawakami)

- マプト火力発電所訪問スケジュールについて確認した。JICA Online Program を紹介した。

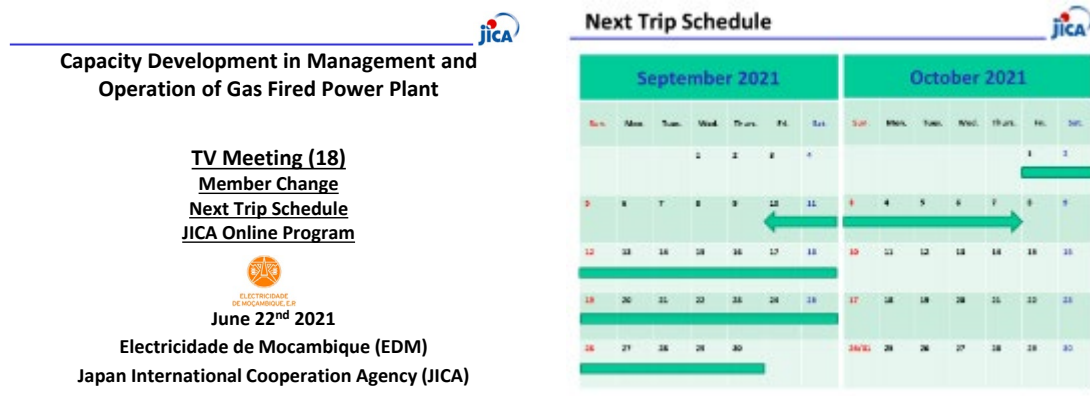


図 2.3-18 第 18 回定例ミーティング

### 2.3.19. 第 19 回定例ミーティング（2021 年 7 月 13 日）

テーマ (O&M) : HSE Manual

テーマ (HRD) : Questionnaires Survey Report

出席者 : EDM (Mr. Firmino, Ms Thandi)

JICA team (Ono, Aoki, Nemoto, Kawakami)

- HSE Manual について EDM の Q&A をもとに説明・協議した。

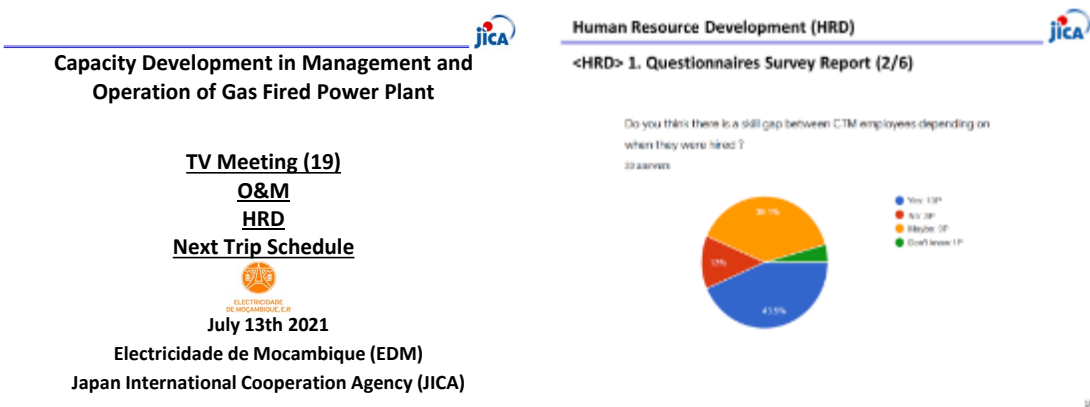


図 2.3-19 第 19 回定例ミーティング

### 2.3.20. 第 20 回定例ミーティング（2021 年 8 月 17 日）

テーマ (O&M) : HSE Manual

テーマ (HRD) : Questionnaires Survey Report

出席者 : EDM (Mr. Inacio, Mr Macau)

JICA team (Ono, Aoki, Nemoto, Kawakami)

- 前回に引き続き HSE Manual について説明・協議した。

**Capacity Development in Management and Operation of Gas Fired Power Plant**

**TV Meeting (20)**

**O&M**

**HRD**

**Next Trip Schedule**



**August 17th 2021**

**Electricidade de Mocambique (EDM)**

**Japan International Cooperation Agency (JICA)**

**Subject & Attendees**

|                     |                                                           |
|---------------------|-----------------------------------------------------------|
| <b>1. Subject</b>   | <b>O&amp;M</b><br><b>HRD</b><br><b>Next Trip Schedule</b> |
| <b>2. Attendees</b> | EDM:<br>Mr. Inacio, Mr. Macau                             |
|                     | JICA Team:<br>Ono, Aoki, Nemoto, Kawakami                 |

図 2.3-20 第 20 回定例ミーティング

### 2.3.21. 第 21 回定例ミーティング（2021 年 9 月 7 日）

テーマ (O&M) : O&M Manual (CTM-2-001 Operation Manual, CTM-3-001 Maintenance manual)

テーマ (HRD) : Training Management Check Sheet, Overall Training Courses

出席者 : EDM (MR. Firmino, Mr. Inacio, Mr Macau)

JICA team (Ono, Aoki, Nemoto, Kawakami)

- O&M Manual, Training Management Check Sheet, Overall Training Courses について説明・協議した。

**Capacity Development in Management and Operation of Gas Fired Power Plant**

**TV Meeting (21)**

**O&M**

**HRD**

**Next Trip Schedule**



**September 7th 2021**

**Electricidade de Mocambique (EDM)**

**Japan International Cooperation Agency (JICA)**

**2. Operation and Maintenance Manual in the Document tree**

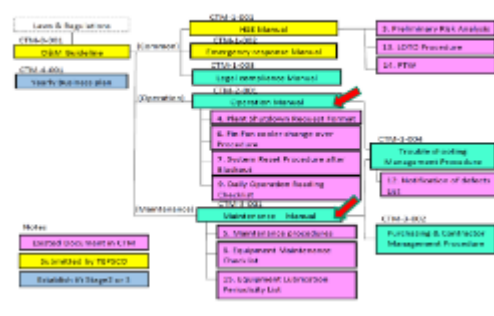


図 2.3-21 第 21 回定例ミーティング

### 2.3.22. 第 22 回定例ミーティング（2021 年 11 月 12 日）

テーマ（O&M）：O&M Manual (CTM-1-003 Legal Compliance Manual, CTM 3-002 Purchasing and Contractor Management Manual)

テーマ（HRD）：Skill Certification System and Training Management Check Sheet, Overall Simulator Training Schedule for Operator

出席者：EDM (Ms. Thandi)

JICA team (Ono, Aoki, Nemoto, Nakajima)

- O&M Manual, Skill Certification System and Training Management Check Sheet, Overall Simulator Training Schedule for Operator について説明・協議した。マプト火力発電所訪問スケジュールについて確認した。



**Capacity Development in Management and Operation of Gas Fired Power Plant**

**TV Meeting (22)**

**O&M**  
**HRD**



**November 12th 2021**

**Electricidade de Mocambique (EDM)**  
**Japan International Cooperation Agency (JICA)**

**Subject & Attendees**



|                                           |            |
|-------------------------------------------|------------|
| <b>1. Subject</b>                         | O&M<br>HRD |
| <b>2. Attendees</b>                       |            |
| EDM:<br>Ms. Thandi                        |            |
| JICA Team:<br>Ono, Aoki, Nemoto, Nakajima |            |

図 2.3-22 第 22 回定例ミーティング

### 2.3.23. 第 23 回定例ミーティング（2022 年 2 月 9 日）

テーマ：第 2 回中間報告書

- 第 2 回中間報告書を説明・協議した。EDM よりできるだけ専門家チームの現地入りが希望された。



**Capacity Development in Management and Operation of Gas Fired Power Plant**

**TV Meeting (23)**  
**Second Interim Report**



**February 9th 2022**

**Electricidade de Mocambique (EDM)**  
**Japan International Cooperation Agency (JICA)**

**9. Second Field Survey**



Period: October 8 (Fri) to Dec 8 (Wed), 2021  
Purpose: Frame Work Establishment (second) and Establishment (third), were carried out.  
Business Traveler: Mr. Ono, Mr. Aoki, Mr. Nemoto



図 2.3-23 第 23 回定例ミーティング

体系的な O&M の仕組み構築、人材育成プログラムの構築の整備を行うため、EDM と 23 回の定例ミーティングを開催した。第 2 ステージの体系的な O&M・人材育成プログラムのフレームワーク構築、第 3 ステージの体系的な O&M・人材育成プログラムの構築を実施した。その際、本邦電力会社の知見ノウハウを共有した。EDM よりできるだけ専門家チームの現地入りが希望された。

#### 2.4. オンラインアカデミー（2020 年 10 月～2021 年 1 月）

新型コロナウイルス（COVID-19）の感染拡大に伴い、現地訪問出来ない状況であることから、人材育成プログラムの一つとして火力発電所の基礎知識について TV 会議にてオンラインアカデミー（計 8 回）を実施した。下記シラバスを作成し事前に配布した。

オンラインアカデミーでは各回講義資料を事前に配布して EDM 技術者が予習できるようにした。また、講義中に質問の機会を設け、講義を録画した翌日には配布して講義の復習や業務都合により参加できなかった EDM 技術者に提供した。質問書を作成し EDM より意見を集約して、次回以降の講義の参考とした。

表 2.4-1 シラバス

|   | Title and Course Aims                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Date             | Lecture    |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|------------|
| 1 | <p><b>Title : Understand numbers used for electrical expression on the complex plane by Geogebra</b></p> <p>Aims: For those unfamiliar with electricity, complex numbers, which are the basis of electrical expressions, will be introduced with concrete examples. For those who are already familiar with the subject, a new method of representing geometric numbers in motion using free software will be introduced. Finally, an example of a complex representation of a generator will be presented, which dynamically represents the phase of the voltage and current.</p>                                                                                                                                                                                                                                                                                                  | 2021,<br>October | Mr. Tanaka |
| 2 | <p><b>Title: Generator and its commissioning test</b></p> <p>Aims: The textbook description of the generator is combined with the behavior of the generator in actual commissioning. Section 1 is the principles and structure, which can be understood without expertise. Section 2 visualizes how the generating voltage varies with the type of load using Geogebra Section 3 explains the generator commissioning test and what it means. Section 4 explains the extent to which a generator can be operated. People in the electrical field should be familiar with jargons at least. This section shows the significance of reactive power in numbers, along with an explanation of the range the generator can operate in. Also, as an example of using Geogebra in the business, it is shown how to illustrate the steady-state stability limits with numerical inputs.</p> | 2021,<br>October | Mr. Tanaka |

|   |                                                                                                                                                                          |                    |                                         |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-----------------------------------------|
| 3 | <b>Title : What is Entropy</b><br>Goals: Introduce Entropy as a basic knowledge of thermal plants.                                                                       | 2021,<br>November  | Dr. Blackstone<br>(Takashi<br>Kuroishi) |
| 4 | <b>Title : History of the thermal power plants</b><br>Goals: This course introduces changes in thermal power plants (Large capacity, high efficiency and etc.)           | 2021,<br>November, | Dr. Blackstone<br>(Takashi<br>Kuroishi) |
| 5 | <b>Title : The role of the thermal power plant in the RE era</b><br>Goals: This course introduces the role and value of thermal power plants for a decarbonized society. | 2021,<br>December  | Dr. Blackstone<br>(Takashi<br>Kuroishi) |
| 6 | <b>Title : Energy Master Plan for the future</b><br>Goals: This course introduces that a draft energy vision for 2030-2050 will be presented.                            | 2021,<br>December  | Dr. Blackstone<br>(Takashi<br>Kuroishi) |
| 7 | <b>Title : What is happen on the earth?</b><br>Goals: This course introduces the background of global warming and its factors                                            | 2022,<br>January   | Dr. Blackstone<br>(Takashi<br>Kuroishi) |

#### 2.4.1. 第1回オンラインアカデミー（2020年10月14日）

テーマ：電気で扱う複素数を Geogebra で図示して理解する

- 交流電力には有効電力と無効電力があり、図式では虚数グラフが用いられ計算が複雑である。本講義では実数、虚数の計算で Geogebra というフリーソフトを使用しており、視覚的に計算のイメージができるように工夫をし、説明した。



図 2.4-1 第1回オンラインアカデミーの様子

#### 2.4.2. 第2回オンラインアカデミー（2020年10月28日）

テーマ：発電機と試運転試験

- 発電機の発電原理ならびに建設期間中の発電機の試運転について、図や写真、Geogebra を使用して説明した。



図 2.4-2 第 2 回オンラインアカデミーの様子

### 2.4.3. 第 3 回オンラインアカデミー（2020 年 11 月 18 日）

テーマ：知って得するエントロピー

- なんとなく言葉は知っているがどのような働きをするのか理解が難しい「エントロピー」について、身近なものに例えて説明をした。また、火力発電所の効率について、ボイラー循環水の温度・圧力とエントロピーの関係の説明を説明した。

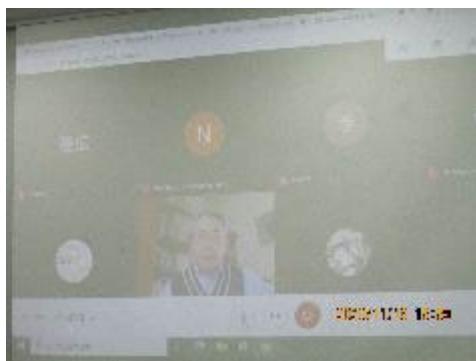


図 2.4-3 第 3 回オンラインアカデミーの様子



#### 2.4.4. 第4回オンラインアカデミー（2020年12月2日）

テーマ：火力プラントの大容量化・高効率化

- 1950年以降の日本の火力発電所の大容量化・高効率化の歴史と、その技術的要因（蒸気圧力及び蒸気温度の向上、コンバインドサイクルの導入）を説明した。



図 2.4-4 第4回オンラインアカデミーの様子

#### 2.4.5. 第5回オンラインアカデミー（2020年12月16日）

テーマ：脱炭素社会に向けた火力発電の役割と価値

- 今後の再生可能エネルギー拡大期において、従来よりも変動が大きくなる電力需給バランスの調整をするために火力発電所が必要であることを説明した。あわせて、CO<sub>2</sub>削減が期待できる新技術である、石炭ガス化複合発電技術とカーボンフリー燃料の混焼・専焼技術を紹介した。



図 2.4-5 第5回オンラインアカデミーの様子

#### 2.4.6. 第6回オンラインアカデミー（2021年1月13日）

テーマ：電力系統制御（周波数制御と電圧制御）

- 電力系統の周波数制御と電圧制御について説明した。あわせて、送電線事故や系統じょう乱から火力発電所を保護する機能である、ファストカットバックとアイランドオペレーションを紹介した。



図 2.4-6 第6回オンラインアカデミーの様子

#### 2.4.7. 第7回オンラインアカデミー（2021年1月27日）

テーマ：What is happen on the earth?

- 温室効果ガスの性質や地球温暖化の影響を説明した。

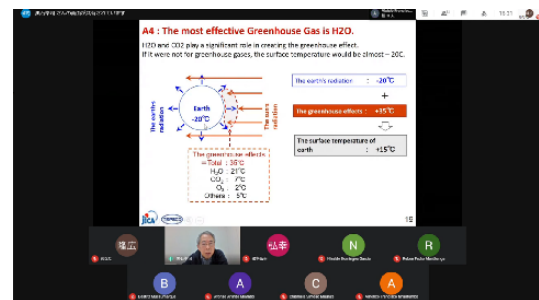
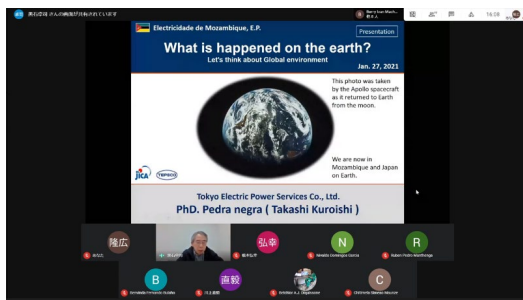


図 2.4-7 第7回オンラインアカデミーの様子

人材育成プログラムの一つとして火力発電所の基礎知識についてオンラインアカデミー（計7回）を実施した。第1、2回目の講義は専門性に特化しており EDM より若干難しいとのコメントがあり、第3回目以降は質問を多く取り入れ双方向での講義に努めた。EDM エンジニア（運転、保守）の幅広い参加を得て火力発電所の基礎知識を多くの発電所技術者と共有した。

#### 2.4.8. 第8回オンラインアカデミー（2021年4月6日）

人材育成プログラムの一つとして火力発電所の PDCA サイクル（Plan Do Check Action:継続的な改善活動）について TV 会議にて第8回オンラインアカデミーを実施した。

講義資料を事前に配布して EDM 技術者が予習できるようにした。また、講義中に質問の機会を設け、講義を録画し翌日には配布して講義の復習や業務都合により参加できなかった EDM 技術者に提供した。

テーマ：PDCA for Thermal power station

出席者：EDM (Mr. Inacio, Mr Macau, Ms.Thandi, EDM Engineers)

JICA team (Ono, Takeda, Nemoto, Nakajima, Kawakami)

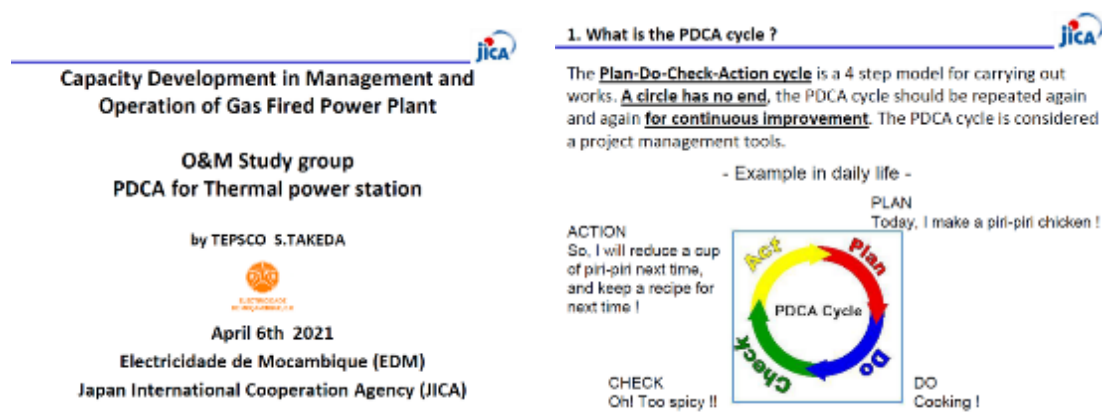


図 2.4-8 第8回オンラインアカデミー

EDM エンジニア（運転、保守）の幅広い参加を得て本邦電力会社の火力発電所の基礎知識を多くの発電所技術者と共有した。EDM より技術・技能の維持・向上は、一朝一夕に成し得るものではないが、今後も持続的な成長により EDM の社会的な責任を果たしていくために、今回学んだ PDCA サイクルをまわし、継続的に効果を高めていきたいとのコメントを頂いた。

## 2.5. 第1次現地業務

### 2.5.1. 概要

JICA Study Team は、2021 年 5 月 5 日（水）から 5 月 27 日（木）までモザンビーク国火力発電所運営能力向上業務の第1次現地業務を計画した。第1次現地業務では、1.2.6 の業務フローに記載した第2、3 ステージの運転補修と人材育成の Frame Work Establishment（第2）と Establishment（第3）を実施した。

### 2.5.2. 出張者

|                    |      |
|--------------------|------|
| 業務主任者／火力発電所運転管理 A  | 小野政義 |
| 火力発電所保守（点検・補修）     | 武田信武 |
| 人材育成 A／火力発電所運転管理 B | 根本弘幸 |

### 2.5.3. スケジュール

| 月 日          |     | 内 容                                                                                                      |
|--------------|-----|----------------------------------------------------------------------------------------------------------|
| 5/3-4        | -   | 移動 東京⇒マプト、ドーハ経由                                                                                          |
| 5/5          | 水   | 午前：JICA モザンビーク事務所説明、午後：EDM マプト火力発電所訪問、環境整備                                                               |
| 5/6          | 木   | キックオフミーティング                                                                                              |
| 5/7-<br>5/21 | -   | 全般；New Generation Director など管理者と打合せ<br>火力発電所保守：メンテナンス/オペレーション G への参加<br>人材育成；EDM アカデミー、EDM マプト火力発電所と打合せ |
| 5/24         | 月   | Warp-up Meeting                                                                                          |
| 5/25-26      | 火-水 | 報告書作成、資料整理、PCR 検査・結果確認                                                                                   |
| 5/27         | 木   | 午前：JICA モザンビーク事務所報告、移動 マプト発                                                                              |
| 5/28-29      | -   | 移動 ドーハ⇒東京                                                                                                |

### 2.5.4. 目的

全般： New Generation Director や管理者（南部地域、所長、運転、補修）と今後の業務実施方法、運営体制などを再確認し良好な関係を維持する。

火力発電所保守： メンテナンス/オペレーショングループへ合流し作業手順（週間、日間、計画、実施、記録）と PMIS (Project Management Information System) の使用状況の確認をする。

人材育成： 人材育成の枠組み構築（組織、スケジュール、方法など）について EDM アカデミー（本社）、マプト火力発電所と確認すること。事前に送付した人材育成に関する質問書の回答を収集する。

### 2.5.5. 特記事項

#### (1) キックオフミーティングの開催

プレゼン資料、スケジュール表をもとに第1次現地業務の目的を説明・スケジュールの確認を実施した。今後は Ms Thandi が EDM 側の Project Leader となり具体的な業務を進める実務クラスの EDM 責任者として本プロジェクトを実施することを確認した。

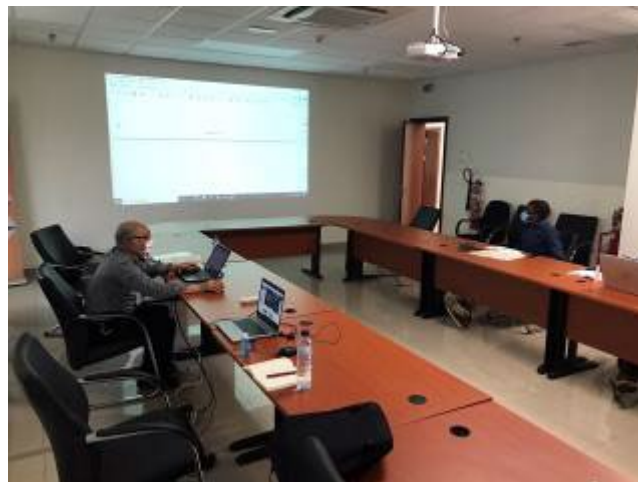


図 2.5-1 キックオフミーティングの状況

#### (2) Generation Director への業務説明および協議

Work Plan、第1回中間報告書をもとにプロジェクトの業務説明・協議を実施した。New Generation Director, Mr. Neves、Head of generation department - South Region, Mr. Firmino と本業務への EDM の協力を相互で再確認した。



New Generation Director, Mr. Neves (中央左側)

Generation Division Director (South Region), Mr. Firmino (中央右側)

図 2.5-2 EDM 責任者との写真



### (3) サイト視察

Ms.Thandi とマプト火力発電所を視察した。プラントは約 7 割の出力で連続運転中であり、構内は隅々まで清掃がいきなりゴミの分別も厳格になされていた。建設後 EDM 独自で安全に関する標識を主要ポイントに設置するなど安全対策も万全である。同構内に設置されているブラックスタート用の GT の試験運転が行われており非常時の危機管理もしっかりしていた。



マプト火力発電所 GT



送電線付近



ゴミの分別



安全標識

図 2.5-3 サイト視察

構内が隅々まで清掃が行われていた理由として、2018 年 8 月の発電所運用開始前日にコンサルタント（専門家チーム）とコントラクター（日本人）が率先して発電所構内のゴミ拾いを行なったときに EDM の発電局長、マネージャークラスも喜んで参加した。これらの経験が引き継がれたのではないかとと思われる。

EDM は発電所建設時にコントラクターの設計連絡会議などで多くの日本の発電所を見学して構内は隅々まできれいになっていることを副長クラス以上は認識しており、これらが反映されていた。

安全標識の設置は、建設時はコントラクター、運転開始後は EDM が行っている。安全の専任者は EDM の女性職員が担当している。専門家チームもサイトを視察する前に安全担当より安全研修を受講した。



図 2.5-4 安全研修を受ける専門家チーム

#### (4) Handbook の紹介並びに供与

コントラクター作成の O&M マニュアルは膨大であるため、簡素に取りまとめた Handbook 類(Operation Hand book, Control Logic Diagram, Set Point List)を紹介し、EDM に供与した。その際 JICA モザンビーク事務所が視察した。



図 2.5-5 Handbook 供与

火力発電プラントの建設、運用に当たっては膨大な建設工事の設計資料、運転資料、保守資料などが含まれている。この中でプラントの安全及び安定運用をするためにプラント運転員に必須な技術資料をまとめてハンドブック化することは非常に有用である。専門家チームの経験でいえば、"運転必携"に相当する。この観点より、Operation Handbook, Setpoint List, etc.を冊子にして EDM に供与した。供与に当たっては、EDM に大変感謝されている。第 2 回現場出張時に中央制御室（CCR）のオペレーターデスクに相当使いこなされた Handbook があったことより有効活用されていると思われる。なお、

原紙及び Soft data も提出しており増刷及び各自 PC へのダウンロードが可能となっている。

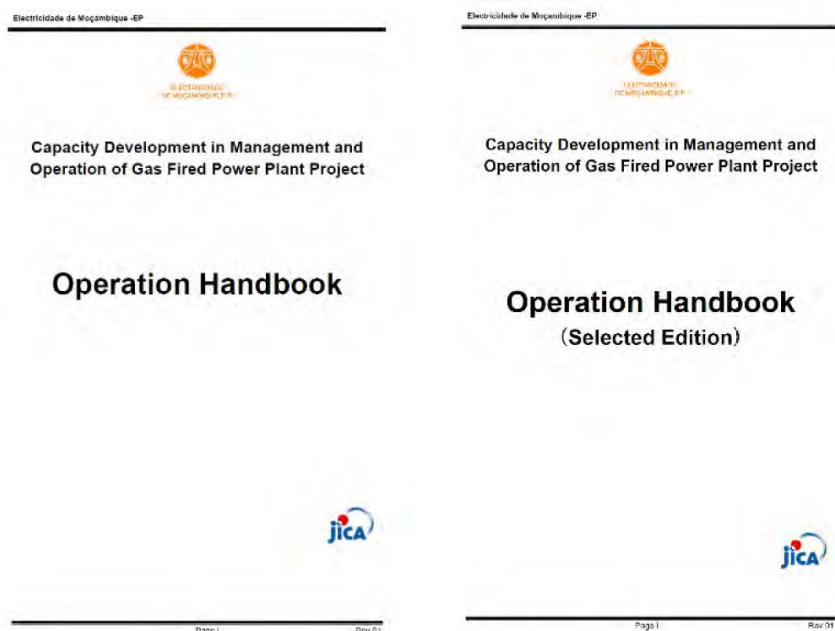


図 2.5-6 オペレーションハンドブックの表紙

| (Paper Size) |                                            |           |     |    |       |
|--------------|--------------------------------------------|-----------|-----|----|-------|
|              | Drawing Title                              | Page      | A4  | A3 | Total |
| 1.           | Documents                                  | (1-126)   |     |    |       |
| 1-1          | Plant Operation Philosophy                 | 1-21      | 21  |    | 21    |
| 1-2          | Plant Start up / Shutdown Procedure        | 22-38     | 17  |    | 17    |
| 1-3          | Gas Turbine Package Operation              | 39-71     | 33  |    | 33    |
| 1-4          | Steam Turbine Operation Procedure          | 72-126    | 55  |    | 55    |
| 2.           | Drawings                                   | (127-192) |     |    |       |
| 2-1          | Plant Equipment Layout (Plant Site Layout) | 127       |     | 1  | 1     |
| 2-2          | System Flow Diagram                        | 128       |     | 1  | 1     |
| 2-3          | Key Single Line Diagram                    | 129       |     | 1  | 1     |
| 2-4          | Control Architecture Diagram               | 130       |     | 1  | 1     |
| 2-5          | Protection Instrument & Configuration      | 131       |     | 1  | 1     |
| 2-6          | GT Sequence Time Chart                     | 132-134   | 1   | 2  | 3     |
| 2-7          | Plant Sequence Time Chart                  | 135-150   | 2   | 14 | 16    |
| 2-8          | Heat Balance Diagram                       | 151-169   | 19  |    | 19    |
| 2-9          | Water Balance Diagram                      | 170-192   | 7   | 16 | 23    |
|              | Total                                      |           | 155 | 37 | 192   |

図 2.5-7 オペレーションハンドブックの目次



## (5) O&M

(5/10～14) マプト火力発電所のメンテナンスグループに合流し、保守点検の計画～実施～実績管理のワークフロー、各保守点検、トラブル対応などの実施状況を確認した。おむね計画に従い各現場作業は実施されているものの、手続きの電子化、業務の細分化に伴い各自が担当している部分以外はわかりにくい状況になっているため、発電所全体のマネジメント力のレベルアップ、個人の対応能力アップのため、これらの見える化・情報共有化などを進めていく。



点検内容確認



ポンプメンテナンス

図 2.5-8 O&M 視察

(5/17～21) マプト火力発電所のオペレーショングループに合流し、日々の運転、現場巡視、機器の切り替え、記録の作成・保管、トラブル対応などの実施状況を確認した。決められた手順に従い実施されているものの必要な記録の選択、記録の保管、運転/停止前の事前確認など改善したほうが望ましいと思われる点もあり、今後の活動の中で進めていく。



中央制御室



当直日誌

図 2.5-9 中央操作室での作業

## (6) HRD

人材育成の枠組み構築について Explanatory Note.をもちいて説明した。それをもとに EDM アカデミー（本社）、マプト火力発電所と主に下記について協議・確認した。

- (1) Explanatory Note.
- (2) Skill Management Plan
- (3) Basic Training System Organization
- (4) Reconfirmation items for HRD on TV meeting (16)
- (5) Concept of Outsourced Contract
- (6) Skill Certification System

事前に送付した人材育成に関する質問書の回答を収集した。人材育成に関する質問書の想定対象者数は 50 名、回答者は 23 名（現地での再要請による回答者 2 名を含む）。回答率は 46%である。



図 2.5-10 Academy Director, Mr. Fabiao（写真中央）

尚、EDM マプト火力発電所より日本の JICA トレーニングセンターや南アフリカ、ザンビアにおける技術研修受講が提案された。

当初、EDM の（前）発電局長より技術研修の実施要請があった。技術研修の実施は本業務の契約に含まれていないことは EDM に理解されたが、予算面と JICA の了解が必要であることを前提にモザンビーク国内では実施出来ない研修を例えば、南アフリカでのベンダー研修の一部を提示した。その後、EDM はザンビア国の KGRTC(Kafue Gorge Regional Training Center)研修、南アフリカでのベンダー研修及び日本での JICA 研修などの項目を提案した。

### 2.5.6. 第1次現地業務の総括

本プロジェクトの最終目標は、マプト火力発電所において、現在の EPC コントラクターに依存した O&M から脱却し、自立した発電所として安定・継続的な発電所運営が可能となるよう、体系的な O&M の仕組み、および、そのための人材育成強化に関する仕組みを構築することである。

その最終目標に向け、第1次現地業務にて下記を実施した。

- 管理者職と今後の業務実施方法、運営体制などの確認。
- メンテナンス/オペレーショングループへ合流し作業手順と PMIS の使用状況の確認。
- 人材育成の枠組み構築（組織、スケジュール、方法など）について、人材育成に関する質問書の回答収集。

新型コロナウイルス（COVID-19）の感染拡大に伴い現地訪問出来ない状況が続き、EDM との毎週のオンラインミーティングを通して第1 ステージである **Clarification** を進めてきた。しかし、お互いに全般的・大略的なことは把握できても、もう一步踏み込んだ理解、深い議論をするところまで至ることは難しく、第一次現地業務を実施することによりマプト火力発電所の O&M 業務に直接触れた中での議論・協議を進めることができた。

専門家チームが現地訪問したことに EDM より感謝の言葉を頂いた。専門家チームの火力発電所保守専門員はマプト火力発電所のメンテナンスグループとオペレーショングループに合流した。EDM のメンテナンスグループと火力発電所保守専門員は保守点検の計画から実施並びに実績管理のワークフロー、各保守点検、トラブル対応の実施状況を共に確認した。オペレーショングループと保守専門員は日々の運転、現場巡視、機器の切り替え、記録の作成・保管、トラブル対応の実施状況を共に確認した。EDM のエンジニアは日常業務が輻輳する中、積極的に対応してくれた。

EDM 本社の EDM アカデミーの Director と人材育成専門家は事前に送付した人材育成に関する質問書について打ち合わせた。打合せ当日に回答できないものは EDM アカデミーの Director より後日延滞なく資料を提供頂いた。

今後の現地業務にて、体系的な O&M の仕組み構築、人材育成プログラムの構築の整備を継続、また改善したほうが望ましいと思われる点について、EDM に提案をしていく予定である。

## 2.6. 第2次現地業務

### 2.6.1. 第2次現地業務概要

JICA Study Team は、2021 年 10 月 8 日（金）から 12 月 8 日（水）までモザンビーク国火力発電所運営能力向上業務の第2次現地業務を実施した。第2次業務では、第3ステージの運転補修と人材育成の Frame Work Establishment/ Establishment 及び今後の計画確認を実施した。

### 2.6.2. 出張者(マプト滞在期間)

|                    |                  |
|--------------------|------------------|
| 業務主任者／火力発電所運転管理 A  | 小野政義（10/8-12/8）  |
| 火力発電所保守（点検・補修）     | 青木正帆（11/12-12/8） |
| 人材育成 A／火力発電所運転管理 B | 根本弘幸（11/12-12/8） |

### 2.6.3. 業務期間

| 月 日         |   | 内 容                                                                                                                                                                    |
|-------------|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10/8        | 金 | EDM マプト火力発電所にて業務開始                                                                                                                                                     |
| 10/11       | 月 | EDM マプト火力発電所                                                                                                                                                           |
| 10/12       | 火 | キックオフミーティング                                                                                                                                                            |
| 10/13-11/11 | - | 全般；Generation Director など管理者と打合せ、EDM の能力強化を実施（火災予防、契約管理、財務管理他）、火力運転保守・人材育成資料作成補助、発電所 O&M の日常業務の改善指導                                                                    |
| 11/12       | 金 | 午前：マプト着（根本、青木）、午後：EDM マプト火力発電所・環境整備                                                                                                                                    |
| 11/13-11/30 | - | 全般；Generation Director など管理者と打合せ、EDM の能力強化を実施（火災予防、契約管理、財務管理他）、発電所 O&M の日常業務の改善指導<br>火力発電所保守：メンテナンス/オペレーション G への参加、EDM マプト火力発電所と打合せ<br>人材育成；EDM アカデミー、EDM マプト火力発電所と打合せ |
| 12/1        | 水 | Wrap-up Meeting                                                                                                                                                        |
| 12/2        | 木 | 報告書作成、資料整理                                                                                                                                                             |
| 12/3        | 金 | 報告書作成、資料整理、PCR 検査                                                                                                                                                      |
| 12/4        | 土 | 報告書作成、資料整理、PCR 結果                                                                                                                                                      |
| 12/5        | 日 | 移動 マプト発                                                                                                                                                                |
| 12/6-8      | - | 移動 成田着                                                                                                                                                                 |

#### 2.6.4. 目的

**全般：** Generation Director や管理者（南部地域、所長、運転、補修）と業務実施方法、運営体制などを確認し良好な関係を維持する。EDM の能力強化を実施（火災予防、契約管理、財務管理他）、発電所 O&M の日常業務の改善を指導する。

**火力発電所保守：** メンテナンス/オペレーショングループへ合流し作業手順（週間、日間、計画、実施、記録）と PMIS の使用状況の確認をする。各種マニュアルを EDM と確認する。

**人材育成：** 人材育成の枠組み構築（組織、スケジュール、方法など）について人材育成に関する質問書の結果を参考に EDM アカデミー（本社）、マプト火力発電所と確認する。第 4 ステージの研修計画について確認する。

#### 2.6.5. 特記事項

##### (1) キックオフミーティングの開催

20 回、21 回、22 回のオンラインプレゼン資料、スケジュール表をもとに第 2 次現地業務の目的を説明・スケジュールの確認を実施した。Ms Thandi が EDM 側の Project Leader となり具体的な業務を進める実務クラスの EDM 責任者として本プロジェクトを実施することを確認した。Ms.Thandi は発電所全体のマネジメント力のレベルアップ、発電所員の能力アップのための部署に異動となった。



図 2.6-1 ミーティングの状況

##### (2) サイト視察

ガスタービンの開放点検に立ち会った。コントラクター（IHI）の作業員に全てを任せるとはせず EDM の職員も積極的に点検作業を実施していた。コントラクターと EDM の職員の役割分担と責任範囲は、着手前に打合せを実施し明確にしている。コントラクターは EDM 職員に対し、技術伝承をすることは LTSA 契約に記載されており EDM の要望にしたがい、コントラクターは適宜説明会を開催している。





GT 取外し作業



工作工場内点検作業

図 2.6-2 ガスタービン開放点検

(3) Handbook の紹介並びに供与

コントラクター作成の O&M マニュアルは膨大であるため、簡素に取りまとめた Operation Handbook を A5 サイズに縮小し 20 部供与した。後日 O&M 業務に重要な Alarm & Set Point List A4 サイズを 20 部提供した。



Operation Handbook



Alarm & Set Point List

図 2.6-3 供与した Handbook

(4) O&M

20 回、21 回、22 回のプレゼン資料のうち保守点検の計画～実施～実績管理のワークフローを含む、下記マニュアル類について打合せを実施した。今後 EDM からの要望をもらい修正していく予定である。

- (CTM-0-001) O&M Guideline
- (CTM-1-001) HSE manual.
- (CTM-1-002) Emergency response manual
- (CTM-1-003) Legal compliance manual.
- (CTM-2-001) Operation manual.
- (CTM-3-001) Maintenance manual

※詳細は別冊資料 O&M マニュアルを参照。



図 2.6-4 O&M でのミーティングの状況

#### (5) HRD

20 回、21 回、22 回のプレゼン資料のうち、人材育成の枠組み構築について EDM アカデミー（メール確認）、マプト火力発電所と主に下記について協議・確認を行なった。今後 EDM からの要望をもらい修正していく予定である。

- (1) Explanatory Note. With Q&A
- (2) Updated Assignment of Training Roles
- (3) Work Assignment & Roles
- (4) Updated Work Flow

※詳細は別冊資料 HRD マニュアルを参照。

専門家チームは EDM に下記を 2 回目の現地業務時に報告した。

第 1 次現地業務時に EDM から提案された外国研修受講は、有意義であると思われるが、

- (1) 本契約範囲には含まれていないこと。
- (2) COVID-19 の影響で今後のザンビアの KGRTC(Kafue Gorge Regional Training Center) 研修及び南アフリカでのベンダー研修については研修項目やスケジュールが現時点では決まっていないこと。
- (3) これらの外国研修は今の COVID-19 状況下では安全管理上、非常に困難であること。





図 2.6-5 HRD でのミーティングの状況

(6) 火災時などを想定した訓練

EDM と協議しコロナの状況のため訓練は中止した。代替案として東京消防庁のネットから消防訓練の動画（English）を紹介した。

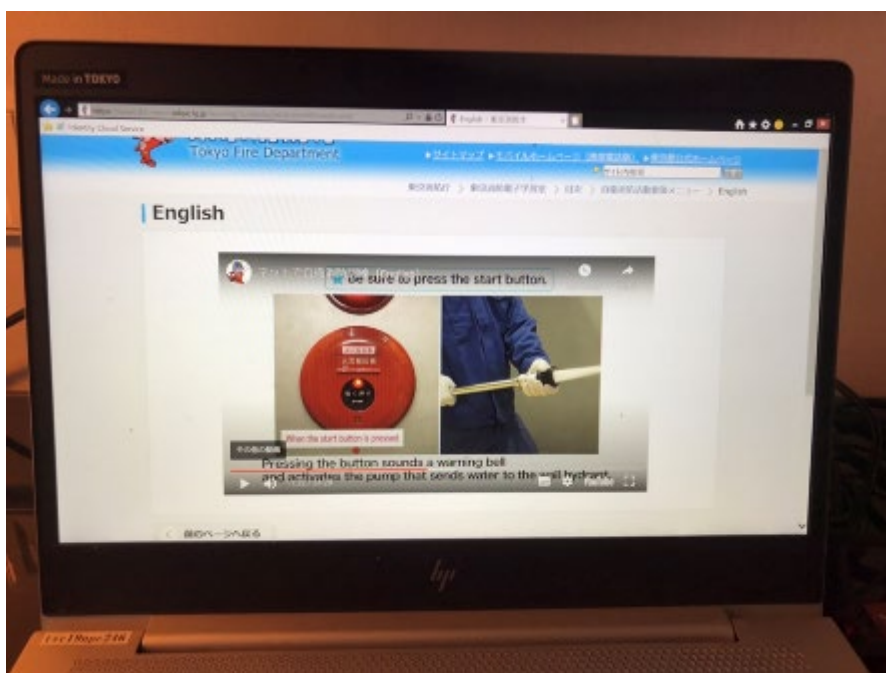


図 2.6-6 東京消防庁の訓練動画

<https://www.tfd.metro.tokyo.lg.jp/learning/contents/jiei/en.html#breadcrumb>

訓練内容は下記である。

火災の発生→火災の発見→火災の確認→119 番通報→消火器による初期消火  
→屋内消火栓による初期消火→避難誘導→消防隊への情報提供→訓練終了

EDM に自主学習をしてもらった。EDM 所員よりできれば火力発電所の消防訓練の動

画が望ましかったとのコメントをもらった。将来は可能なかぎり、火力発電所の消防訓練の動画の提供を計画したい。

EDM のマプト所長と質疑応答を行った。コロナ前は所員の慰労を兼ねて年に 2 回ほど、消火器、屋外消火栓での実施訓練をしていた。特別な契約はしていないが消防署に通報すれば 15 分ほどで消防隊（消防車）が発電所に駆けつけてくれる。

#### (7) 契約管理能力強化

EDM の契約管理業務能力強化を実施するためオンラインで紹介した。講義後 PDF ファイルではなく、オリジナルのパワーポイントの資料の提供をお願いされるなど契約管理について興味を持った様子だった。

※詳細は添付 Appendix-6: 契約管理能力強化資料を参照。

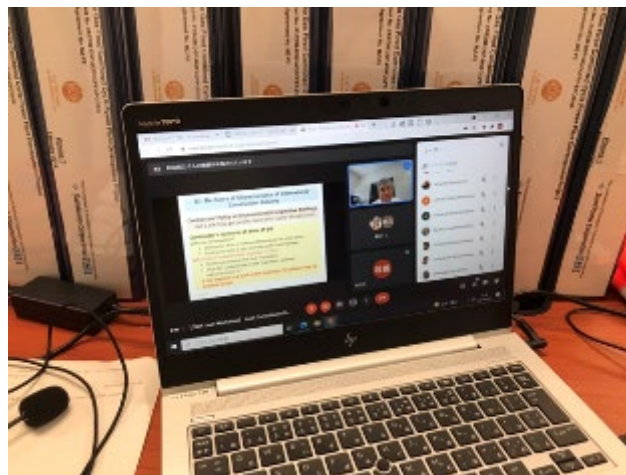


図 2.6-7 オンライン学習の状況

#### (8) 財務管理能力強化

EDM の財務管理業務能力強化を実施するため財務分析研修（モザンビーク電力公社の事例）を紹介した。こちら EDM からのお願いで自主学習とした。マプト火力発電所には経済財務の専門家はいないので、他部門の経済財務専門家へ資料を提供した。経済財務専門家より社内資料として活用したいとのことでオリジナルのパワーポイントの資料を提供した。

※詳細は添付 Appendix-7: 財務管理能力強化資料を参照。

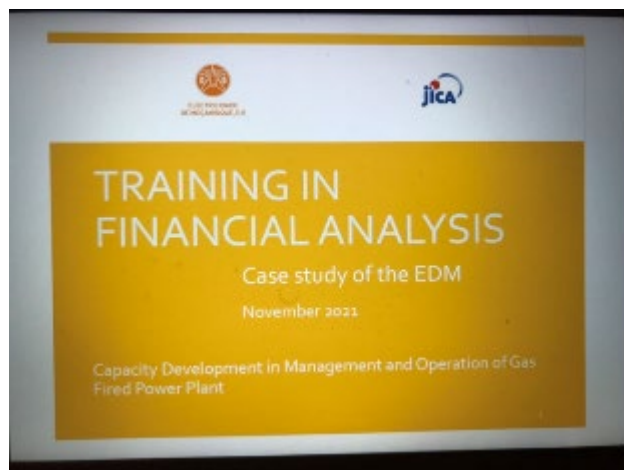


図 2.6-8 財務分析研修資料

#### 2.6.6. 第2次現地業務の総括

本プロジェクトの最終目標は、マプト火力発電所において、現在の EPC コントラクターに依存した O&M から脱却し、自立した発電所として安定・継続的な発電所運営が可能となるよう、体系的な O&M の仕組み、および、そのための人材育成強化に関する仕組みを構築することである。

その最終目標に向け、第2次現地業務にて主に下記を実施した。

- O&M のマニュアル類について。
- 人材育成の枠組み構築（組織、スケジュール、方法など）について。
- 今後の業務実施方法の確認。

新型コロナウイルス（COVID-19）の感染拡大に伴い現地訪問出来ない状況が続き、EDM との毎週のオンラインミーティングを通して業務を進めてきた。しかし、第1次現地業務（5月実施）及び今回の第2次現地業務を実施することによりマプト火力発電所の O&M 業務に直接触れた中での議論・協議を進めることができた。

EDM はマスクの着用、手洗い手指消毒をこまめにして、会議室の窓を開放するなどこまめな換気を心がけ新型コロナウイルスの感染防止対策を徹底していた。

EDM と専門家チームの火力発電所保守専門員は保守点検の計画から実施そして実績管理のワークフローを含む、マニュアル類について打合せを実施して EDM の要望を回収した。

EDM と人材育成専門家は人材育成の枠組み構築について具体的なスケジュール表を用いて打合せ EDM のコメントを回収した。日常業務に追われるなかで EDM は積極的な対応をしてくれた。

今後の業務にて、上記の最終目標にむけて体系的な O&M の仕組み構築、人材育成プログラムの構築の整備を継続し、見える化・情報の共有化を進めていく。見える化・情報の共有化について、すでに運用を行っている Computer Management Information System (e-Serv) の

活用をうながすようにする。これはメンテナンスグループ、オペレーショングループ共に同じである。また保安上義務付けられた紙ベースでの記録、報告書の洗い出しとその他の紙ベースの文書の保管方法及び保管期間の明文化を EDM に求めていく。

## 2.7. 第3次現地業務

### 2.7.1. 第3次現地業務概要

専門家チームは、2022年3月18日（金）から6月11日（土）までモザンビーク国火力発電所運営能力向上業務の第3次現地業務を計画した。第3次業務では、第4ステージの体系的なO&M・人材育成プログラムの実施及び第5ステージの体系的なO&M・人材育成プログラムの評価改善を実施予定である。またワークショップを開催予定である。

### 2.7.2. 出張者(マプト滞在期間)

|                             |                 |
|-----------------------------|-----------------|
| 業務主任者／火力発電所運転管理 A           | 小野政義（3/20-6/10） |
| 火力発電所保守（点検・補修）              | 青木正帆（4/8-4/20）  |
| 人材育成 A／火力発電所運転管理 B          | 根本弘幸（4/8-4/20）  |
| 火力発電所運転シミュレーション A           | 中嶋隆広（5/13-5/25） |
| 火力発電所運転シミュレーション B/<br>業務調整員 | 古藤泰輔（5/13-5/25） |

### 2.7.3. 業務期間

| 月 日           | 内 容                                                                                                                                                |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| 3/18          | 金 移動 東京⇒ドーハ                                                                                                                                        |
| 3/19,20       | ‘- 移動 ドーハ⇒マプト                                                                                                                                      |
| 3/21          | 月 EDM マプト火力発電所にて業務開始                                                                                                                               |
| 3/22          | 火 キックオフミーティング                                                                                                                                      |
| 3/23-<br>4/7  | - 全般；Generation Director など管理者と打合せ、火力運転保守・人材育成マニュアル作成補助、発電所 O&M の日常業務の改善指導                                                                         |
| 4/8           | 金 午前：マプト着（根本、青木）、午後：EDM マプト火力発電所・環境整備                                                                                                              |
| 4/11<br>-4/19 | - 全般；Generation Director など管理者と打合せ、EDM の能力強化を実施（火災予防、契約管理、財務管理他）、発電所 O&M の日常業務の改善指導<br>火力発電所保守：EDM マプト火力発電所と打合せ<br>人材育成；EDM アカデミー、EDM マプト火力発電所と打合せ |
| 4/20          | 水 移動 マプト発（青木、根本）                                                                                                                                   |
| 4/21          | 木 移動 ドーハ⇒東京（青木、根本）                                                                                                                                 |
| 5/11-<br>5/26 | - 中嶋、古藤 マプト出張                                                                                                                                      |
|               | プロジェクトのまとめと今後の展望、ワークショップ開催予定                                                                                                                       |
| 6/10          | 金 移動 マプト発                                                                                                                                          |
| 6/11          | 土 移動 ドーハ⇒東京                                                                                                                                        |

#### 2.7.4. 目的

全般：Generation Director や管理者（火力局長、南部地域、所長、運転、補修）と良好な関係を維持する。プロジェクトのまとめと今後の展望を確認する。

火力発電所保守：マニュアル類を最終確認する。

人材育成：人材育成について最終確認する。

#### 2.7.5. 特記事項

##### (1) キックオフミーティングの開催

EDM 側の Project Leader の Ms Thandi とスケジュール表をもとに第3次現地業務の目的を説明・スケジュールの確認を実施した。火力発電所保守、人材育成についてマニュアル類を提出して最終確認をお願いした。



図 2.7-1 キックオフミーティング

##### (2) シミュレーターの動作確認

専門家チームにてシミュレーターの動作確認を行った。現状あまり使われていないのが実情である。シミュレーターに興味を持ってもらうため、コントラクター作成の Start Sequence の Exercise の模範解答を作成した。

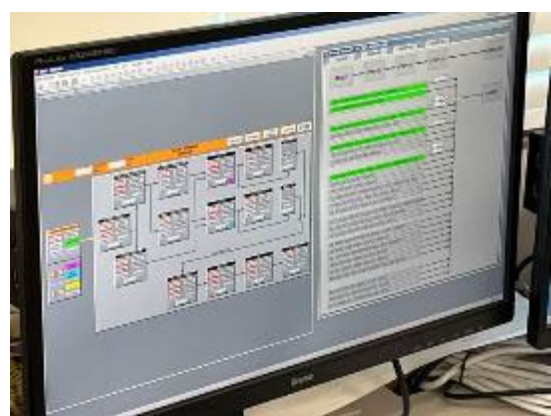




図 2.7-2 シミュレーター動作確認

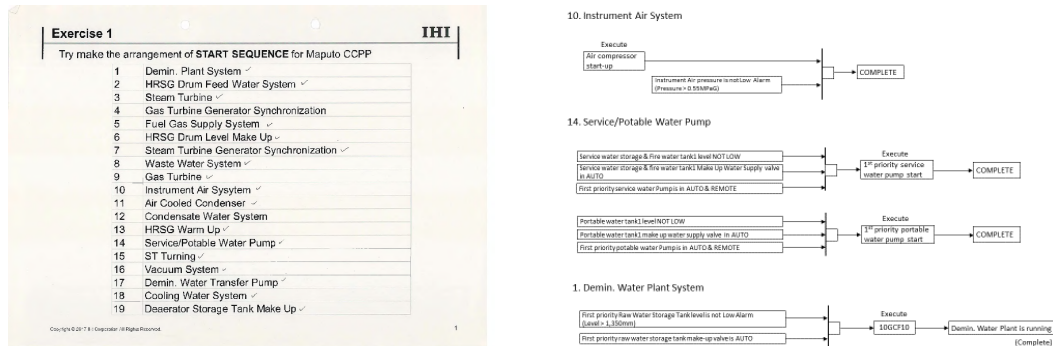


図 2.7-3 Start Sequence

### (3) LTSA 業務への参加

ガスタービン、蒸気タービンおよび排熱回収ボイラーを対象に、マプト火力発電所と日本の機器製造企業間で、定期的な保守点検、遠隔監視システムを活用した運転や保守支援、緊急時の技術者派遣、技術者 1 名発電所常駐などを内容とした 6 年間の長期保守契約（Long Term Service Agreement: LTSA）を締結している。

表 2.7-1 おもな点検停止計画

| ガスタービン点検種別                                              | 点検計画日       | その他点検計画                             |
|---------------------------------------------------------|-------------|-------------------------------------|
| 1 <sup>st</sup> . Annual Inspection                     | 2019 年 8 月  |                                     |
| 2 <sup>nd</sup> . Annual Inspection                     | 2020 年 6 月  | 排熱回収ボイラー点検                          |
| 3 <sup>rd</sup> . Annual Inspection                     | 2021 年 6 月  | 蒸気タービン Minor Inspection             |
| 4 <sup>th</sup> . Annual Inspection                     | 2022 年 6 月  | 排熱回収ボイラー点検                          |
| 5 <sup>th</sup> . Semi-Annual Inspection                | 2022 年 12 月 | ガスタービン高温部品精密点検                      |
| 6 <sup>th</sup> . Annual Inspection<br>(Major Overhaul) | 2024 年 6 月  | 蒸気タービン Major Overhaul<br>排熱回収ボイラー点検 |

運転保守のノウハウを移転するため毎週コントラクター主催の技術報告会を開催している。専門家チームも報告会に参加してコントラクター、EDM、専門家チームにて活発な議論を行った。この報告会は EDM からの評判がよく、専門家チームよりコントラクターに継続実施をお願いした。





図 2.7-4 LTSA ミーティング

#### (4) インターンシップ

EDM は学生を対象に実際の業務や働く環境の体験を通じて、業務内容や働くことの理解を深めることを目的としてインターンシップを積極的に行い将来の人材確保に努めていた。



図 2.7-5 インターンシップ

#### (5) Handbook の供与

O&M 業務に重要な Alarm & Set Point List を A5 サイズに縮小し追加で 20 部供与した。中央制御室 (CCR) のオペレーターデスクに相当使いこなされた Handbook があったことより有効活用されていた。



図 2.7-6 Handbook

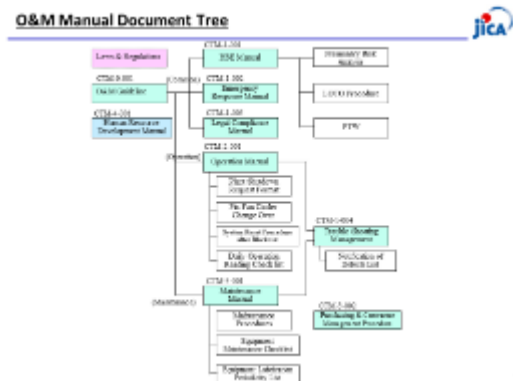
#### (6) ワークショップ

本業務の成果発表のためオンラインのワークショップを計画した。

プレゼンテーション資料を準備する際、EDM より最も精巧なマニュアルを選び、それぞれの目的は何か、作成するためにどんな情報を基にしたかを説明して欲しいとのお願いがあった。

ワークショップはスケジュールの都合で専門家チーム帰国後の 2022 年 7 月 15 日の開催となった。EDM（管理者、運転、保修）の 20 名近い参加を得た。

専門家チームは O&M マニュアルや人材育成プログラムのそれぞれ目的は何かと全体概要について説明し O&M は Emergency Response Manual を選び、人材育成プログラムは新卒のエンジニアのトレーニングスケジュールや技能認定制度などを紹介した。



## Human Resource Development (HRD) 1/13

HRD Report consists of the followings;

| Manual & List Number | Description                                                  |
|----------------------|--------------------------------------------------------------|
| 1 CTM-4-001          | Human Resource Development Manual                            |
| 2 CTM-4-002          | KPI for O&M and HRD                                          |
| 3 CTM-4-003          | Training Record Notebook for HRD                             |
| 4 CTM-4-004          | Training Management Check Sheet for CTM Operator             |
| 5 CTM-4-005          | Training Management Check Sheet for CTM Maintenance Engineer |
| 6 CTM-4-006          | Q&A of Examination for Skill Certification System            |
| 7 CTM-4-007          | Questionnaires Survey Report                                 |
| 8 CTM-4-008          | Inspection Report for Existing HRD Program                   |
| 9 CTM-4-009          | Training List of Training Center                             |
| 10 CTM-4-010         | List received from EDM and Website                           |

## Human Resource Development (HRD) - 4/13

2. Training schedule for new employee-1, 2



図 2.7-7 ワークショップ

EDM より下記のコメントをもらった。

- ・今後の活動計画を説明して欲しい。
- ・O&M マニュアル、HRD ガイドラインについてマプト火力発電所にどう適用できるかを説明して欲しい。

専門家チームは今後の技術レベル向上研修について業務完了報告書で提案することを EDM に説明した。O&M のマニュアル類や人材育成プログラムはソフトデータ (Word, Excel) を EDM に提供しており、今後 EDM 独自で修正・変更が可能であることを説明した。

EDM と専門家チームは今後お互いに協力することを確認した。

### 2.7.6. 第3次現地業務の総括

新型コロナウイルス (COVID -19) の変異株の感染拡大に伴い現地訪問出来ない状況が続くスケジュールが遅れ十分な準備期間がとれず、第4ステージの体系的な O&M・人材育成プログラムの実施及び第5ステージの体系的な O&M・人材育成プログラムの評価改善を実施することができなかった。EDM は引き続き新型コロナウイルスの感染防止対策を徹底していた。

本業務の成果発表のためオンラインでワークショップを開催し、O&Mのマニュアルや人材育成プログラムの概要について発表した。マニュアルやガイドラインについてマプト火力発電所にどう適用できるかについてEDMより質問され、専門家チームはO&Mのマニュアル類や人材育成プログラムはソフトデータをEDMに提供しており、今後EDM独自で修正・変更が可能であることを説明した。EDMと専門家チームは今後お互いに協力することを確認した。

個々のエンジニアやテクニシャンの技術レベルの向上のために、EDMから提案された第三国研修受講は、有意義であると思われるので業務完了報告書の中で提案する。

### 3. プロジェクト業務実施上の課題・工夫・教訓（業務実施方法、運営体制など）

本プロジェクトは、2020 年 8 月から業務が始まったがモザンビーク・日本の双方がコロナ禍に見舞われ、当初計画通りの渡航が実現できなかった中で、TV 会議システムを最大限活用し、カウンターパートとも頻繁にコミュニケーションを取った。

人材育成プログラムの一つとして火力発電所の基礎知識についてオンラインアカデミー（計 8 回）を実施した。各回講義資料を事前に配布して EDM 技術者が予習できるようにした。また、講義を録画して講義の復習や業務都合により参加できなかった EDM 技術者に提供した。質問書を作成し EDM より意見を集約して、次回以降の講義の参考とした。たとえば第 1、2 回目の講義は専門性に特化しており EDM より若干難しいとのコメントがあり、第 3 回目以降は質問を多く取り入れ双方向での講義に努めた。

人材育成プログラムの一つとして火力発電所の PDCA サイクル（Plan Do Check Action:継続的な改善活動）について第 8 回オンラインアカデミーを実施した。EDM より技術・技能の維持・向上は、一朝一夕に成し得るものではないが、今後も持続的な成長により EDM の社会的な責任を果たしていくために、今回学んだ PDCA サイクルをまわし、継続的に効果を高めていきたいとのコメントを頂いた。

EDM エンジニア（運転、保修）のオンラインアカデミーへの幅広い参加を得て本邦電力会社の火力発電所の基礎知識を多くの発電所技術者と共有した。

EDM との 23 回のオンラインミーティングを通して第 1 ステージである Clarification、第 2 ステージの体系的な O&M・人材育成プログラムのフレームワーク構築、第 3 ステージの体系的な O&M・人材育成プログラムの構築を実施した。しかし、お互いにオンラインミーティングに不慣れなことより全般的・大略的なことは把握できても、もう一步踏み込んだ理解、深い議論をするところまで至ることは難しかった。

プレゼンテーション資料だけでの議論に終わらず、実際のマプト火力発電所 O&M で使用している資料を活用して議論を進めるようにはしていたが、現地での O&M 業務に直接触れた中での議論・協議を進めることが EDM より望まれた。そこで第 1 次現地業務、第 2 次現地業務及び第 3 次現地業務を実施することによりマプト火力発電所の O&M 業務に直接触れた中での議論・協議を進めることができた。EDM はマスクの着用、手洗い手指消毒をこまめにして、会議室の窓を開放するなどこまめな換気を心がけ新型コロナウイルスの感染防止対策を徹底していた。

2021 年末の COVID-19 の変異株の影響により出張制限などがあり出張スケジュールが遅れ十分な準備期間がとれず、第 4 ステージの“体系的な O&M・人材育成プログラムの実施”及び第 5 ステージの“体系的な O&M・人材育成プログラムの評価改善”を実施することが

できずに、PDCA が回せなかった。しかしながら、O&M のマニュアル類や人材育成プログラムはソフトデータを EDM に提供しており、今後 EDM 独自で修正・変更が可能となるように配慮した。

EDM の組織改編や人事異動によりカウンターパートが途中変更となったが、Ms Thandi が EDM 側の Project Leader となり具体的な業務を進める実務クラスの EDM 責任者として本プロジェクトを実施した体制は最適であった。また Ms.Thandi は発電所全体のマネジメント力のレベルアップ、発電所員の能力アップのための部署に異動となった。日常業務に追われるなかで EDM は積極的な対応をしてくれた。

## 4. 本業務成果の達成度

本プロジェクトの目的は、マプト・ガスコンバインドサイクル発電所において、現在の EPC コントラクターに依存した O&M から脱却し、自立した発電所として安定・継続的な発電所運営が可能となるよう、体系的な O&M の仕組み、および、そのための人材育成強化に関する仕組みを構築することである。

第 1 章の 1.2.3.に記載したように期待される最終成果（上位目標）は下記である。

- 将来にわたって安定した発電所の運転、突発的な停止や出力抑制の防止により、マプト首都圏への安定した電力供給が行われる。
- O&M の全体・詳細を理解し、管理能力・技術力が向上する。
- 人材育成プログラムに基づいた研修が行われ、発電所技術者の技術力が向上する。

期待される最終成果を達成するための、本プロジェクトによる成果（プロジェクトにより整備される環境基盤）について、その達成度を個々に確認した。

| 本プロジェクトによる成果                                                      | 達成度                                                                                                                                                                                                                                                                                                                                                                            |
|-------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 体系的な O&M がマプト火力発電所により実施される。                                       |                                                                                                                                                                                                                                                                                                                                                                                |
| O&M 業務全体を網羅した O&M ガイドライン(仮称)に基づき、各発電所組織の責任と権限において運転や保守の各業務が実施される。 | EDM との定例オンラインミーティングを通して、発電所 O&M に関する発電所組織の責任と権限をレビューし、O&M ガイドライン (Maputo thermal power station organization, division of duties and responsibilities of each group, outline of each manual / regulation. etc.) に纏めた。<br>新型コロナウイルス (COVID-19) の感染拡大に伴い出張制限などがあり、また EDM 内部のコンセンサスが必要のためトライアル実施などには十分な準備期間が必要であったため、第 4 ステージの体系的な O&M の実施及び第 5 ステージの体系的な O&M の評価改善を実施することができなかった。 |
| O&M ガイドラインに基づく各マニュアル・手順などにより運転や保守の各業務が日常・中長期に渡り計画的に実施される。         | O&M ガイドラインに基づいて、<br>(a) HSE マニュアル (Risk management, Health/ Safety/ Environment management, Compliance items for dangerous work and low, etc.)<br>(b) 法令遵守マニュアル (Records and reports of power plant operations under the                                                                                                                                                       |



|                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                     | <p>law. Laws and regulations applicable to power plant operations)</p> <p>(c) 運 転 マ ニ ュ ア ル (Daily Operation (Monitoring, Patrol, Testing, Switching, etc.) Plant Start-up / Shut-down Operation, etc.)</p> <p>(d) 保守マニュアル (Scheduled Maintenance and Equipment Improvement Plan, Maintenance Work, Spare Parts Management, etc.)</p> <p>(e) 購 買 お よ び 請 負 管 理 マ ニ ュ ア ル (Structure of ordering specifications, points to note, Work Supervision, Work Cost Estimation System, etc.)</p> <p>を取り纏めた。</p> <p>COVID -19 の感染拡大に伴い出張制限などがあり、また EDM 内部のコンセンサスが必要のためトライアル実施などには十分な準備期間が必要であったため、体系的な O&amp;M の実施及び体系的な O&amp;M の評価改善を実施することができなかった。</p> |
| <p>トラブル発生時などに適切な運転・補修対応が図られるよう、対応・報告手順などが整備される。</p> | <p>O&amp;M ガイドラインに基づいて、</p> <p>(a) 緊 急 対 応 マ ニ ュ ア ル (Emergency organization, typical emergency response, emergency response plan, etc.)</p> <p>(b) ト ラ ブ ル シ ュ ー テ ィ ン グ 管 理 手 順 (How to troubleshoot, Trouble Shorting Flow Diagram, etc.)</p> <p>を取り纏めた。</p>                                                                                                                                                                                                                                                                                                                                                                                  |
| <p>継続的な評価と改善が図られる仕組みが構築される。</p>                     | <p>人材育成プログラムの一つとして火力発電所の PDCA サイクル (Plan Do Check Action: 継続的な改善活動) について第 8 回オンラインアカデミーを実施した。EDM エンジニア (運転、保修) の幅広い参加を得て本邦電力会社の火力発電所の基礎知識を多くの発電所技術者と共有した。</p> <p>すでに運用を行っている本邦電力会社の知見を活用しながら円借款事業で導入した Computer Management Information System (e-</p>                                                                                                                                                                                                                                                                                                                                                                                            |

|                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                               | Serv) の承認手続を整理し、保守マニュアルに取り入れた。EDM は e-Serv をすでに運用している。                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| マプト火力発電所にて人材育成プログラムが導入される(技術水準に応じた階層制度の構築・導入) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 技術者に求められる育成水準（目標）に到達するための人材育成プログラムが策定される。     | <p>マプト火力発電所の人員構成は、マプト火力建設前から採用されたエンジニア、マプト火力建設プロジェクト開始時から 2018 年 8 月のプラント運用開始までに採用されたオペレータやメンテナンスエンジニアである。</p> <p>2019 年 3 月に採用されたオペレータやメンテナンスエンジニアとすでに採用されたエンジニアの間でスキルギャップがあることが指摘された。</p> <p>このため、既存の新入社員研修システムの改善は 2019 年 3 月に採用された従業員及びそれ以降の定期採用者を対象に今後の研修システムを作成した。</p>                                                                                                                                                                                                                                                                                                                                  |
| 人材育成目標に到達するための研修プログラムが整備され、実施される。             | <p>今後のマプト火力発電所社員の想定した研修プログラムを作成した。</p> <ul style="list-style-type: none"> <li>・ 2019 年 3 月採用した従業員について <ul style="list-style-type: none"> <li>(a) オペレータとメンテナンスエンジニアの技能認定制度の取得スケジュール</li> <li>(b) 全体の研修スケジュール</li> <li>(c) 技能認定制度をベースにしたオペレータ研修スケジュール</li> <li>(d) 技能認定制度をベースにしたメンテナンスエンジニア研修スケジュール</li> <li>(e) 技能認定制度をベースにしたシミュレーター研修スケジュール</li> </ul> </li> <li>・ 2022 年 4 月採用の場合の従業員について <ul style="list-style-type: none"> <li>(a) オペレータとメンテナンスエンジニアの技能認定制度の取得スケジュール</li> <li>(b) 全体の研修スケジュール</li> <li>(c) 技能認定制度をベースにしたオペレータ研修スケジュール</li> <li>(d) 技能認定制度をベースにしたメンテナンスエンジニア研修スケジュール</li> </ul> </li> </ul> |

|                                            |                                                                                                                                                                                                                                       |
|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                            | <p>(e) 技能認定制度をベースにしたシミュレーター研修スケジュール</p> <ul style="list-style-type: none"> <li>・技能認定制度に適用する OJT をベースとした研修チェックシート</li> </ul> <p>(a) オペレータの研修チェックシート</p> <p>(b) メンテナンスエンジニアの研修チェックシート。</p> <p>(c) トレーニング・シミュレータの研修チェックシート。</p>          |
| 業務品質に対する意識、モチベーション向上などを目的に技術者認定制度などが整備される。 | <ul style="list-style-type: none"> <li>・技能認定制度の導入について</li> </ul> <p>技能認定制度の提案は、EDM から受領した EDM Skill Management Plan (2020 年 9 月発行) の技能認定制度と整合のとれた技能認定制度とした。</p>                                                                       |
| 技術者に求められる育成水準（目標）に到達するための人材育成プログラムが策定される。  | <p>オペレータとメンテナンスエンジニアの認定レベルを初級、中級、上級とした。さらに、技能認定制度の年度別の受験者数及び合格者数を KPI として設定した。</p>                                                                                                                                                    |
| 継続的な評価と改善が図られる仕組みが構築される。                   | <p>本技能認定制度は EDM では初めての導入であり事前にトライアル実施を行い PDCA によりアップデートして本格導入を計画したが実施出来なかった。</p> <p>これは、COVID-19 の影響により出張制限などがあり予定した技能認定制度のトライアル実施が出来なく PDCA が回せなかった。</p> <p>さらに、本制度は EDM 全社大のものとなり、EDM 内部のコンセンサスが必要のためトライアル実施などには十分な準備期間が必要であった。</p> |

## 5. 今後の課題と活動計画

モザンビーク国の近年の順調な経済成長や電化率の向上などに伴い、電力需要が大幅に増加しており、JICA 支援の電力マスタープラン(2018)によると電力需要の年平均成長率は12.4%、ピーク需要は2015年の655MWから2042年には6,500MW以上になると想定されている。新型コロナウイルスの影響により一時的な電力需要の低下が見込まれるが、コロナの影響などが緩和されれば、これからも堅調にモザンビーク国の電力需要は伸びていくものと推測される。

EDM のオフィシャルレポート (BUSINESS PLAN 2020-2024) における、平均発電コストの比較によると自社電源<IPP<輸入電力となっている。2020年時点でモザンビーク国におけるEDMによる発電量の割合は全体の12%程度であり、国内の電力需要を満たすためにEDMは輸入電力やIPPより電力を買い取る必要がある。前述のように輸入電力やIPPからの買い取りは高価でありEDMの財政に悪影響を及ぼしている。低コストの自社電源を増やしてコスト高の輸入電力やIPPからの購入量を減らすことによりEDMの財務状況の改善が期待できる。今後もEDM独自の火力発電所や再生可能エネルギーによる発電所の計画を進めて行く必要がある。したがってEDM独自の発電所運営は必要なものである。

円借款事業のマプト火力発電所の質の高いO&Mを維持するためには、マプト火力発電所のO&Mに従事する社員の能力を開発・維持することが重要である。

本プロジェクトは、単に発電所技術者個人の技術能力強化を図るものではなく、発電所組織として体系的にO&Mを実施出来る仕組みの構築、そのために不可欠な人材育成のためのプログラム構築の支援を実施することである。

これと併せて、マプト火力発電所の社員に対して個々の技術レベルの向上に力点を置いた十分な教育を提供することが重要である。個々のエンジニアやテクニシャンの技術レベルの向上のために、EDMから提案された第三国研修受講は、有意義であると思われるので下記に取り纏めた。

### 5.1. EDMのニーズに合わせた第三国研修の必要性

#### 5.1.1. 背景

EDMは2020年9月に全社大でスキルマネジメントプランを策定した。

このスキルマネジメントプランによると発電部門、特にマプト火力発電所としては計装・制御、電気及びプラントのオペレーション及びメンテナンスエンジニアの中級クラスのレベル2を増やすことが急務であると報告された。すなわち、初級クラスのレベル1を中級クラスのレベル2にステップアップさせることである。

これは、マプト火力発電所の人員構成は、マプト火力建設前からのエンジニア、マプト火力建設プロジェクト開始時から 2018 年 8 月のプラント運用開始までに採用されたオペレータやメンテナンスエンジニアと、2019 年 3 月に採用されたオペレータやメンテナンスエンジニアとの間でスキルギャップがあることが指摘された。

#### 5.1.2. マプト火力発電所から研修の実施の要請の経過

本業務を通して EDM より計装・制御及び電気関係の保守技術者に対して計装・制御及び電気関係などのベンダーによる座学研修及び実機研修の実施を強く要請された。

しかし、本業務は O&M, RD のシステム構築が目的であり研修の実施業務は含まれていないこと、さらに、COVID-19 の状況下での外国研修は、感染防止など安全対策上からも実施は困難であることより断った。

なお、第 3 国に於ける研修については、南アフリカ共和国及びザンビア共和国に於いて有効な研修が可能であることを EDM の情報や Website 情報により確認出来た。

#### 5.1.3. 今後の研修の必要性

従って、さらなる研修が必要ならば基本的には EDM 自身が自己資金で年度計画により実施すべきと考えられるが今後のマプト火力発電所の自主技術による長期的な安定運転の確保のため JICA による研修支援は次の理由により非常に有益であるとする。

- (1) マプト火力発電所は首都圏マプトに於ける最重要な位置づけの発電所であり長期的な安定運転は必須である。
- (2) 最新鋭の高度化されたプラントの運用・保守に関しては、スペシャライズされた運用・保守技術の習得が必須である。これらの自主技術を向上させることによりプラントの運用信頼度の向上や保守業務の直営化により保守費用の低減が図れる。
- (3) リモート研修も考えられるが専門の指導員による実機研修がいろいろなトラブル事例の解決方法など訓練センターやベンダー研修は非常に有益である。
- (4) マプト火力発電所はパターン化された連続運転火力であるため装置の分解点検などの技能習得は訓練センターやベンダー研修が非常に有益である。

このためモザンビーク国内では実施出来ない研修を隣国南アフリカ共和国やザンビア共和国での専門的な研修及び日本での Overall の発電所運営の研修などを推奨する。

なお、ザンビア共和国のカフエ渓谷地域訓練センター（Kafue Gorge Regional Training Center(以下、KGRTC)）での研修項目は多岐にわたり非常に有効と考える。

#### 5.1.4. 支援の必要な研修項目

EDM が第 3 国で希望する支援の必要な研修項目は下記のとおりである。

- (1) Thermal Power Plant Operations and maintenance for Mechanical engineer
- (2) GT Package Routine maintenance for mechanical engineer
- (3) Power Plant Planning System for planning engineer
- (4) Maintenance Management System (eServ) for planning engineer
- (5) Customized On-site Planner training for planners for planning engineer
- (6) Instrumentation and Process Control for I&C engineer
- (7) Allen Bradley PLC System
- (8) Maintenance of the FM200 Fire Fighting System
- (9) Certification in Fire Fighting System
- (10) CEMS (Continuous Emission Monitoring System)
- (11) Water Treatment Technique
- (12) Power Management and Control Room Operations
- (13) Training of Trainer

注： (1)～(5), (11) ～(13): JICA に依頼する項目

(6)～(10): 可能ならば JICA に依頼する項目

※参考：

KGRTC は、ザンビアのカフエ溪谷にある、マラウイ、エスワティニ、タンザニア、ウガンダ、ザンビア、ジンバブエの地域評議会（BOT）によって管理されている電力関係の研修センターである。KGRTC は、1989 年にスカンジナビアの資金援助を受けて設立され、南部アフリカ開発共同体（SADC）およびサブサハラ地域の電力会社に水力発電および関連分野の競争力のある専門トレーニングソリューションを提供することを目的としている。KGRTC は ISO 9001 の認証を受けている。同センターは、アフリカ電力事業協会（APUA）より、アフリカにおける電力の訓練センターとして認定されている。KGRTC は、ルサカから南に約 100 キロ、チルンドゥ道路から 28 キロ離れたナマルンドゥの静かな環境にあり、ザンビア最大の水力発電所であるカフエ溪谷発電所と同じ地域に位置している。現在、105 の研修コースがありエネルギーや情報通信技術に関する知識、スキル、能力を習得するための学習者中心の環境を提供することに重点を置いている。

#### 5.2. まとめ

本プロジェクトにおいて EDM と専門家チームで作成した O&M マニュアル、HRD マニュアルが今後も EDM が独自に修正・変更を行うことが重要である。当該マニュアルは常にマプト火力発電所の現場に合わせてアップデートし続けなければ、マニュアルが実際の業務に即した内容になっていないことになる。

業務マニュアルをきちんと整備しておくことで、新しいエンジニアの入所教育時や人事異動で業務の引き継ぎをするとき迅速に対応できるはずである。マニュアルを整備しておけ

ば EDM マプト火力発電所のエンジニアの誰もが標準化された業務の流れやルールに沿って仕事を進めていけるため、業務上で発生するトラブルの軽減につながるはずである。

修正・更新を主体的に行う管理責任者を決めておき、確実に更新が行われる状態にすることを推奨する。マプト火力発電所主導でマニュアルを増やしていき、ある程度たまった段階で、管理責任者が指示してマニュアルを EDM の全社に展開することである。これを繰り返すことで、マニュアルが整備され、活用しやすくなり、トラブルの再発防止につながることを専門家チームは推奨する。



## **Appendix**



## List of Appendices

1. **【Presentation Material of Kick-off Meeting】**
2. **【MOM on Kick-off Meeting】**
3. **【Clarification on TV Meeting】**
4. **【Presentation Materials of Online Academy】**
5. **【Presentation Material of Strengthen Contract Management Capacity】**
6. **【Presentation Material of Strengthen Financial Management Capacity】**
7. **【MOM on Field Survey】**
8. **【Presentation Material of Work Shop】**



## Appendix-1

### Presentation Material of Kick-off Meeting



jica

## Capacity Development in Management and Operation of Gas Fired Power Plant

### Kick-off Meeting



ELECTRICIDADE  
DE MOÇAMBIQUE, E.P.

September 2020

Electricidade de Mocambique (EDM)  
Japan International Cooperation Agency (JICA)

jica

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- 5-2. Human Resource Development Program(HRD)

Appendix: Source from Work Plan Report

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## 1. Introduction of the JICA Experts

| Name              | Area of charge                                                                                                                                                   |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Masayoshi Ono     | Chief of Operations /<br>Thermal power plant operation<br>management A         |
| Shinobu Takeda    | Thermal power station maintenance<br>(inspection/repair)                      |
| Hiroyuki Nemoto   | Human resources development A/<br>Thermal power plant operation management B  |
| Takahiro Nakajima | Thermal power plant operation simulation A                                    |
| Takashi Kuroishi  | Human resource development B (TV conference lecturer)                         |
| Tsutomu Tanaka    | Human resource development C (TV conference lecturer)                         |
| Masahiro Sado     | Economic and financial management                                             |
| Naoki Kawakami    | Thermal power plant operation simulation B/<br>Operation Coordinator          |

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## 2. Outline of the Project

Expected Goals

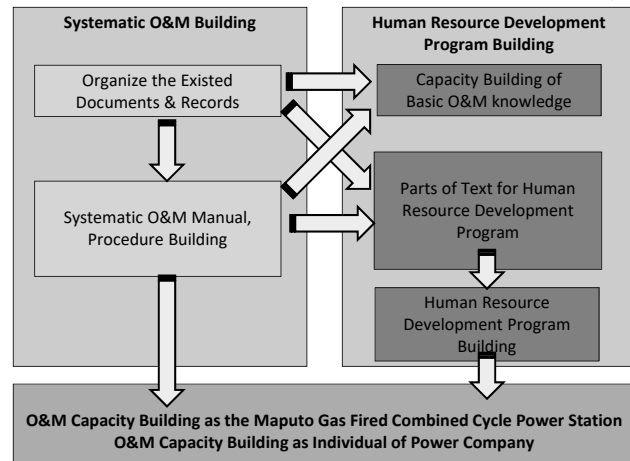
- Capable of sustainably O&M the Maputo Gas Fired Combined Cycle Power Plant

Project Activities

- Implementation of Systematic O&M Practice by EDM
  - Systematic plan to evaluate, take countermeasures & develop preventive measures for trouble including natural & human disasters is established.
  - The established systematic plan for trouble is implemented.
  - Work flow for the utilization of PMIS is developed.
  - Structure of O&M implementation is developed.
  - The HSE for the power plant O&M is defined & introduced.
  - The KPI for the power plant O&M is defined & introduced.
  - Capacity of EDM for contract management (e.g. LTSA) is developed.
- Introduction of Human Resource Development Program by EDM
  - The existing training system for new employee is improved.
  - The existing training program for the simulator system is improved.
  - The plan & system for human resource development & training is introduced.

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## 2. Outline of the Project (cont'd)



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## 3. Work flow & Schedule



### Project Period

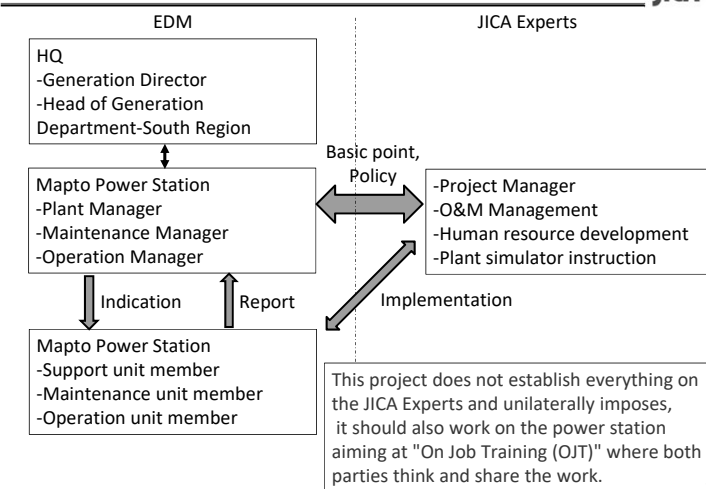
■ Aug 2020 through to July 2022 (Approx. 24 months)

|         | Work flow                                                                                                                                 | Schedule             |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| Stage 1 | • <b>Clarification</b> the current situation of Power Station                                                                             | Sep to Dec 2020      |
| Stage 2 | • Organize the Existed Documents and Records<br>• <b>Framework Establishment</b> of Systematic O&M and Human Resource Development Program | Jan to Apr 2021      |
| Stage 3 | • <b>Establishment</b> of Systematic O&M and Human Resource Development Program                                                           | May 2021 to Jan 2022 |
| Stage 4 | • <b>Implementation</b> of Systematic O&M and Human Resource Development Program                                                          | Feb to May 2022      |
| Stage 5 | • <b>Evaluation and improvement</b> of Systematic O&M and Human Resource Development Program                                              | May to July 2022     |

Subject to change depending on the COVID-19 conditions.

6

## 4. Project Team's Structure



7

## 5-1. Image of Activities – O&M



|         | Work flow                                                                                   | Schedule             |
|---------|---------------------------------------------------------------------------------------------|----------------------|
| Stage 1 | • <b>Clarification</b> the current situation of Power Station                               | Sep to Dec 2020      |
| Stage 2 | • Organize the Existed Documents and Records<br>• Framework Establishment of Systematic O&M | Jan to Apr 2021      |
| Stage 3 | • <b>Establishment</b> of Systematic O&M                                                    | May 2021 to Jan 2022 |
| Stage 4 | • <b>Implementation</b> of Systematic O&M                                                   | Feb to May 2022      |
| Stage 5 | • <b>Evaluation and improvement</b> of Systematic O&M                                       | May to July 2022     |

8



### Stage 1: Clarification the current situation of Power Station



What are the overall O&M work ?

Which Group/Person have to do & have first/final responsibility ?

What kinds of Documents/Manuals/Procedures/Records established ?

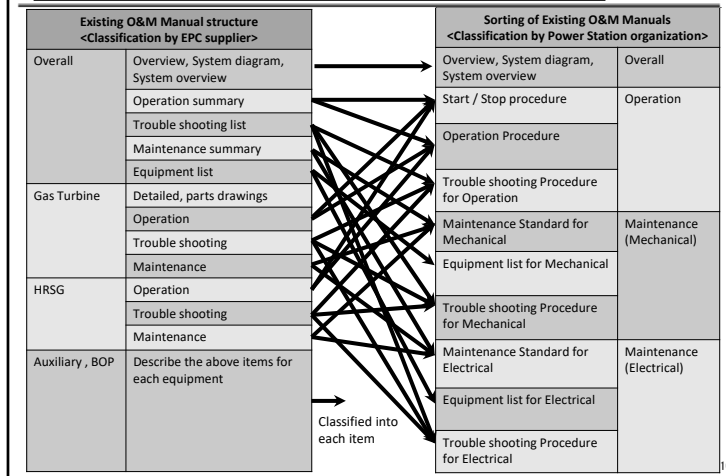
| O&M work (e.g.)          | Excerpt from work (e.g.)                                                      | Scope of work |
|--------------------------|-------------------------------------------------------------------------------|---------------|
| Legal Compliance         | List up legal requirements, Compliance check, Update legal requirements, etc. |               |
| Emergency response       | Organization, Communication, Responses Flow, Drill, Equipment, etc.           |               |
| Mid & Long term O&M plan | Scheduled outage plan, To shorten a planned outage, Cost vs Performance, etc. |               |
| Daily O&M                | Daily O&M plan, records, approval, evaluation, etc.                           |               |
| Budget control           | Budget plan, Expenditure control, Cost vs Performance, etc.                   |               |
| Contractor Management    | LTSA, Local contractors, etc.                                                 |               |
| (Many others)            | (others)                                                                      |               |

9

### Stage 2: Organize the Existed Documents and Records

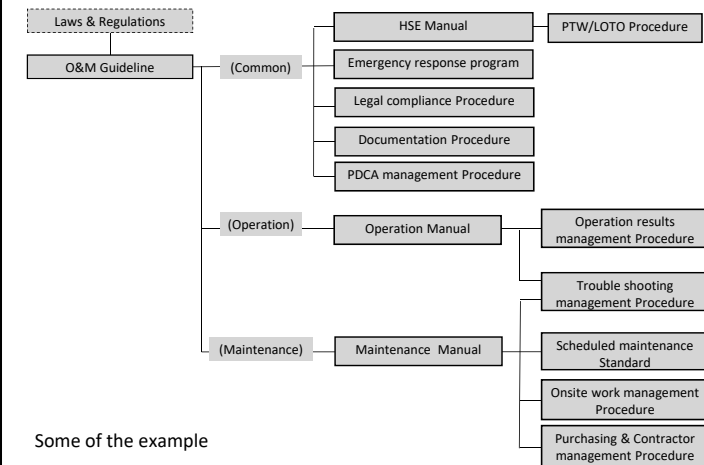


What kinds of documents/records use/make/store and how manage?



10

### Stage 3: Establishment of Systematic O&M



11

### Stage 4, 5: Implementation, Evaluation and Improvement of O&M



#### Stage 4

- conduct trial operation of actual work based on the establishment of the systematic O&M manuals/procedures in Stage 3

#### Stage 5

- Based on the trial operation results of each program in Stage 4, evaluate and improve each program
- examine the necessity of revision of manuals/procedures, and if necessary, carry out revision work

12

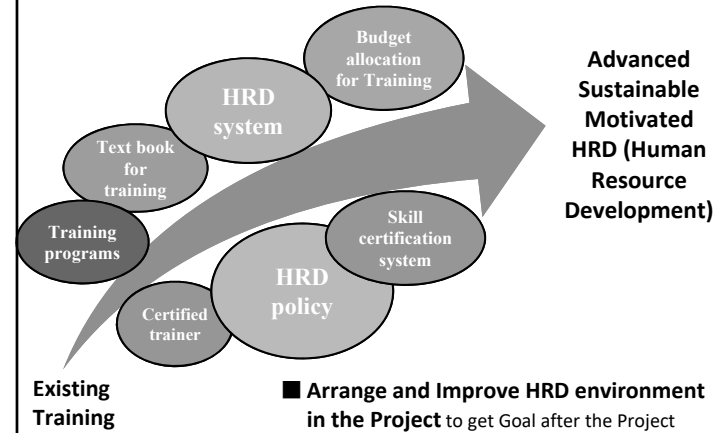
## 5-2. Image of Activities – HRD



|         | Work flow                                                                                                       | Schedule             |
|---------|-----------------------------------------------------------------------------------------------------------------|----------------------|
| Stage 1 | • <b>Clarification</b> the current situation of Power Station                                                   | Sep to Dec 2020      |
| Stage 2 | • Organize the Existed Documents and Records<br>• Framework Establishment of Human Resource Development Program | Jan to Apr 2021      |
| Stage 3 | • <b>Establishment</b> of Human Resource Development Program                                                    | May 2021 to Jan 2022 |
| Stage 4 | • <b>Implementation</b> of Human Resource Development Program                                                   | Feb to May 2022      |
| Stage 5 | • <b>Evaluation and improvement</b> of Human Resource Development Program                                       | May to July 2022     |

13

## HRD Planning (concept of the Project)

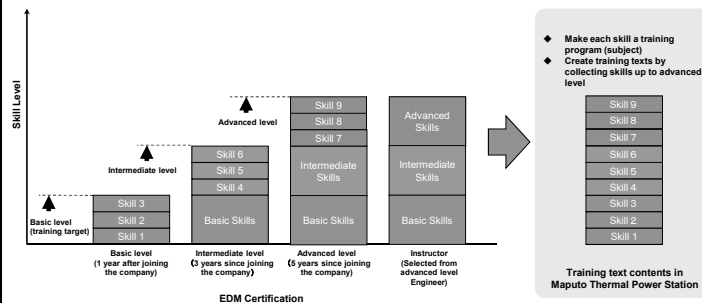


14

## Stage 3: Framework study of human resource development plan



- Step 1:  
Set target skill level (Set skill requirement level as a officer)
- Step 2:  
Compose training program along with target
- Step 3:  
Collect program and Publish text book

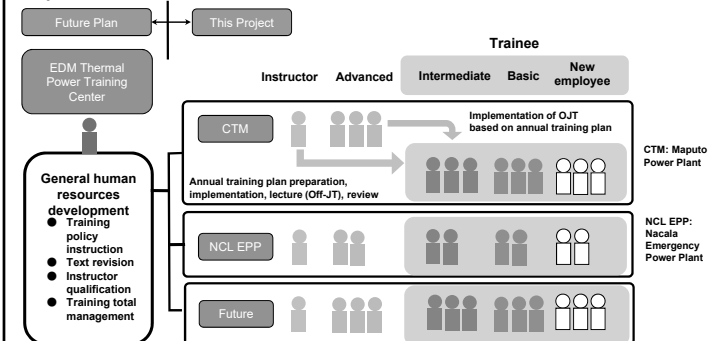


15

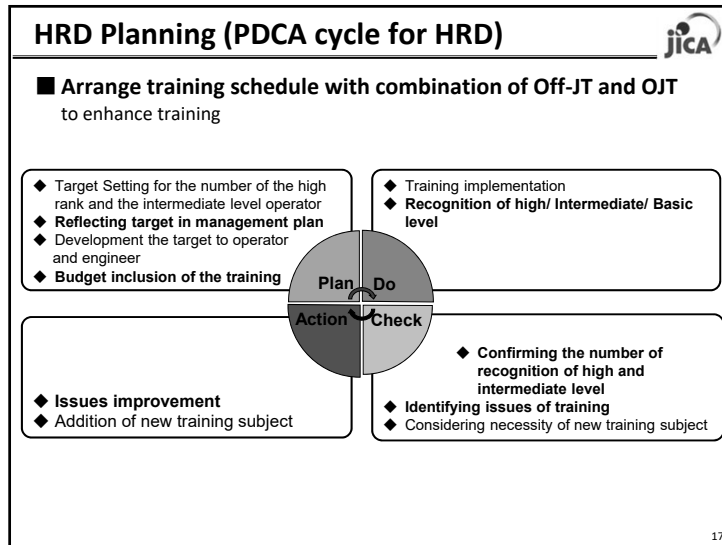
## Human Resource Development Planning



### Implementation structure



16



### TEPSCO Online Academy

Electricidade de Mozambique, E.P.

What is happened on the earth?

Oct. 8 2020

TEPSCO

Tokyo Electric Power Services Co., Ltd.  
Dr. Blackstone ( Takashi Kuroishi )

Total 8times (2times/month, Oct.2020- Jan.2021)

18

### Schedule under local travel restriction



| Year       | 2020                                           |    |    |    | 2021                  |   |   |   |
|------------|------------------------------------------------|----|----|----|-----------------------|---|---|---|
| Month      | 9                                              | 10 | 11 | 12 | 1                     | 2 | 3 | 4 |
| Stage      | ★ 1 <sup>st</sup> Stage<br>Kick-Off            |    |    |    | 2 <sup>nd</sup> Stage |   |   |   |
| TV Meeting | 1 Time (Every Tuesday) / Week = Total 20 Times |    |    |    |                       |   |   |   |
| Maputo     |                                                |    |    |    |                       |   |   |   |

### NEXT Schedule

Date: 29 (Tues.)September 2020  
Time: 9:00 a.m. Mozambique Time  
Items: Confirmation of EDM  
Maputo Latest Staffing and Organization etc.

20



jica

22

Appendix: Questionnaires (Sample) for HRD

Questionnaires

October, 2020

We would like to express our sincere appreciation for your great support to us.  
It is appreciated if you could provide your comments/opinions on our questionnaires for reflect to technical support to your power plant in the below form.  
Thank you for your kind cooperation.

Information

Dispatch Country

Mozambique

Survey team Name

Consultation on Technical Support in the Field of Power Generation

Dispatch Period

October , 2020 ~ October , 2020

Q1-1

Please write down:

Are you male or female ?

Male

Female

Less 10

10-20

20-30

30-40

Over 50

What is your age ?

Operation/Mechanical

Operation/Electrical/IC

Maintenance/Mechanical/Chemical

Maintenance/Electrical/IAC

Planning/Engineering

Others

What is your occupation ?

Operation/Mechanical

Operation/Electrical/IC

Maintenance/Mechanical/Chemical

Maintenance/Electrical/IAC

Planning/Engineering

Others

Q1-1

Please write down your experience:

Do you have experience the Operation work at Factory and/or Power station before EDM ? If yes, Periods \*

Yes

No

Do you have experience the Maintenance work at Factory and/or Power station before EDM ? If yes, Periods \*

Yes

No

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Appendix: Handbook List (Draft) and Sample

Handbook List (Draft) and Sample

Maputo 106MW Gas Fired Combined Cycle Power Plant Development Project

Operation Handbook

No.

Items

1

Operation Handbook

2

Set Point List Handbook

3

DCS Logic Handbook

4

Safety Handbook

5

To be discussed with EDM

6

To be discussed with EDM

7

To be discussed with EDM

8

To be discussed with EDM

9

To be discussed with EDM

10

To be discussed with EDM

26

ご清聴ありがとうございました

Muito Obrigado

7

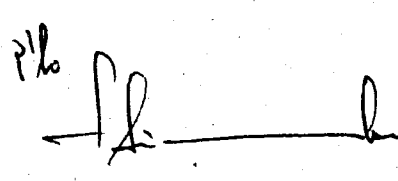
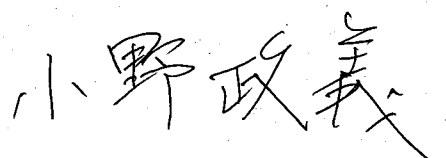


## Appendix-2

### MOM on Kick-off Meeting





| MINUTES OF MEETING                                                                                                                                                 |                                                                                                                 | Page 1 of 3                                                                                                                                                |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <b>Date</b> : Thursday / September 24, 2020                                                                                                                        |                                                                                                                 | <b>Meeting No.</b> : MOM-2020-09-24-01                                                                                                                     |  |
| <b>Hours</b> : 9.00 to 10.30 MST (16:00-17:30 JST)                                                                                                                 |                                                                                                                 |                                                                                                                                                            |  |
| <b>Meeting between</b> :<br>JICA, EDM, TEPCO                                                                                                                       |                                                                                                                 | <b>Location</b> :<br>TV Meeting by Google Meet                                                                                                             |  |
| <b>Subject</b> : Kick-off Meeting for JICA Capacity Development and Operation of Gas Fired Power Plant                                                             |                                                                                                                 |                                                                                                                                                            |  |
| <b>Attended by</b> :                                                                                                                                               |                                                                                                                 | <b>Attachment</b> :                                                                                                                                        |  |
| JICA                                                                                                                                                               | : Mr. Iijima Daisuke<br>Mr. Soyama Tsunenari<br>Mr. Tomura Hiroyuki<br>Mr. Ishiguro Ryo                         | 1.Presentation Material                                                                                                                                    |  |
| EDM                                                                                                                                                                | : Mr. Narendra Gulab<br>Mr. Firmino Licumba<br>Mr. Inacio Manuel                                                |                                                                                                                                                            |  |
| JICA Team                                                                                                                                                          | : Mr. Ono Masayoshi<br>Mr. Nemoto Hiroyuki<br>Mr. Takeda Shinobu<br>Mr. Nakajima Takahiro<br>Mr. Kawakami Naoki |                                                                                                                                                            |  |
|                                                                                                                                                                    |                                                                                                                 |                                                                                                                                                            |  |
| <b>Distribution:</b><br>1.JICA<br>2.EDM<br>3.TEPCO                                                                                                                 |                                                                                                                 |                                                                                                                                                            |  |
| <b>MINUTES REVIEWED AND AGREED</b>                                                                                                                                 |                                                                                                                 |                                                                                                                                                            |  |
| <b>For and on behalf of:</b><br>Counterpart<br><br><br><br>Narendra Gulab / EDM |                                                                                                                 | <b>For and on behalf of:</b><br>JICA Team<br><br><br><br>M.ONO / TEPCO |  |
| 1.                                                                                                                                                                 | General                                                                                                         |                                                                                                                                                            |  |

|                 |                           |                    |
|-----------------|---------------------------|--------------------|
| <b>FORM -11</b> | <b>MINUTES OF MEETING</b> | <b>Page 2 of 3</b> |
|-----------------|---------------------------|--------------------|

| <b>No.</b> | <b>Item / Meeting Result</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Action By</b> | <b>Target Completion</b> |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|--------------------------|
|            | <p>At first the JICA, Mr.Iijima welcome the participants and the meeting open.</p> <p>The EDM, Mr. Narendra thanked to attend the meeting the JICA and JICA Team</p> <p>Then, all party was introduced by themselves.</p> <p>JICA Team explained the Project Work Plan in accordance with MOM between EDM and JICA dated May 15, 2019.</p>                                                                                                                                                                                             |                  |                          |
| <b>2</b>   | <b>Meeting Results</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                  |                          |
|            | The outcome of main points is as follows;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                  |                          |
| <b>2.1</b> | <p>Title of the Project</p> <p>Capacity Development in Management and Operation of Gas Fired Power Plant</p>                                                                                                                                                                                                                                                                                                                                                                                                                           |                  |                          |
| <b>2.2</b> | <p>Expected goals</p> <p>EDM becomes capable of sustainable operate and maintain the Maputo Gas Fired Combined Cycle Power Plant</p>                                                                                                                                                                                                                                                                                                                                                                                                   |                  |                          |
| <b>2.3</b> | <p>Project Activities</p> <p>(1)Implementation of systematic O&amp;M practice by EDM</p> <p>(2)Introduction of Human Resource Development Program by EDM</p>                                                                                                                                                                                                                                                                                                                                                                           |                  |                          |
| <b>2.3</b> | <p>Duration</p> <p>August 2020 through to August 2022 (Around Two (2) Years)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                  |                          |
| <b>2.4</b> | <p>Implementation Structure</p> <p>(1)EDM</p> <p>(a)The Generation Director:</p> <p>Mr. Narendra Gulab</p> <p>(b)The Head of generation department – South Region:</p> <p>Mr. Firmino Licumba</p> <p>(c)The Maputo Plant Manager:</p> <p>Mr. Inacio Manuel</p> <p>(2)JICA Team</p> <p>(a)PM/Thermal power plant operation management A :</p> <p>Mr. Masayoshi Ono</p> <p>(b)Thermal power station maintenance (inspection/repair):</p> <p>Mr. Shinobu Takeda</p> <p>(c)Human resources development A/thermal power plant operation</p> |                  |                          |



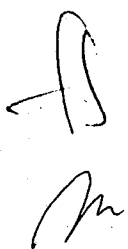

FORM -11

## MINUTES OF MEETING

Page 3 of 3

| No. | Item / Meeting Result                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Action By | Target Completion |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------------------|
|     | <p>management B:<br/>Mr. Hiroyuki Nemoto<br/>(d)Thermal power plant operation simulation A :<br/>Mr. Takahiro Nakajima<br/>(e)Human resource development B (TV conference lecturer)<br/>Dr.Takashi Kuroishi<br/>(f)Human resource development C (TV conference lecturer)<br/>Mr. Tsutomu Tanaka<br/>(g)Thermal power plant operation simulation B/Operation Coordinator :<br/>Mr. Naoki Kawakami</p>                                                                                                                             |           |                   |
| 2.5 | <p>Work Schedule<br/>JICA Team explained including implementation of under local travel restriction for new coronavirus (COVID-19).<br/>The personnel schedule was revised with the assumption that travel will resume in April 2021.<br/>JICA Team asked that TV meeting will be held on every Tuesday until March 2021 with On line Academy (two times per month).<br/>JICA Team will submit detailed schedule October 2020 as soon as possible.</p>                                                                           | TEPSCO    | Early next week   |
| 2.6 | <p>Human resource development<br/>EDM explained Maputo Gas Power Plant is the first combined cycle thermal power plant in the republic of Mozambique. Most of the power station staff are young employees who were hired in March 2017 when the construction started, and young employees who were newly hired after the start of commercial operation, and O&amp;M skill proficiency varies from engineer to engineer.<br/>JICA Team understood and will consider that conditions at project implementation stage with EDM.</p> |           |                   |
| 2.7 | <p>On line Academy<br/>EDM asked information required for attendee selection.<br/>TEPSCO will submit schedule with materials and brief personal record of lectures.</p> <p>End</p>                                                                                                                                                                                                                                                                                                                                               |           |                   |

(END)





Appendix-3

Clarification on TV Meeting



## Clarification on TV meeting (Oct to Dec, 2020) for O&amp;M

(6 Oct, 2020) 1<sup>st</sup> meeting **(Staffing and organization)** Could you please provide information/documents on the following?  
Related to iv. Structure of O&M implementation is developed, Implementation of Systematic O&M Practice by EDM (MOM<sup>#1</sup> between EDM and JICA at 15 May, 2019)

| Question items                                                                                                                                            | Answers & Comments                                                                                                                                           | Attachments                      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| 1_Organization charts & Number of Personnel(each section)                                                                                                 | Received                                                                                                                                                     | CTM Organization chart at 26 Oct |
| 2_Outsourcing Personnel (Permanent/Temporary local contractor)                                                                                            | (Scheduled maintenance, Minor repair work) Actual field works carry out by CTM engineers, not use contractor or technician.<br>(LTSA, PMIS) use contractors. | None                             |
| 3_Responsibility assignment matrix(RAM for whole O&M works)                                                                                               | CTM does not have materials related to responsibility assignment and authority, it is only have HQ boards.                                                   | None                             |
| 4_Authority and responsibilities of each job position                                                                                                     |                                                                                                                                                              |                                  |
| Others                                                                                                                                                    |                                                                                                                                                              |                                  |
| 5_ CTM Support unit (HSE, Operation support, Statistics, Procurement, etc.) does not have specific Manager. Managed by Plant Manager.                     |                                                                                                                                                              |                                  |
| 6_ Personnel rotation of Operation and Maintenance is being done on a trial basis in three-month cycles. The future of the system is under consideration. |                                                                                                                                                              |                                  |
| 7_ EDM asked JICA Team support of PMIS utilization, ISO9001, 14001 preparation for acquisition etc.                                                       |                                                                                                                                                              |                                  |

**TEPSCO Comment**

Responsibility assignments of overall O&M works are not clearly defined on the document. So, own group assignments and other group assignments, and the specific division of responsibilities may become unclear. As a result, there are also concerns about the difficulty of proactive work and delays in responding to emergencies. It also makes it difficult for new employees and others to catch the overall O&M works.

Therefore, it is necessary to create a document that summarizes the overall O&M works and shows the division of duties. So, we will develop O&M guidelines with CTM that organize the overall O&M works include responsibility assignments matrix in Stage 2.

(13 Oct, 2020) 2<sup>nd</sup> meeting **(Documents and Records)** What kinds of Documents/Manuals/Procedures/Records established?

Related to iv. Structure of O&M implementation is developed, Implementation of Systematic O&M Practice by EDM (MOM between EDM and JICA at 15 May, 2019)

| Question items                                                                                                                                         | Answers & Comments                      | Attachments                |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|----------------------------|
| Documents list and documents tree (EDM thermal power dept. and CTM)                                                                                    | Received                                | CTM      Power      Plant  |
| Operation & Maintenance Records list                                                                                                                   |                                         | Documentation List (Rev.3) |
| Are there any legal requirements such as the Japanese Safety/Security regulations and are there any documents based on it? If so, please provide them. | No legal requirements in the Mozambique | None                       |

#### **TEPSCO Comment**

Insufficient documentation for O&M. As a result, there is a risk of individual differences or unclear in the way for understanding and carried out works. So, it is difficult to improve the O&M capabilities of the organization and individuals. Therefore, We will establish the documentation system and documentation with CTM in Stage 2 or 3.



| (20 Oct, 2020) 3 <sup>rd</sup> meeting ( <b>Maintenance and Outage plan</b> ) How do you manage / decide the maintenance and outage plan on the following?<br>Related to <u>iii. Work flow for the utilization of PMIS is developed</u> , Implementation of Systematic O&M Practice by EDM (MOM between EDM and JICA at 15 May, 2019) |                                                                                                                                                                                                      |             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Question items                                                                                                                                                                                                                                                                                                                        | Answers & Comments                                                                                                                                                                                   | Attachments |
| 1_<Legal periodic inspection> Are there any standards in the Mozambique Electricity law that are similar to the periodic inspections in Japan (e.g. Boiler: Every 2years, Turbine: Every 4years)?                                                                                                                                     | No legal periodic inspection for main equipment in the Mozambique law that are similar to the periodic inspections in Japan.                                                                         | None        |
| 2_<Scheduled Maintenance standards> Is that reflected in the PMIS or other documents if periodic inspections need in the law?                                                                                                                                                                                                         | Maintenance are being done using a CMS (PMIS) and using CTM standards, Manufacture recommendation and so on for best practice.<br>And also considering strategic maintenance through PM, CBM and BM. | None        |
| 3_<Procedure> Do you have clear procedures in your manual or other documents, I previously described like procedures.<br>- Maintenance & Outage planning (Mid & Long term) procedure<br>- MW and Maintenance planning (Short term) procedure                                                                                          | Implemented in EDM's Practice. Procedure is under review with the Market player and NLDC.                                                                                                            | None        |
| Others                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                      |             |
| - Scheduled Maintenances are carried out in accordance with PMIS, and when maintenances are postponed, they are blanked and checked.                                                                                                                                                                                                  |                                                                                                                                                                                                      |             |

#### **TEPSCO Comment**

|                                                                            |
|----------------------------------------------------------------------------|
| Review the use of PMIS at site and discuss how to proceed in Stage 2 or 3. |
|----------------------------------------------------------------------------|

| (27 Oct, 2020) 4 <sup>th</sup> meeting ( <b><u>Legal compliance</u></b> ) How do you ensure and manage your compliance?<br>Related to <u>iv. Structure of O&amp;M implementation is developed</u> , Implementation of Systematic O&M Practice by EDM (MOM between EDM and JICA at 15 May, 2019) |                                                                                                                   |             |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|-------------|
| Question items                                                                                                                                                                                                                                                                                  | Answers & Comments                                                                                                | Attachments |
| 1_ I think there are many laws and regulations that regulate power plants, but how do you share information with your staff?                                                                                                                                                                    | There are also many regulations that regulate power plants in Mozambique, but these management are big challenge. | None        |
| 2_ How do you manage the implementation of legal procedures?<br>Does the PMIS or other documents clarify the contents and timing of inspections in accordance with the regulations?                                                                                                             |                                                                                                                   |             |

**TEPSCO Comment**

The items and procedures for legal compliance that must be implemented in O&M may not share/control the Information in CTM. There is a concern that legal violations may occur.

Therefore, we will organize the items and procedures for legal compliance with CTM in Stage 2 or 3.

| (10 Nov, 2020) 5 <sup>th</sup> meeting ( <b><u>O&amp;M Targets, Yearly business plan</u></b> )<br>Related to <u>iv. Structure of O&amp;M implementation is developed</u> and <u>vi. The KPI for the power plant O&amp;M is defined &amp; introduced</u> , Implementation of Systematic O&M Practice by EDM (MOM between EDM and JICA at 15 May, 2019) |                                          |                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|------------------|
| Question items                                                                                                                                                                                                                                                                                                                                        | Answers & Comments                       | Attachments      |
| Could you please send your actual 2020 business implementation plan?                                                                                                                                                                                                                                                                                  | EDM send Business plan 2020 include KPI. | Not yet received |

**TEPSCO Comment**

The business plan created at EDM HQ seems to be the reference for CTM work, but there is currently no plan that breaks it down into CTM. So, we feel that it is not easy to understand the yearly plans and targets of CTM in all CTM worker.

Therefore, we will establish yearly business plan and targets of CTM with CTM in Stage 3.

| (17 Nov, 2020) 6 <sup>th</sup> meeting ( <b>HSE, PTW, LOTO</b> )<br>Related to <u>v. The HSE for the power plant O&amp;M is defined &amp; introduced</u> , Implementation of Systematic O&M Practice by EDM (MOM between EDM and JICA at 15 May, 2019) |                                                                                |                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|------------------|
| Question items                                                                                                                                                                                                                                         | Answers & Comments                                                             | Attachments      |
| 1_Do you use the safety procedure like PTW, LOTO and Work procedure? Please send your procedure if you use.                                                                                                                                            | CTM is implementing PTW/LOTO system for both electrical and mechanical work.   | None             |
| 2_ Do you do Tool box meeting (TBM) before start of field work? And keeping records?                                                                                                                                                                   | CTM is implementing TBM by Preliminary Risk Analysis (Documentation list no.3) | Not yet received |
| 3_Do you have HSE manual?                                                                                                                                                                                                                              | EDM has the HSE manual as a whole company, but don't have one as a CTM.        | Not yet received |

#### **TEPSCO Comment**

|                                                                                                                                                                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Review the use of PTW/LOTO/Preliminary risk analysis at site and discuss how to proceed in Stage 2 or 3.<br>We will establish HSE manual of CTM with CTM in Stage2 or 3. |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

| (24 Nov, 2020) 7 <sup>th</sup> meeting ( <b>Emergency response, Disaster prevention</b> )<br>Related to <u>i. Systematic plan to evaluate, take countermeasures &amp; develop preventive measures for trouble including natural &amp; human disasters is established</u> , Implementation of Systematic O&M Practice by EDM (MOM between EDM and JICA at 15 May, 2019) |                                                                                                                                                                                                                                                              |             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Question items                                                                                                                                                                                                                                                                                                                                                         | Answers & Comments                                                                                                                                                                                                                                           | Attachments |
| 1_Do you have emergency response manual / procedure?<br>Please send your manual / procedure if you have.                                                                                                                                                                                                                                                               | Natural disasters are rare In Mozambique, only general information/instructions such as forecast, cutting power lines are provided by the government and HQ, so no manuals have now. But it is useful to have a manual because CTM is gas-fired power plant. | None        |
| 2_ How often emergency response drill? What kinds of drill you did?                                                                                                                                                                                                                                                                                                    | Time to time, firefighting with fire engine test run, evacuation drill, etc. are conducted.                                                                                                                                                                  | None        |

#### **TEPSCO Comment**

|                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Concerns about crisis management for emergency/disaster without procedures include organization, equipment and so on.<br>Therefore, we will establish emergency response manual with CTM in Stage 2 or 3. |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

| (1 Dec, 2020) 8 <sup>th</sup> meeting ( <b>Maintenance</b> )<br>Related to <u>i. The established systematic plan for trouble is implemented</u> , <u>ii. Work flow for the utilization of PMIS is developed</u> , <u>iv. Structure of O&amp;M implementation is developed</u> and <u>vii. Capacity of EDM for contract management (e.g. LTSA) is developed</u> , Implementation of Systematic O&M Practice by EDM (MOM between EDM and JICA at 15 May, 2019) |                                                                                                                                                                                             |             |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Question items                                                                                                                                                                                                                                                                                                                                                                                                                                               | Answers & Comments                                                                                                                                                                          | Attachments |
| 1_Are you using PMIS effectively for Maintenance? Have concerns?                                                                                                                                                                                                                                                                                                                                                                                             | CTM and TEPCO will discuss PMIS matters at site.                                                                                                                                            | None        |
| 2_What do you do annual inspection and overhaul after 6years LTSA?                                                                                                                                                                                                                                                                                                                                                                                           | EDM is still not decide future LTSA after current 6years LTSA. EDM is accumulating a maintenance experience at site and training with IHI. Some maintenance works may can be doing by self. | None        |

PMIS (Plant Maintenance Management by eServ): Maintenance Management, Lube Oil Management, Spare Parts Management, O&M Document Management, As-Built Drawing Management

#### **TEPSO Comment**

It is difficult to review utilization of PMIS without seeing the real PMIS. Review the use of PMIS at site and discuss how to proceed in Stage 2 or 3.

| (8 Dec, 2020) 9 <sup>th</sup> meeting ( <b>Operation</b> )<br>Related to <u>ii. The established systematic plan for trouble is implemented</u> , <u>iii. Work flow for the utilization of PMIS is developed</u> and <u>iv. Structure of O&amp;M implementation is developed</u> , Implementation of Systematic O&M Practice by EDM (MOM between EDM and JICA at 15 May, 2019) |                                                                                                                                                                                                                                        |             |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Question items                                                                                                                                                                                                                                                                                                                                                                | Answers & Comments                                                                                                                                                                                                                     | Attachments |
| 1_Are you using PMS effectively for Operation? Have concerns?                                                                                                                                                                                                                                                                                                                 | CTM and TEPCO will discuss PMS matters at site.                                                                                                                                                                                        | None        |
| 2_On the Operation side, how do you use your previous experience with trouble? e.g. Review of operation, Information sharing with operators as a record, use training or simulators, etc.                                                                                                                                                                                     | Operation team is conducting review of operation with writing indication, information sharing operators with report, training and so on after trouble. In addition, CTM carry out root cause analysis (RCA). But need more experience. | None        |

PMS (Operation Monitoring & Analysis): Trend Data Monitoring, Plant Performance Monitoring, Utility Consumption Simulator, Troubleshoot Guidance, Reporting, Remote Monitoring)

#### **TEPSO Comment**

It is difficult to review utilization of PMS without seeing the real PMS. Review the use of PMS at site and discuss how to proceed in Stage 2 or 3.

#1: MOM between EDM and JICA at 15 May, 2019

(Outputs)

Implementation of Systematic O&M Practice by EDM

(Activities)

- i. Systematic plan to evaluate, take countermeasures & develop preventive measures for trouble including natural & human disasters is established.
- ii. The established systematic plan for trouble is implemented.
- iii. Work flow for the utilization of PMIS is developed.
- iv. Structure of O&M implementation is developed.
- v. The HSE for the power plant O&M is defined & introduced.
- vi. The KPI for the power plant O&M is defined & introduced.
- vii. Capacity of EDM for contract management (e.g. LTSA) is developed.

**EDM Comment**

|                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------------|
| The site visit is crucial for EDM. Anyway, EDM & TEPSCO will proceed Stage 2&3 based on last week's presentations. |
|--------------------------------------------------------------------------------------------------------------------|

Clarification on TV meeting (Oct to Dec, 2020) for HRD (1/7)

| <p>(13 Oct. 2020) 2<sup>nd</sup> and (26 Nov. 2020) 7<sup>th</sup> meeting <b><u>(Employee Recruitment, Company life and Promotion flow)</u></b><br/> Related to <u>iii. The plan and system for human resource development and training is introduced</u>, Introduction of Human Resource Development Program by EDM (MOM<sup>#1</sup> between EDM and JICA at 15 May, 2019)</p> |                                                                                                                                      |             |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Question and Confirmation items                                                                                                                                                                                                                                                                                                                                                   | Answers & Comments                                                                                                                   | Attachments |
| <p>1. EDM Employee Recruitment:<br/> Our assumed employee recruitment system is:<br/> (1) Recruitment of employees in accordance with the staffing plan<br/> (2) Periodic hiring and non-periodic (mid-career) hiring</p>                                                                                                                                                         | <p>Confirmed that Employee recruitment system is basically the same as assumed employee recruitment by TEPSCO</p>                    | <p>None</p> |
| <p>2. EDM Company life and promotion flow:<br/> Our assumed company life and promotion flow is:<br/> (1) Type of company life is Life-time employment<br/> (2) Standard promotion flow is from Staff to Manager through Chief and Sub-leader</p>                                                                                                                                  | <p>Confirmed that EDM Company life and promotion flow is basically the same as assumed company life and promotion flow by TEPSCO</p> | <p>None</p> |
|                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                      |             |

**TEPSCO Comment**

Confirmed.  
However, if necessary, we will confirm and discuss at site later stage.

Clarification on TV meeting (Oct to Dec, 2020) for HRD (2/7)

(13 Oct. 2020) 2<sup>nd</sup> and (26 Nov. 2020) 7<sup>th</sup> meeting **(New employee Training)**

Related to i. The existing training system for new employee is improved, Introduction of Human Resource Development Program by EDM (MOM<sup>#1</sup> between EDM and JICA at 15 May, 2019)

| Question and Confirmation items                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Answers & Comments                                                                                               | Attachments |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|-------------|
| <p>1. New employee training</p> <p>Our assumed New employee trainings are:</p> <p>(1) At EDM training center: Company-wide training such as Awareness as a company employee of EDM, Basic business processing, etc.</p> <p>(2) At Maputo CTM: Basic knowledge of safety, Basic technologies and skills of the thermal power plant, etc.</p> <p>(3) Approximately 6 months of shift operator training with an instructor</p> <p>(4) Assign to operation shift after 7 months of employment, they will be officially certified as a Qualified operator.</p> | <p>1. Confirmed that New employee training is basically the same as assumed New employee training by TEPSCO.</p> | <p>None</p> |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                  |             |

**TEPSCO Comment**

Confirmed.

However, if necessary, we will confirm and discuss at site later stage.

Clarification on TV meeting (Oct to Dec, 2020) for HRD (3/7)

| (13 Oct. 2020) 2 <sup>nd</sup> and (26 Nov. 2020) 7 <sup>th</sup> meeting ( <b>New employee Training for a Qualified Operator</b> )<br>Relate Related to <u>i. The existing training system for new employee is improved and ii. The existing training program for the simulator system is improved.</u><br>Introduction of Human Resource Development Program by EDM (MOM <sup>#1</sup> between EDM and JICA at 15 May, 2019)                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |             |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Question and Confirmation items                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Answers & Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Attachments |
| <p>1. New employee training for a qualified operator</p> <p>Our assumed New employee training for qualified operator is performed by OJT and attending to the following Regular technical meetings:</p> <p>(1) OJT</p> <p>(a) OJT of Operation training and simulator training by Shift Supervisor, Chief Operator and Simulator instructor.</p> <p>(b) Class room and/or practical training at site during warranty period and LTSA by the Contractor.</p> <p>(2) Regular technical meetings are covered as:</p> <p>(a) Weekly technical meeting. (b) Troubleshooting meeting.</p> <p>(c) Pre-meeting before plant outage work and major works.</p> <p>(d) Others.</p> | <p>Confirmed that New employee training for qualified operator is basically the same as assumed New employee training by TEPSCO.</p> <p>EDM informed that from perspective of human resource development, after about 2 years of operation experience, the employees are rotated with the maintenance section.</p> <p>There is a technical gap in skill levels between engineers depending on when they joined the Maputo power station, and we want to know how to improve it.</p> <p>The possibility of modifying the Simulator</p> | None        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |             |

**TEPSCO Comment**

|                                                                                                                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>We confirmed that the rotation system between operation and maintenance section is very good system for improvement of overall skills.</p> <p>Technical gap of above engineers and possibility of simulator modifying will be reflected in the Training system at later stage.</p> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|



Clarification on TV meeting (Oct to Dec, 2020) for HRD (4/7)

| <p>(13 Oct. 2020) 2<sup>nd</sup> , (27 Oct. 2020) 4<sup>th</sup> and (26 Nov. 2020) 7<sup>th</sup> meeting <b>(Operator &amp; maintenance training after employment of 2-3 years)</b><br/> Related to <u>iii. The plan and system for human resource development and training is introduced.</u> Introduction of Human Resource Development Program by EDM (MOM<sup>#1</sup> between EDM and JICA at 15 May, 2019)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                          |             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| Question and Confirmation items                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Answers & Comments                                                                                                                                                       | Attachments |
| <p>1. Operator and maintenance engineer training after employment of 2-3 years.</p> <p>(1) Our assumed above experienced employee training is performed:</p> <p>(a) Training by OJT and attending to the Regular technical meeting</p> <p>(b) Class room and/or practical training at site during warranty period and LTSA by the Contractor.</p> <p>(2) Our assumed following training plan is applicable in near future</p> <p>(a) Training at the rehabilitated EDM Vocational Training Center and/or EDM Existing training center.</p> <p>(b) Specialized vendor technical training in Mozambique such as Pump and Motor (assumed factory is Tecnel).</p> <p>(3) Specialized vendor technical training at South Africa by EDM suggestion (*1) such as Transformer, 11kV, 6.6kV, 400V and 200V switchgear and protection relay for operator and electrical engineer, and PLC (Programmable Logic Controller) training for I&amp;C engineer. (assumed factory is ABB and Allen Bradley).</p> <p>(4) Overall operation and maintenance training for thermal power station at Japan which is not included in this scope, however since this training is available arranged by JICA in future.</p> | <p>Confirmed that training after employment of 2-3 years is basically the same as assumed by TEPSCO</p> <p>EDM stated that South Africa has some Training Place (*1)</p> | None        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                          |             |

**TEPSCO Comment**

We confirmed the applicable training at South Africa by the website, and we added the applicable specialized training at South Africa (3) (\*1)  
We will confirm and discuss at site later stage.

Clarification on TV meeting (Oct to Dec, 2020) for HRD (5/7)

| <p>(20 Oct, 2020) 3<sup>rd</sup> meeting <b>(Skill Certification System)</b><br/> Related to <u>iii. The plan and system for human resource development and training is introduced.</u> Introduction of Human Resource Development Program by EDM (MOM<sup>#1</sup> between EDM and JICA at 15 May, 2019)</p>                                                                                                                                                                                                                                                       |                     |             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-------------|
| Question and Confirmation items                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Answers & Comments  | Attachments |
| <p>1. Skill Certification System</p> <p>We explained that the Skill Certification System will be applied to CTM Operator and Maintenance engineer.</p> <p>(1) Estimated target level of skills are classified into 3 grades:</p> <p>Grade-1. Advanced level, after 8 years of experience.</p> <p>Grade-2: Intermediate level, after 4 years of experience.</p> <p>Grade-3: Elementary level, after 1 year of experience.</p> <p>(2) Operation and maintenance Certification method with judgment criteria.</p> <p>(3) Operation and maintenance skill training.</p> | No further comment. | None        |

**TEPSCO Comment**

|                                                                                                              |
|--------------------------------------------------------------------------------------------------------------|
| <p>Confirmed.</p> <p>We will discuss and decide in the “Skill Certification System” at site later stage.</p> |
|--------------------------------------------------------------------------------------------------------------|

Clarification on TV meeting (Oct to Dec, 2020) for HRD (6/7)

| (11 Nov. 2020) 5 <sup>th</sup> and (19 Nov. 2020) 6 <sup>th</sup> and (01 Dec.2020) No.8 <sup>th</sup> meeting <b>(Rehabilitated Vocational Training Center)</b><br>Related to <u>iii. The plan and system for human resource development and training is introduced</u> , Introduction of Human Resource Development Program by EDM (MOM <sup>#1</sup> between EDM and JICA at 15 May, 2019)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|-------------|
| Question items                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Answers & Comments                       | Attachments |
| <p>Confirmation of Rehabilitated Vocational Training Center</p> <ol style="list-style-type: none"> <li>1. Training Policy and Roadmap (approved by EDM's Board) (December, 2018) (Obtained from Website)</li> <li>2. Upgrade the Vocational Training System of the Public Energy Company in Mozambique (Obtained from Website)</li> <li>3. Overview of Learning Needs Analyses (December, 2016) (Received from EDM)</li> <li>4. Technical Assistance for project definition and supervision related to the Rehabilitation of EDM Vocational Training Centers – Skill Management Plan (September, 2020) (Received from EDM)</li> </ol> <p>EDM Rehabilitation of Maputo Vocational training center is very useful for the training of thermal power station employee, therefore we want to confirm the Implementation status and actually applied training programs with materials such as laboratories, practical fields, class room and/or remote training and so on.</p> | Under confirmation to related divisions. | None        |

**TEPSCO Comment**

|                                                               |
|---------------------------------------------------------------|
| <p>Confirmed.</p> <p>We will confirm at site later stage.</p> |
|---------------------------------------------------------------|

Clarification on TV meeting (Oct to Dec, 2020) for HRD (7/7)

| <p>(08 Dec. 2020) 9<sup>th</sup> meeting <b>(Reward System for passing National exams and RDM In-house exams)</b><br/> Related to <u>iii. The plan and system for human resource development and training is introduced</u>, Introduction of Human Resource Development Program by EDM (MOM<sup>#1</sup> between EDM and JICA at 15 May, 2019)</p> |                                                   |             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|-------------|
| Question items                                                                                                                                                                                                                                                                                                                                     | Answers & Comments                                | Attachments |
| <p>Confirmation of National and EDM in-house Exams applicable to CTM employee.</p> <p>We explained that the reward system for EDM employees for passing National exams and EDM in-house exams will be applied to CTM Operator and maintenance engineer to motivate and further develop their skills and self-development.</p>                      | EDM will check performance of Employees annually. | None        |
|                                                                                                                                                                                                                                                                                                                                                    |                                                   |             |

**TEPSCO Comment**

|                                                                           |
|---------------------------------------------------------------------------|
| <p>Confirmed.</p> <p>We will confirm and discuss at site later stage.</p> |
|---------------------------------------------------------------------------|

-Note-

#1: MOM between EDM and JICA at 15<sup>th</sup> May, 2019

(Outputs)

Introduction of Human Resource Development Program by EDM

(Activities)

- i. The existing training system for new employee is improved.
- ii. The existing training program for the simulator system is improved.
- iii. The plan and system for human resource development and training is introduced.

**EDM Comment**

The site visit is crucial for EDM. Anyway, EDM & TEPSCO will proceed Stage 2&3 based on last week's presentations.



## Appendix-4

### Presentation Materials of Online Academy








## Entenda os números usados para expressão elétrica no plano complexo por geogebra

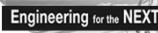
Understand numbers used for electrical expression on the complex plane by geogebra

Outubro de 2020

TANAKA Tsutomu



東電設計株式会社



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## 1. Objetivo Purpose

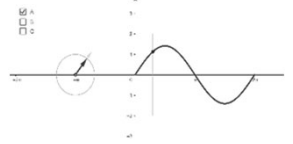
Engineering for the NEXT

Reverendo uma ideia básica de número para compreender os circuitos alternativos de corrente com a ajuda do geogebra, um software educacional gratuito para matemática.

Reviewing a basic idea of number for understanding the alternative current circuits with the help of geogebra, an educational free software for mathematics.

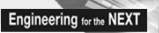
Você pode entender a correspondência da onda senoidal com uma seta em movimento.

You can understand the correspondence of sine wave to an moving arrow.





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## 2. um número e aritmética a number and arithmetic

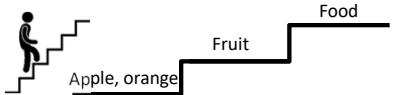
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 plus  equal    $\Rightarrow 1+1=2$

 mais  igual  

Pode ser igual ao anterior?  
Can it be same as above?

**etapas de abstração (steps of abstraction)**



Selecione cuidadosamente um voo e use as ferramentas matemáticas adequadas.  
Subir para um mundo abstrato e calcular, depois voltar para o mundo real.  
Carefully select a flight and use proper mathematical tools.  
Going up to an abstract world and calculate, then back to a real world.



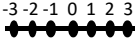
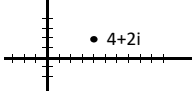
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## 3. números e expressões numbers & expressions

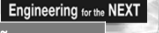
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| Números (Numbers)              | Exemplos (Examples)                     | Equações (Equations) | Expressão (Expression)                                                                                                 |
|--------------------------------|-----------------------------------------|----------------------|------------------------------------------------------------------------------------------------------------------------|
| Núm. Natural (Natural num.)    | 1,2,3,...                               | $x - 4 = 1$          | linha numérica (number line)                                                                                           |
| Inteiro (Integer)              | -3,-2,-1, 0,1,2,3,...                   | $x + 4 = 1$          |                                   |
| Núm. racional. (rational num.) | $\frac{3}{4}$ , 0.8, -1/5, 1, -4        | $2x - 4 = 1$         |                                                                                                                        |
| Real num. (Real num.)          | 0.7, -1/3, $\pi$ , $\sqrt{2}$ , 8, -4   | $x^2 = 2$            | avião complex (complex plane)<br> |
| Núm. Complexo (Complex num.)   | $\sqrt{2}+i$ , $\sqrt{3}+\pi i$ , -4+2i | $x^2 = -5$           |                                                                                                                        |

**Conveniente para usar números complexos no circuito AC.**  
Convenient to use complex num. in AC circuit.



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## Geogebra




Geogebra é um software educacional gratuito para matemática. Principalmente, a relação entre a álgebra e sua geometria pode ser expressa facilmente. Métodos básicos de operação e exemplos disso são carregados no You Tube. Você também pode criar uma conta e baixar muitos aplicativos úteis feitos por professores em todo o mundo.

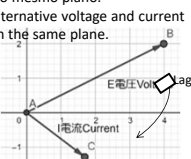
Geogebra is an educational free software for mathematics. Mainly, the relation between the algebra and its geometry can be expressed easily. Basic operation methods and examples of it are uploaded on You Tube. You can also create an account and down load many useful applications made by worldwide teachers.

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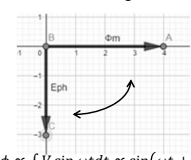
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## 4. Quantidades elétricas no plano complexo Electrical quantities on the complex plane

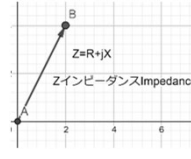
(1) Tensão e corrente alternadas no mesmo plano.  
Alternative voltage and current on the same plane.



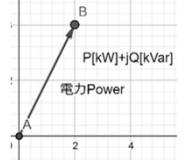
(2) Fluxo e tensão induzida  
Flux and induced voltage



(3) A impedância de transmissão observada por um relé é composta principalmente por X. Transmission impedance observed by a relay is composed mainly by X.



(4) expressão de poder  
expression of power



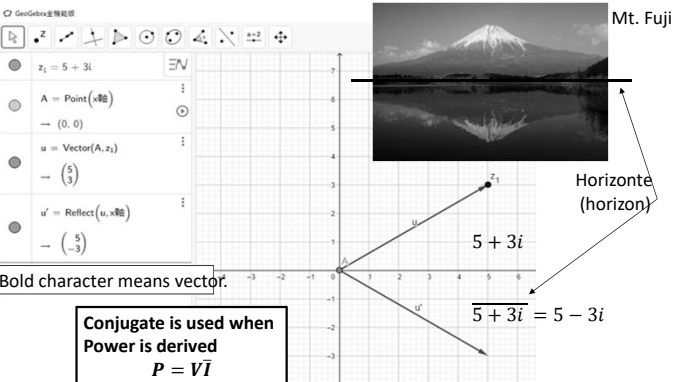
O eixo horizontal representa a potência ativa, sempre positiva, e o eixo vertical é a potência reativa.  
Horizontal axis represents active power, always positive, and vertical axis is reactive power.

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## 5-1. Plano complexo e conjugado Complex plane and conjugate

O reflexo de u pelo eixo x mostra u', que é chamado de conjugado.  
Reflection of u by x-axis shows u', which is called conjugate.



**Bold character means vector.**

**Conjugate is used when Power is derived**  
 $P = \bar{V}I$

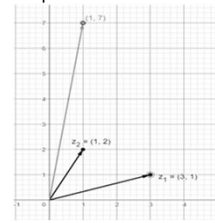
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## 5-2. Expressão de produtos no plano complexo Products expression on the complex plane

Diferente de vetores compostos por números reais, produtos de dois números complexos podem ser expressos no mesmo plano complexo pelo vetor, cujo tamanho são os dois produtos de cada magnitude de número multiplicado e o ângulo é a soma dos ângulos de cada um dos multiplicados número.

Different from vectors composed by real numbers, products of two complex numbers can be expressed on the same complex plane by the vector, whose size is the two products of the each magnitude of multiplied numbers and the angle is the sum of the angles of each multiplied number.



$$Z_1 \times Z_2 = (3 + i) \times (1 + 2i) = 1 + 7i$$
  
$$= \sqrt{10}e^{i\alpha} \times \sqrt{5}e^{i\beta} = \sqrt{50}e^{i(\alpha+\beta)}$$

Euler's formula can explain the above relation.

$$e^{i\omega t} = \cos \omega t + i \sin \omega t$$

Used when calculate sum of parallell impedance

$$\frac{1}{Z} = \frac{1}{Z_1} + \frac{1}{Z_2}$$

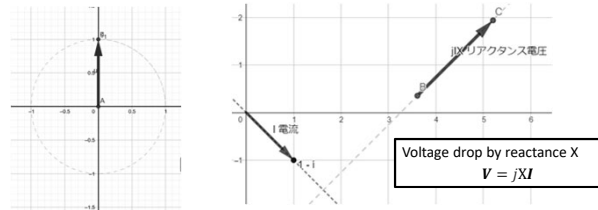
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### 5-3. Rotação de 90 graus de $j$ no plano complexo 90 degree rotation of $j$ on the complex plane

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No plano complexo,  $j$  funciona como um operador girando um vetor 90 graus no sentido anti-horário por multiplicação.  
On the complex plane,  $j$  works as an operator rotating an vector 90 degrees anti-clockwise by multiplication.

Por exemplo, a multiplicação de um vetor de corrente  $I$  por uma reatância  $jX$  produz um vetor de tensão  $jXI$  que é perpendicular a  $I$ .  
For example, the multiplication of an current vector  $I$  by a reactance  $jX$  produces an voltage vector  $jXI$  which is perpendicular to  $I$ .



【図面情報】 図の再使用・複製・転載・頒布禁止

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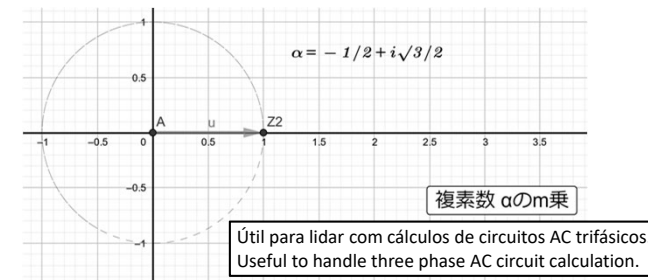
8

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### 5-4. Rotação de 120 graus de $\alpha$ no plano complexo 120 degree rotation of $\alpha$ on the complex plane

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No plano complexo,  $\alpha$  funciona como um operador girando um vetor 120 graus no sentido anti-horário por multiplicação.  
On the complex plane,  $\alpha$  works as an operator rotating an vector 120 degrees anti-clockwise by multiplication.



【図面情報】 図の再使用・複製・転載・頒布禁止

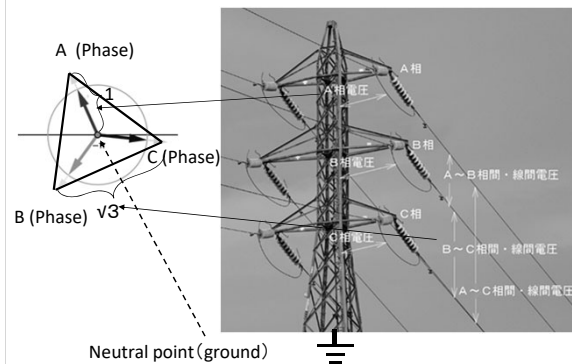
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### 6-1. Tensões de linha e tensões de fase Line voltages and phase voltages

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【図面情報】 図の再使用・複製・転載・頒布禁止

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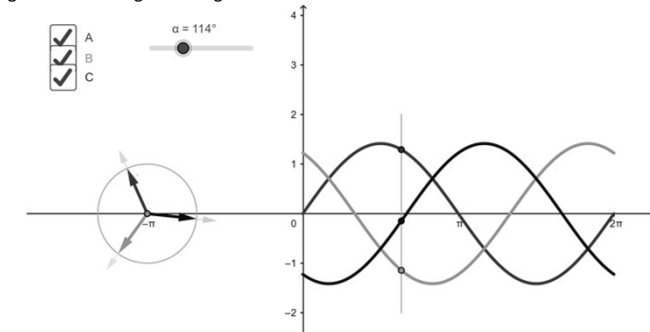
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### 6-2. Expressão de tensão alternada no plano complexo Expression of alternating voltage on the complex plane

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O vetor no plano complexo é um instantâneo, a partir do qual o ângulo de fase  $\theta$  e a magnitude da tensão podem ser dados.

The vector on the complex plane is a snap shot, from which the phase angle  $\theta$  and a magnitude of Voltage can be given.



【図面情報】 図の再使用・複製・転載・頒布禁止

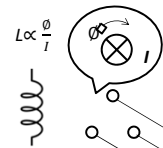
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### 6-3. Capacitância e indutância das linhas de transmissão Capacitance and inductance of transmission lines

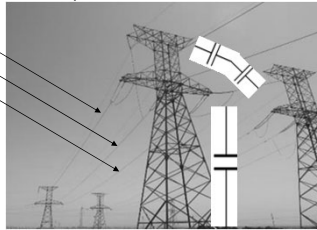
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T / L tem características de capacitância e indutância

T/L has capacitance and inductance characteristics.

Mudança de corrente induz potencial no próprio e em outros fios na direção de impedir a mudança.  
Change of current induces potential on self and other wires in the direction of impeding the change.



Entre os fios e / ou fio e terra, existem capacitâncias.

Between wires and/or wire & ground, there are capacitances.

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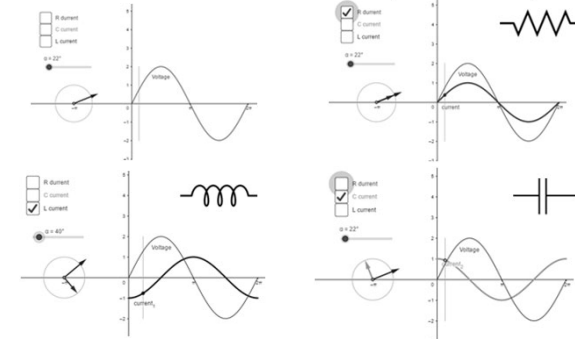
### 7-1 Tensão e corrente alternadas

#### Alternating voltage and current

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Fase de correntes expressa com base nas formas de onda por onda de tensão e gráfico fasorial.

Express currents phase based on the voltage wave by wave forms and phasor graph.



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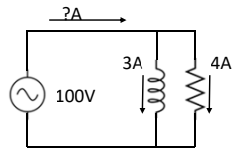
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### 7-2 Adição de correntes, expressão de fasores e formas de onda

Addition of currents, phasor expression and wave forms

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☒ R current  
☒ L current

φ = 0°

I

I<sub>1</sub> = 3  
I<sub>2</sub> = 4

Current

I

I

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【図面情報】 図の内容使用・複製・転載・再配布禁止

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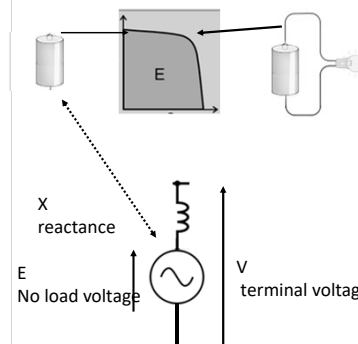
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### 8-1. Gerador (sem carga e tensões de carga no terminal)

Generator (no load and load voltages at terminal)

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DC: Conectando a carga, a tensão do terminal cai pela taxa de IR, resistência atual e interna

DC: Connecting load, the terminal voltage drops by rate of IR, current and internal resistance

Gerador AC com circuito aberto, ou seja, sem carga, sem fluxo de corrente, portanto  $E = V$ .

AC generator with open circuit, namely no load, no current flows, therefore  $E = V$ .

Ao conectar à rede, V segue a tensão da rede, ou seja, é constante.  
When connecting to the grid, V follows the grid voltage, namely it is constant.

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## 8-2. Relações de tensão induzida E, tensão terminal V e I

Relations of induced voltage E, terminal voltage V and I

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A tensão da rede é estável e a tensão terminal V é constante. Mantenha a potência ativa  $P \propto VI \cos \theta$  constante. Mova o I e investigue as relações entre a tensão induzida E, a tensão terminal V e a corrente I.

The grid voltage is stable and the terminal voltage V is constant. Keep the active power  $P \propto VI \cos \theta$  constant. Move the I and investigate the relations among induced voltage E, terminal voltage V and current I.

Geogebra records the drawing steps as shown below.



【図形情報】 図の再利用: 複製・移動・消去禁止

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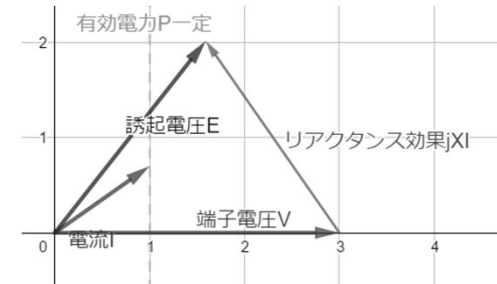
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## 8-3. No caso dessa corrente, I, conduzir a tensão, V.

In the case that current, I, leads voltage, V.

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Defina o vetor de tensão terminal V como referência e conduza a corrente I, então a tensão terminal se torna maior do que a tensão induzida E.  
Set the terminal voltage vector V as a reference and lead the current I, then the terminal voltage becomes larger than the induced voltage E.

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## 9. Resumo summary

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Conveniente para usar um número complexo. no mundo elétrico; tensão, corrente, potência, ângulo de fase, etc.  
Convenient to use complex num. in electrical world; voltage, current, power, phase angle, etc.

Número complexo. é visualizado no plano complexo.  
Complex num. is visualized on the complex plane.

Número complexo. é visualmente móvel no geogebra para melhor compreensão.  
Complex num. is visually movable on geogebra for better understanding.

Produtos de amplitudes são derivados por multiplicação e produtos de ângulos são expressos por adição.  
Products of amplitudes is derived by multiplication and products of angles is expressed by addition.

Existem operadores úteis, como i e α.  
There are useful operators such as i and α.

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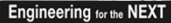


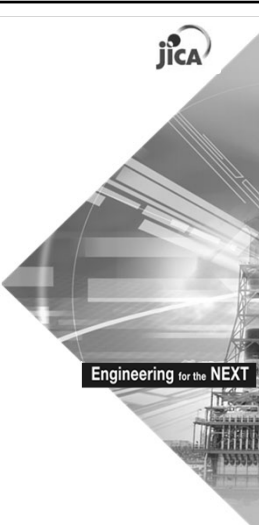
Gerador e seu teste de comissionamento  
**Generator and its commissioning test**

A abreviação em negrito foi tomada pela simplicidade  
Bold abridgement has taken for simplicity

Outubro de 2020

TANAKA Tsutomu



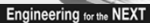


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## Conteúdo Contents

1. Princípio de um gerador e estrutura  
Principle of a generator and structure
2. Resposta de um gerador conectado a uma rede  
Response of a generator connected to a grid
3. Teste de circuito fechado e circuito aberto, testes de curto-circuito, estabilidade  
Closed Circuit & Open Circuit tests, Short circuit tests, stability
4. Curva de capacidade e tensão do lado da demanda  
Capability Curve and demand side voltage
5. Resumo  
Summary





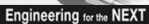
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## 1. Princípio de um gerador e estrutura Principle of a generator and structure





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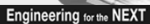
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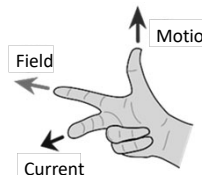


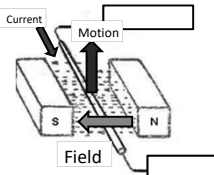
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### 1-1-1. Princípio de geração Principle of generation

**O gerador segue a regra da mão direita de Fleming: do dedo médio ao polegar, lembre-se da força elétrica (E) magnética (B) (F) da parte inferior.**  
Generator follows Fleming's right hand rule: From the middle finger to thumb, Remember Electric(E) Magnetic(B) Force(F) from the bottom.







A direção do campo magnético, fluxo, segue a direção do dedo indicador. Abaixo desse campo, subindo pelo condutor na direção do polegar, aparece o gradiente potencial na direção do dedo médio.  
The direction of magnetic field, flux, follows the direction of index finger. Under this field, moving up the conductor in the direction of thumb, then there appears potential gradient in the direction of the middle finger.

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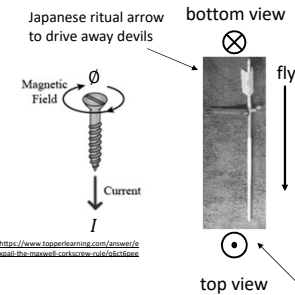
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### 1-1-2. A regra do parafuso de Maxwell & descrição da direção do fluxo atual

The Maxwell's Screw Rule & description of current flow direction



A relação do fluxo de corrente no fio e o campo magnético criado. Imagine que um parafuso destro é girado e continua, então ele pode ser considerado a direção da corrente. A direção de rotação fornece a direção do campo magnético.

The relation of the current flow in the wire and magnetic field created. Imagine a right handed screw is turned and proceeds, then it can be regarded the direction of the current. The direction of rotation gives the direction of the Magnetic field.

A direção da corrente pode ser representada como mostrado na imagem, que se parece com uma seta do lado inferior e superior de uma seta.

The direction of the current can be shown with marks,  $\odot$   $\otimes$

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### 1-1-3. A direção da corrente na bobina do estator

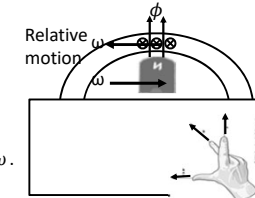
The direction of current in the stator coil

Em um gerador, um ímã permanente é girado por uma força externa e seu campo magnético afeta as bobinas circundantes para induzir eletricidade.

In a generator, a permanent magnet is rotated by an outer force and its magnetic field affects surrounding coils to induce electricity.

Apply the right hand rule to a generator.

1. O fio é fixo e o ímã se move para a direita com velocidade  $\omega$ .  
The wire is fixed and the magnet moves to the right with speed  $\omega$ .



2. Assume fixing the magnet then the wire relatively moves to the left with speed  $\omega$ .  
Assume fixing the magnet then the wire relatively moves to the left with speed  $\omega$ .

3. A corrente flui de um lado próximo ao outro, conforme mostrado.  
The current flows from near side to far side as shown.

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### 1-1-4. A relação de fluxo, tensão e frequência

The relation of flux, voltage, and frequency

A tensão induzida, V é proporcional ao produto da velocidade angular,  $\omega$ , e a magnitude do fluxo magnético,  $\phi$ .

Induced voltage, V is proportional to the product of angular velocity,  $\omega$  and the magnitude of magnetic flux,  $\phi$ .

$$V \propto \omega \times \phi \propto 2\pi f \phi.$$

Hence,

$$\phi \propto V/f.$$

Suponha que a tensão seja constante. Então, quando a frequência diminui, o fluxo aumenta.

Suppose the voltage is constant. Then when frequency declines, the flux increases.



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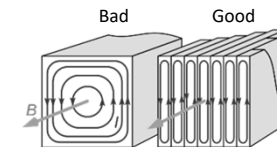
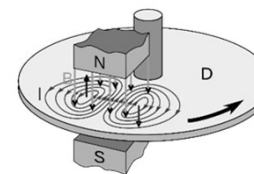
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### 1-1-5. Efeito e contra-medida contra o fluxo de vazamento (1)

Effect and counter measure against leakage flux (1)

Se o fluxo muda em um condutor, ele cria uma corrente parasita e aquece a estrutura.

If flux changes in a conductor, then it creates eddy current and heats up the structure.



Para reduzir o impacto, são usados aços laminados.  
To reduce the impact, laminar steels are used.

[https://en.wikipedia.org/wiki/Eddy\\_current](https://en.wikipedia.org/wiki/Eddy_current)

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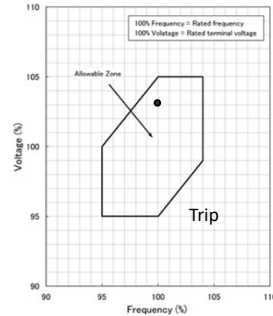


## 1-1-6. Contra-medida contra fluxo de vazamento (2)

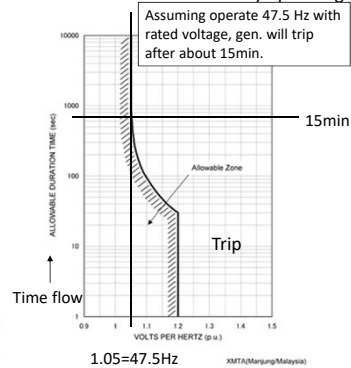
## Counter measure against leakage flux (2)

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Limites operacionais com tensão terminal e frequência  
Operational limits with terminal voltage and frequency



Excitação excessiva é limitada pelo tempo de operação.  
Over Excitation is limited by operating time.



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## 1-2-1. Gerador síncrono, pólo e revolução por minuto.

## Synchronous generator, pole and revolution per minute.

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**N, a revolução nominal de um gerador síncrono é derivada de P, pólo e f, frequência**

**N, rated revolution of a synchronous generator is derived from P, pole, and f, frequency**

In case of 50Hz, 2poles: n=3000 rpm and 4poles:1500 rpm

$$\text{In general,} \\ n = 120 \times \frac{f}{p}$$

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## 1-2-2. Bobina Coil

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Sample image of coil



Uma bobina é composta por um núcleo de ferro e fios de cobre.  
A coil is composed by an iron core and copper wires.

A capacidade de um gerador é determinada pelo produto da carga magnética e da carga elétrica.  
A capacity of a generator is determined by the product of magnetic loading and electric loading.

O carregamento magnético refere-se a um núcleo de ferro no qual o fluxo magnético perfura e o carregamento elétrico relaciona os fios de cobre nos quais a corrente flui.  
Magnetic loading relates an iron core in which magnetic flux pierces and electric loading relates copper wires in which current flows.

A porção de quantidade utilizada de ferro ou cobre, o gerador é denominado rico em ferro ou rico em cobre.  
The portion of used amount of iron or copper, the generator is called iron rich or copper rich.

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## 1-2-3. Característica da máquina de ferro e da máquina de cobre

## Feature of the iron machine and the copper machine

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A máquina de ferro é maior e mais cara do que a mesma capacidade da máquina de cobre.

Mas as partes do fio são menores, o que significa menos impedância, e a perturbação das tensões causada pelas mudanças de corrente será menor, ou seja, estável.

The iron machine is bigger and more expensive than the same capacity of the copper machine.

But the wire parts are less, which means less impedance, and the perturbation of voltages caused by current changes will be smaller, namely stable.

A relação de curto-circuito,  $I_s / I_n$  é grande.

Short Circuit Ratio,  $I_s / I_n$  is big.

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## 1-2-4. Rotor gerador de 2 pólos

### 2-pole generator rotor

O rotor é um grande eletroímã e os pólos são energizados por corrente contínua (DC). Na inicialização, a DC é fornecida por baterias externas e, após a inicialização, a DC é autoalimentada através da excitatriz. As bobinas de placa são feitas de cobre com prata enraizada e resfriadas por hidrogênio.

The rotor is a large electromagnet and poles are energized by direct current (DC). At the start up, DC is supplied by outer batteries and after start up, DC is self supplied through the exciter. Plate coils are made of copper with silver ingrain and cooled by hydrogen.

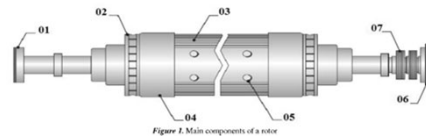


Figure 1. Main components of a rotor

|                    |                    |
|--------------------|--------------------|
| 01. COUPLING       | 05. BALANCING PLUG |
| 02. FAN            | 06. COLLECTOR FAN  |
| 03. COIL SLOT      | 07. COLLECTOR RING |
| 04. RETAINING RING |                    |

|                |                                           |
|----------------|-------------------------------------------|
| Rotor Shaft    | Monoblock steel, Ni-Cr-Mo-V steel         |
| Fan ring       | Axial fan blades are bolted               |
| Retaining ring | Non-magnetic, 18Mn-18Cr anti-corrosion    |
| Wedge          | Aluminum                                  |
| Coupling       | Monoblock with shaft, Not shrink-fit type |

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## 1-2-5. Estator do gerador (armadura) e suas características

### Generator stator (armature) and its characteristics

Converte o campo magnético giratório em corrente elétrica (armadura).

Converts the rotating magnetic field to electric current (armature).

Algumas bobinas do estator são resfriadas por água pura.

Some stator coils are cooled by pure water.

O estator é composto por aços laminados para reduzir o efeito da corrente parasita.

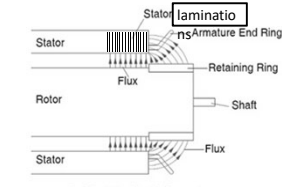
Stator is composed by laminar steels to reduce Eddy current effect.

A extremidade da bobina é exorbitante e a extremidade do estator está sujeita a um fluxo magnético perpendicular.

Coil end is exorbitant and the stator end part is subjected to perpendicular magnetic flux.



From Asian Tec Indonesia Home Page



End Part Heating in Generator  
From Electrical Concepts Home Page

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## 2. Comportamento de um gerador conectado a um sistema de rede

### Behavior of a generator connected to a grid system

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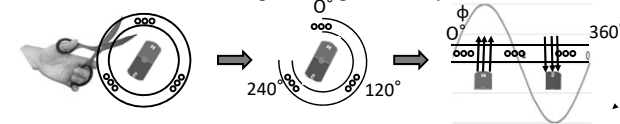
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## 2-1. Um rotor e um estator de fluxos magnéticos

### A rotor and a stator magnetic fluxes

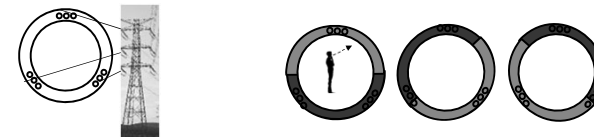
Corte o estator e endireite-o. O fluxo magnético pelo rotor é mostrado abaixo.

Cut the stator and straighten. Magnetic flux by the rotor is shown below.



Conectando-se à grade, o estator atua como um ímã giratório.

Connecting to the grid, the stator acts as a rotating magnet.



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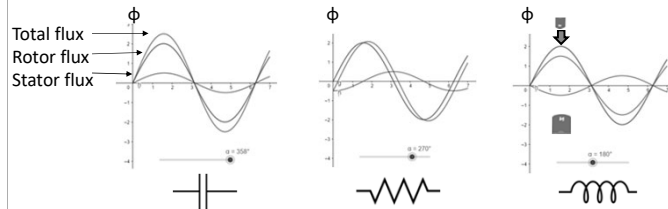
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## 2-2. Interação mútua do estator e os fluxos do rotor (reação da armadura em uma máquina síncrona) Mutual interaction of the stator and the rotor fluxes (armature reaction in a synchronous machine)

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O fluxo do rotor (fluxo principal) induz tensão na bobina do estator.  
A corrente de carga flui. A corrente faz o fluxo do estator.  
Ambos os fluxos são combinados e criam o fluxo total.  
A resistência varia de acordo com o tipo de carga.  
The rotor flux (Main flux) induces voltage on the stator coil.  
The load current flows. The current makes the stator coil.  
Both fluxes are combined and create the total flux. The strength varies according to the type of loads.

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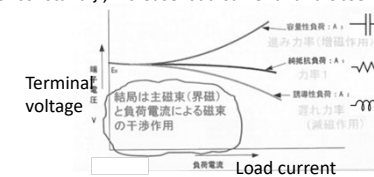
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## 2-3. Efeito dos tipos de carga para o gerador. tensão terminal Effect of load types to the gen. terminal voltage

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Sob constante  $I_f$ , aumente a corrente de carga  $I$  e observe  $V$  com três tipos de cargas.  
Under constant  $I_f$ , increase load current  $I$  and observe  $V$  with three kinds of loads.



Quando a carga se torna capacitiva, ou seja, rica em condensador, a corrente de chumbo reforça o fluxo magnético do gerador e a tensão terminal aumenta.

When the load becomes capacitive, namely condenser rich, the lead current enforces the magnetic flux of the generator and the terminal voltage increases.

À noite, quando as demandas reativas diminuem, como motores, a influência de longas linhas de transmissão ou cabos que são comparativamente capacitivos tornaria a tensão mais alta. ⇒ Quebra de isolamento

At night when reactive demands decrease such as motors, the influence of long transmission lines or cables which are comparatively capacitive would make the voltage higher. ⇒ Insulation breakdown

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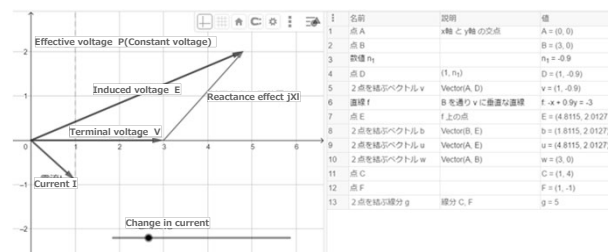
## 2-4. Relações de tensão induzida E, terminal V e I Relations of induced voltage E, terminal V and I

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A tensão da rede é estável e a tensão terminal  $V$  é constante. Mantenha a potência ativa  $P \propto VI \cos \theta$  constante. Mova o  $I$  e investigue as relações entre a tensão induzida  $E$ , a tensão terminal  $V$  e a corrente  $I$ .

The grid voltage is stable and the terminal voltage  $V$  is constant. Keep the active power  $P \propto VI \cos \theta$  constant. Move the  $I$  and investigate the relations among induced voltage  $E$ , terminal voltage  $V$  and current  $I$ .

Geogebra records the drawing steps as shown below.



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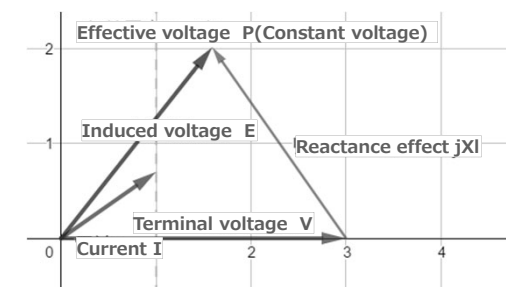
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## 2-5. No caso dessa corrente, I, tensão dos cabos, V In the case that current, I, leads voltage, V.

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Defina o vetor de tensão terminal  $V$  como referência e conduza a corrente  $I$ , então a tensão terminal se torna maior do que a tensão induzida  $E$ .  
Set the terminal voltage vector  $V$  as a reference and lead the current  $I$ , then the terminal voltage becomes larger than the induced voltage  $E$ .

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### 3. Teste de circuito fechado e circuito aberto, relação de curto-circuito e estabilidade

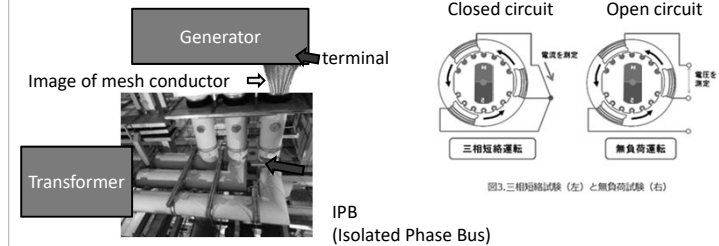
Closed Circuit & Open Circuit tests, Short circuit ratio, and Stability

### 3-1. Preparação para testes de circuito fechado e circuito aberto Preparation for closed circuit and open circuit tests

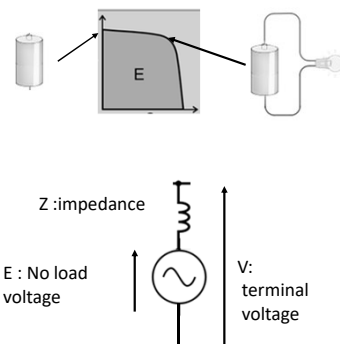
Sob o gerador, desconecte os condutores de malha que fazem parte do IPB, barramento de fase de isolamento.

Under the generator, disconnect mesh conductors which are part of IPB, isolation phased bus. O teste de circuito fechado é realizado conectando-se os terminais. O teste de circuito aberto está removendo os condutores.

Closed circuit test is carried out by connecting terminals together. Open circuit test is removing the conductors.



### 3-2. Gerador (sem carga e tensões de carga no terminal) Generator (no load and load voltages at terminal)



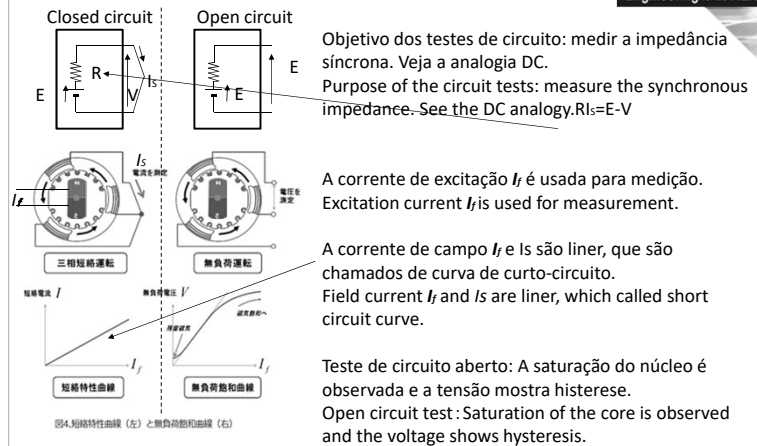
Caso DC, carga de conexão, a tensão do terminal cai pela taxa de  $IR$ , corrente e resistência interna. Quanto menor for o  $R$ , melhor será a bateria. DC case, Connecting load, the terminal voltage drops by rate of  $IR$ , current and internal resistance. The smaller  $R$  is, the better the battery is.

**No caso de um gerador CA com circuito aberto, nomeadamente sem carga, não flui corrente, portanto  $E = V$ .**

In case of a AC generator with open circuit, namely no load, no current flows, therefore  $E=V$ .

Então, o que acontece quando a corrente flui? Then, what happens when current flows?

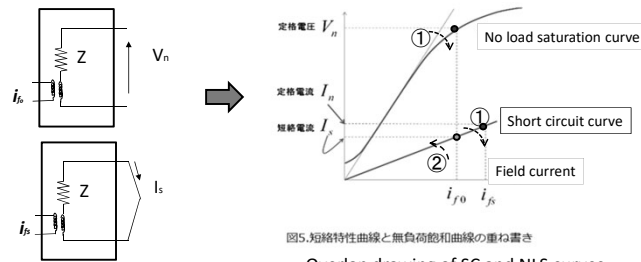
### 3-3. Teste e resultado do gerador Generator test and result



### 3-4. Processamento de dados de teste Processing of test data

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- ① Meça as correntes de campo,  $i_{f0}$ ,  $i_{fs}$ , correspondentes à tensão nominal e à corrente nominal. Calcule  $i_{f0}/i_{fs}$ . Este valor é semelhante à relação de curto-circuito,  $I_s/I_n$ .  
Measure field currents,  $i_{f0}$ ,  $i_{fs}$ , corresponding to the rated voltage and the rated current. Calculate  $i_{f0}/i_{fs}$ . This value is similar to the short circuit ratio,  $I_s/I_n$ .
- ② Read  $I_s$  correspondendo a  $i_{f0}$  e calcule  $Z = V_n/I_s$ .  
Read  $I_s$  corresponding to  $i_{f0}$  and calculate  $Z = V_n/I_s$ .



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### 3-5. Relação da razão de curto-circuito e impedância síncrona Relation of short circuit ratio & synchronous impedance

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A relação de curto-circuito significa  $I_s/I_n$  a robustez da flutuação de tensão, normalmente mais de 0,5.  
Short circuit ratio  $I_s/I_n$  means the robustness of voltage fluctuation, normally **more than** 0.5.

A impedância síncrona é  $Z = V_n/I_s [\Omega]$   
Synchronous impedance is  $Z = V_n/I_s$ .

Expresse a impedância síncrona pela razão da impedância de base, ou seja, por unidade de expressão.

$$Z[p.u.] = Z/Z_{base} = Z \times I_n/V_n$$

Sendo pequeno, este valor significa que a perturbação da tensão é pequena.

Express the synchronous impedance by the ratio of the base impedance, namely per unit expression.

$$Z[p.u.] = Z/Z_{base} = Z \times I_n/V_n$$

Being small this value means the voltage perturbation is small.

A impedância síncrona [p.u.] é recíproca para a relação de curto-circuito, SCR. Synchronous impedance [p.u.] is reciprocal to the short circuit ratio, SCR.

$$Z[p.u.] = 1/SCR$$

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### 4. Curva de capacidade e tensão do lado da demanda Capacity Curve and demand side voltage

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### 4-1. Três tipos de notificação de energia elétrica Three types of notification of electrical powers

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Potência ativa, P, significa a potência que realmente funciona ou é utilizada.  
Active Power, P, means the power that actually works or utilized.

$$P = VI \cos \theta$$

Potência reativa, Q, significa a potência que interage com a carga de bobina ou condensador, que não pode ser usado para o trabalho.  
Reactive Power, Q, means the power interacting with the load of coil or condenser, which cannot be used for work.

$$Q = VI \sin \theta$$

A potência aparente pode ser dita como a capacidade de alimentação vista pela fonte.

Apparent Power can be said as the power supply capacity seen by the source.

$$V \times I$$

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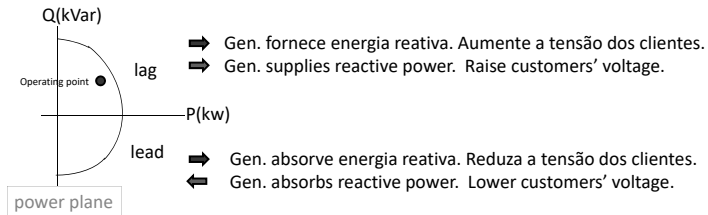
## 4-2. Verificação operacional do gerador Generator operational check

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A área operacional de um gerador é verificada no comissionamento.  
Operable area of a generator is checked at commissioning.

A área operável está dentro da curva no plano de potência ativa, P, e potência reativa, Q como mostrado abaixo. A fronteira é decidida pelos limites de calor das peças do gerador.

Operable area is inside the curve on the plane of active power, P, and reactive power, Q as shown below. The border is decided by the heat limits of generator parts.



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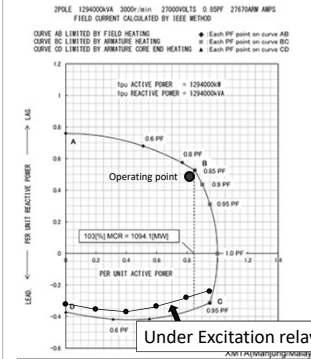
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## 4-3. curva de capacidade capability curve

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O ponto operacional se move para o retardo quando a corrente de excitação aumenta e se move para o avanço quando ela diminui.

Operating point moves toward lag when the exciting current increases and moves toward lead when it decreases.

O teste próximo à borda do condutor deve ter cuidado para não ultrapassá-lo, pois a extremidade do estator seria superaquecida em breve. Para a proteção, UEL é definido.

Test near the lead border should be careful not to surpass it because the stator end would be overheated in short. For the protection, UEL is set.

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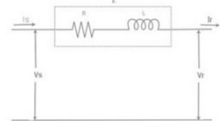
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## 4-4. Por que a energia reativa é eficaz para o controle de tensão?

Why reactive power is effective for voltage control?

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Suponha que a impedância de uma linha de transmissão seja  $Z = R + jX$ , então a queda de tensão entre a tensão do lado do receptor,  $V_r$  e a tensão do lado da alimentação,  $V_s$  é descrita  $Z\bar{I}_r$ .

Suppose the impedance of a transmission line is  $Z = R + jX$ , then the voltage drop between receiver side voltage,  $V_r$  and supply side voltage,  $V_s$  is described  $Z\bar{I}_r$ .

$$V_s - V_r \approx Z\bar{I}_r \approx R\bar{I}_r \cos \phi + jX\bar{I}_r \sin \phi = \frac{RP + XQ}{V_r}$$

Onde P é a potência ativa e Q é a potência reativa.  
Where P is active power and Q is reactive power.

R é muito menor que X e a queda de tensão é dominante no item Q.  
R is much smaller than X and voltage drop is dominant by item Q.

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## (Reference) More precise model calculation

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P: active power Q: reactive power  
r: resistance x: reactance then  $Z = r + jx$   
 $V_s$ : Supply side voltage (base)  
 $V_r e^{-j\theta}$ : Receive side voltage (lag)

$$P - jQ = \bar{V}_r \bar{I} = V_r e^{j\theta} \frac{V_s - V_r}{r + jx} \quad \text{* Take conjugate of } V_r \text{ to get power.}$$

$$(P - jQ)(r + jx) = V_r e^{j\theta} (V_s - V_r e^{-j\theta})$$

$$rP + xQ - j(rQ - xP) = V_r V_s \cos \theta - V_r^2 + jV_r V_s \sin \theta$$

$$\text{Compare the real part and the imaginary part} \begin{cases} rP + xQ = V_r V_s \cos \theta - V_r^2 \\ rQ - xP = V_r V_s \sin \theta \end{cases}$$

Take square of both equations and add them for deleting trigonometric functions.

$$(rP + xQ + V_r^2)^2 + (rQ - xP)^2 = V_r^2 V_s^2$$

Assume that  $V_r$  is a function  $f(P, Q)$  and partial differentiation by P or Q is taken to assess the rate of influence.

$$2(rP + xQ + V_r^2) \left( r + 2V_r \frac{\partial V_r}{\partial P} \right) + 2(rQ - xP)(-x) = 2V_r \frac{\partial V_r}{\partial P} V_s^2$$

$$(rP + xQ + V_r^2)r + 2V_r(rP + xQ + V_r^2) \frac{\partial V_r}{\partial P} - (x^2P - r^2P) = V_s^2 V_r \frac{\partial V_r}{\partial P}$$

$$V_r(2rP + 2xQ + 2V_r^2 - V_s^2) \frac{\partial V_r}{\partial P} = -x^2P - r^2P - rV_r^2$$

$$\frac{\partial V_r}{\partial P} = -\frac{Z^2 P + rV_r^2}{V_r(2rP + 2xQ + 2V_r^2 - V_s^2)}$$

Similarly we get

$$\frac{\partial V_r}{\partial Q} = -\frac{Z^2 Q + xV_r^2}{V_r(2rP + 2xQ + 2V_r^2 - V_s^2)}$$

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## Continue: Input typical numbers and calculate

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|                          |          |
|--------------------------|----------|
| $z(\Omega)$              | 0.502494 |
| $r(\Omega)$              | 0.05     |
| $x(\Omega)$              | 0.5      |
| $P(\text{kw})$           | 6125     |
| $Q(\text{kvar})$         | 1250     |
| $V_s(\text{kV})$         | 125.02   |
| $V_r(\text{kV})$         | 125      |
| $z^2 P + V_r^2$ (分子部分)   | 2327.813 |
| $z^2 Q + x V_r^2$ (分子部分) | 8128.125 |

Denominators are the same, then calculate only each numerator and compares.

As a result, changing of Q is about four (4) times effective than that of P.

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## 5.Summary

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## Resumo Summary

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Um rotor é um eletroímã e fornece o fluxo magnético para a armadura. A corrente parasita criada pelo aumento do fluxo de vazamento aqueceria as peças e deve-se tomar cuidado.  
A rotor is an electro magnet and supply the magnetic flux to the armature. The eddy current created by the increased leakage flux would heat up the parts and care should be taken.

Conectando-se à grade, a armadura atua como um ímã giratório. O efeito mútuo com o fluxo do rotor influencia a tensão terminal.

Connecting to the grid, the armature acts as an rotating magnet. The mutual effect with the rotor flux influences the terminal voltage.

Os testes de classificação de circuito e circuito aberto derivam a relação de curto-circuito, da qual é maior do que a estabilidade é alta.

Sort circuit and open circuit tests derive short circuit ratio, of which is larger then the stability is high.

O gerador pode ser operado dentro da curva de capacidade. O controle da potência reativa é eficaz para controlar a tensão do lado do usuário.

Generator can be operable inside the capability curve. Control of reactive power is effective to control the user side voltage.

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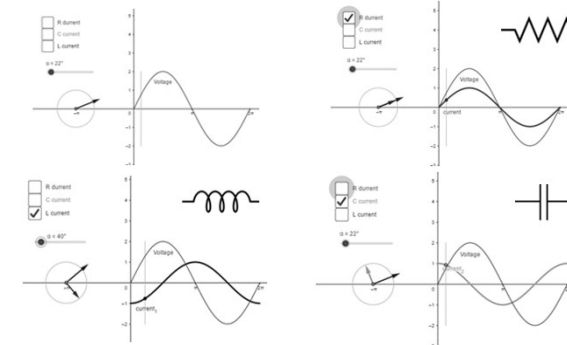
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## 付録: 電気の基礎知識

### Appendix: Review of basic electricity

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負荷による電流の位相を電圧を基準にして実際の波とフェーザ図で表す。  
Express currents phase based on the voltage wave by actual wave form and phasor graph.



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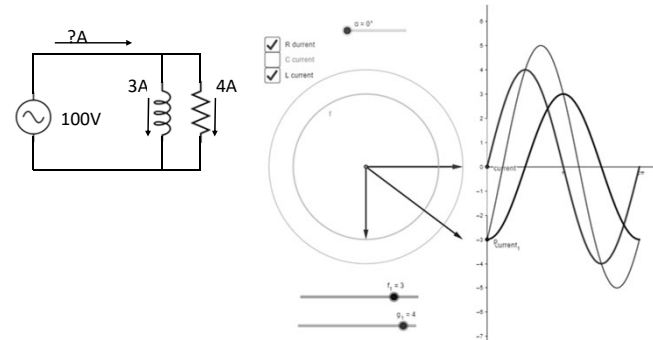
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電流の合成、フェーザ表現、波形  
Addition of currents, phasor expression and wave forms

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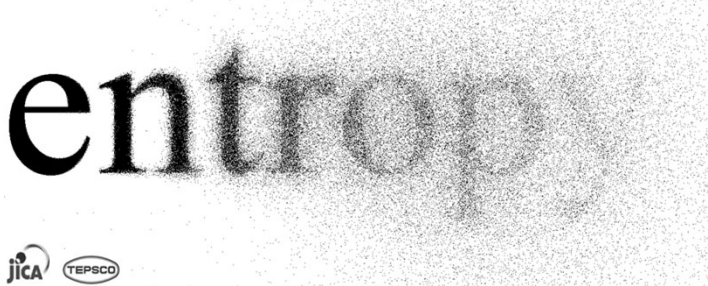
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Electricidade de Mozambique, E.P. Presentation

**What is Entropy?**  
*O que é entropia ?* Nov. 18, 2020



jica TEPSCO

Tokyo Electric Power Services Co., Ltd.  
**Dr. Blackstone ( Takashi Kuroishi )**

Entropy = Clutter, Messy, Randomness  
*Entropia = desordem, bagunça, aleatoriedade*

$$dS = \frac{dQ}{T}$$

Entropy

$$S = k \ln W$$

↑

**This is called Entropy, do you understand?**  
*(Isso se chama Entropia, entendeu?)*

jica TEPSCO

**Do not be hesitant to know what Entropy is.**  
*Não hesite em saber o que é a Entropia.*



Entropy You

[ Definition of entropy in thermodynamics ]

- The entropy is defined as the sum of the converted heat quantity of the system when the system is changed reversibly from state O to any state Z. The entropy is defined as the sum of the converted heat quantity of the system when the system is changed reversibly from state O to any state Z.
- The fact that the entropy is a state quantity is a remarkable feature compared to the fact that the heat quantity is not a state quantity. The fact that entropy is a quantity of state is a remarkable feature compared with the fact that the heat quantity is not a quantity of state, which is the reason why entropy is emphasized in thermodynamics.
- A entropia é definida como a soma da quantidade de calor convertida do sistema quando o sistema é alterado reversivelmente do estado O para qualquer estado Z. A entropia é definida como a soma da quantidade de calor convertida do sistema quando o sistema é alterado reversivelmente do estado O para qualquer estado Z.
- O fato de a entropia ser uma quantidade de estado é uma característica notável em comparação com o fato de que a quantidade de calor não é uma quantidade de estado. O fato de a entropia ser uma quantidade de estado é uma característica notável em comparação com o fato de que a quantidade de calor não é uma quantidade de estado, razão pela qual a entropia é enfatizada na termodinâmica.

jica TEPSCO

[ Definition of entropy in thermodynamics ]

- In the case of a reversible change, the sum of the converted calorific values obtained by the system is equal to the increase in the entropy of the system due to the process, whereas in the case of irreversible change, the former is always smaller than the latter.
- Whenever an adiabatic system undergoes an irreversible change, the entropy of the system increases. (Second law of thermodynamics: law of entropy increase)
- *No caso de alteração reversível, a soma dos valores caloríficos convertidos obtidos pelo sistema é igual ao aumento da entropia do sistema devido ao processo, enquanto no caso de alteração irreversível, o primeiro é sempre menor que o último.*
- *Sempre que um sistema adiabático sofre uma mudança irreversível, a entropia do sistema aumenta. (Segunda lei da termodinâmica: lei do aumento da entropia)*



This is called Entropy on the textbooks, do you understand?  
(*Nos livros didáticos isso se chama entropia, entendeu?*)



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[ What is the entropy? ] Qual é a entropia?

- This room is cluttered and has high entropy.
- I added milk to my coffee and stirred it and the entropy had been high.
- The important thing in environmental matters is not to increase entropy.
- To lose the value of information is to receive information entropy.
- *Esta sala é desordenada e tem alta entropia.*
- *Acréscentei leite ao café e mexi, e a entropia estava alta.*
- *O importante em questões ambientais é não aumentar a entropia.*
- *Perder o valor da informação é receber entropia da informação.*



Can you understand the meaning of these sentences?  
(*Você consegue entender o significado dessas frases?*)



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[ Entropy is like garbage, trash and waste. ] *A entropia é como lixo, lixo e lixo.*

- This room is cluttered and full of trash.
- I put milk in my coffee and stirred it up and it looked like garbage.
- The important thing in environmental matters is not to increase waste.
- To lose the value of information is to receive information garbage.
- *Esta sala está desordenada e cheia de lixo.*
- *Coloquei leite no meu café e mexi e ficou parecendo lixo.*
- *O importante em questões ambientais é não aumentar o desperdício.*
- *Perder o valor da informação é receber lixo de informação.*



Can you imagine the meaning of entropy in these sentences?  
(*Você pode imaginar o significado de entropia nessas frases?*)



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(*lei do aumento da entropia*)

## law of increasing entropy

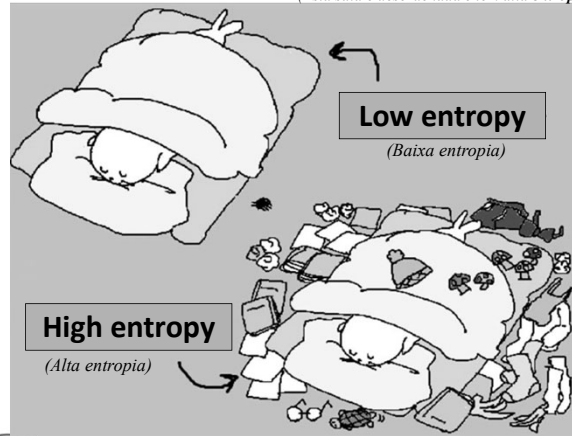
### [ The Second Law of Thermodynamics ]

(*A Segunda Lei da Termodinâmica*)



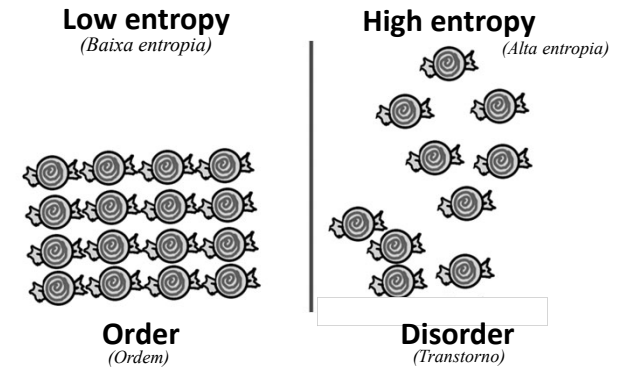
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This room is cluttered and full of trash. *(Esta sala está desordenada e cheia de lixo)*  
 This room is cluttered and has high entropy. *(Esta sala é desordenada e tem alta entropia)*



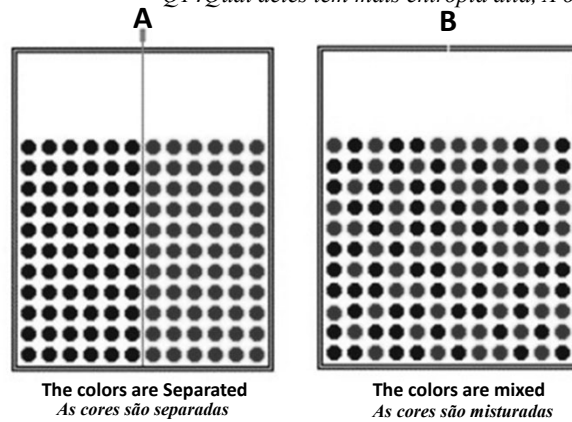
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Ordered candy has low entropy. *(O doce pedido tem baixa entropia.)*  
 Disordered candy has High entropy. *(O doce pedido tem baixa entropia.)*



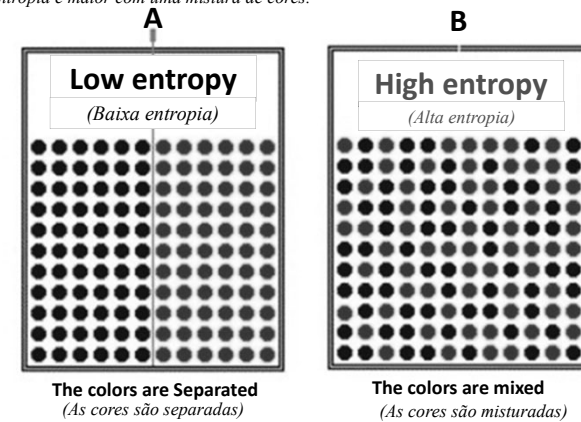
10

Q1: Which one has more high entropy, A or B?  
*Q1: Qual deles tem mais entropia alta, A ou B?*



11

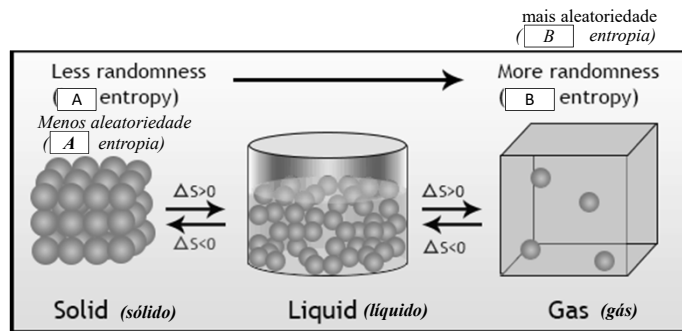
A1: Entropy is higher with a mix of colors.  
*A1: A entropia é maior com uma mistura de cores.*



12

Q2: Put the appropriate words in A and B.

Q2: Coloque as palavras apropriadas em A e B.



13

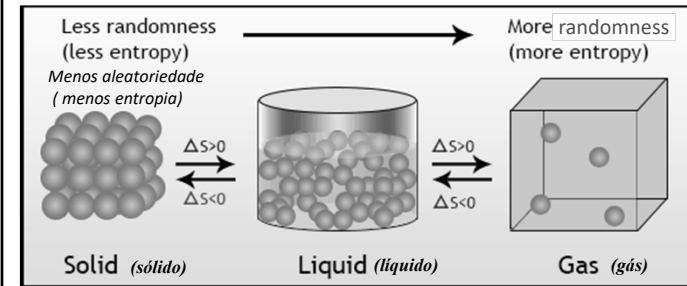
A2: Less randomness means less entropy.

More randomness means more entropy.

A2: Menos aleatoriedade significa menos entropia.

Mais aleatoriedade significa mais entropia.

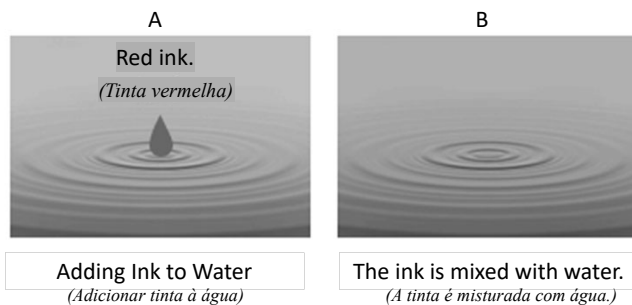
*mais aleatoriedade  
( mais entropia )*



14

Q3: Which one has more high entropy, A or B?

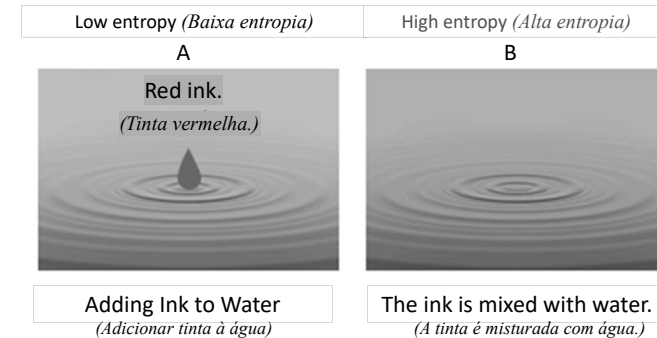
Q3: Qual deles tem mais entropia alta, A ou B?



15

A3: Entropy is higher with a mix of colors.

(A3: A entropia é maior com uma mistura de cores.)



16

**Q4: Which one has higher entropy, A or B?**  
 Also does it take more energy to change entropy, C or D?  
 (Q4: Qual deles tem entropia mais alta, A ou B?  
 Também é necessário mais energia para alterar a entropia, C ou D?)

**A** **B**

Supermarket (Supermercado) House full of garbage. (Casa cheia de lixo)

C D

jica TEPCO 17

**A4: Entropy is high, in B.**  
 Also, movement D, which lowers entropy, requires energy.  
 (A4: A entropia é alta, em B.  
 Além disso, o movimento D, que reduz a entropia, requer energia.)

**A** **B**

Physical phenomenon (Fenômeno físico) Conscious Actions (Ações Conscientes)

Supermarket (Supermercado) House full of garbage. (Casa cheia de lixo)

Order Low entropy Disorder High entropy

It takes energy. (É preciso energia.)

jica TEPCO 18

**Q5: Which one has higher entropy, A or B?**  
 (Q5: Qual deles tem entropia mais alta, A ou B?)

People are always standing on the hill.  
 (As pessoas estão sempre paradas na colina.)

**A** **B**

People

Slope is a force of environment and events. (Slope é uma força do ambiente e dos eventos.)

- Collapse (Colapso)
- Laziness (Preguiça)
- Escape (Escapar)
- Sadism (Sadismo)
- Giving up (Desistindo)

- Formation (Formação)
- Growth (Crescimento)
- Challenge (Desafio)
- Optimism (Otimismo)
- Readiness (Prontidão)

jica TEPCO 19

**A5: Entropy is high, in A.**

People are always standing on the hill.  
 (As pessoas estão sempre paradas na colina.)

**A** **B**

People

Slope is a force of environment and events. (Slope é uma força do ambiente e dos eventos.)

- Collapse (Colapso)
- Laziness (Preguiça)
- Escape (Escapar)
- Sadism (Sadismo)
- Giving up (Desistindo)

- Formation (Formação)
- Growth (Crescimento)
- Challenge (Desafio)
- Optimism (Otimismo)
- Readiness (Prontidão)

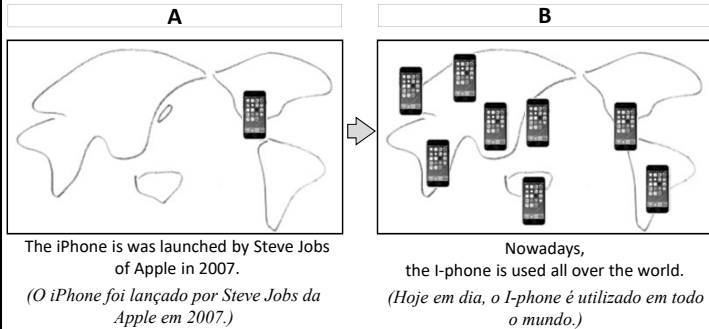
High entropy

When people are lazy, they go downhill. (Quando as pessoas são preguiçosas, elas decaem.) People can work their way up a hill. (As pessoas podem subir uma colina.)

jica TEPCO 20

Q6: Which one has higher entropy, A or B?

(Q6: Qual deles tem entropia mais alta, A ou B?)

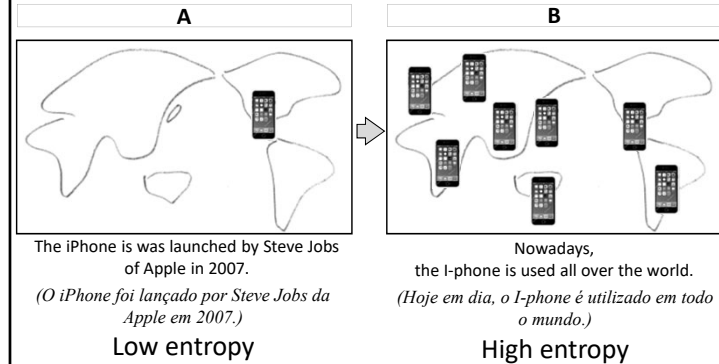


21

A6: Entropy is high, in B.

Good things can spread.  $\Rightarrow$  **Law of increasing entropy**

(Coisas boas podem se espalhar.  $\Rightarrow$  Lei do aumento da entropia)



22

### The Irreversibility of Entropy Increasing

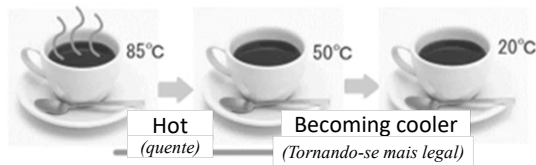
(A irreversibilidade do aumento da entropia)

- Entropy in physics means that if any matter is left alone, it heads toward a disordered state and becomes indistinguishable from its surroundings.

(Entropia na física significa que se qualquer matéria for deixada sozinha, ela se dirige para um estado desordenado e se torna indistinguível de seus arredores.)

- For example, if you leave a hot cup of coffee alone, it will soon be the same temperature as the vessel and will be the same as the room temperature.

(Por exemplo, se você deixar uma xícara de café quente sozinha, ela logo terá a mesma temperatura da vasilha e será a mesma que a temperatura ambiente.)



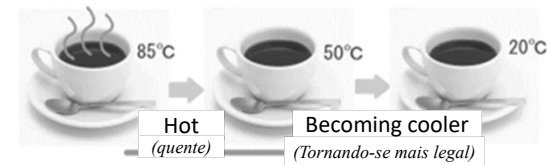
23

### The Irreversibility of Entropy Increasing

(A irreversibilidade do aumento da entropia)

- This phenomenon, which occurs as a matter of course in the world of things, reflects the flow from order to disorder (entropy), and all matter cannot escape from this flow.

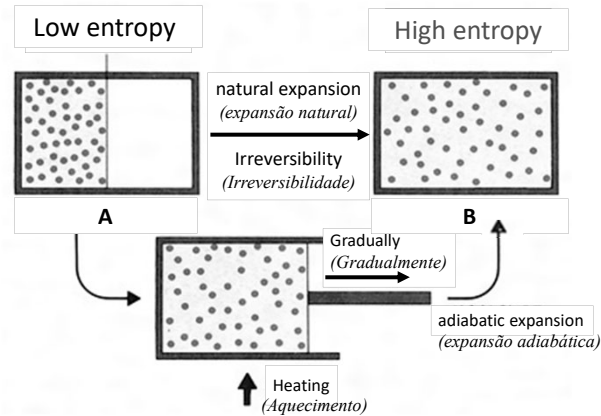
(Este fenômeno, que ocorre naturalmente no mundo das coisas, reflete o fluxo da ordem à desordem (entropia), e toda matéria não pode escapar desse fluxo.)



24

### The Irreversibility of Entropy Increasing

(A irreversibilidade do aumento da entropia)



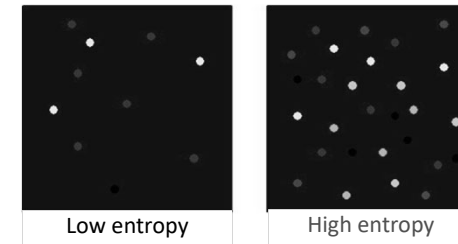
25

### Disease and Biological Entropy (1/3)

(Doença e entropia biológica (1/3))

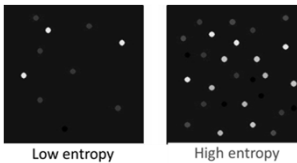
The left is called the low entropy state and the right is called the high entropy state. The colored round balls are organisms in the body (viruses, bacteria, white blood cells, etc.)

(A esquerda é chamada de estado de baixa entropia e a direita é chamada de estado de alta entropia. As bolas redondas coloridas são organismos no corpo (vírus, bactérias, glóbulos brancos, etc.))



26

### Disease and Biological Entropy (2/3)



- Activities of living organisms are usually wired to lower entropy. This is because this high and low entropy is used as active energy. But while this is true in terms of the concept of energy use, it is exactly the opposite when it comes to immunity.

(As atividades dos organismos vivos geralmente são programadas para diminuir a entropia. Isso ocorre porque essa entropia alta e baixa é usada como energia ativa. Mas, embora isso seja verdade em termos do conceito de uso de energia, é exatamente o oposto quando se trata de imunidade.)

- Activities of living organisms are usually wired to lower entropy. This is because this high and low entropy is used as active energy. But while this is true in terms of the concept of energy use, it is exactly the opposite when it comes to immunity.

(As atividades dos organismos vivos geralmente são programadas para diminuir a entropia. Isso ocorre porque essa entropia alta e baixa é usada como energia ativa. Mas, embora isso seja verdade em termos do conceito de uso de energia, é exatamente o oposto quando se trata de imunidade.)



27

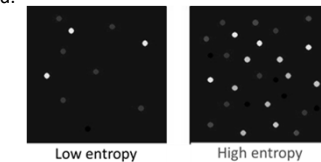
### Disease and Biological Entropy (3/3)

- Normally, organisms have a high entropy, which prevents certain bacteria from growing, but this high entropy is acquired after birth. Therefore, infants and others are vulnerable to unknown bacteria because they do not have sufficiently high entropy. If an unknown virus or bacterium invades, there is not enough room for it to reproduce in a high entropy state.

(Normalmente, os organismos têm uma entropia alta, o que impede o crescimento de certas bactérias, mas essa entropia alta é adquirida após o nascimento. Portanto, bebês e outras pessoas são vulneráveis a bactérias desconhecidas porque não têm entropia suficientemente alta. Se um vírus ou bactéria desconhecido invadir, não há espaço suficiente para que ele se reproduza em um estado de alta entropia.)

- For that reason, we often don't even notice that a virus or other organism we've never heard of has invaded.

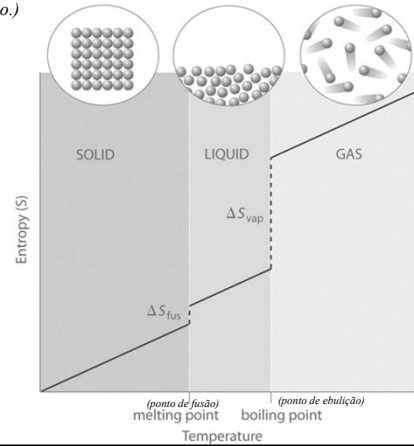
(Por esse motivo, muitas vezes nem percebemos que um vírus ou outro organismo do qual nunca ouvimos falar nos invadiu.)



28

As the temperature increases,  
entropy increases as it changes from a solid to a liquid to a gas.

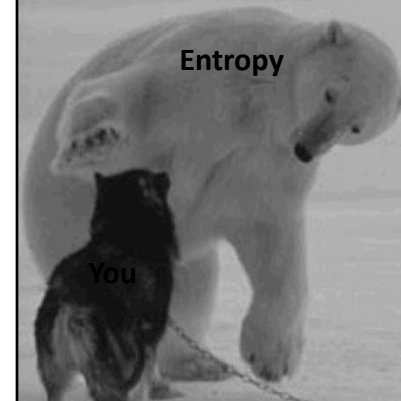
(Conforme a temperatura aumenta, a entropia aumenta à medida que muda de sólido para líquido para gasoso.)



29

## Welcome to Entropy !

*Bem-vindo à Entropia.*



30



## Carnot cycle (Ciclo de Carnot)

- Nicolas Léonard Sadi Carnot (French: Nicolas Léonard Sadi Carnot, 1 June 1796, Paris - 24 August 1832, Paris) was a French soldier, physicist, and engineer whose work on the "Carnot cycle", a virtual heat engine, led to the prototype of the second law of thermodynamics. It is known for its
- The Carnot cycle is a type of reversible heat cycle that operates between two heat sources of different temperatures.

- Nicolas Léonard Sadi Carnot (francês: Nicolas Léonard Sadi Carnot, 1 de junho de 1796, Paris - 24 de agosto de 1832, Paris) foi um soldado, físico e engenheiro francês cujo trabalho no "ciclo de Carnot", uma máquina térmica virtual, levou ao protótipo da segunda lei da termodinâmica. É conhecido por sua
- O ciclo de Carnot é um tipo de ciclo de calor reversível que opera entre duas fontes de calor de diferentes temperaturas.



31

The cycle of a jet engine is the same in principle as that of a car engine.

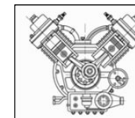
(O ciclo de um motor a jato é o mesmo em princípio que o de um motor de carro.)



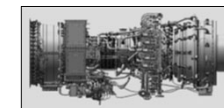
A car engine (Um motor de carro)



A jet engine (Um motor a jato)



Cylinder engine (Motor de cilindro)

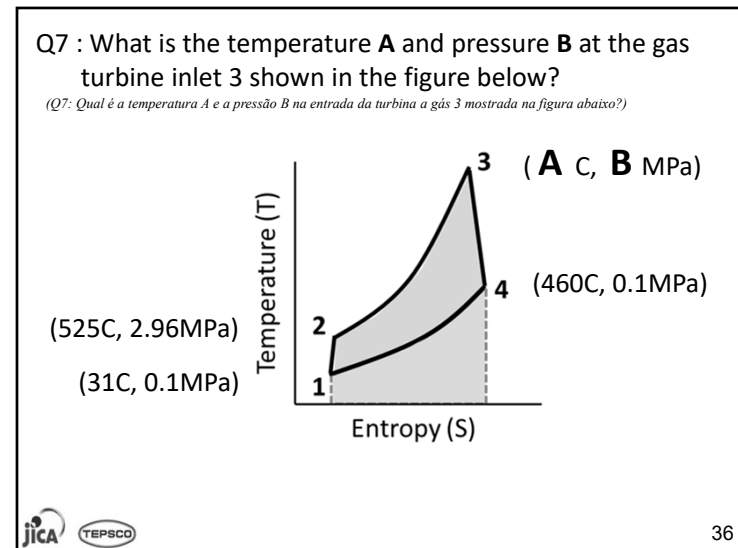
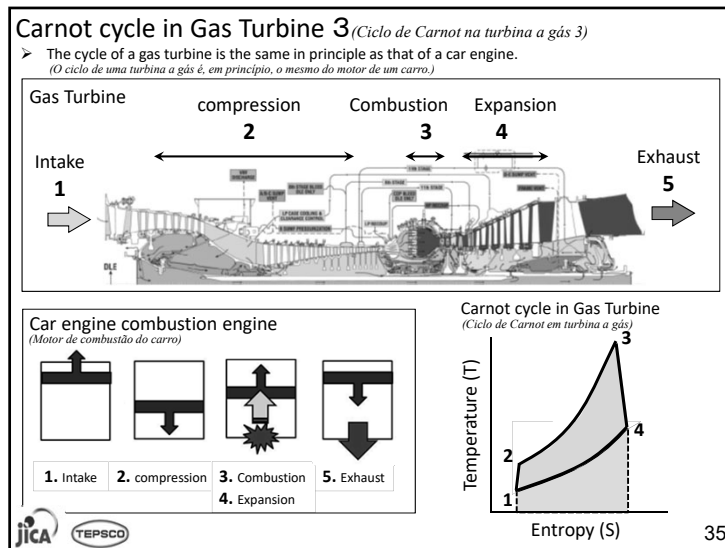
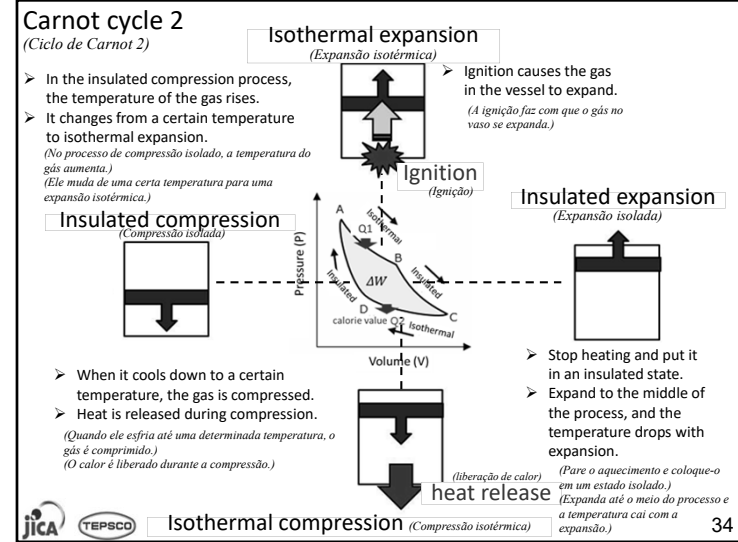
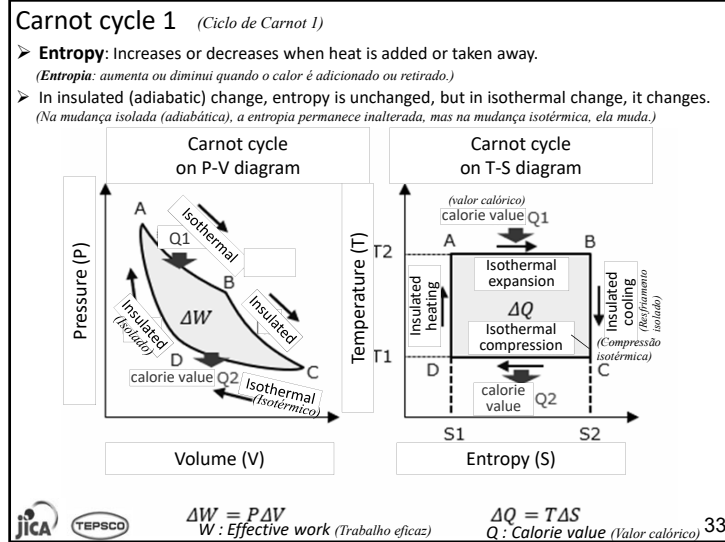


Gas turbine (Turbina a gás)



32



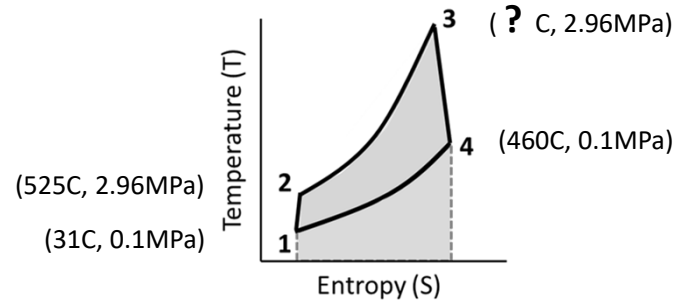


A7 : **A** is undisclosed. Please image for yourself.

*(A não é divulgado. Por favor, imagine você mesmo.)*

**B** is almost same as point 2.

*(B é quase igual ao ponto 2.)*



37

## Embrace Entropy !

*Abraçar a Entropia!*

Entropy



38

## What is the difference between enthalpy and entropy?

*(Qual é a diferença entre entalpia e entropia?)*

- Enthalpy and entropy are thermodynamic terms that describe the state of energy or clutter.  
*(Entalpia e entropia são termos termodinâmicos que descrevem o estado de energia ou desordem.)*
- Although the names are similar, the only similarity is in the name, they are completely different concepts.  
*(Embora os nomes sejam semelhantes, a única semelhança está no nome, são conceitos completamente diferentes.)*
- **Enthalpy = Energy State** *(Entalpia = Estado de Energia)*
- **Entropy = Clutter, Randomness** *(Entropia = desordem, aleatoriedade)*

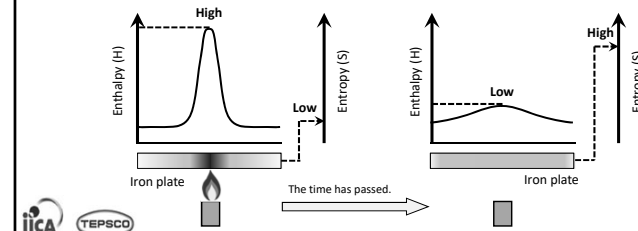


39

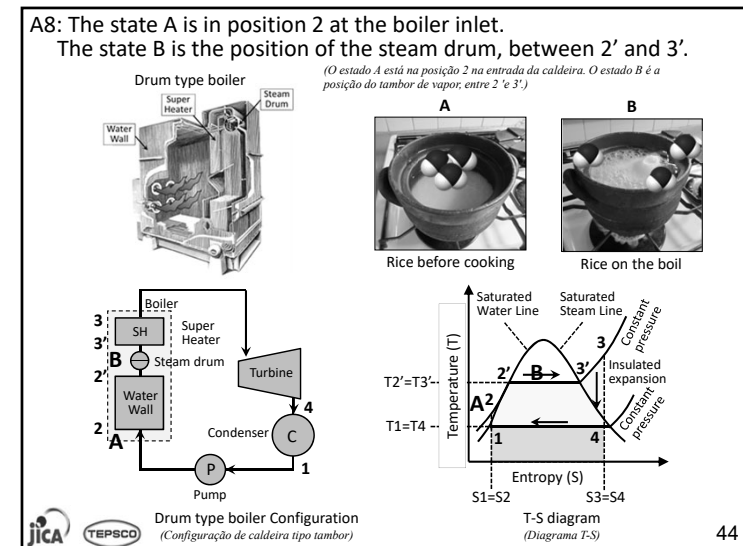
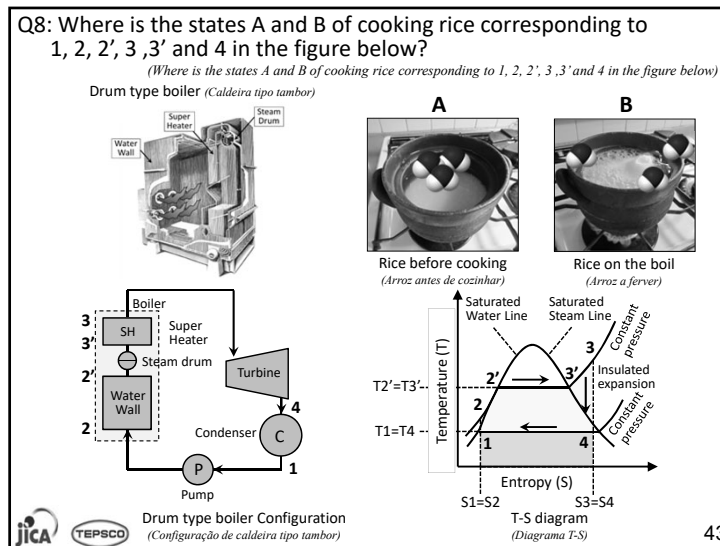
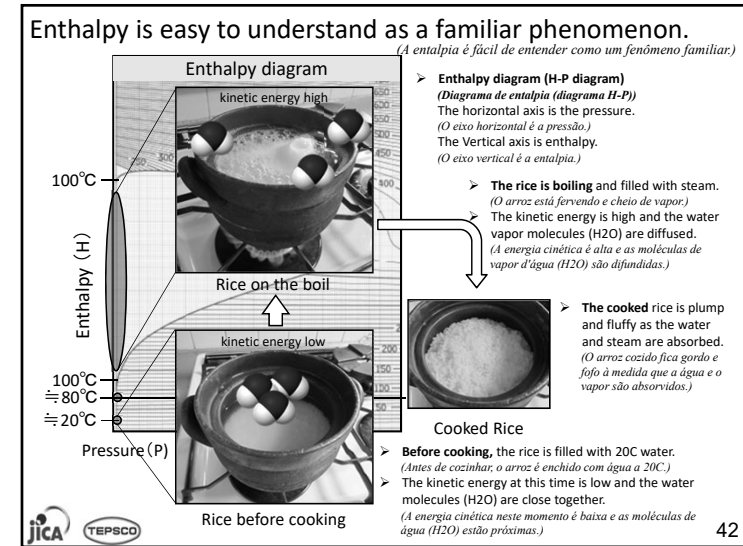
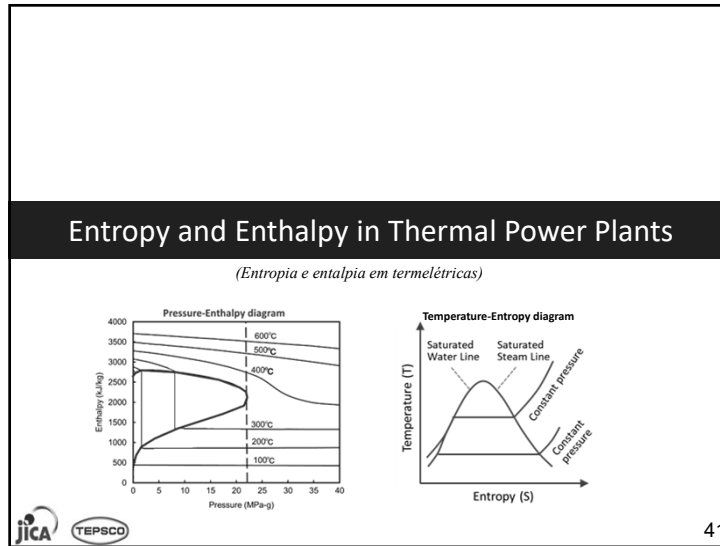
## What is the difference between enthalpy and entropy?

*(Qual é a diferença entre entalpia e entropia?)*

- To give you an example of **enthalpy** and **entropy** combined.  
If you heat a steel plate for only a portion of the plate, that portion of the plate has **higher enthalpy** than the other cooler portions.  
*(Para dar um exemplo de entalpia e entropia combinadas.)*  
*(Se você aquecer uma placa de aço para apenas uma parte da placa, essa parte da placa terá uma entalpia mais alta do que as outras partes mais frias.)*
- The **entropy** of the plate as a whole is low (heat is unevenly distributed to one portion).  
*(A entropia da placa como um todo é baixa (o calor é distribuído de maneira desigual em uma parte).)*
- As time passes, the heat spreads over the whole area and the difference in **enthalpy** disappears, and the **entropy** is high (heat is diffused).  
*(A entropia da placa como um todo é alta (o calor é distribuído de maneira desigual em uma parte).)*

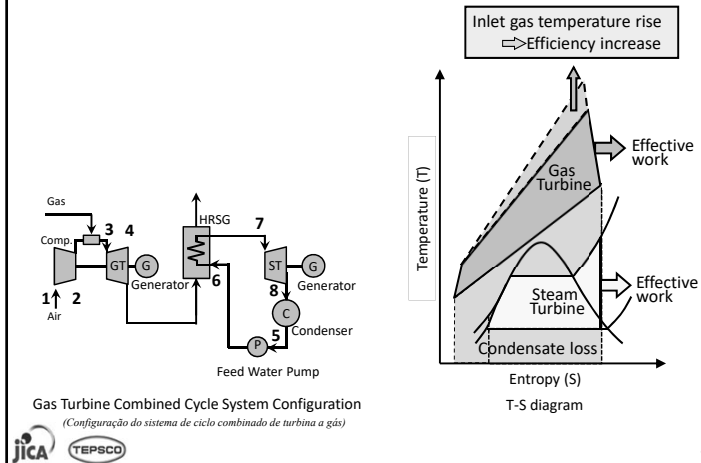


40



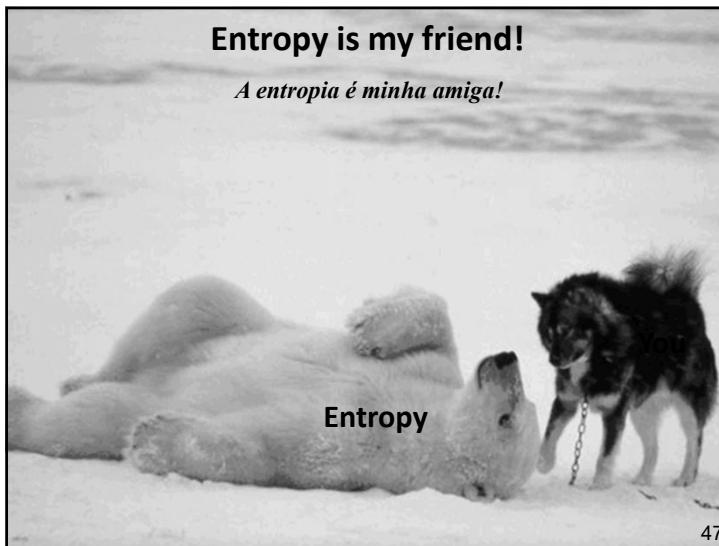
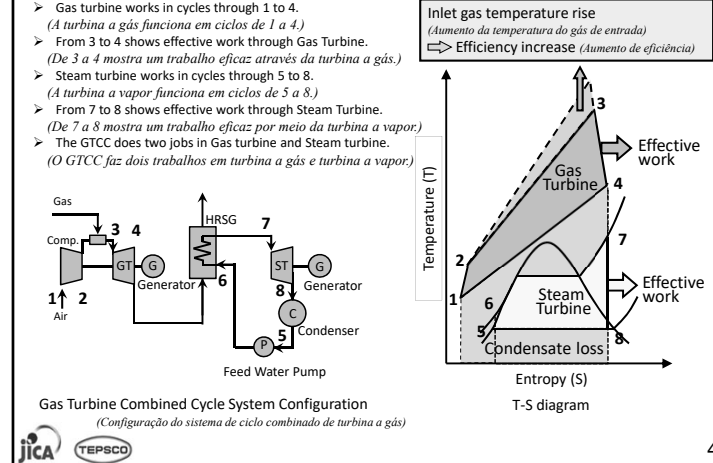
Q9: Where is the states 1 through 8 shown in the GTCC configuration diagram show on the T-S diagram?

(Onde estão os estados 1 a 8 mostrados no diagrama de configuração GTCC mostrado no diagrama T-S)



A9: Where is the states 1 through 8 shown in the GTCC configuration diagram show on the T-S diagram?

(Onde estão os estados 1 a 8 mostrados no diagrama de configuração GTCC mostrado no diagrama T-S)



You don't need to know entropy to get the job done.  
(Você não precisa saber entropia para fazer o trabalho.)

But if you know entropy, your work will change.  
(Mas se você conhece a entropia, seu trabalho mudará.)

entropia

Muito obrigado

Electricidade de Mozambique, E.P. Presentation

## History of the thermal power plants

(História das termelétricas)

Dec. 2, 2020

**History** → **Future**

Tokyo Electric Power Services Co., Ltd.  
Dr. Blackstone (Takashi Kuroishi)

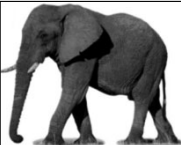
JICA TEPCO

Q1 : What is the weight of the animals shown here?  
(Q1. Qual é o peso dos animais mostrados aqui?)  
Please choose between A, B and C. (Escolha entre A, B e C.)

| Kitti's Hog-nosed Bat<br>(Kitti's Chocinho)                                                                                                                                                                                                                                                | Elephant (Elefante)                                                                              | Blue whale (Baleia Azul)                                                                                                                                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                         |               |                                                                                                         |
| The smallest mammal discovered in Thailand in 1973.<br>Hard to maintain their body temperature, and restricted in activity. Fly only night.<br>(O menor mamífero descoberto na Tailândia em 1973. Difícil de manter a temperatura corporal e com atividade restrita. Voar apenas à noite.) | Leg size limits to sustain the weight.<br>(Limites do tamanho das pernas para sustentar o peso.) | No need to support its weight. Cooling by water provides good heat transfer.<br>(Não há necessidade de suportar seu peso. O resfriamento por água fornece uma boa transferência de calor.) |
| Body length (Comprimento do corpo) 3 cm                                                                                                                                                                                                                                                    | 4 m                                                                                              | 24 m                                                                                                                                                                                       |
| Weight (Peso)<br>A : 0.5 g<br>B : 2 g<br>C : 100 g                                                                                                                                                                                                                                         | A : 1 ton<br>B : 2 ton<br>C : 4 ton                                                              | A : 10 ton<br>B : 20 ton<br>C : 100 ton                                                                                                                                                    |

JICA TEPCO 2

A1 : The answer is as follows. (A resposta é a seguinte.)  
➤ High efficiency heat engines are getting bigger.  
(Os motores térmicos de alta eficiência estão ficando maiores.)

| Minimum                                                                                                                                     | Maximum                                                                             |                                                                                     |
|---------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                                                                                                                                             | Land                                                                                | Sea                                                                                 |
| Kitti's Hog-nosed Bat                                                                                                                       | Elephant                                                                            | Blue whale                                                                          |
|                                                          |  |  |
| The smallest mammal discovered in Thailand in 1973.<br>Hard to maintain their body temperature, and restricted in activity. Fly only night. | Leg size limits to sustain the weight.                                              | No need to support its weight. Cooling by water provides good heat transfer.        |
| Body length 3 cm                                                                                                                            | 4 m                                                                                 | 24 m                                                                                |
| body weight B: 2 g                                                                                                                          | C: 4 ton                                                                            | C: 100 ton                                                                          |

JICA TEPCO 3

A1: High efficiency heat engines are getting bigger.  
(A1: Os motores térmicos de alta eficiência estão ficando maiores.)

[For your reference] (Para sua referência)  
"The Time of the Elephant and the Time of the Mouse" (O tempo do elefante e o tempo do rato)  
From Tatsuo Honkawa's book (Do livro de Tatsuo Honkawa)

- The heart beats about 2 billion times in the lifetime of any mammal.  
(O coração bate cerca de 2 bilhões de vezes na vida de qualquer mamífero.)
- During their lifetime, they breathe about 500 million times.  
(Durante sua vida, eles respiram cerca de 500 milhões de vezes.)
- This is about the same for mammals, regardless of body size.  
(Isso é quase o mesmo para os mamíferos, independentemente do tamanho do corpo.)
- Life span varies greatly with size. (A expectativa de vida varia muito com o tamanho.)
- The amount of energy used per kg of body weight in a lifetime is constant.  
(A quantidade de energia usada por kg de peso corporal ao longo da vida é constante.)
- Smaller ones have a shorter life span and burn out more violently.  
(Os menores têm uma vida útil mais curta e queimam com mais violência.)
- Larger animals use less energy for their body weight and therefore have a longer life span.  
(Animais maiores usam menos energia para seu peso corporal e, portanto, têm uma vida útil mais longa.)
- Larger animals are more sensitive to their environment. (Animais maiores são mais sensíveis ao ambiente.)
- Larger ones have more leeway. (Os maiores têm mais margem de manobra.)

JICA TEPCO 4

### A1 :High efficiency heat engines are getting bigger.

(Os motores térmicos de alta eficiência estão ficando maiores.)

| Kitti's Hog-nosed Bat                                                             | Elephant                                                                          | Blue whale                                                                        |
|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
|  |  |  |
| < Reference : Life time ><br>5 years                                              | 80 years                                                                          | 110 years                                                                         |



5

### Increasing the Capacity of Thermal Power Plants

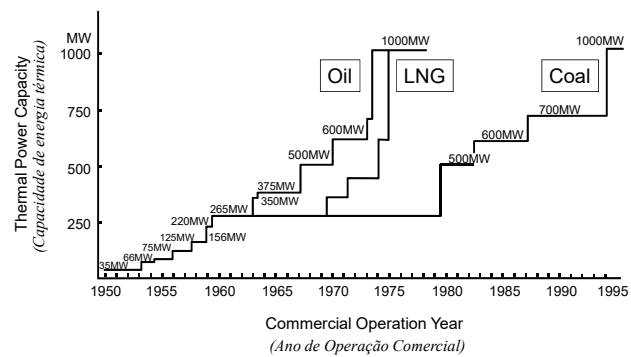
(Aumentando a capacidade das usinas termelétricas)



6

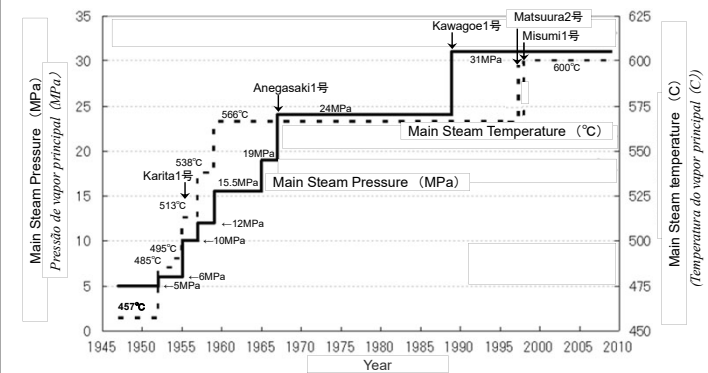
### Transition of Thermal Power Capacity in Japan

(Transição da capacidade de energia térmica no Japão)



7

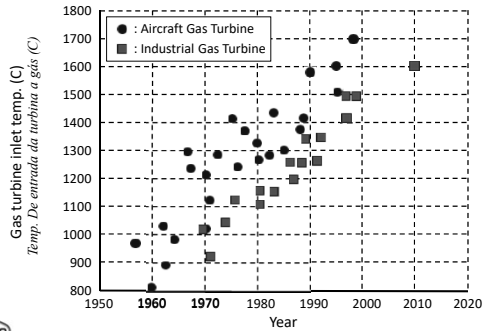
### Changing of Steam Condition (Mudança da condição do Steam)



8

### Trends in the temperature increase at the gas turbine inlet

- Aircraft gas turbines have generally led industrial gas turbines. Also, Aircraft gas turbine inlet temperatures are about 10 years ahead from industrial ones.  
(As turbinas a gás aeronáuticas têm geralmente liderado as turbinas a gás industriais. Além disso, as temperaturas de entrada das turbinas a gás aeronáuticas estão cerca de 10 anos à frente das turbinas industriais..)
- It has also been rising at a rate of about 20C/year.  
(Também tem aumentado a uma taxa de cerca de 20C / ano.)



9

### Efficiency comparison between cars and power systems

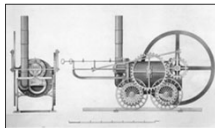
(Comparação de eficiência entre carros e sistemas de energia)



10

### Q2: Setting the Heat Efficiency Ranking as bellows.

(Q2: Definir a classificação de eficiência de calor como fole.)



**Trevithick boiler 1800**  
(Caldeira Trevithick 1800)



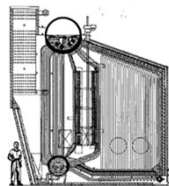
**Electric Car**  
(Carro elétrico)



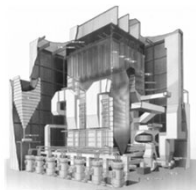
**Fuel Cell Engine Car**  
(Carro com motor a célula de combustível)



**Engine Car**  
(Carro com motor)



**Two drum Boiler 1899**  
(Caldeira de dois tambores 1899)



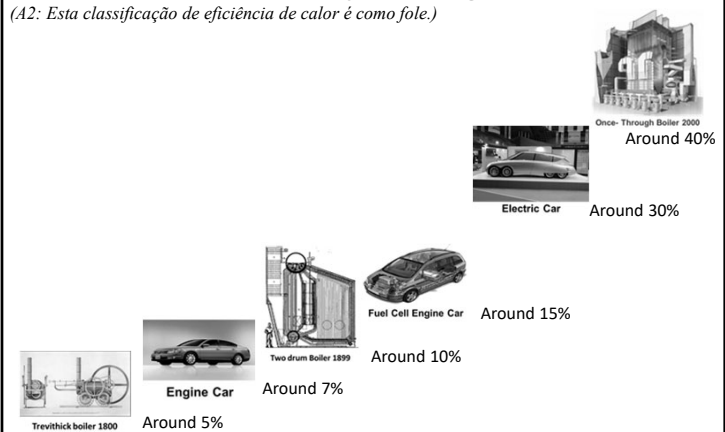
**Once- Through Boiler 2000**  
(Caldeira de passagem única 2000)



11

### A2 : These Heat Efficiency Ranking are as bellows.

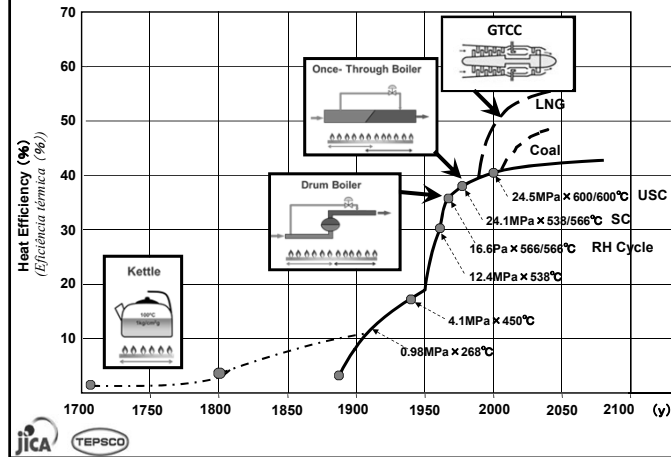
(A2: Esta classificação de eficiência de calor é como fole.)



12

## A2: Heat Efficiency level of Drum Boiler, Once-Through Boiler and GTCC.

(A2 : Nível de eficiência de calor da caldeira de tambor, caldeira de passagem única e GTCC.)

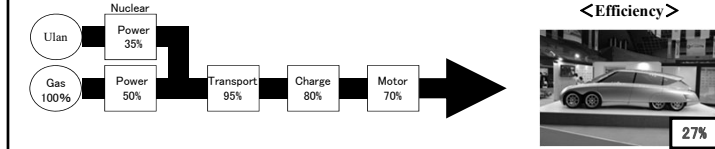


13

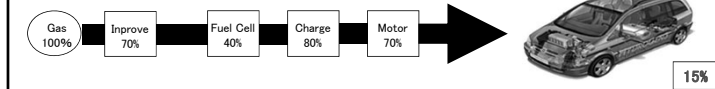
## A2: Electric Car is the best efficiency

(A2: Carro elétrico é a melhor eficiência)

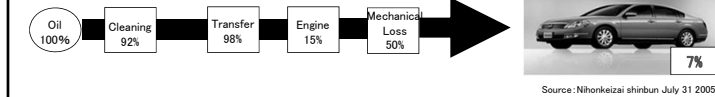
### <Electric Car (Carro elétrico)>



### <Fuel Cell Engine Car (Carro com motor a célula de combustível)>



### <Engine Car (Carro com motor)>



Source: Nihonkeizai shinbun July 31 2005

Logos: JICA, TEPSCO

14

## History of Heat Efficiency regarding thermal Power

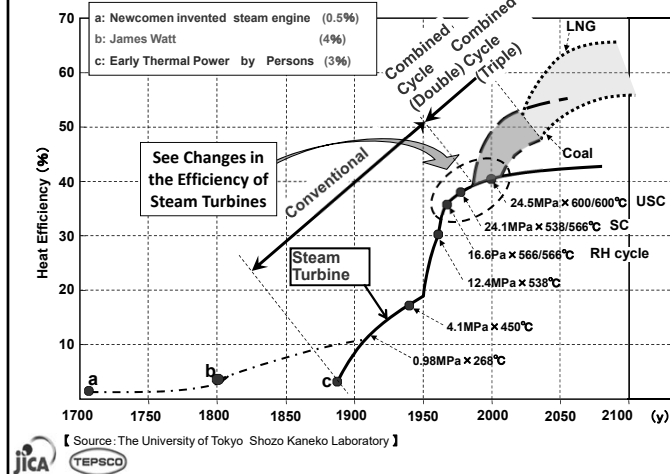
(História da eficiência térmica em relação à energia térmica)

Logos: JICA, TEPSCO

15

## History of Heat Efficiency regarding thermal power.

(História da Eficiência Calórica em relação à energia térmica.)



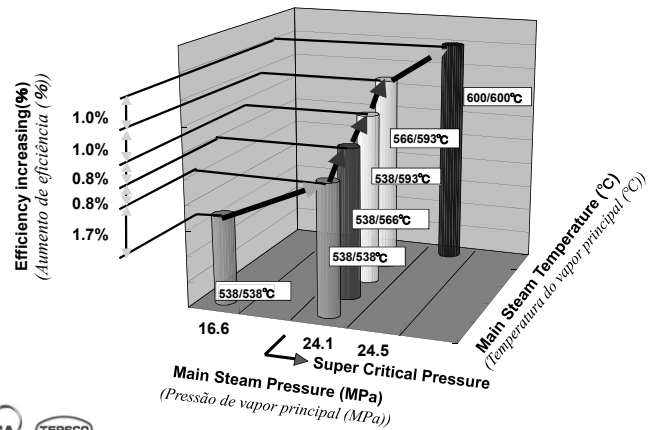
【 Source: The University of Tokyo Shozo Kaneko Laboratory 】

16



## Changes in the Efficiency of Steam Turbines

(Mudanças na eficiência das turbinas a vapor)

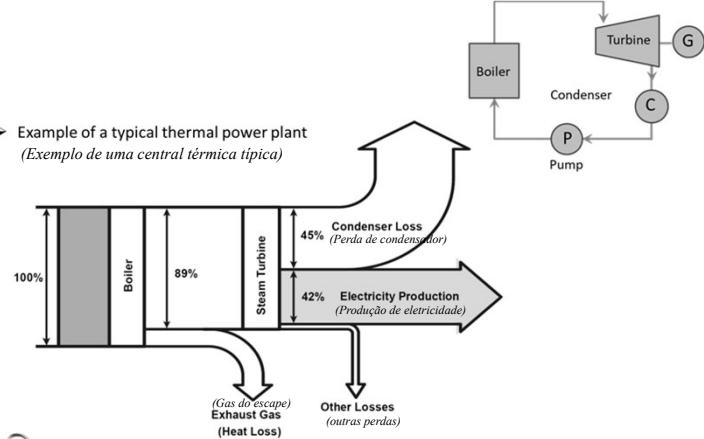


17

## Breakdown of efficiency regarding a typical thermal power plant

(Repartição da eficiência em relação a uma central térmica típica)

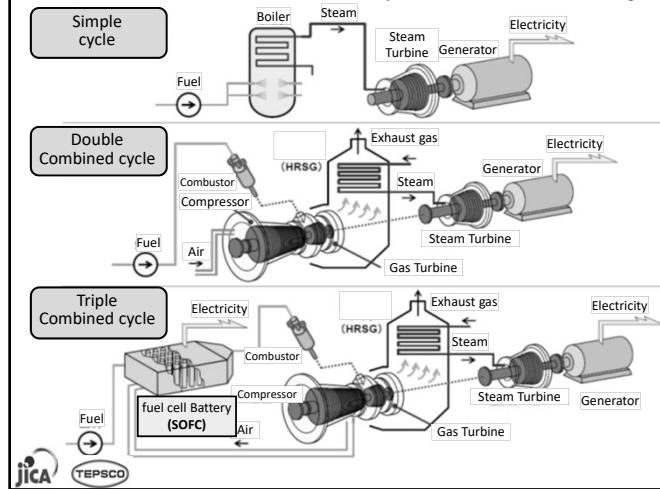
➤ Example of a typical thermal power plant  
(Exemplo de uma central térmica típica)



18

## Heat Efficiency level of Thermal power systems.

(Nível de eficiência térmica de sistemas de energia térmica.)



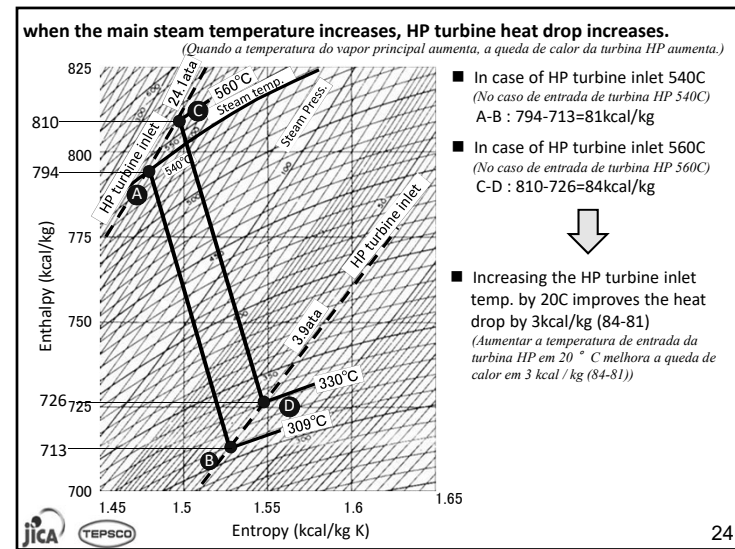
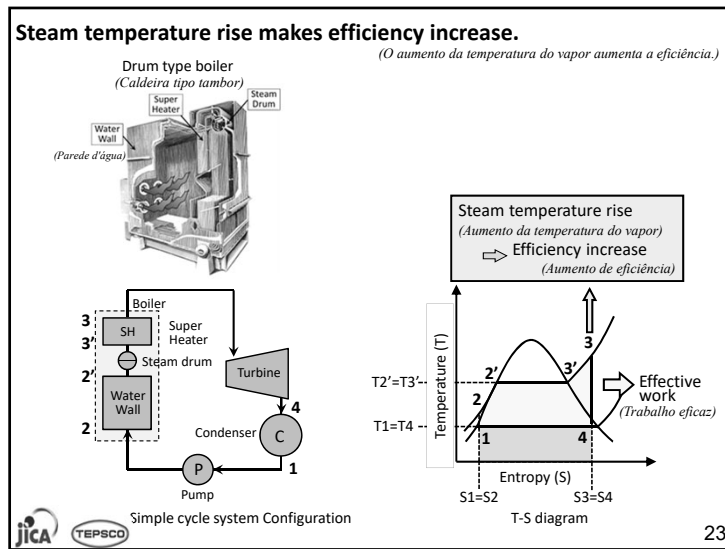
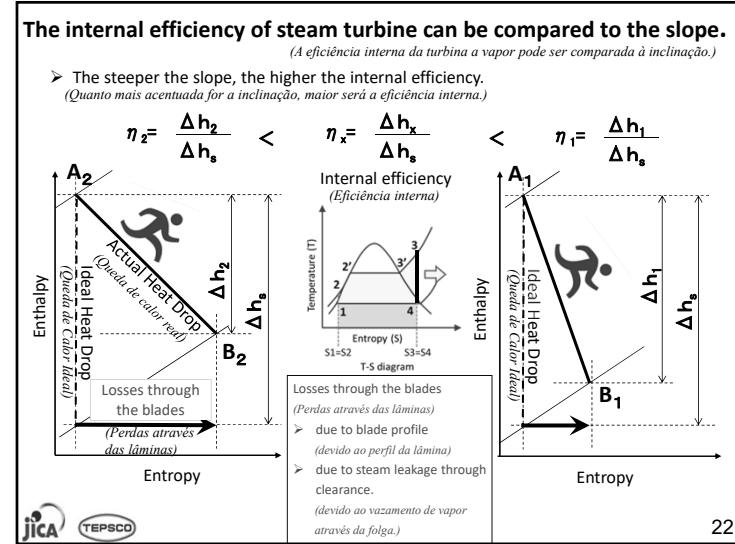
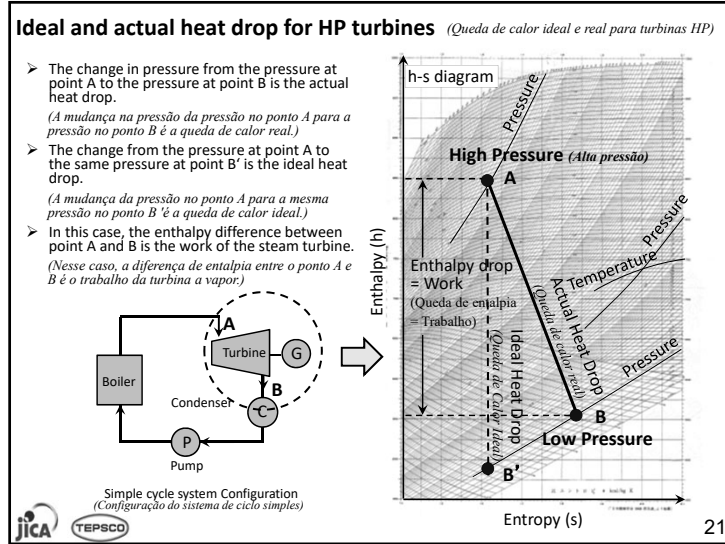
19

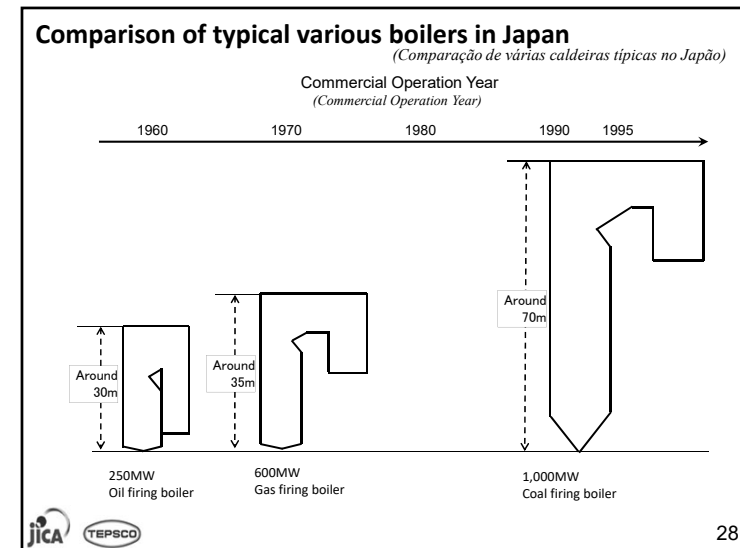
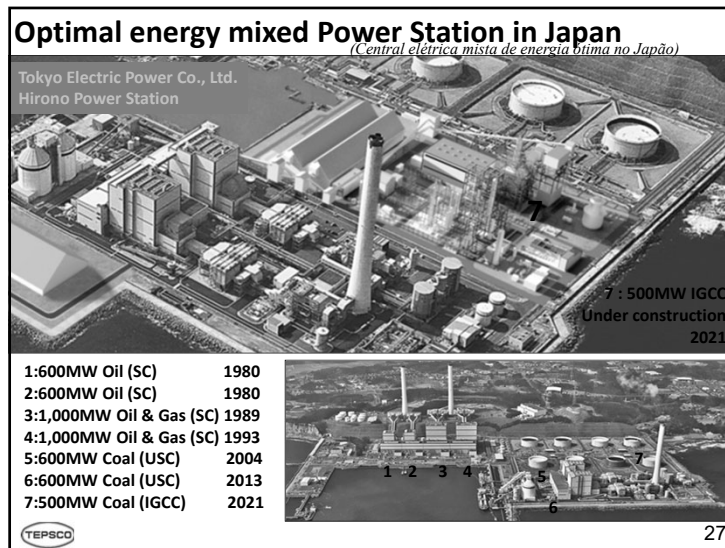
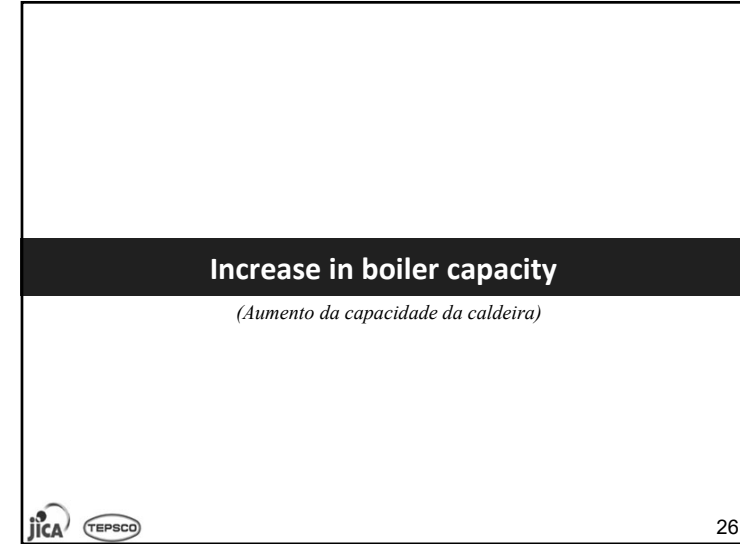
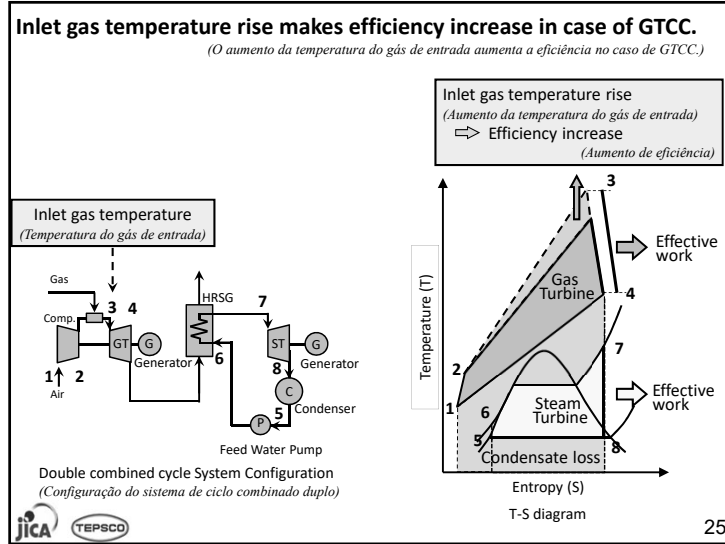
## How to improve efficiency?

(Como melhorar a eficiência?)



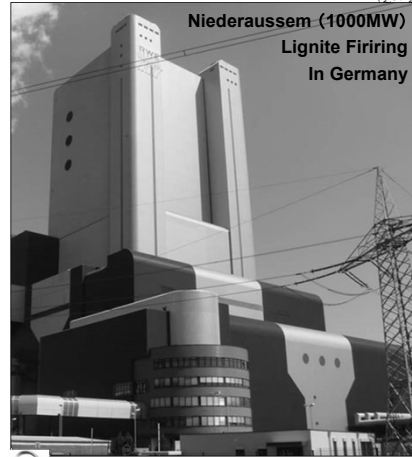
20





### Q3:How high is The World Highest Boiler ?

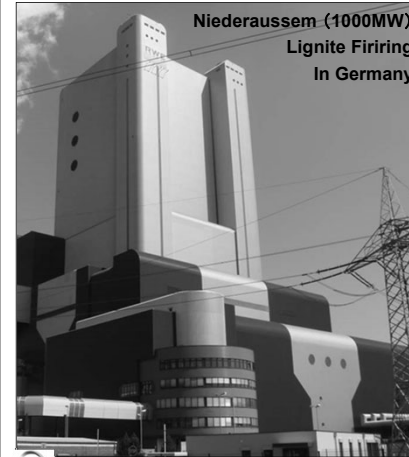
(Q3: Qual é a altura da caldeira mais alta do mundo ?)



29

### A3 :The World Highest Boiler is 150m

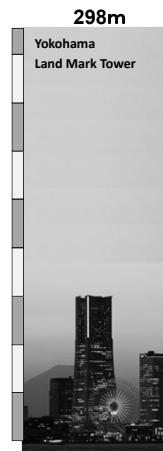
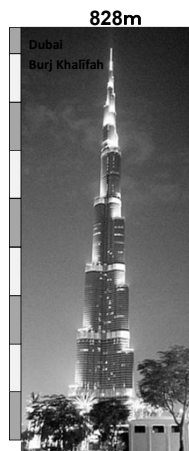
(A3: A caldeira mais alta do mundo é 150m)



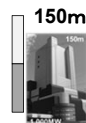
150m

30

### A3:World Building Comparison (A3: Comparação de edificios mundiais)



The World Highest Boiler In Germany



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### The world's largest thermal power plant

(A maior usina termelétrica do mundo)

Mountaineer (1,300MW) in U.S.A



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## Increasing the Capacity of Gas Turbines

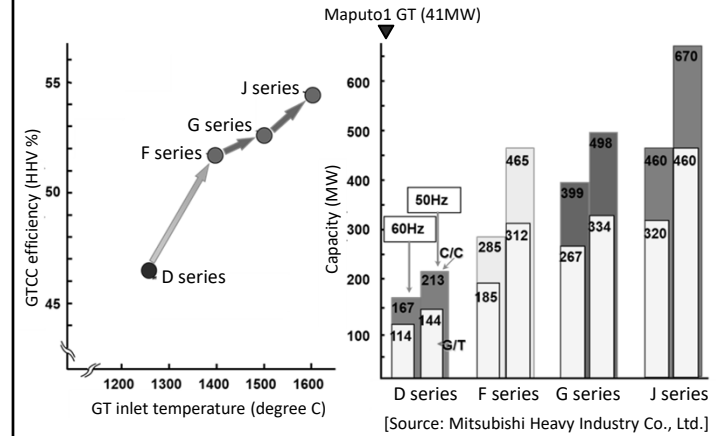
(Aumentando a capacidade das turbinas a gás)



33

## Transition to High Power and High Efficiency Gas Turbines

(Transição para turbinas a gás de alta potência e alta eficiência)



34

## Latest GTCC thermal power plant (Usina termelétrica GTCC mais recente)

Jera KAWASAKI thermal power station



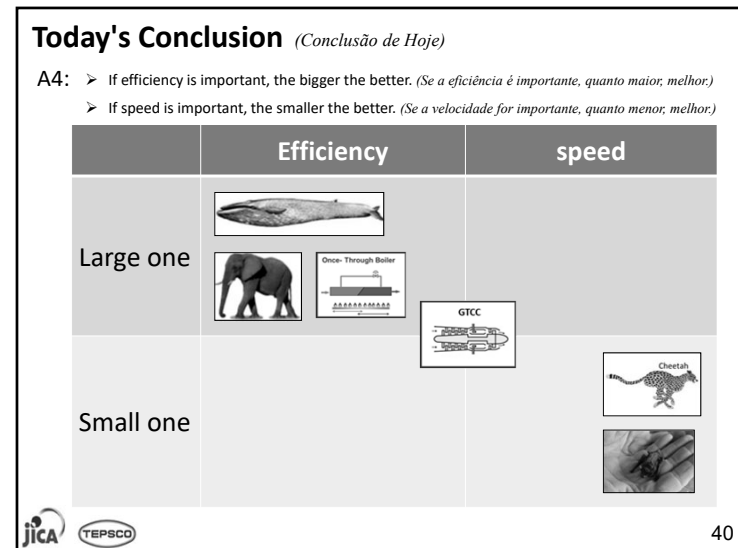
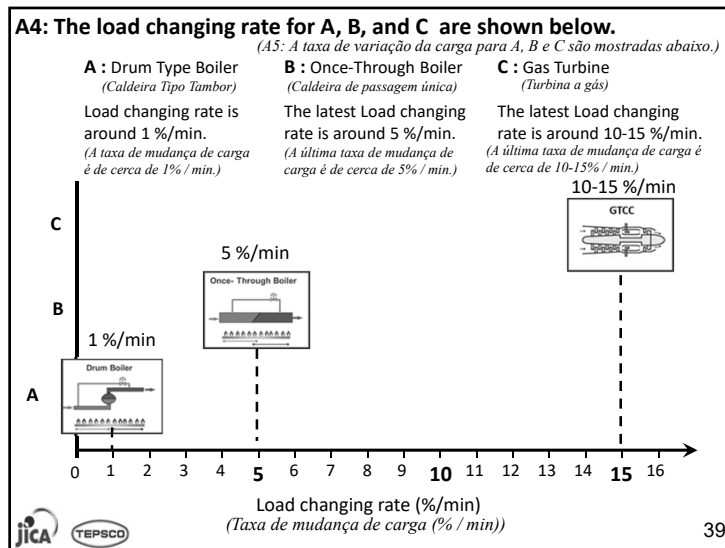
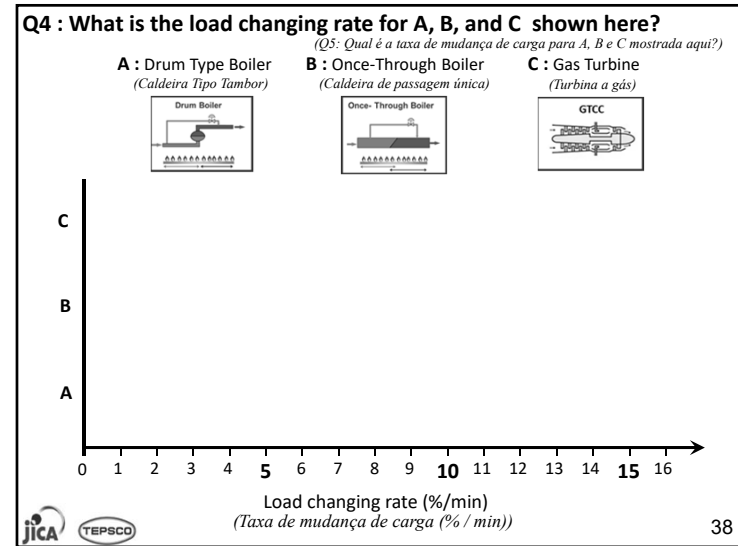
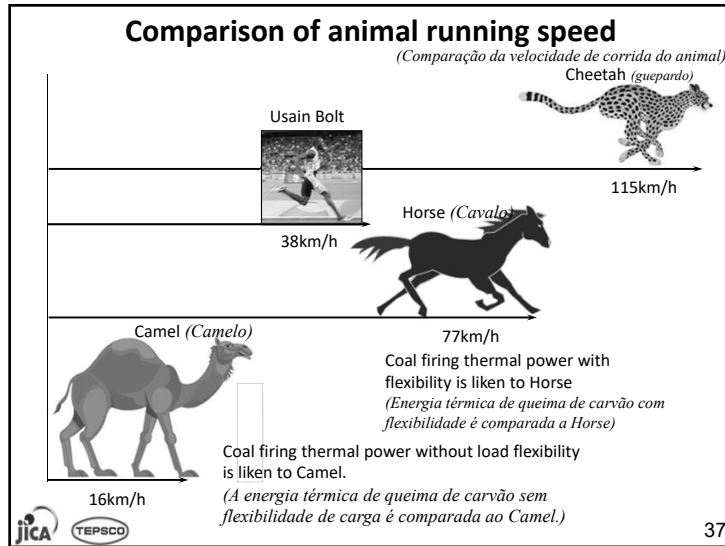
35

## Load changing rate of Thermal Power Plants

(Taxa de variação de carga de usinas termelétricas)



36



You don't need to know history to get the job done.  
However if you know history, your work will change.

*Você não precisa saber de história para fazer o trabalho.  
No entanto, se você conhece a história, seu trabalho mudará.*

**Muito obrigado**

JICA TEPCO

**For your reference information**

*(Para sua informação de referência)*

JICA TEPCO

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**What material does Boiler use for ?**  
*(Que material a caldeira usa para ?)*

[Light Gray Box] : Carbon steel (*Aço carbon*)  
 [Medium Gray Box] : Alloy steel (*Liga de aço*)  
 [Dark Gray Box] : Stainless steel (*Aço inoxidável*)

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**Q5: How long does the boiler extend as the temperature rises?**  
*(Q4: Quanto tempo dura a caldeira à medida que a temperatura aumenta?)*

➤ The boiler (Water Wall) is suspended from the ceiling. (*A caldeira (Water Wall) é suspensa no teto.*)

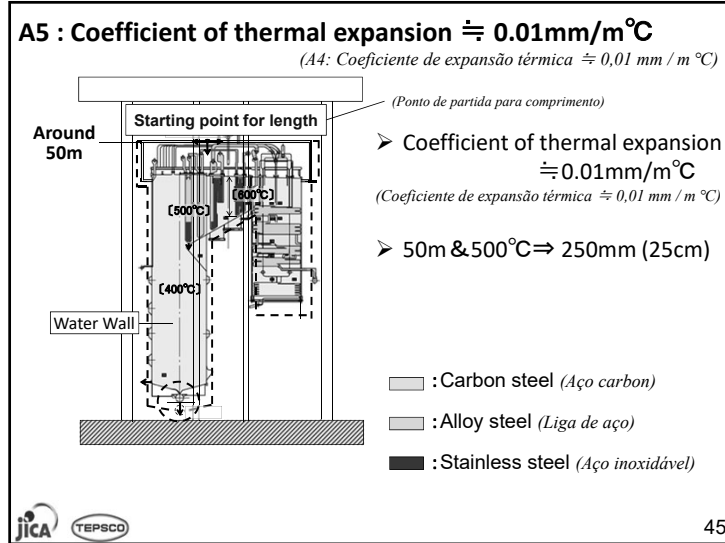
➤ The height of Water Wall is around 50m. (*A altura da Parede de Água é de cerca de 50m.*)

Q: How long does the Water Wall extend, when Water Wall temperature increases from 0 °C to 500 °C ?  
*(P: Quanto tempo a parede de água se estende, quando a temperatura da parede de água aumenta de 0 °C para 500 °C?)*

[Light Gray Box] : Carbon steel (*Aço carbon*)  
 [Medium Gray Box] : Alloy steel (*Liga de aço*)  
 [Dark Gray Box] : Stainless steel (*Aço inoxidável*)

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Electricidade de Mozambique, E.P. Presentation

## CO2 Reduction Technologies In the thermal power plants

Dec. 16, 2020

GTCC

IGCC

The Integrated Thermal Power Technologies

Flex-USC

Supporting Renewable Energy Expansion

Tokyo Electric Power Services Co., Ltd.  
PhD. Pedra negra ( Takashi Kuroishi )

## Growing up In Mozambique

➤ Mozambique has grown rapidly since independence in 1975.

Mozambique Before Independence in 1975

Mozambique

Current Maputo

45years

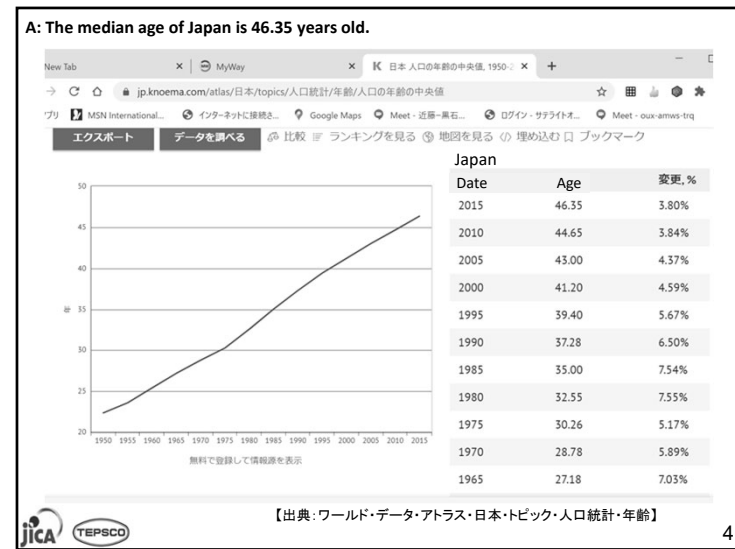
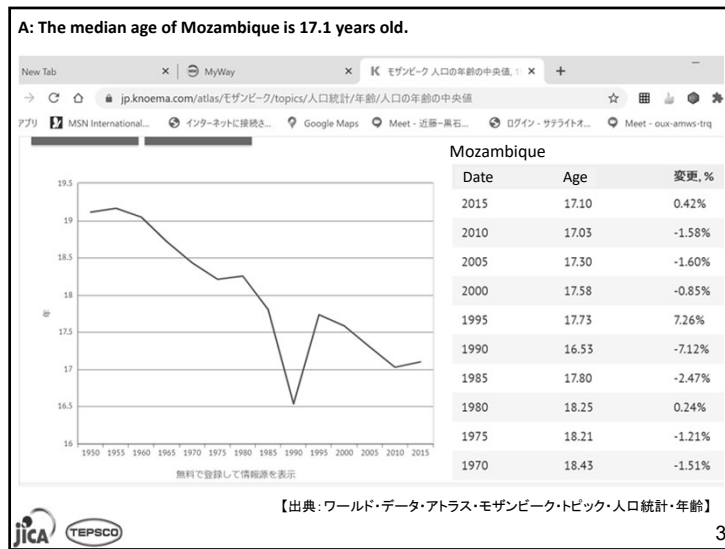
Q: Do you know the median age of Mozambique?

Q: Do you know the median age of Japan?

Maputo

JICA TEPSCO

2



### A: Comparison of workshop attendances



The median age of Philippines is 23 years old.

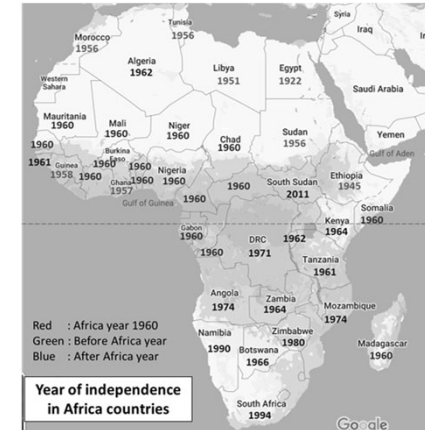
Which country is more promising, Philippines or Japan?



5

### Mozambique has the huge promising in the future

- Africa will be an important position in the world by 2100.
- That is why African people median age is so YOUNG!



6

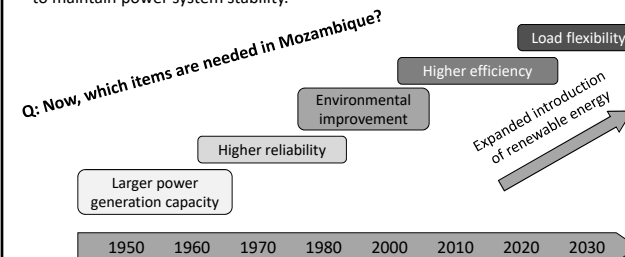
### Sustainable Development Goals in Mozambique



7

### The transition of needs for thermal power surrounding the world

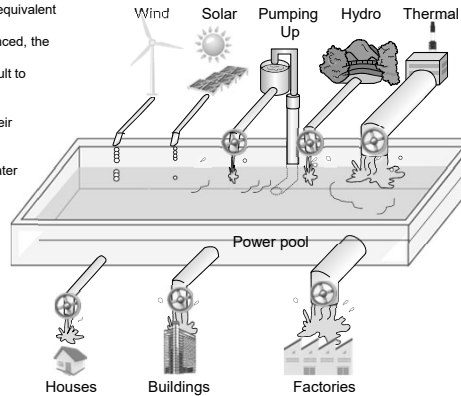
- In the 1950s, when thermal power became the leading role of power generation, it responded to needs such as increasing the capacity of power and then improving reliability and the environment in response to changes in the times.
- Then, in the 2000s, high efficiency aimed at reducing fuel costs became a need for thermal power.
- In the expanded RE era, thermal power plants are required to have load flexibility in order to maintain power system stability.



8

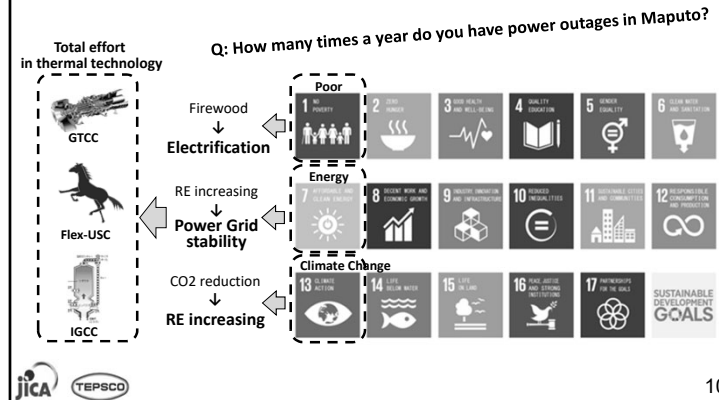
### The structure of Power Grid is similar to pooling water in a swimming pool.

- Water level control in a pool is equivalent to frequency control.
- If supply and demand are balanced, the water level will be maintained.
- Solar and wind power are difficult to control the water level.
- Pumped water and hydraulic power can be controlled, but their capacity is small.
- Thermal power has a large capacity and can control the water level.



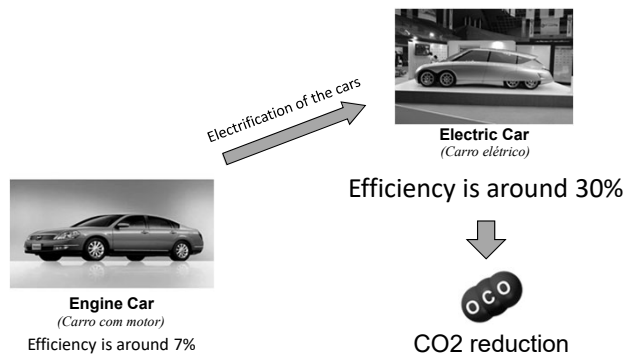
### Sustainable Development Goals ( We Say SDGs)

- Unanimously adopted at the United Nation Summit in September 2015.
- The "17 International Sustainable Development Goals" for a sustainable, diverse and inclusive society "leaving no one behind", with the year 2030.



### Electrification of the cars

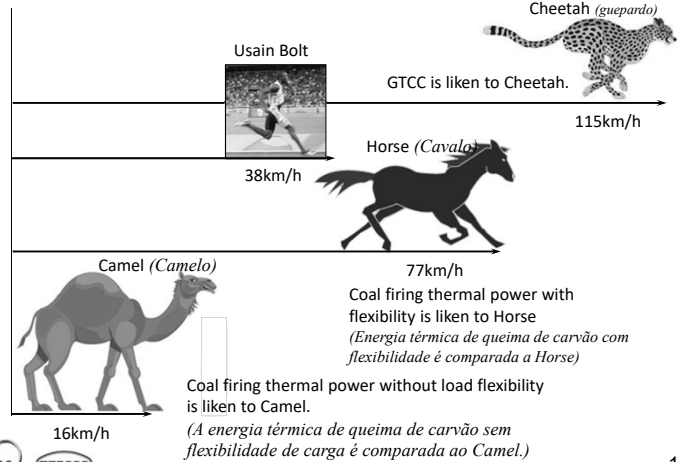
- Converting the engine car to the electric car greatly improves efficiency.
- As a result, CO2 can be reduced.



### The best energy mix to maintain the stability of the power system

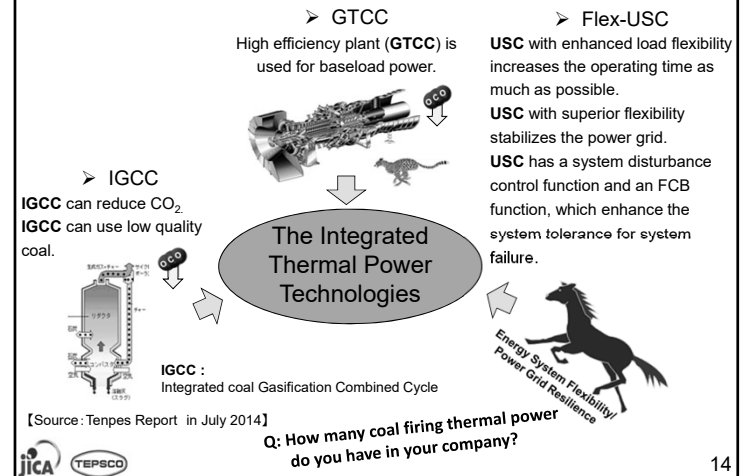
## Comparison of animal running speed

(Comparação da velocidade de corrida do animal)



13

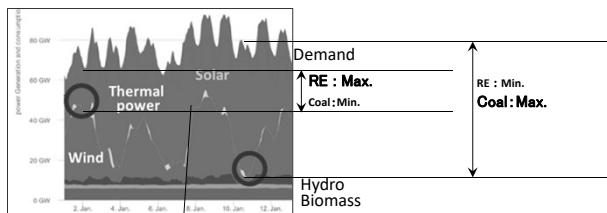
## The Integrated Thermal Power Technologies in the Renewable Energy Era



14

## Regarding Load changing rate and Minimum load

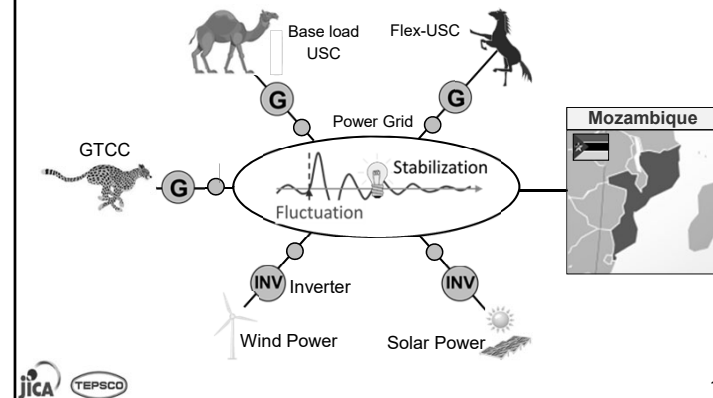
- The lower the minimum load, the wider the operating range.
- The faster the load change rate, the more stable the system frequency.



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## The best energy mix to maintain the stability of the power system

- To reduce CO<sub>2</sub>, increase the ratio of RE in the future.
- In the expanded RE era, thermal power plants are required to have load flexibility in order to maintain power system stability.



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## GTCC

GTCC is liken to Cheetah.



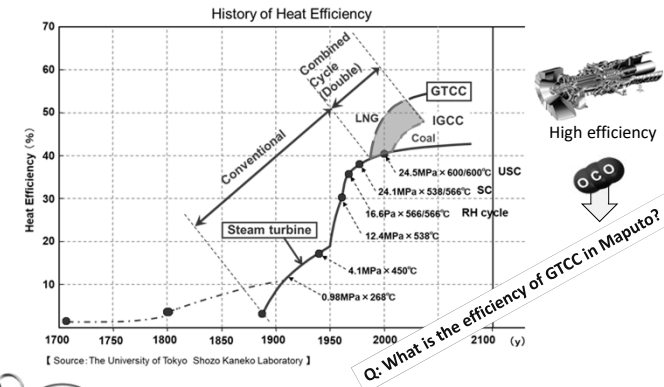
Cheetah



17

## GTCC contributes to the reduction of CO2 at high efficiency

- By integrating a conventional thermal power system into a combined-cycle system (GTCC), the efficiency is greatly improved.
- By applying GTCC, efficiency can be improved and CO2 can be reduced.



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## Flex-USC

Coal firing thermal power with flexibility is liken to Horse.



Horse

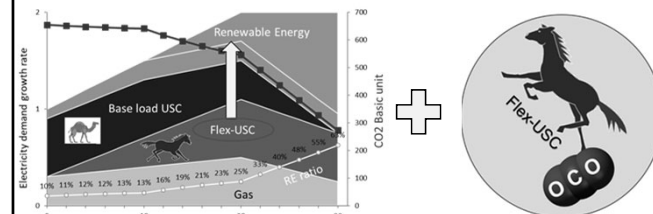


19

## The role of the Coal fired plants in the RE era is - - -

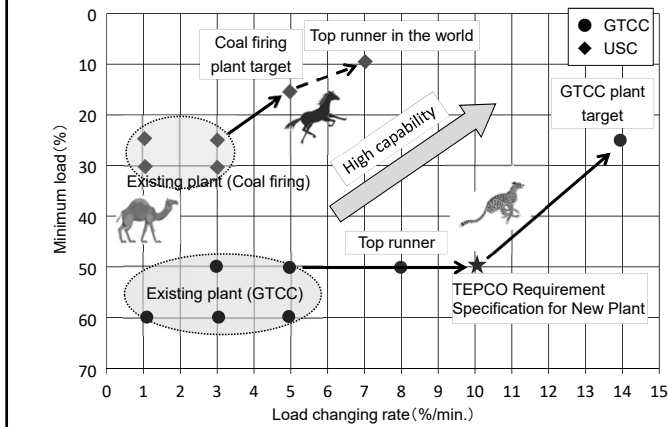
① Support RE increasing  
In the future.

② Load flexibility for  
power grid resilience



20

### Required Load Changing Rate and Minimum Load in the RE Era

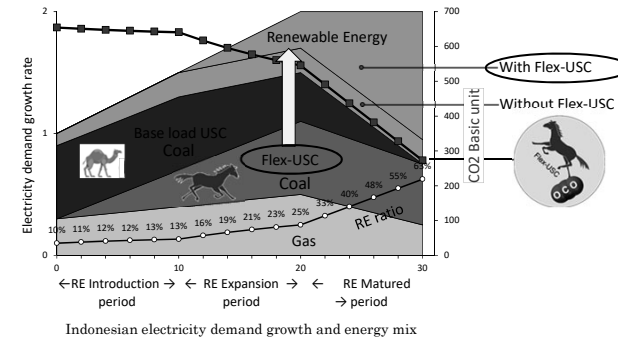


【Source: Tenpes Report in July 2014】

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### Coal-Fired thermal Power to Support Renewable Energy Expansion

- In order to meet increasing power demand in Indonesia,
- The first solution is to increase the amount of electricity by thermal power.
- Thermal power with Flex-USC can also contribute to the expansion of renewable energy.

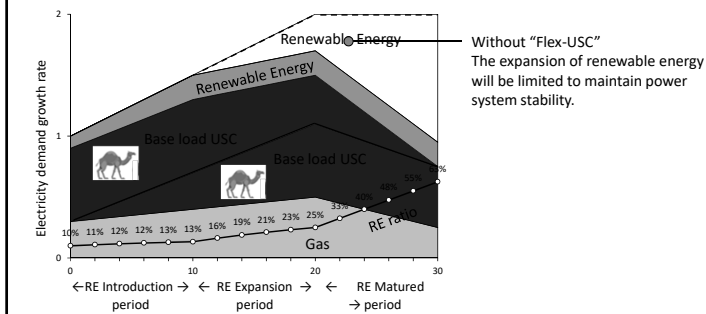


Indonesian electricity demand growth and energy mix

22

### Coal-Fired Power without "Flex-USC" will limit RE expansion

- In case of Coal-Fired Power without "Flex-USC", the expansion of RE will be limited to maintain power system stability.



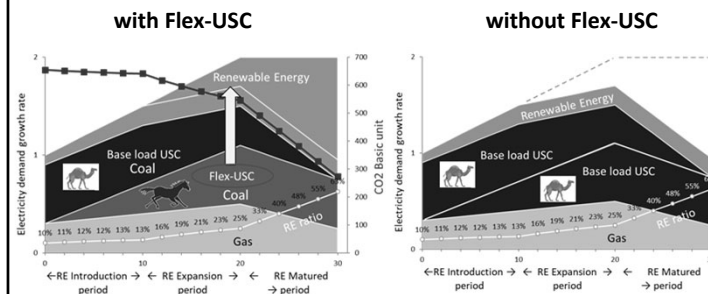
Without "Flex-USC"  
The expansion of renewable energy will be limited to maintain power system stability.

Indonesian electricity demand growth and energy mix

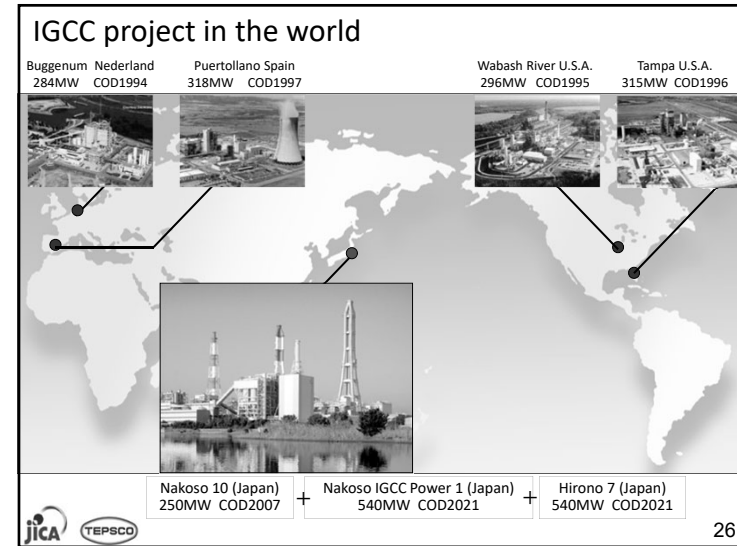
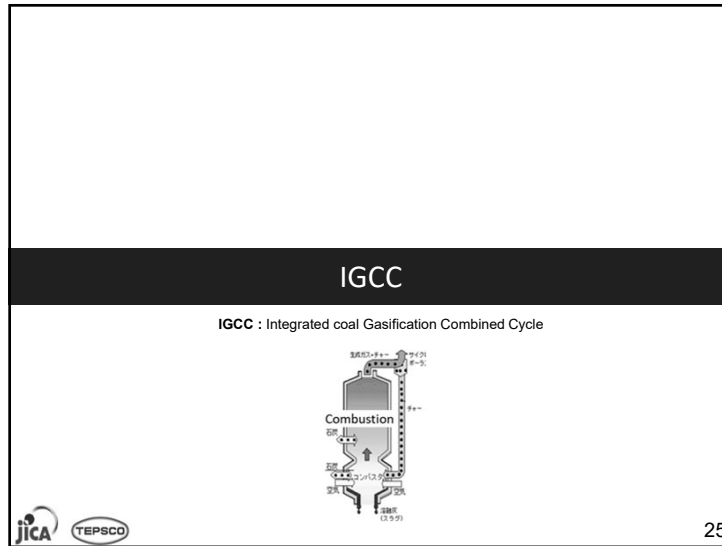
23

### Comparison between with Flex-USC and without Flex-USC

- Flex-USC can contribute to the expansion of renewable energy.

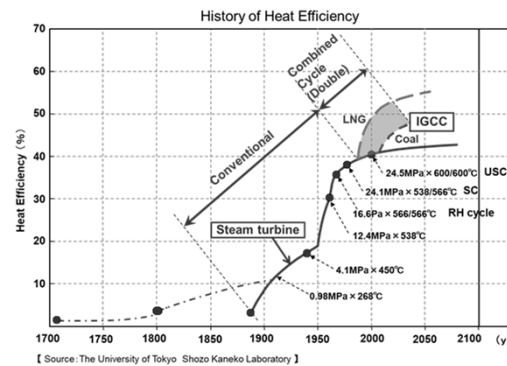


24



### Why is the IGCC desired now?

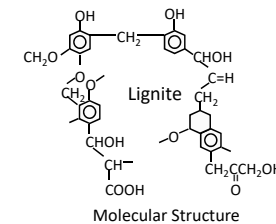
- High efficiency
- Excellent environmental performance  
CO<sub>2</sub> reduction, Low SO<sub>x</sub>, Low NO<sub>x</sub>, Particulate matter



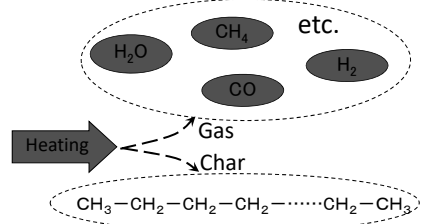
### The principle of gasification



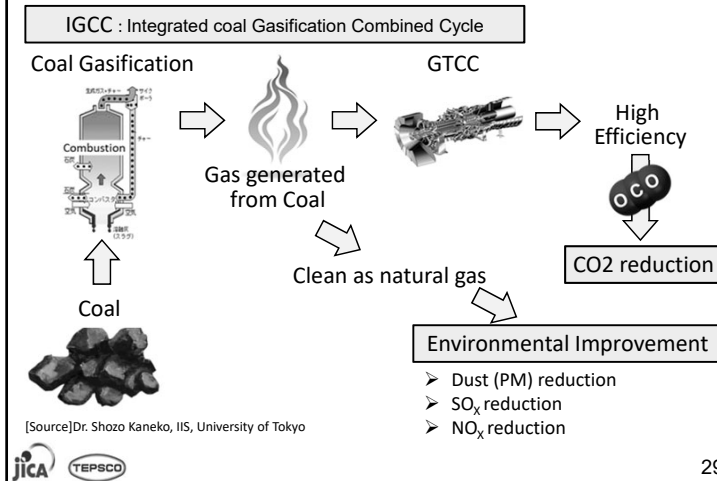
Indirect heating (Dry stoves)



- British engineer Murdoch invented the world's first coal gasification system with indirect heating.  
William **Murdoch** (1792~1807)
- Coal molecular structure is shown as bottom left.
- When coal is heated indirectly using a dry stove, the coal molecules decompose and gas is produced.
- The produced gases are CH<sub>4</sub>, CO, H<sub>2</sub>, H<sub>2</sub>O and etc.



### Gasification can make coal as clean as natural gas.



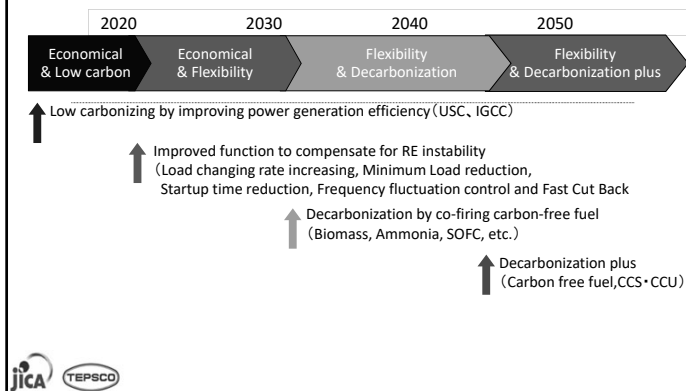
### Future vision



30

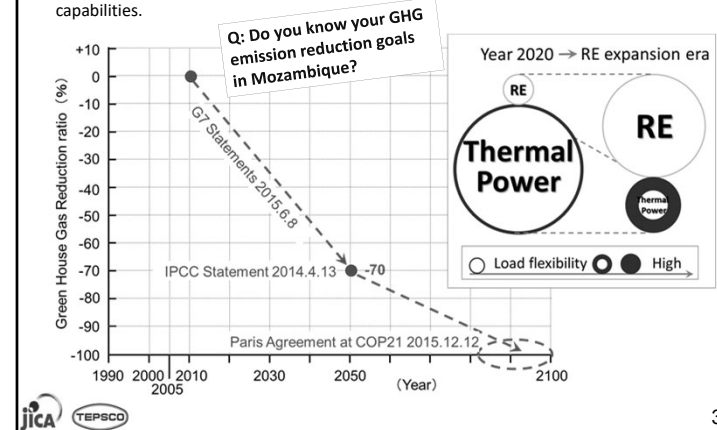
### Thermal power that can be transformed according to the needs of the times

- Considering the thermal power by 2050,
- it is necessary for thermal power plants to change the role of thermal power and itself according to the needs of the times.



### GHG emission reduction goals

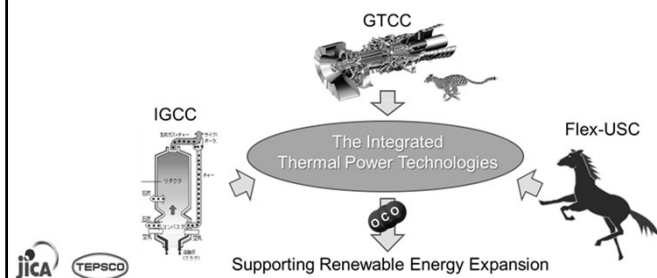
- The following are the GHG reduction targets of the Paris Agreement.
- In order to significantly reduce GHGs in this way, RE needs to be significantly introduced and the remaining thermal power plants need to improve their load balancing capabilities.





We have the integrate technologies regarding Thermal power plants  
in Japan.

We would like to walk together with you.



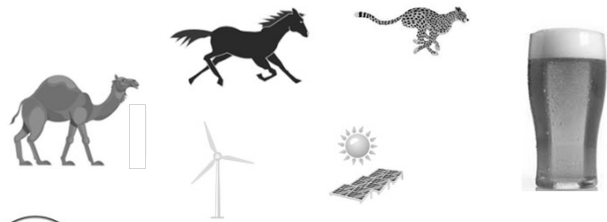
Muito obrigado



Electricidade de Mozambique, E.P. Presentation

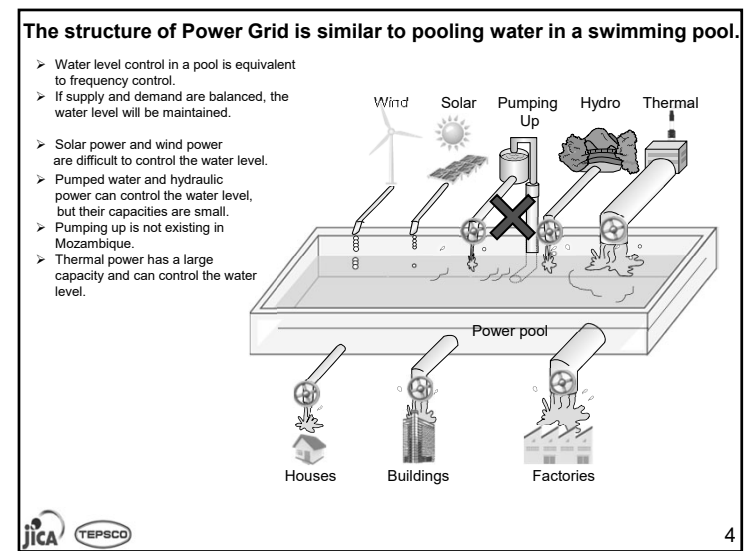
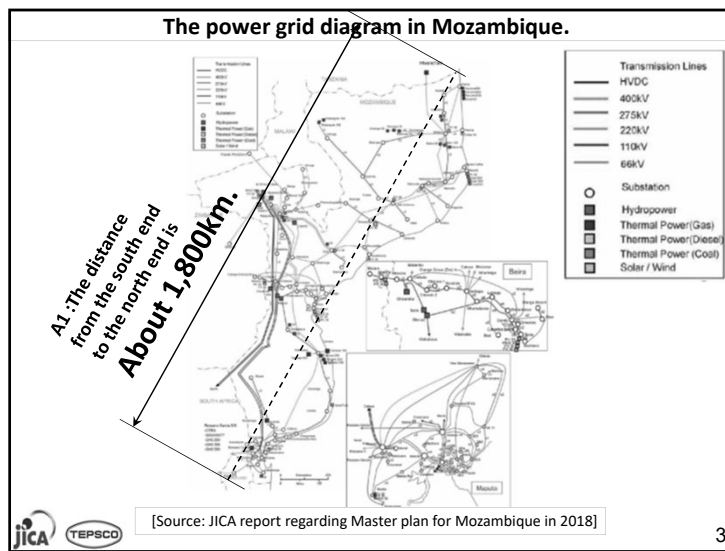
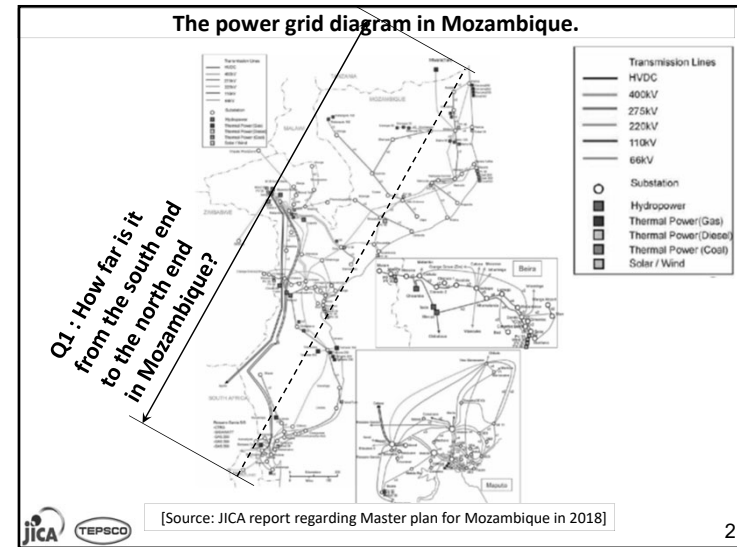
## Power Grid control

Active power & Reactive power Jan. 13, 2021



jica TEPCO

Tokyo Electric Power Services Co., Ltd.  
PhD. Pedra negra ( Takashi Kuroishi )

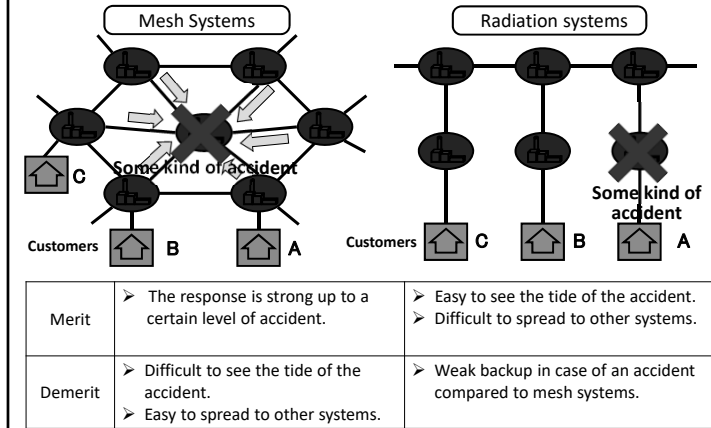


## World Power Systems



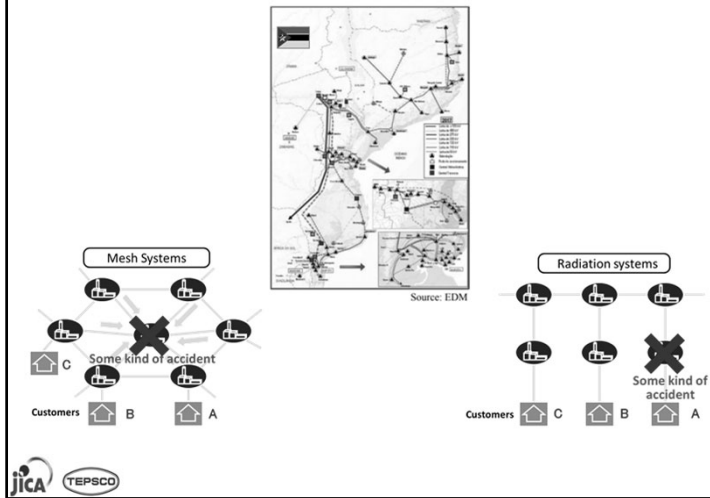
5

## Comparison of power systems



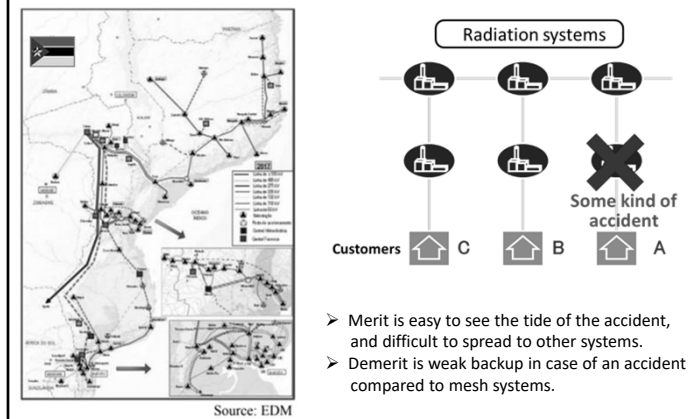
6

## Q2: Which power system in Mozambique is Mesh or Radiation?



7

## A2: Power system in Mozambique is Radiation system.



8

**Q3 : How many times is the power capacity in Japan compare to Mozambique?**

|                |                           | Mozambique | Japan                 |
|----------------|---------------------------|------------|-----------------------|
| Land Area      | $\times 10^3 \text{km}^2$ | 810 (1.0)  | 380 ( $\approx 0.5$ ) |
| Population     | Million Person            | 23.9 (1.0) | 126 ( $\approx 5$ )   |
| Power Capacity | GW                        | 0.9 (1.0)  | ?                     |

A : 10  
B : 100  
C : 200  
D : 500

Source: EDM

9

**A3 : Japan's power capacity is about 240 times that of Mozambique.**

|                |                           | Mozambique | Japan                 |
|----------------|---------------------------|------------|-----------------------|
| Land Area      | $\times 10^3 \text{km}^2$ | 810 (1.0)  | 380 ( $\approx 0.5$ ) |
| Population     | Million Person            | 23.9 (1.0) | 126 ( $\approx 5$ )   |
| Power Capacity | GW                        | 0.9 (1.0)  | 234 ( $\approx 240$ ) |

Source: EDM

10

**Blackout in the world**

Source: FEMA

11

**What are the lessons learned from the North American Blackout?**

This blackout happened in 2003

- Land area :  $9.67 \times 10^6 \text{km}^2$
- Power capacity : 1,018GW
- Population : 312million person

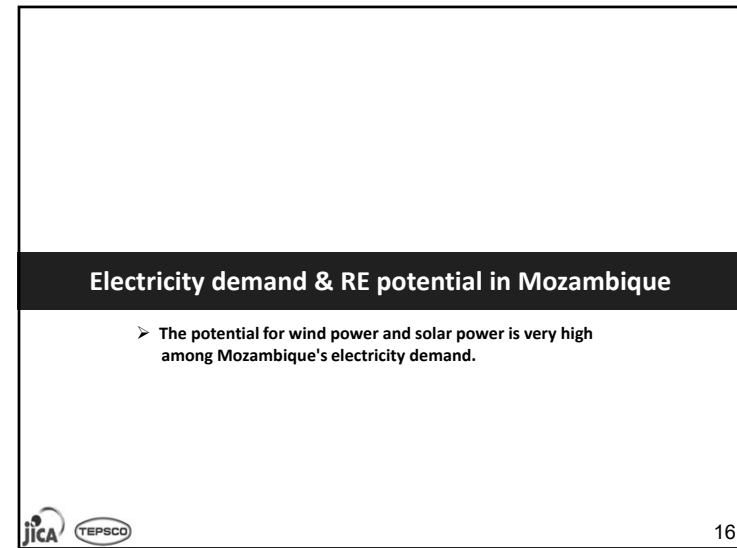
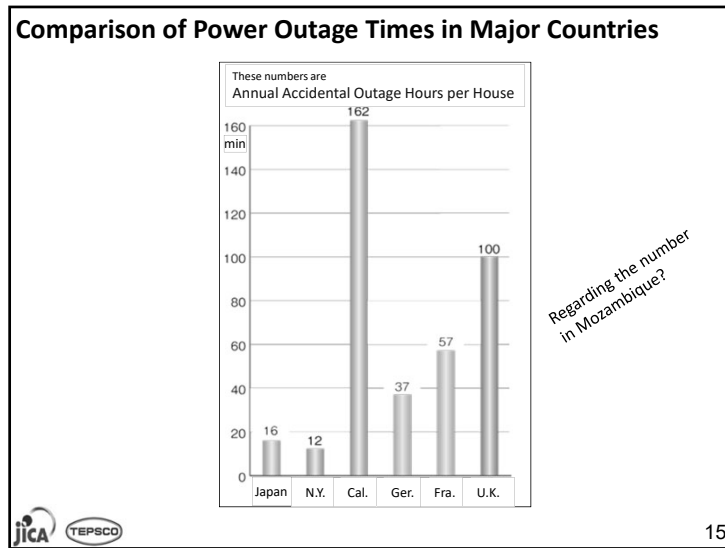
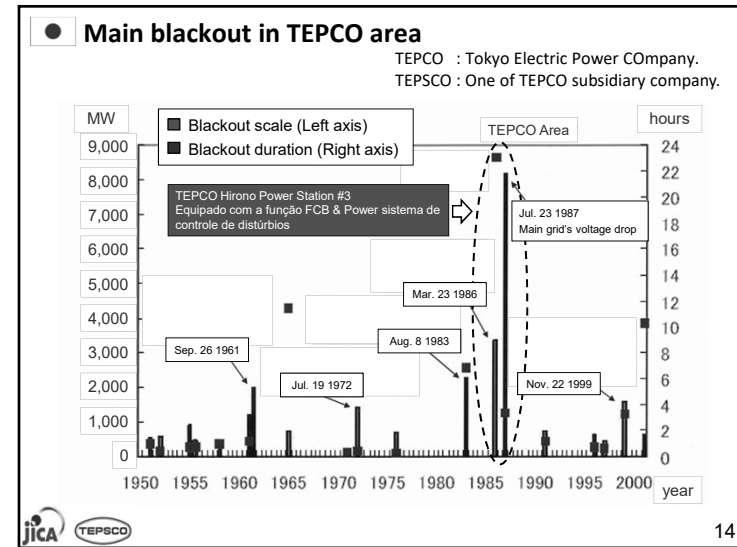
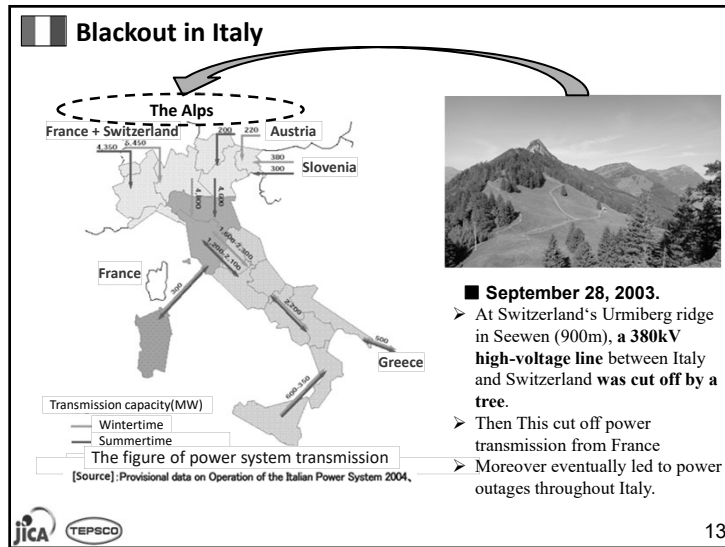
The North American Blackout  
Size is : 61.8 GW  
Effect for : 50 million person

United States transmission grid  
Source: FEMA

[The cause]

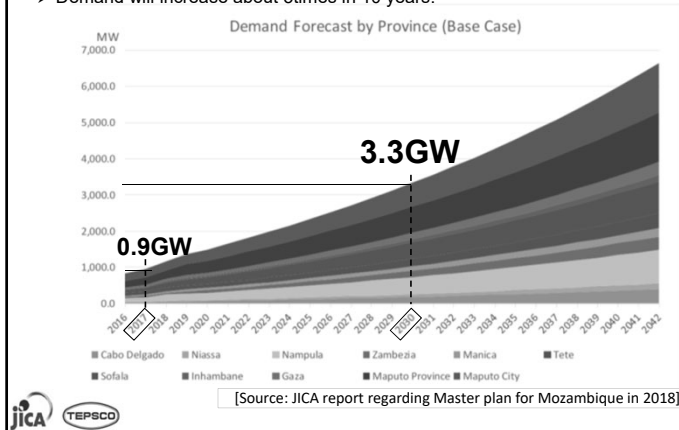
- Neglected tree trimming
- Meshed power system has resulted in widespread blackout.
- There was a **shortage of reactive power**, which is critical to grid stabilization.
- Lack of operator **reactive power knowledge**.

12



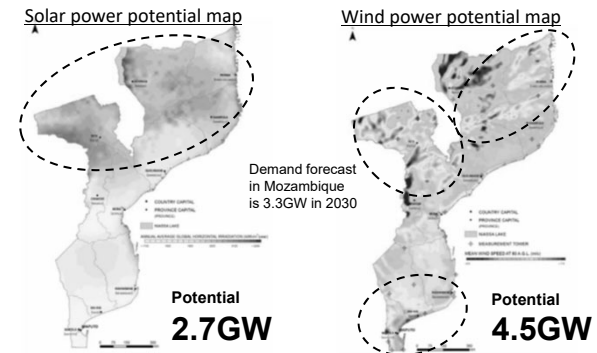
### Demand forecast in Mozambique.

- Demand in 2007 was 0.9GW.
- Demand forecast in 2030 will be 3.3GW.
- Demand will increase about 3times in 10 years.



17

### Solar power & Wind power potential is so high in Mozambique.



[Source: JICA report regarding Master plan for Mozambique in 2018]

- Northern Mozambique Has High Potential for Solar Power.
- Solar power potential is 2.7GW
- Northern & Southern Mozambique Has High Potential for Wind Power.
- Wind power potential is 4.5GW



18

### Minimum load & Load changing rate

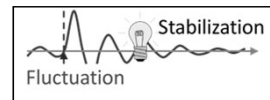
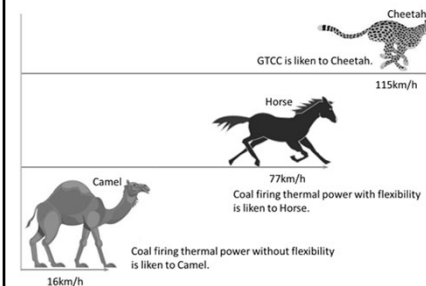
- Flexibility is very important for power resilience



19

### Flexibility is very important for power resilience

There are camel, house and cheetah.  
These animals can be likened to the ability of power systems regarding load flexibility.



Contribute to

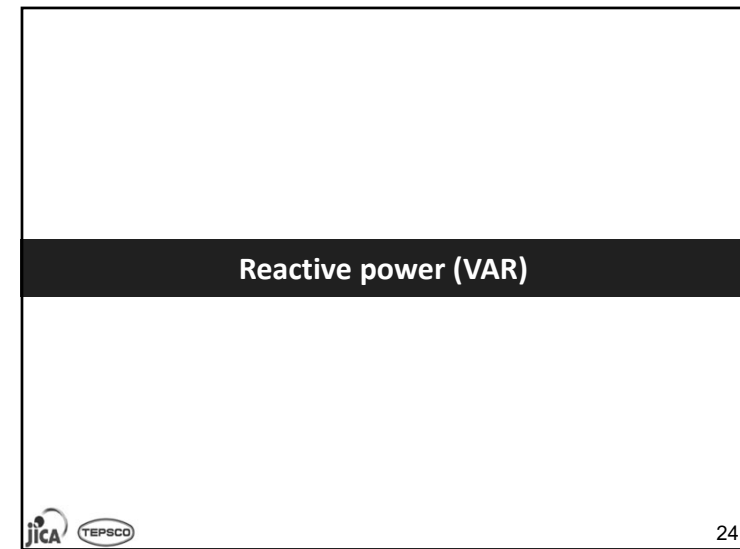
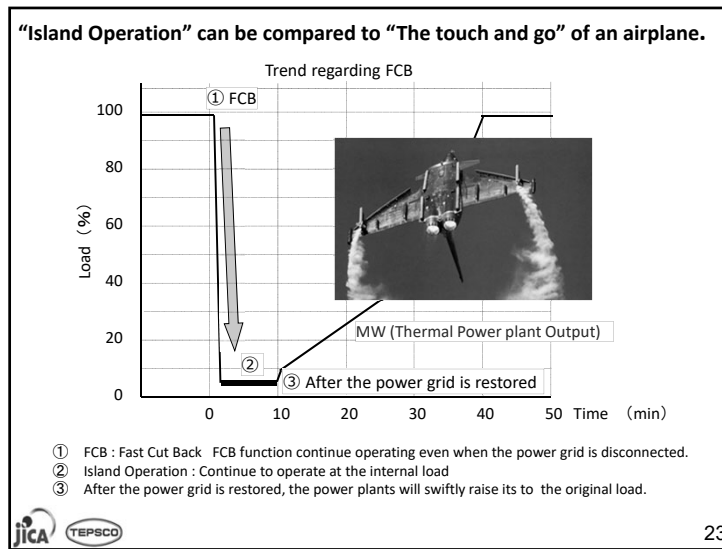
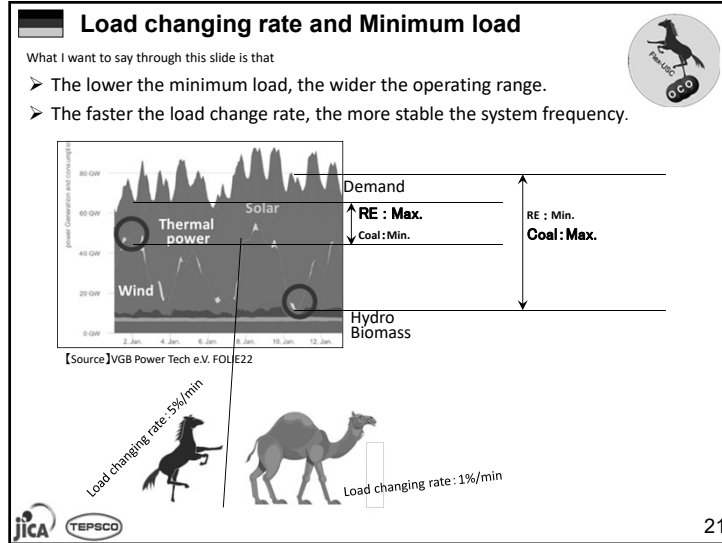


The Load Flexibility function

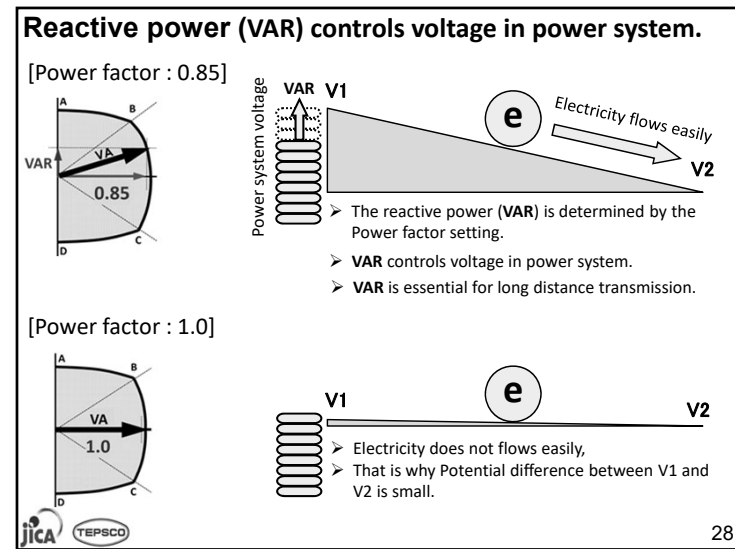
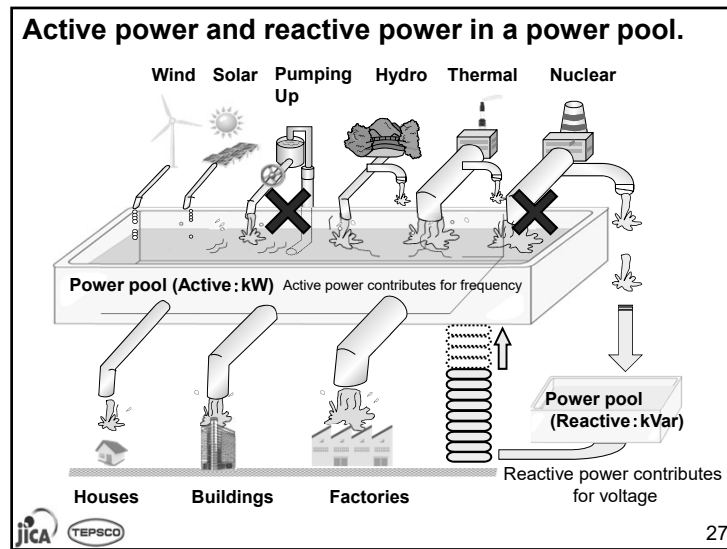
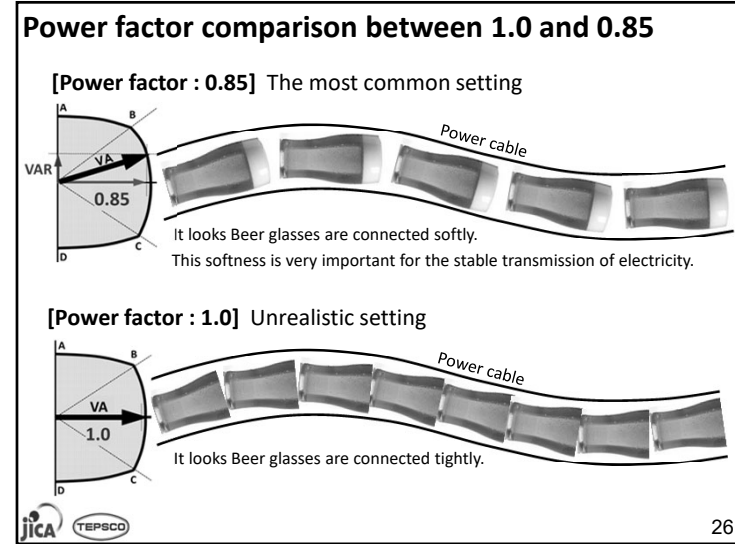
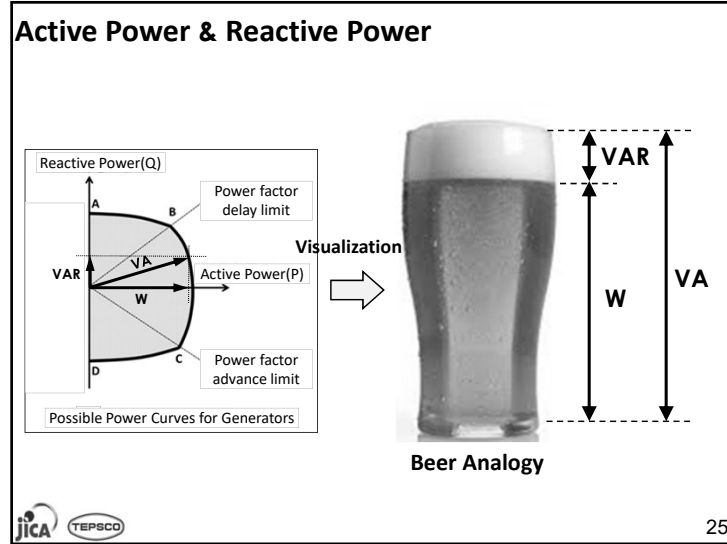
- Load changing rate increasing
- Minimum load reduction
- FCB (Fast Cut Back)



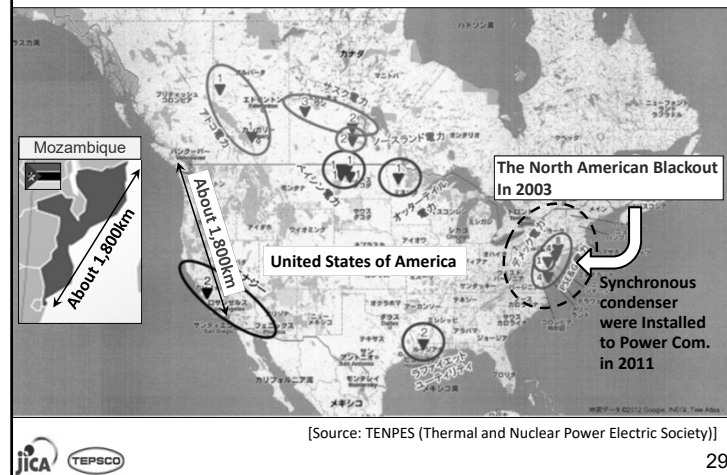
20







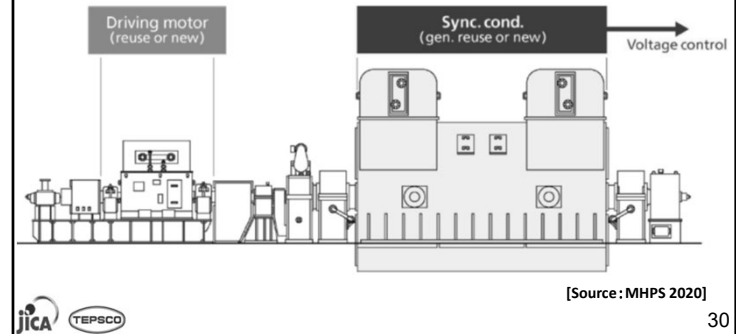
### Installation map of Synchronous condenser in U.S. & Canada.



### Synchronous Condenser external view

[What can Synchronous condenser contribute to?]

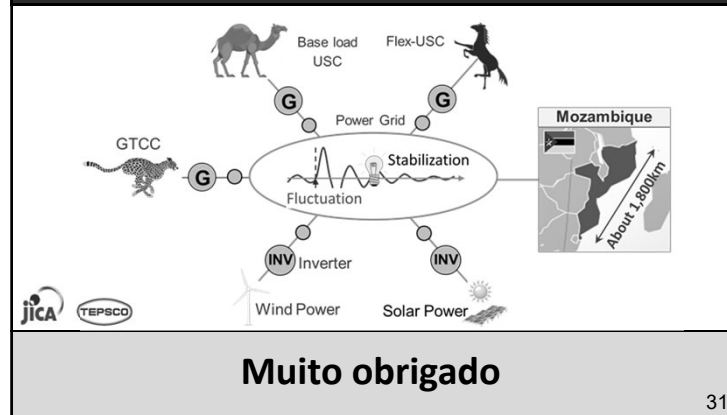
- Synchronous condenser supplies Reactive power (VAR) for power systems.
- Synchronous condenser is effective for long distance transmission.



The best energy mix maintain the stability of the power system.

For this purpose,

Flexibility thermal power plays a very important role.



Electricidade de Mozambique, E.P. Presentation

## What is happened on the earth?

Let's think about Global environment Jan. 27, 2021



This photo was taken by the Apollo spacecraft as it returned to Earth from the moon.

We are now in Mozambique and Japan on Earth.

jica TEPCO

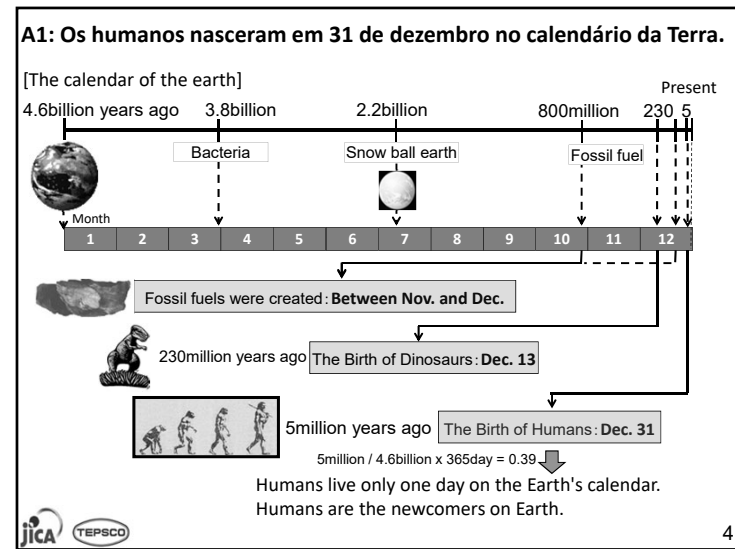
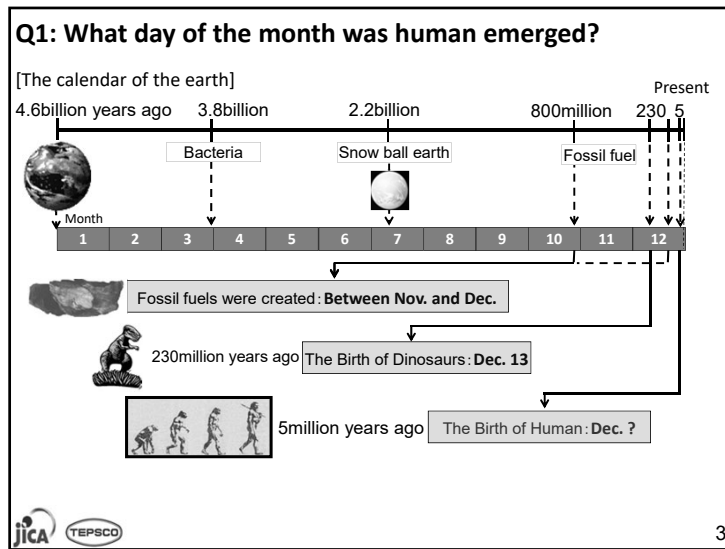
Tokyo Electric Power Services Co., Ltd.  
PhD. Pedra negra ( Takashi Kuroishi )

## The birth of the earth

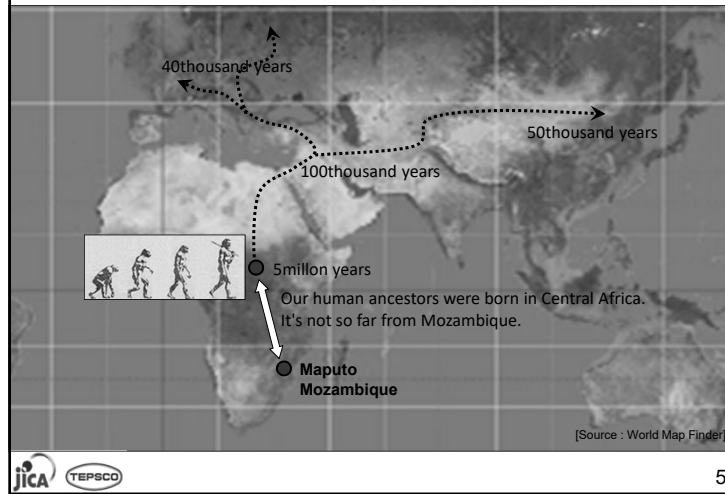
The earth was born in 4.6 billion years ago

jica TEPCO

2



### Humans emerged from Africa 5 million years ago.



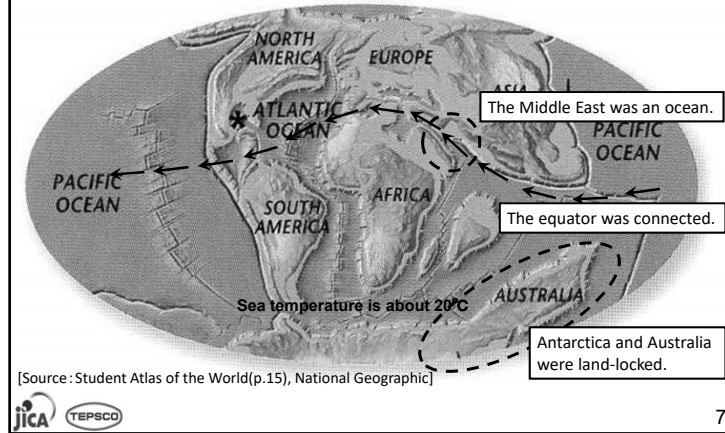
### The dinosaurs died out

- A huge meteorite, over 10km in diameter, crashed into the earth 650 million years ago.
- The dinosaurs died out because of the crash



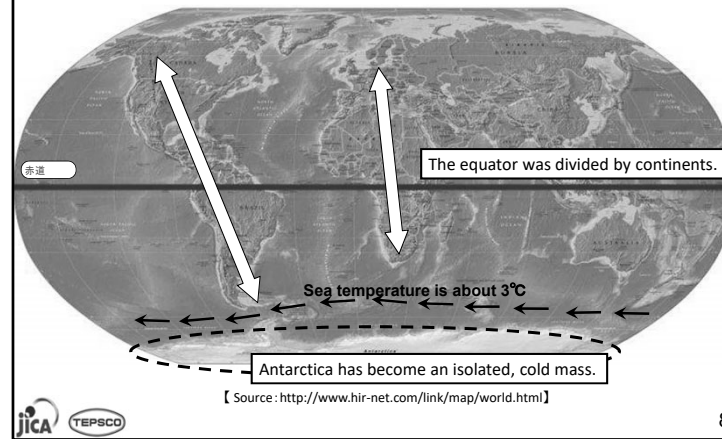
### The earth 650million years ago

- A huge meteorite crashed into the earth in this period.
- The dinosaurs died out because of the crash



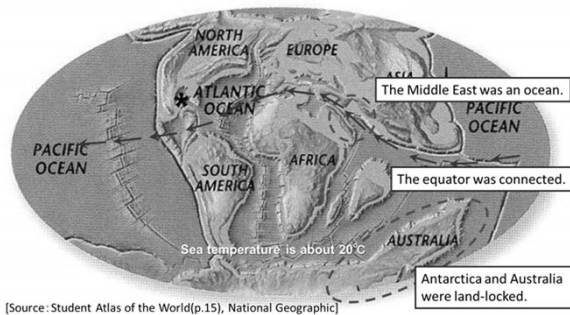
### The earth today

- The equator was divided by continents.
- Antarctica has become an isolated, cold mass.



**Q2 : What was the surface temperature of the Earth 650million years ago?**

- 1) + 10°C from present.
- 2) + 20°C from present.
- 3) + 30°C from present.

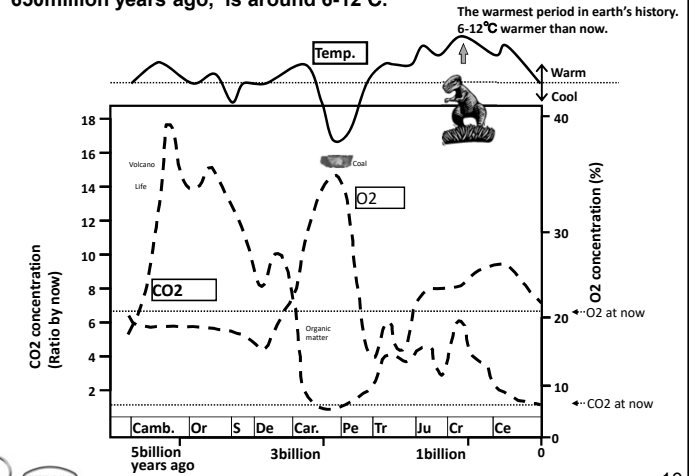


[Source: Student Atlas of the World(p.15), National Geographic]



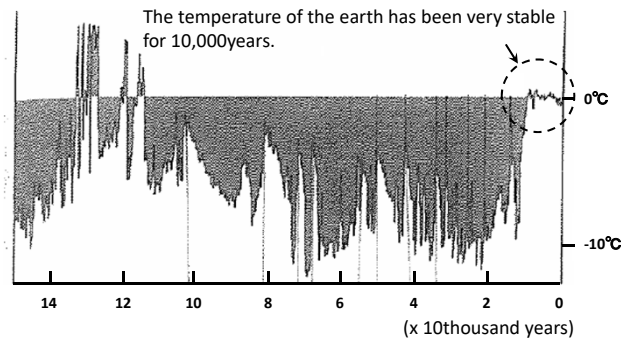
9

**A2 : Earth's surface temperature in the Jurassic Period dinosaur lived, 650million years ago, is around 6-12°C.**



10

**The temperature of the earth has been very stable for 10,000 years.**



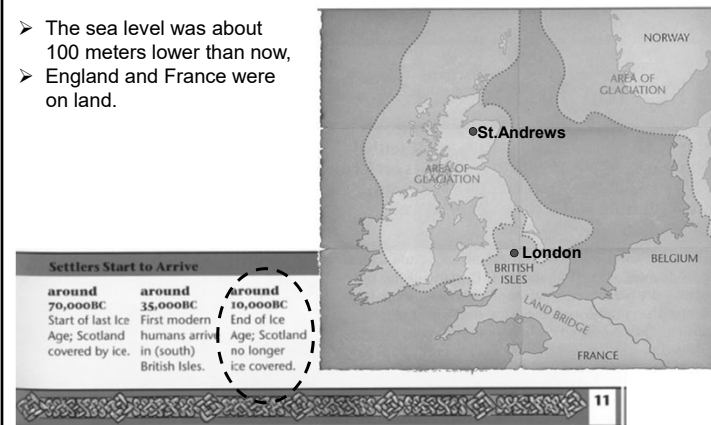
Temperature trend of Greenland in last 140 thousand years.



11

**Scotland was covered with ice 10,000 years ago in Scandinavia**

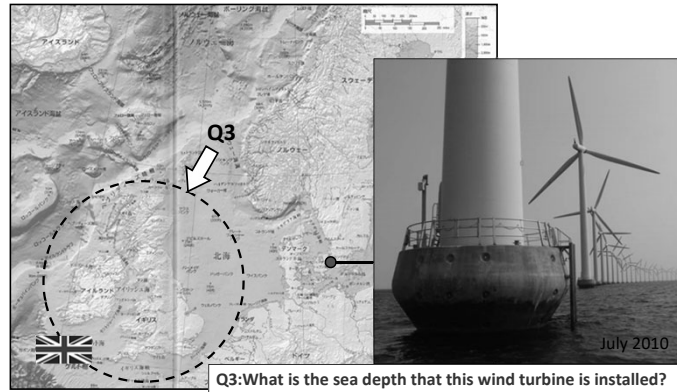
- The sea level was about 100 meters lower than now,
- England and France were on land.



12

**Q3:What is the sea depth around UK ?**

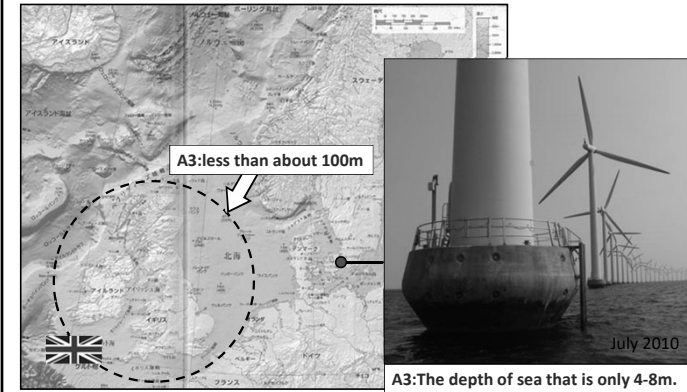
- The UK plans to build 30 GW of offshore wind turbines by 2030.
- 8GW of Offshore wind turbine had already sat up.
- The water depth of the North Sea is very shallow.



13

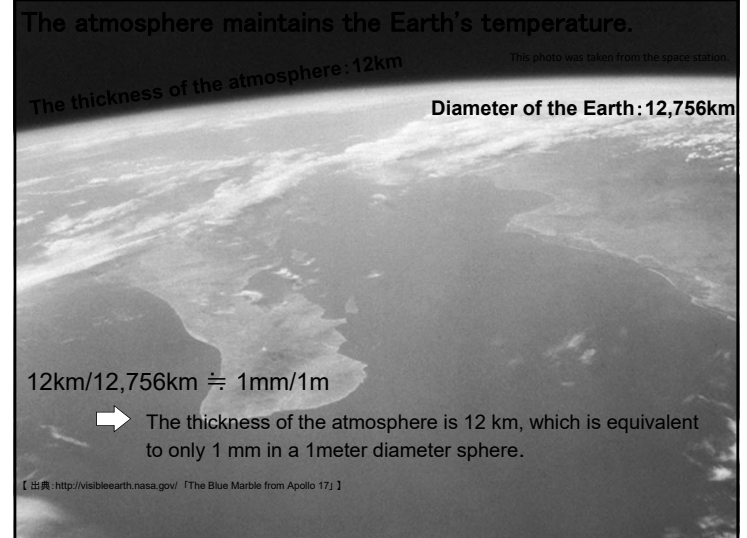
**A3 : See depth around UK is less than about 100m**

- The UK plans to build 30 GW of offshore wind turbines by 2030.
- 8GW of Offshore wind turbine had already sat up.
- The water depth of the North Sea is very shallow.



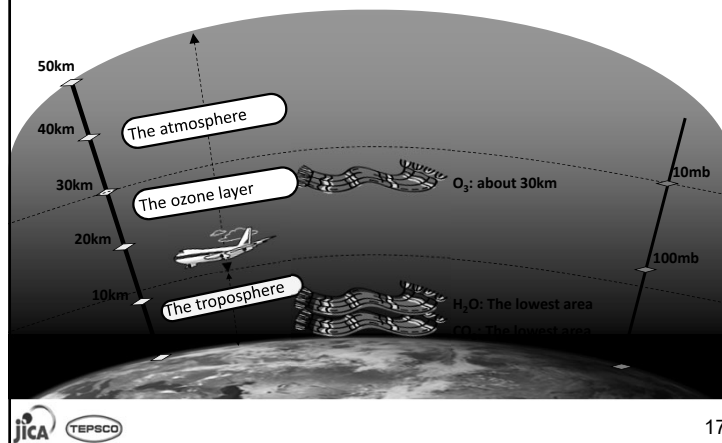
14

**Greenhouse Gas**



### H<sub>2</sub>O, CO<sub>2</sub> and O<sub>3</sub> are staying there as below.

➤ H<sub>2</sub>O, CO<sub>2</sub> and O<sub>3</sub> are just like three blankets in the atmosphere.

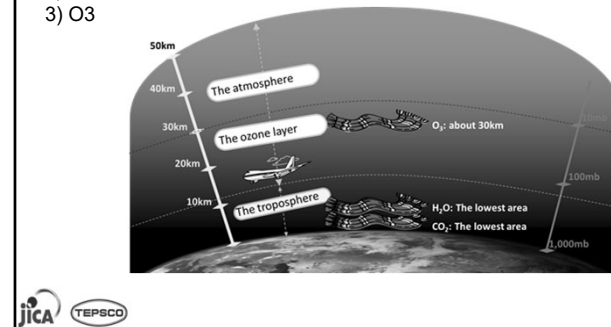


17

### Q4 : What is the most effective Greenhouse Gas?

Typical Greenhouse Gas are carbon dioxide(CO<sub>2</sub>), vapor(H<sub>2</sub>O), ozone(O<sub>3</sub>).  
What is the most effective Greenhouse Gas that covers the earth just like a blanket?

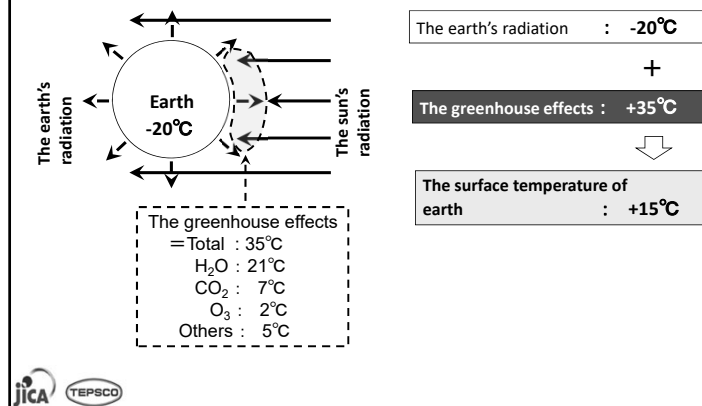
- 1) CO<sub>2</sub>
- 2) H<sub>2</sub>O
- 3) O<sub>3</sub>



18

### A4 : The most effective Greenhouse Gas is H<sub>2</sub>O.

H<sub>2</sub>O and CO<sub>2</sub> play a significant role in creating the greenhouse effect.  
If it were not for greenhouse gases, the surface temperature would be almost - 20C.



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Water vapor (H<sub>2</sub>O)



20

### 60% of the Earth is always covered with clouds.

Water vapor (H<sub>2</sub>O) have a greenhouse effect  $\longleftrightarrow$  Cloud (H<sub>2</sub>O) have a cooling effect  
Changing in a short time



[Source : <http://visibleearth.nasa.gov/> 「The Blue Marble: Land Surface, Ocean Color, Sea Ice and Clouds」]



21

### Carbon dioxide (CO<sub>2</sub>)



22

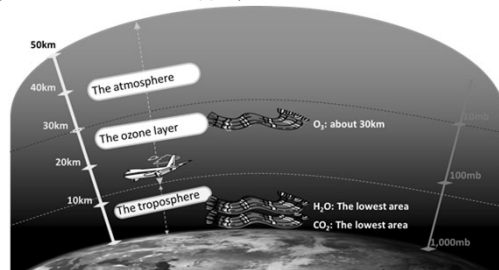
### Q5 : What percent carbon dioxide is there in the atmosphere?

Oxygen, which makes up 21% of atmosphere, is necessary for man to live on earth.

Carbon dioxide is also necessary for plants to conduct photosynthesis.

Then, what percent carbon dioxide is there in the atmosphere?

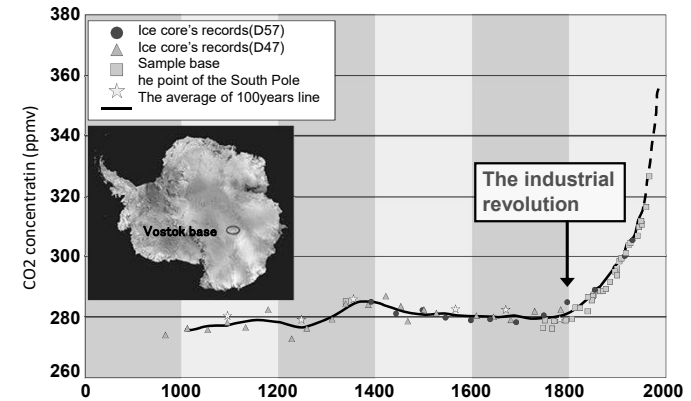
- 1) 0.3% (3000ppm)
- 2) 0.03% (300ppm)
- 3) 0.003% (30ppm)



23

### A5 : Around 300ppm carbon dioxide is in the atmosphere

➤ The amount of CO<sub>2</sub> has been increasing from the industrial revolution with rising speed.



24



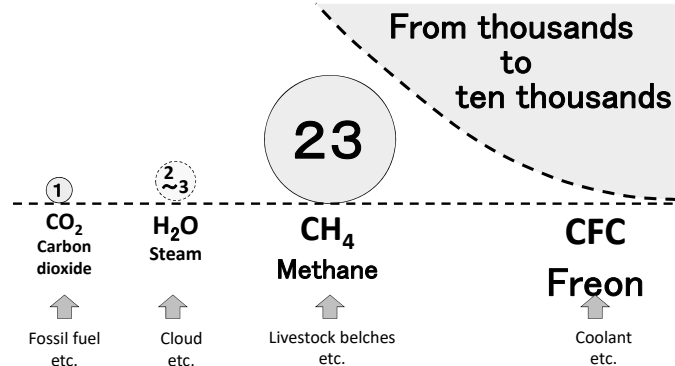
**Methane gas (CH<sub>4</sub>)**



25

### The coefficient of greenhouse gases

The coefficient of greenhouse gases indicates the effect of each gas in proportion to that of CO<sub>2</sub> set at 1



**From thousands to ten thousands**

**23**

**CH<sub>4</sub> Methane**

**CFC Freon**

CO<sub>2</sub> Carbon dioxide (Fossil fuel etc.)  
H<sub>2</sub>O Steam (Cloud etc.)  
CH<sub>4</sub> Methane (Livestock belches etc.)  
CFC Freon (Coolant etc.)

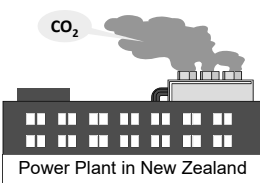


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### Greenhouse gases in New Zealand



CO<sub>2</sub>



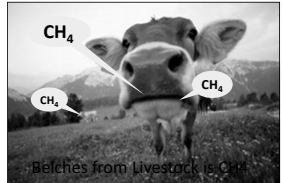
Power Plant in New Zealand

In New Zealand, the number of Sheep and Cows is over ten times the human population of 4million.

×

CH<sub>4</sub>'s coefficient of greenhouse gases is 23 times that of CO<sub>2</sub>.

↓



Belches from Livestock is CH<sub>4</sub>

≡

The greenhouse effect is almost the same as the CO<sub>2</sub> emitted from power plants and CH<sub>4</sub> emitted from livestock.



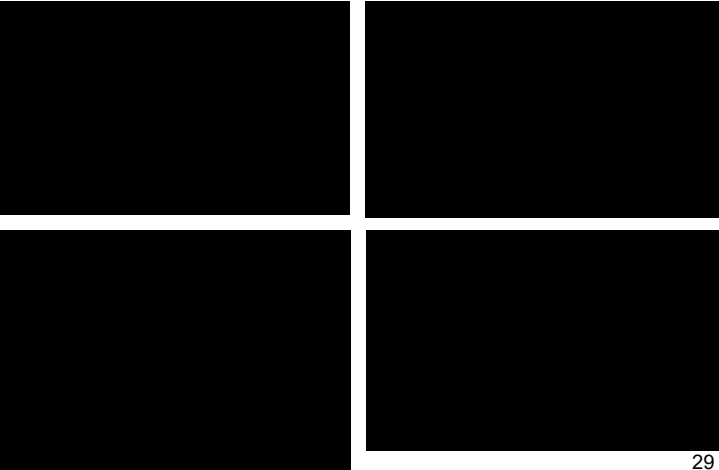
27

**Global warming felt in the world**



28

**Global warming happening on the planet**



29

**Arctic sea ice has decreased by half from 1980 to 2012.**  
 ➡ Maybe, next 30 years, there will be no more ice in Arctic.



Sea Ice Change (Sep.)

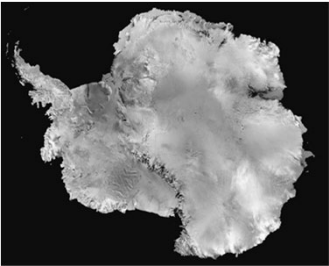
【Source: NHK TV 150905】

TEPSCO

30

**Q6: How thick is the ice in the Antarctic and the Arctic, respectively?**

**The ice  
on the Antarctic Continent**

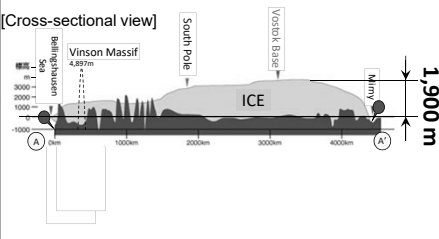


**The ice  
on the Arctic Ocean**



**A6: The thickness of the Antarctic ice is 1,900 meters.**  
**The thickness of the Arctic ice is 3 to 4 meters.**

**The ice  
on the Antarctic Continent**



[Cross-sectional view]

**The ice  
on the Arctic Ocean**



The ice 3 - 4 m

Sea water

 **Global warming felt in the United States**

33

**US Record Warmth on June 19 ,2017**

[ Source: CNN Weather Forecast June 19 ,2017 ]

34

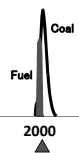
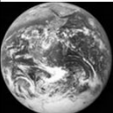
**US Record Warmth on June 19 ,2017**

[ Source: CNN Weather Forecast June 19 ,2017 ]

35

**What will be our future?**  
We need to think seriously about Global environment!



4.6 billion years ago      2000

We are currently living in one of the best times of the earth's history.

100 years later?  
1,000 years later?

I hope human will still be in 1,000 years later.

**Muito obrigado**

36

## ***Final secret massage for you***

- ***You have the big possibility in Africa  
to be next driving force in the world.***

That is why

- ***Your average age is 17years old,  
so young compare to Japan 46years old.***
- ***You have women energy*** for driving society.

We want to continue to walk together with you.



***Adeus !***

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# Capacity Development in Management and Operation of Gas Fired Power Plant

## O&M Study group PDCA for Thermal power station

by TEPCO S.TAKEDA



April 6th 2021  
Electricidade de Mocambique (EDM)  
Japan International Cooperation Agency (JICA)

### Today's Contents

1. What is the PDCA cycle ?
2. What is QMS (ISO9001) / EMS (ISO14001) ?
3. Why do we need QMS (ISO9001) / EMS (ISO14001) ?
4. What are the importance of QMS / EMS for O&M works?
5. How to do PDCA cycle for O&M works in Thermal Power Station?
6. Japan's unique statutory PDCA cycle for Thermal Power Station
7. Capacity Development Project in Management and Operation of Gas Fired Power Plant in Mozambique

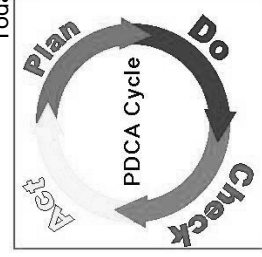
### 1. What is the PDCA cycle ?

The Plan-Do-Check-Action cycle is a 4 step model for carrying out works. A circle has no end, the PDCA cycle should be repeated again and again for continuous improvement. The PDCA cycle is considered a project management tools.

- Example in daily life -

PLAN

Today, I make a piri-piri chicken !



**ACTION**  
So, I will reduce a cup of piri-piri next time, and keep a recipe for next time !

**CHECK**  
Oh! Too spicy !!

**DO**  
Cooking !

### 2-1. What is QMS (ISO9001) ? <Quality Management System>

QMS is defined as a formalized system that documents processes, procedures, and responsibilities for achieving quality policies and objectives.

QMS helps coordinate and direct an organization's activities to meet customer and regulatory requirements and improve its effectiveness and efficiency on a continuous basis.

#### 7 principles of QMS

- ① Customer Focus
- ② Leadership
- ③ All participants
- ④ Process Approach (Doing based on a necessary process?)
- ⑤ Improvement
- ⑥ Decision making based on the facts(Data, Records, etc.)
- ⑦ Relationship management (Stakeholder management)

## 2-2. What is EMS (ISO14001) ? < Environmental Management System>

EMS is a framework that helps an organization achieve its environmental goals through consistent review, evaluation, and improvement of its environmental performance.

### 5 principles of EMS <Continuous Improvement>

- ① Commitments and Policies by Leader
- ② **Plan** (Environmental aspect, Goals and Objectives, etc.)
- ③ **Do** (Organization and Responsibilities, Documentation system, Communication, etc.)
- ④ **Check** (Monitoring, Measurement and Evaluation, etc.)
- ⑤ **Action** (Review and Improvement, etc.)

5

## 3. Why do we need QMS (ISO9001) / EMS (ISO14001) ?

For Manufacture such as food, beer, cement, EPC, etc.

⇒ Products quality assurance, Purchasing conditions, Global brand power, Social awareness, etc.

For Thermal Power station (TPS)

⇒ **Improve the quality of O&M works** in Power station

(In case of Japan, the quality of electricity as a product has already been secured and recognized by society.)

Many TPS in Japan obtained certification once, but stopped it.

However, TPS have been conducting O&M works in accordance with the concept of QMS / EMS.

(Maintaining the certification of QMS/EMS is a heavy burden of manpower, costs, etc.)

6

## 4. What are the importance of QMS / EMS for O&M works?

| QMS(ISO9001)                      | EMS(ISO14001)                      |
|-----------------------------------|------------------------------------|
| ◆ Formalized system               | ◆ Documentation system             |
| ◆ Documents processes, procedures | ◆ Goals and Objectives             |
| ◆ Process Approach                |                                    |
| ◆ Organization                    | ◆ Organization                     |
| ◆ Leadership                      | ◆ Commitments / Policies by Leader |
| ◆ All participants                | ◆ Responsibilities                 |
| ◆ Responsibilities                | ◆ Communication                    |
| ◆ Relationship management         |                                    |
| ◆ Data, Records                   | ◆ Monitoring, Measurement          |
| ◆ Improvement                     | ◆ Review, Improvement              |
| ◆ Continuous basis                | ◆ Continuous Improvement           |

*QMS /EMS concepts are effective to systematic O&M in TPS*

7

## Short break <Spring of Northern Japan>



8

### 5-1. How to do PDCA cycle for O&M works in TPS? <Plan / Do>



#### Plan

- Documentation system
  - Business Plan (Mid/Long terms plan, Yearly business plan)  
based on Legal regulations, External requirements, Forecast of Power demands, Plant conditions, Maintenance schedule, etc.
- #### Do
- Basically implemented based on the Plan
- Safety first
  - Organization and Responsibilities, Communication
  - Education and Training (OJT and Off-JT)
  - Documents and Records management
  - Power station 's activities management (Progress and results)
  - Preparing and responding to Emergencies

9

### 5-3. Yearly business plan in TPS (Simplify example)



| Items                              | Contents (e.g.)                                                   |  |  |
|------------------------------------|-------------------------------------------------------------------|--|--|
| The surroundings of CTM            | Lack of power in country, Increasing environmental awareness      |  |  |
| The situation of CTM               | Many trouble, Last 4years of LTSA, 2nd Annual Inspection          |  |  |
| What CTM should be                 | Base load operation, Minimize shutdown time (Planned & Unplanned) |  |  |
| CTM Targets (include KPI)          | Availability rate XX%, No LTI (Lost time incident)                |  |  |
| Implementation of Maintenance team | Reduce outstanding items to X, Clarification of work Procedures   |  |  |
| Implementation of Operation team   | Early detection of problems, Secure handover to next shift        |  |  |
| Implementation of Support team     | Improve unsafety works, Information sharing of Environment data   |  |  |

| Yearly development        | Before start of new year        | Start of year           | Middle of year      | End of year                 |
|---------------------------|---------------------------------|-------------------------|---------------------|-----------------------------|
| Schedule                  | Planning of implementation plan |                         | Review & Adjustment | Review & Next year planning |
| All staff include Manager | Discuss with all team staff     | Implementation & Review |                     |                             |
| Manager                   | Support, Approve                | Announcement by PM      | Support, Approve    |                             |

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### 5-2. Documentation system of O&M in Japan (Example)



Electricity Business Law, Art. 42 Safety/Security regulations

| Enforcement rules Art. 50 (Law requirements) | (e.g.) Power Company Security regulation | (e.g.) Thermal Power Dept. and Power station Standards/Manuals (Excerpt)                                           |
|----------------------------------------------|------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| 1. Organization                              | 1. General                               | ●Operational standard of Security regulation                                                                       |
| 2. Safety/Security education                 | 2. Organization                          | ●Operational standard of Authority and Responsibilities                                                            |
| 3. Test/Inspection                           | 3. Safety/Security education             | ●Rules for Handling of Safety/Security education                                                                   |
|                                              | 4. Maintenance                           | ●Maintenance standard<br>- Scheduled maintenance Standard<br>- Onsite work management Procedure                    |
| 4. Operation                                 | 5. Operation                             | ●Operation standard<br>- Operation results management manual                                                       |
| 5. Preservation                              | 6. Preservation                          | - Management value manual                                                                                          |
| 6. Emergency response                        | 7. Emergency/Accident                    | ●Operation Management standard<br>- Chemical management manual<br>- Equipment Preservation for long time shut down |
|                                              |                                          | ●Emergency response standard                                                                                       |
|                                              | 8. Evaluation/Improvement                | - Safety/Security activity review manual<br>- Internal Audit manual                                                |
| 7. Records                                   | 9. Documents/Records                     | ●Documents/Records Management standard                                                                             |
| 8. Keeping records                           |                                          | - Records approved by Licensed engineer                                                                            |
|                                              | 10. Procurement                          | - Purchasing & Contractor management manual                                                                        |
| 9. Other                                     | 11. Other                                | ●HSE Manual<br>●Legal compliance management manual                                                                 |

### 5-4. Legal compliance for O&M



|                              |                                    |                             |
|------------------------------|------------------------------------|-----------------------------|
| Crane Regulation             | Electricity business law           | Air Pollution Control Law   |
| Pressure vessel Regulation   | Occupational Health and Safety Law | Water Pollution Control Law |
| Fire Prevention law          | Thermal Power Station              | Energy Conservation Law     |
| High Pressure Gas Safety law |                                    | Industrial Water Supply law |
| Waste management law         |                                    | River law                   |
| Building Standards law       | Measurement Law                    | Septic Tank Law             |
| PRTR law                     | local government act               | Road Transport Vehicle Law  |
| XXXXX law                    | XXXXX act                          | XXXXX regulation            |

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## 5-5. How to do PDCA cycle for O&M works in TPS? <Check/Action>

### Check and Action

#### ➤ **By own organization(TPS):**

- Evaluation, Acceleration of the implementation status of the Business plan (Quarterly, Yearly)
- Review of each manual / procedure, Revised as necessary (Yearly)

Did you perform the work according to the manual?

Is it correct to perform the work according to the manual?

Is it best to do things differently from the manual?

- Works Improvement Proposal System (All the time)

A system that allows anyone to suggest things that they think will improve the works, even if they are small things.

Set reward levels according to the impact on improvement

#### ➤ **By Internal auditors(HQ)** after check by own organization:(by timely)

- Reward good practices. But, corrective actions and improvement orders are issued by HQ Director if not good practices.

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## 6-2. Japan's unique statutory PDCA cycle for TPS

### 6 items for System Inspection

- ① Inspection organization
- ② Inspection procedure
- ③ Process management
- ④ Subcontractor management
- ⑤ Records management
- ⑥ Education, Training

→ Basically, the same as the concept of QMS / EMS

*These concepts are effective to systematic O&M in TPS*

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## 6-1. Japan's unique statutory PDCA cycle for TPS

### **Periodic statutory Inspection** (Electricity Business Law, Art. 55)

- Boilers, turbines, etc. for power generation that are subjected to pressure above a certain level are required to be inspected by Owner. (e.g. Boiler=Every 2years, Turbine=Every 4years)
- Owner shall undergo system inspection by the Government agency regarding system for conducting the Periodic statutory inspection.

1. (Plan, Do) Periodic Inspection by Owner(TPS)
2. (Check) Internal Audit by Owner(HQ)
3. (Check) System Inspection by Government(METI)
4. (Action) Incentives (Extension of Periodic inspection interval, e.g. Boiler=Every 2 to 4years), or guidance and penalties depending on results of system inspection by Government(METI)

Periodic inspections are conducted based on a documentation system specific to this inspection.

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## Short break <Winter of Northern Japan>



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## 7-1. Capacity Development Project in Management and Operation of Gas Fired Power Plant in Mozambique



### Expected Goals

- Capable of sustainably O&M the Maputo Gas Fired Combined Cycle Power Plant

### Project Activities

- Implementation of **Systematic O&M Practice** by EDM
  - **Systematic plan** to evaluate, take countermeasures & develop preventive measures **for trouble including natural & human disasters** is established.
  - The established **systematic plan for trouble** is implemented.
  - Work flow for the utilization of **PMIS** is developed.
  - **Structure of O&M** implementation is developed.
  - The **HSE** for the power plant O&M is defined & introduced.
  - The **KPI** for the power plant O&M is defined & introduced.
  - Capacity of EDM for **contract management** (e.g. LTSA) is developed.
- Introduction of **Human Resource Development Program** by EDM
  - The existing **training system for new employee** is improved.
  - The existing **training program for the simulator system** is improved.
  - The plan & system for **human resource development & training** is introduced.

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## 7-3. Goal of Systematic O&M in the Project

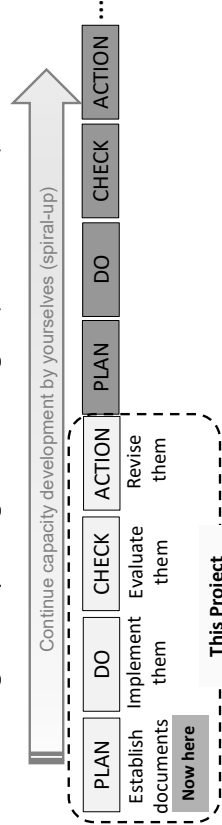


One of the goals (Main) of this project is to create a system that CTM to continue sustainable capacity development of O&M management independently.

It is impossible to complete capacity building in one or two years.

So, we will try to build a system that PDCA cycle to be implemented by

- Establishing about 10 guidelines and manuals in Stages 2, 3 (Plan)
- Implementing works based on them in Stage 4 (Do)
- Checking and improving them in Stage 5 (Check, Action).



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## 7-2. Work flow & Schedule of the Project



### Project Period

■ Aug 2020 through to July 2022 (Approx. 24 months)

|         | Work flow                                                                                                                                 | Schedule             |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| Stage 1 | • Clarification the current situation of Power Station                                                                                    | Sep to Dec 2020      |
| Stage 2 | • Organize the Existed Documents and Records<br>• <b>Framework Establishment</b> of Systematic O&M and Human Resource Development Program | Jan to Apr 2021      |
| Stage 3 | • <b>Establishment</b> of Systematic O&M and Human Resource Development Program                                                           | May 2021 to Jan 2022 |
| Stage 4 | • <b>Implementation</b> of Systematic O&M and Human Resource Development Program                                                          | Feb to May 2022      |
| Stage 5 | • <b>Evaluation and improvement</b> of Systematic O&M and Human Resource Development Program                                              | May to July 2022     |

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## 7-4. The Existed Documents and Records in CTM



| No.         | Document title                                         |
|-------------|--------------------------------------------------------|
| Common      | From CTM Power Plant Documentation List (Rev.3)        |
| 3           | Preliminary Risk Analysis (For safety)                 |
| 13          | Equipment consignment- LOTO- Log Out Tag out Procedure |
| 14          | Permit to Work from e-Serv / PMIS                      |
| Operation   |                                                        |
| 4           | Plant Shutdown Request Format                          |
| 6           | Fin Fan cooler change over Procedure                   |
| 7           | System Reset Procedure after Blackout                  |
| 9           | Daily Operation Reading Checklist                      |
| 12          | Notification of defects List                           |
| Maintenance |                                                        |
| 5           | Maintenance Procedures                                 |
| 8           | Equipment Maintenance Checklist                        |
| 15          | Equipment Lubrication Periodicity List                 |
| 16          | eServ Monthly Report                                   |

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7-5. Current situation of CTM (by Stage 1 Clarification)

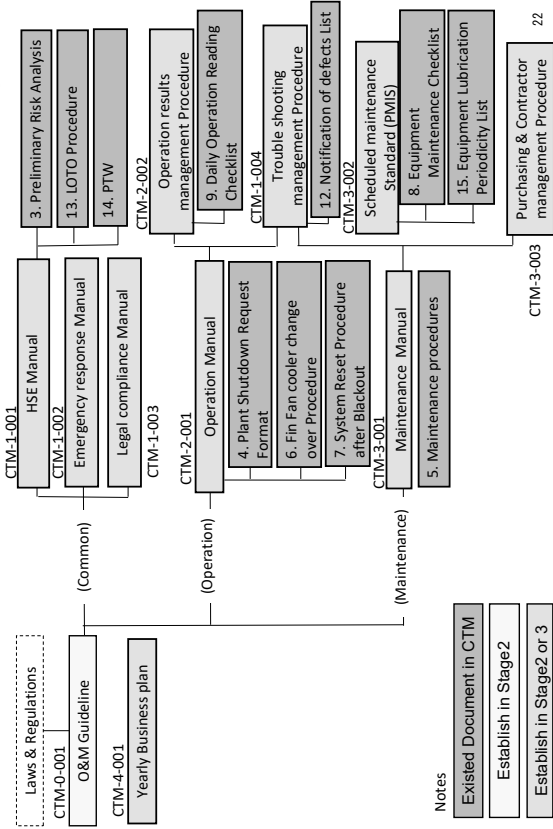


Documents system (Gap between CTM and Japanese power station)

- Exist some Procedures, Lists that are actually used in the field  
<Lower layer document>.
  - Overall O&M works are not clearly defined on the document  
<Upper / middle layer document>.
- ⇒ Each group assignments may become unclear.  
As a result, there are concerns about the difficulty of proactive work and delays in responding to emergencies.
- ⇒ There is a risk of individual differences or unclear in the way for understanding and carried out works.
- ⇒ It also makes it difficult for new employees and others to catch the overall O&M works.
- We will establish document tree and some documents in Stage 2 and 3 for capacity building of systematic O&M.

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7-6. Establishment of Documents tree and Documents



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7-7. Request to CTM for establishment of guideline / manuals



- **This is a collaborative work.** The outline will be presented, but it needs to be revised and expanded to fit the actual situation of CTM. We need your active cooperation.
- **This is one of the OJT** of Human Resource Development Program. We look forward to your active involvement.

We believe that this Project is one that will lead to sustainable O&M of CTM.

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Obrigada por perguntar.



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## Appendix-5

### Presentation Material of Strengthen Contract Management Capacity



Capacity Development in Management and Operation of Gas Fired Power Plant

# Maputo Conditions of Contract



October 2021  
Electricidade de Mocambique (EDM)  
Japan International Cooperation Agency (JICA)

## Table of Contents

### 1. Standard Conditions of Contract

#### 1.1 Standard Conditions of Contract for International Projects (FIDIC GC)

Ref. What is FIDIC

#### 1.2 Standard Condition of Contract of Japanese ODA Projects

#### 1.3 Conditions of Contract for MGFCPP Development Project

#### 1.4 ENAA Form International Contract for Process Plant Construction

### 2. Typical Development Sequence of an Infrastructure Construction Project

### 3. Project Overview

2

### 1.1 Standard Conditions of Contract for International Projects - FIDIC-

FIDIC (International Federation of Consulting Engineers) publish the most highly respected and used conditions of contract for international construction projects.

FIDIC publishes variety kinds of Standard Forms for various delivery methods.

The major forms are:

- **Conditions of Contract for Construction –for Building and Engineering Works for Designed by the Employer** (CONS/Red Book, MDB version/Pink Book)
- **Conditions of Contract for Design-Build – for Electrical and Mechanical Plant, and for Building and Engineering Works, Designed by the Contractor.** (P&DB/Yellow Book)
- **Conditions of Contract for EPC/Turnkey Project** (EPCT, Silver Book)



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### Ref. What is FIDIC

**FIDIC, the International Federation of Consulting Engineers, is the global representative body for national associations of consulting engineers and represents over one million engineering professionals and 40,000 firms in more than 100 countries worldwide.**

- Founded in 1913, FIDIC is charged with promoting and implementing the consulting engineering industry's strategic goals on behalf of its Member Associations and to disseminate information and resources of interest to its members. Today, FIDIC membership covers over 100 countries of the world.
- FIDIC, in the furtherance of its goals, publishes international standard forms of contracts for works and for clients, consultants, sub-consultants, joint ventures and representatives, together with related materials such as standard pre-qualification forms.
- FIDIC also publishes business practice documents such as policy statements, position papers, guidelines, training manuals and training resource kits in the areas of management systems (quality management, risk management, business integrity management, environment management, sustainability) and business processes (consultant selection, quality based selection, tendering, procurement, insurance, liability, technology transfer, capacity building).
- FIDIC organises the annual FIDIC International Infrastructure Conference and an extensive programme of seminars, capacity building workshops and training courses.

Member Association representing Mozambique is Associação de Empresas Moçambicanas de Consultoria (AEMC)

Interestingly, in 2020 amid of pandemic, FIDIC published FIDIC COVID-19 Guidance, Memorandum to Users to FIDIC Standard Form of Works Contract. It is available free in FIDIC Website .

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## 1.2 Standard Bidding Documents (“SBD”) for Japanese ODA Loan Projects

For Japanese ODA loan projects, using Standard Bidding Documents (“SBD”) issued by JICA is (a kind of) mandatory.

JICA publishes various SBDs for construction of infrastructure projects as follow:

**SBD (Works)** for Procurements of Works, published in 2009, 2012, 2019

**SBD (Plant)** for Plant Procurements of Plant Design, Supply and Installation, published in 2010, 2013 and 2021

**SBD (Design-Build)** for Procurement of Electrical and Mechanical Plant and for Building and Engineering Works designed by the Contractor published in 2017 (trial Version ), 2021 (final version) .

Conditions of Contract incorporated in the above SBDs are:

SBD (Works): **FIDIC** Pink Book

SBD (Plant): **ENAA Model Forms**

SBD (Design Build): **FIDIC** Yellow Book

At the time of preparing the bidding documents for MGFCPP, the SBD (Design-Build) was not available and the use of SBD (Plant) was recommended by JICA .

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## 1.3 SBD and General Conditions of Contract for MGFCPP

SBD used for EPC contract of MGFC Development Project is JICA SBD (Plant) 2013 which says in **Preface**, among other things:

*These Standard Bidding Documents for Procurement of Plant Design and Installation (SBD (Plant)) have been prepared by Japan International Cooperation Agency (JICA) ,*

*These SBD (Plant) are consistent with the Guideline for Procurement under Japanese ODA Loans, April 2012 and their use is **required** for all Plant Design, Supply and Installation contracts to be financed, in whole or in part, by JICA under the aforesaid Guideline.*

*The procedure and practice incorporated in these SBD (Plant) have been developed through broad international experience and are based **on the Master Bidding Documents** for Procurements of Plant Design, Supply and Installation, prepared by Multinational Development Banks and other public international institutions. These SBD (Plant) have the structure and the provisions of the Master Procurement Documents, except where specific considerations within JICA have required a change.*

JICA SBD (Plant) also says in **Notes for Users**, among other things:

*Conditions of Contract are based on the **Model Forms of International Contract for Process Plant Construction published by the Engineering Advancements Association of Japan (ENAA)** ... JICA gratefully acknowledge the permission of ENAA to make use of and amend the Model form for inclusion in this Standard Documents*

Therefore, Conditions of Contract for MGFC is ENAA

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## Reference: What is the Master Bidding Documents

This Master Bidding Document for Procurement of Goods and User's Guide have been prepared through the joint efforts of the Multilateral Development Banks and International Financial Institutions, namely: the Asian Development Bank (ADB), African Development Bank (AfDB); Caribbean Development Bank (CDB), Commission of the European Communities (CEC), European Bank for Reconstruction and Development (EBRD), European Investment Bank (EIB), Inter-American Development Bank (IDB), International Bank for Reconstruction and Development (IBRD), North American Development Bank (NADB), and the United Nations Development Programme (UNDP). The Master Document is intended to be used as a model by these organizations for issuing new and better harmonized Standard Bidding Documents for each individual institution. The document reflects what are considered best practices, and is intended to be followed, insofar as possible, while allowing for institutional and member country considerations. The text shown in *Italics* corresponds to institution specific clauses that each MDB will replace with provisions consistent with its respective policy.

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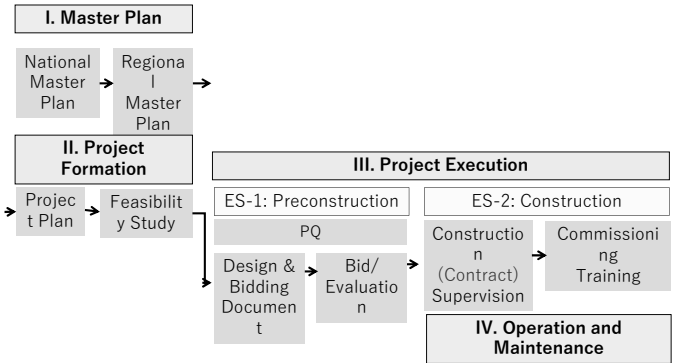
## Ref. What is ENAA

**The Engineering Advancement Association of Japan (ENAA)** is a **non-profit** organization established in 1978 with the support of the Ministry of International Trade & Industry ( the present Ministry of Economy, Trade and Industry (METI)) to aim at developing diversified activities such as advancement of technological capabilities and promotion of technical development. It is also contemplated herein to assume a role of Front Runner to establish a social system in harmony with the development of social economy and environment through participation of a lot of enterprises engaged in engineering business under the close cooperation with government, academia and industry. (from ENAA Website)

8

## 2. Typical Development Sequence of an Infrastructure Construction Project

(Translated from EFCA Website with modifications)

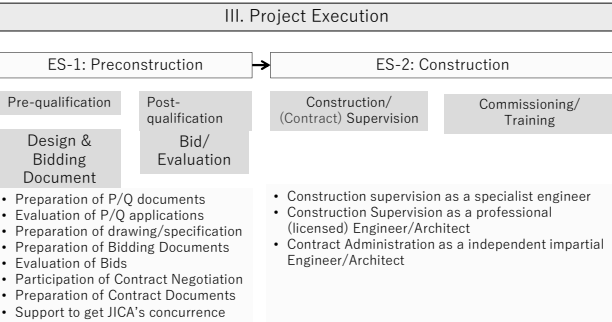


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## 3. Project Overview

The large infrastructure construction projects definitely require involvement of a consultant during the project execution stage.

Therefore, JICA SBDs require involvement of a consultant (the Engineer in ES-2)



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## Appendix-6

### Presentation Material of Strengthen Financial Management Capacity






# TRAINING IN FINANCIAL ANALYSIS

Case study of the EDM  
November 2021

Capacity Development in Management and Operation of Gas  
Fired Power Plant

1

## PROGRAMS

1. Basic knowledge of financial analysis
2. How to read financial statements
3. Typical Financial Indicators
4. Case Study: EDM

2

## 1. BASIC KNOWLEDGE OF FINANCIAL ANALYSIS

Basic terms needed for financial analysis

3

## WHAT ARE FINANCIAL STATEMENTS?

Financial Statement shows the financial situation and business condition in a financial year.

Prepared in accordance with Accounting Standards of the country.

It is prepared for reporting to interested parties, and listed and public companies are required to make it available to the public.

4

## WHAT IS AN ACCOUNTING STANDARD?

Rules for the preparation of financial statements.

Each country has its own accounting standards, but IFRS (International Financial Standard) is a generally-accepted worldwide standard.

In Japan, the following four accounting standards are allowed to be applied.

- Japanese Accounting Standards
- U.S. Accounting Standards
- International Financial Reporting Standards: IFRS
- J-IFRS

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## COMPOSITION OF FINANCIAL STATEMENTS

Japanese companies prepare the following financial statements

- Balance Sheet: B/L
- Profit and Loss Statement: P/L, Income Statement
- Cash flow Statement: C/F
- Statement of Profit and Loss
- Annexed (statistical) specification

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## WHAT IS A BALANCE SHEET (B/S)?

Indicates the financial position of a company at the end of its fiscal year.

It is composed of

- **Assets**
- **Liabilities**
- **Equity (Net Assets)**

$$\text{Assets} = \text{Liabilities} + \text{Equity}$$

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## MAJOR ITEMS ON THE BALANCE SHEET (B/S)

| Assets                                                                                                                                | Liabilities                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| Current Assets                                                                                                                        | Current Liabilities                                                                                   |
| <ul style="list-style-type: none"> <li>● Cash and deposits</li> <li>● Accounts Receivable</li> <li>● Inventories</li> </ul>           | <ul style="list-style-type: none"> <li>● Accounts Payable</li> <li>● Short-term Borrowings</li> </ul> |
| Non-current Assets                                                                                                                    | Non-current Liabilities                                                                               |
| <ul style="list-style-type: none"> <li>● Land</li> <li>● Buildings</li> <li>● Machinery, Equipment</li> <li>● Depreciation</li> </ul> | <ul style="list-style-type: none"> <li>● Long-term Borrowings</li> <li>● Bonds</li> </ul>             |
|                                                                                                                                       | Equity                                                                                                |
|                                                                                                                                       | <ul style="list-style-type: none"> <li>● Capital Stock</li> <li>● Retained Earnings</li> </ul>        |

Management of funds

Procurement of funds

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## BALANCE SHEET (B/S) GLOSSARY

- **Assets**
  - **Current assets** : assets that can be converted to cash within one year. They have higher liquidity
  - **Fixed assets** : Assets to be used and held for longer than one year
    - **Depreciation and amortization** : Depreciation is calculated by dividing the cost of an aging asset, such as a building, by the period in which it is used, and subtracting the depreciation expense from the asset value. The depreciation period and method depends on the type of asset and are determined by the accounting standard of the country.

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## BALANCE SHEET (B/S) GLOSSARY

- **Liabilities**
  - **Current liabilities** : Debts that will become due for payment or repayment within one year
  - **Fixed liabilities** : Obligations that will not be paid or repaid within one year
- **Capital stock**
  - **Capital stock** : Funds invested by shareholders
  - **Profit reserve** : Reserves accumulated from retained earnings (retained earnings)

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## WHAT IS A PROFIT AND LOSS STATEMENT (P/L)?

The status of a company's revenues and expenses for one year (fiscal year).

Operating results of the company

- **Revenue**
- **Expenses**
- **Profit**

$$\text{Revenue} - \text{Expenses} = \text{Profit}$$

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## MAJOR ACCOUNTS IN THE STATEMENT OF INCOME

| Revenue                         | Expenses                         | Profit                        |
|---------------------------------|----------------------------------|-------------------------------|
| Sales Revenue                   | Cost of Sales/ Cost of Goods     | Sales Profit/Loss             |
|                                 | General and Administration Cost  | Operating Profit/ Loss        |
| Financial/Non operating Revenue | Financial/Non-operating expenses | Profit/Loss before Income Tax |
|                                 | Income Tax                       | Profit/Loss after income Tax  |

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## 2. HOW TO READ FINANCIAL STATEMENTS

Balance Sheet and Profit & Loss Statement

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## HOW TO READ FINANCIAL STATEMENTS

- Before looking at the financial statements, review the Annual Report entirely.
- Grasp the characteristics of the company and its industry.
- Understand the trends and characteristic events of the year.
- Compare financial data over time (multiple years).
- Read Notes that have important information

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## POINTS TO CONSIDER WHEN LOOKING AT B/S (1)

### ● Assets

#### ● Current assets: Accounts receivable

→ Be careful if there is an increasing trend. Also pay attention to the trend of revenue/ income collection rate. If the collection rate is declining, it may be a sign that accounts receivable will increase. If it cannot be collected for a certain period of time, a loss will be recorded on the income statement.

#### ● Changes in fixed assets: land, buildings, and machinery (in the case of electricity, power supply equipment)

→ If the trend is upward, it means that capital investment is expanding. This will lead to an increase in depreciation expenses. Also, pay attention to how the company is raising funds.

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## POINTS TO CONSIDER WHEN LOOKING AT B/S (2)

### ● Liabilities

#### ● Trade payables within current liabilities

→ If there is an increasing trend, be careful because fuel and other payments may be overdue.

#### ● Changes in long-term debt within non-current liabilities

→ This increase may come from finance capital expenditure. In case that the total liabilities exceed total assets, the company is "insolvent" (an extremely dangerous situation that cannot be repaid even if all assets are given up) and equity is negative.

#### ● Capitalization

→ It may be increased by capital injections by the government. In such cases, the long-term debt may be amortized in the meantime.

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## WHAT TO READ WHEN LOOKING AT A P/L

- Sales (revenue from electricity sales) (level of electricity prices and amount of electricity sold must be confirmed)
- Cost of sales (generation costs, transmission costs, distribution costs)
- Depreciation and amortisation
- Changes in non-operating income (government subsidies)
- Non-operating expenses (finance costs/interest expense)
- Other gains/losses (B/S reconfiguration may result in gains/losses)

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## 3. FINANCIAL INDICATORS

Types of financial indicators and how they are calculated

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## TYPES OF FINANCIAL INDICATORS

- Safety and soundness (corporate insolvency risk) indicators
- Profitability indicators (profit on sales and profit on capital)

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## TYPICAL SAFETY AND SOUNDNESS INDICATORS (1) LIQUIDITY RATIO

- Current Ratio:  $\text{Current Assets} / \text{Current Liabilities}$

A measure of a company's short-term financial security (solvency) → The bigger, the better

(Reference: 120% for electricity and gas in Japan, 300% average for all industries)

In a case of power utilities in developing countries, the key to improve this ratio is to reduce in accounts receivable (collect receivable faster) and accounts payable (pay costs slower)

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## TYPICAL SAFETY AND SOUNDNESS INDICATORS (2) CAPITAL ADEQUACY

●Capital Adequacy Ratio :  $\text{Own capital} / \text{Total capital}$

An indicator that measures the medium- to long-term financial security of a company. A capital adequacy ratio of 100% is debt-free management.

(Reference) Electricity and gas in Japan: approx. 30%, average of all industries: approx. 50%.

A reduction in long-term debt and an increase in equity capital (capital or retained earnings) will help to improve the situation.

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## TYPICAL SAFETY AND SOUNDNESS INDICATORS (3) DE RATIO (DEBT-EQUITY RATIO)

●Debt Equity Ratio :  $\text{Liabilities for liqueurs} / \text{Main capital of the plant}$

A measure of a company's capability to pay its debts over the long term. →The smaller it is, the more likely a company is able to repay its debts.

(Reference) Electricity and gas in Japan: about 1.7 times, average of all industries: about 1 times.

Reduction of interest-bearing debt or increase in shareholders' equity are effective measures for improvement.

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## TYPICAL SAFETY AND SOUNDNESS INDICATORS (4) FIXED RATIO

●Fixed Ratio :  $\text{Fixed assets} / \text{shareholders' equity}$

An indicator of the extent to which fixed assets such as buildings and machinery are financed by shareholders' equity → the smaller the ratio, the less reliance on debt (Reference) Electricity and gas in Japan: around 300%, average of all industries: around 100%.

The fixed ratio tends to be high in the equipment industry. It is necessary to monitor fixed liabilities to prevent them from becoming too high.

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## TYPICAL PROFITABILITY INDICATORS (1) GROSS PROFIT TO SALES RATIO

●Gross Profit Margin =  $\text{Gross Profit Margin} / \text{Turnover}$

Gross profit as a percentage of turnover. Gross profit margin.

(Reference) Electricity and gas in Japan: around 20%, average for all industries: around 30%.

In developing countries, electricity prices (tariff) are sometimes determined at a level that can be covered by policy-determined cost of sales, and gross margins are generally low.

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## TYPICAL PROFITABILITY INDICATORS (2) OPERATING PROFIT MARGIN

- Operating Profit Margin = Operating profit / Net sales

Operating profit as a percentage of turnover. The profitability of a business.

(Reference) Electricity and gas in Japan: around 7%  
Average for all industries: around 1

In developing countries, electricity prices are in some cases at a level that can be covered by policy-determined cost of sales, and gross margins are generally low.

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## TYPICAL PROFITABILITY INDICATORS (3) GROSS RETURN ON EQUITY

- Total Capital Gross Profit Margin = Gross profit / Total capital

It looks at how much gross profit is generated by the total capital raised (debt + equity). → The higher the ratio, the more efficiently the capital is used to generate profit.

(The higher the ratio, the more efficiently the capital is used to generate profit. (Reference) Electricity and gas in Japan: around 12%, average for all industries: around 32%.

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## TYPICAL PROFITABILITY INDICATORS (3) RETURN ON ASSETS

- Return on Asset (ROA) = Business profit / Total assets

An index that measures the overall profitability of a company. Business profit = operating profit + non-operating profit

(Reference) Electricity and gas in Japan: around 5%  
Average for all industries: around 5-6%.

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## TYPICAL PROFITABILITY INDICATORS (4) RETURN ON EQUITY

- Return on Equity (ROE) = Current net profit / Own capital

(Reference) Electricity and gas in Japan: around 7%,  
average for all industries: around 3%

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## 4. CASE STUDY FINANCIAL ANALYSIS

Case study of the EDM

29

## FINANCIAL ANALYSIS PROCEDURE

- Gathering of financial data (financial statements for the last 5 years or so are needed to identify trends)
- Organizing and checking financial data (entering data into EXCEL sheets. (Re-organization of data entry to conform to the general format of English financial statements)
- Analyse changes in financial data over time
- Calculation of financial indicators and analysis of trends

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## MOZAMBIQUE ELECTRICITY AUTHORITY FINANCIAL DATA OVER TIME (B/S)

- Accounts receivable goes double in 2019 and remain high thereafter
- Expansion of tangible fixed assets → expansion of capital investment
- Accounts payable (fuel costs?) High prices
- Gradual increase in non-current liabilities
- Gradual decline in equity capital (net losses continue)

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BS

| Balance Sheet                  | (Unit: million MZN) |                |                |                |
|--------------------------------|---------------------|----------------|----------------|----------------|
|                                | 2018                | 2019           | 2020           | 2021           |
| <b>Assets</b>                  |                     |                |                |                |
| Current Assets                 | 26,101              | 34,740         | 35,167         | 36,817         |
| Inventory                      | 3,123               | 2,247          | 1,798          | 1,438          |
| Trade Debtors                  | 5,937               | 14,510         | 13,784         | 12,768         |
| Other Financial Assets         | 4,887               | 4,020          | 3,939          | 3,742          |
| Other Current Assets           | 7,077               | 8,244          | 9,069          | 9,976          |
| Cash and Banks                 | 4,077               | 5,719          | 6,677          | 7,893          |
| Non-Current Assets             | 190,189             | 193,553        | 202,177        | 217,486        |
| Tangible Assets                | 186,063             | 190,312        | 203,089        | 212,277        |
| Financial Assets Held for Sale | 763                 | 777            | 777            | 777            |
| Other Financial Assets         | 1,587               | 1,587          | 1,587          | 1,587          |
| Deferred Tax Assets            | 1,756               | 1,277          | 1,724          | 2,845          |
| <b>Total Assets</b>            | <b>216,290</b>      | <b>228,293</b> | <b>242,344</b> | <b>253,303</b> |
| <b>Liabilities</b>             |                     |                |                |                |
| Current Liabilities            | 36,273              | 48,457         | 57,000         | 55,092         |
| Provisions                     | 135                 | 28             | 30             | 32             |
| Loans Obtained                 | 1,051               | 551            | 496            | 1,157          |
| Suppliers                      | 24,906              | 25,896         | 30,400         | 26,556         |
| Other Financial Liabilities    | 8,574               | 19,692         | 22,859         | 23,321         |
| Other Current Liabilities      | 1,607               | 2,290          | 3,205          | 3,526          |
| Non-Current Liabilities        | 93,135              | 97,098         | 107,615        | 121,375        |
| Provisions                     | 8,109               | 11,958         | 12,914         | 13,431         |
| Loans                          | 1,357               | 1,016          | 914            | 3,769          |
| Other Financial Liabilities    | 32,931              | 34,103         | 36,603         | 41,254         |
| Other Non-Current Liabilities  | 10,500              | 11,070         | 13,284         | 17,933         |
| Deferred Tax Liabilities       | 40,238              | 38,951         | 40,900         | 44,988         |
| <b>Total Liabilities</b>       | <b>129,408</b>      | <b>145,555</b> | <b>164,615</b> | <b>176,467</b> |
| <b>Equity</b>                  |                     |                |                |                |
| Share Capital                  | 6,197               | 6,197          | 6,197          | 6,197          |
| Reserves                       | 349                 | 349            | 349            | 349            |
| Share Premium                  | 11,648              | 11,648         | 11,648         | 11,648         |
| Revaluation Surplus            | 77,111              | 71,111         | 74,232         | 75,569         |
| Retained Earnings              | -5,976              | -9,443         | -10,802        | -14,698        |
| Net Income for the Year        | -3,467              | -2,132         | -3,895         | -2,229         |
| <b>Total Equity</b>            | <b>86,882</b>       | <b>82,738</b>  | <b>77,729</b>  | <b>76,836</b>  |
| <b>Liabilities and Equity</b>  | <b>216,290</b>      | <b>228,293</b> | <b>242,344</b> | <b>253,303</b> |

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## EDM FINANCIAL DATA OVER TIME (P/L)

- Revenue from electricity sales increases year by year (increase in number of subscribers due to higher electrification rates)
- The company records an operating loss every year.
- Losses on impairment of accounts receivable in 2018 and 2019
- Financial costs are high
- In 2018 and 2019, the company received a corporate tax refund due to a net loss

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## PL

| Income Statement                                 |               |               |               |               |
|--------------------------------------------------|---------------|---------------|---------------|---------------|
|                                                  | 2018          | 2019          | 2020          | 2021          |
| Sales                                            | 31,145        | 39,549        | 39,008        | 41,649        |
| Cost of Sales                                    | -23,341       | -27,571       | -29,266       | -31,759       |
| <b>Sales Profit/Loss</b>                         | <b>7,804</b>  | <b>11,978</b> | <b>9,742</b>  | <b>9,890</b>  |
| Supplemental Income                              | 38            | 284           | 334           | 72            |
| Personnel Expenses                               | -3,467        | -4,663        | -4,836        | -5,152        |
| Third Party Service Supplies                     | -3,383        | -4,970        | -3,073        | -3,132        |
| Depreciation and Amortization                    | -4,445        | -4,727        | -5,003        | -5,650        |
| Reversals                                        | 4             | 37            |               |               |
| Impairment Expenses on Financial Assets          | -2            |               |               |               |
| Provisions                                       | -995          | -1,216        | -1,255        | -1,380        |
| Inventory Adjustment                             |               |               |               |               |
| Financial Investment                             | -0            |               |               |               |
| Gain/Loss from Impairment on Account Receivables | -1,321        | -970          |               |               |
| Other operational Income and Expenses            | 2,692         | 1,622         | -181          | 3,216         |
| <b>Operating Profit/Loss</b>                     | <b>-3,075</b> | <b>-2,625</b> | <b>-4,272</b> | <b>-2,136</b> |
| Financial Income                                 | 5,995         | 6,131         |               |               |
| Financial Expenses                               | -6,755        | -6,447        |               |               |
| <b>Net Profit Before Tax</b>                     | <b>-3,835</b> | <b>-2,941</b> | <b>-4,272</b> | <b>-2,136</b> |
| Income Tax                                       | 368           | 809           |               |               |
| <b>Net Profit After Tax</b>                      | <b>-3,467</b> | <b>-2,132</b> | <b>-4,272</b> | <b>-2,136</b> |

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## TRENDS IN FINANCIAL INDICATORS OF EDM

- Safety
  - The current ratio needs to be improved.
  - Long-term repayment capacity is not a problem as far as the indicators are concerned, but both long-term liabilities and equity capital are too low against tangible fixed assets.
- Profitability
  - Return on sales to the total capital is very low at 4%.

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## Appendix-7

### MOM on Field Survey



**Minutes of Meeting**  
**On**  
**Capacity Development in Management**  
**and Operation of Gas Fired Power Plant in Mozambique**  
**(1st Mission Schedule May 5 to May 24, 2021)**

Venue: Conference Room, Maputo CTM

Date: May 24, 2021

1. General

- (1) The confirmation and request items discussed between EDM CTM and the Study Team such as O&M and HRD and Others.
- (2) EDM requested overseas training programs for turbine governor, I&C, management level position training and so on.
- (3) JICA Study Team submitted copy of work plan, first interim report, operation handbook each five (5) sets and DVD (Online Academy) one (1) set.

2. O&M

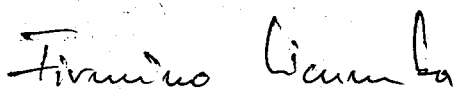
- (1) JICA Study Team joined and confirmed the daily O&M activities and will connect to the next activities which establishment of systematic O&M such as make manuals, work flow and so on.
- (2) JICA Study Team asked whether revised condition of submitted - 2 documents (O&M guideline and Emergency response manual) on March, CTM will revise the documents by June. JICA Study Team will submit other documents based on the O&M guideline.

3. HRD

- (1) JICA Study Team explained the outline of HRD framework construction to Academy and EDM CTM based on the attachemnt-1.
- (2) Both parties discussed and confirmed above mentioned. Confirmation Items was mentioned in the attachment-2.
- (3) The Questionnaires by Study Team to reflect the Human Resource Development Program was received from EDM.

4. Next Schedule

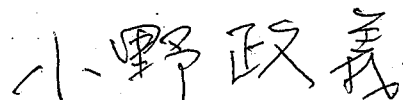
- (1) 2nd Survey schedule will be Middle of July, 2021 in accordance with COVID-19 Situations.
- (2) June 22 (Tues), 2021 Regular TV Meeting with EDM No.18 at 9:00 a.m.-10:00a.m. Mozambique Time by Google Meet.



**Firmino Licumba**

**Generation Division Director – South  
Region**

**EDM**



**Masayoshi ONO**

**Team Leader of JICA Study Team**

**TEPSCO**

Attachment-1

Attachment-2

Rev1 May 06, 2021  
May 05, 2021

## Meeting Materials for HRD with Academy and CTM

|      |                                                                   |    |
|------|-------------------------------------------------------------------|----|
| I.   | Explanatory Note -----                                            | 2  |
| II.  | Human Resource Development Program -----<br>-Draft- (In progress) | 4  |
| III. | Attachment-----                                                   | 23 |

| No. | Confirmation items and Reference materials                                                                                   | page  |
|-----|------------------------------------------------------------------------------------------------------------------------------|-------|
| 1   | Applicable Learning Programs for Academy                                                                                     | 24    |
| 2   | Applicable Learning Programs for CTM                                                                                         | 28    |
| 3   | Skills Management Plan for CTM                                                                                               | 32    |
| 4   | Assignment of Training Roles for Academy and CTM                                                                             | 33    |
| 5   | Responsibility and Authority for Academy and CTM                                                                             | 34    |
| 6   | Flow Chart of Training for Academy and CTM                                                                                   | 36    |
| 7   | Basic Training System Organization of CTM                                                                                    | 44    |
| 8   | Reference Materials                                                                                                          |       |
| 8.1 | Overview of Learning Needs Analyses                                                                                          | 53    |
| 8.2 | Technical Assistance for project definition and supervision related to the Rehabilitation of EDM Vocational Training Centers | 76    |
| 8.3 | Training Policy and Roadmap                                                                                                  | 103   |
| 8.4 | Upgrade The Vocational Training System of The Public Energy Company in Mozambique                                            | 112   |
| 9   | Reconfirmation items for HRD on TV Meeting (16)                                                                              | 45    |
| 10  | Questionnaires                                                                                                               | 46    |
| 11  | Award System for Academy and CTM                                                                                             | Add-1 |
| 12  | KPI for HRD                                                                                                                  | Add-2 |



**Minutes of Meeting  
On  
Capacity Development in Management  
and Operation of Gas Fired Power Plant in Mozambique  
(2nd Mission Schedule October to December, 2021)**

Venue: Maputo CTM

Date: December 01, 2021

1. General

(1) The confirmation and request items discussed between EDM CTM and the Study Team such as O&M and HRD and Others.

(2) Handbook

JICA Study Team submitted Operation Handbook and Alarm & Set Point List each Twenty (20) sets.

2. O&M

(1) JICA Study Team explained 6 documents (O&M guideline, HSE manual, Emergency response manual, Operation manual, Maintenance manual, Legal compliance manual). CTM will review the documents by End of December 2021.

3. HRD

(1) JICA Study Team explained the HRD Documents (such as work flow). CTM will review the documents by End of December 2021.

4. Next Schedule

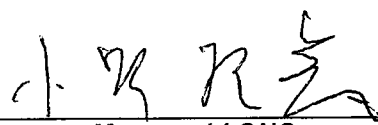
(1) 3rd Survey schedule will be Middle of January, 2022 in accordance with COVID-19 Situations.



*Thandi Tekwasse*

*HRD Project Coordinator*

*EDM*



*Masayoshi ONO*

*Team Leader of JICA Study Team*

*TEPSCO*



**Minutes of Meeting**  
**On**  
**Capacity Development in Management**  
**and Operation of Gas Fired Power Plant in Mozambique**  
**(3rd Mission Schedule March to June, 2022)**

Venue: Maputo CTM  
Date: June 06, 2022

1. General

(1) The confirmation and request items discussed between EDM CTM and JICA Study Team such as O&M and HRD and Others.

(2) Handbook

JICA Study Team submitted Alarm & Set Point List Twenty (20) sets.

2. O&M

(1) JICA Study Team explained the O&M documents as per Attachment-1.

(2) Both parties agreed to continue to review manuals via email and online meetings.

3. HRD

(1) JICA Study Team explained the HRD Documents as per Attachment-2.

(2) Both parties agreed to continue to review manuals via email and online meetings.

4. Draft Final Report

(1) JICA Study Team will submit a draft final report to the EDM in mid-July, 2022.

EDM will review it.

  
\_\_\_\_\_  
**Thandi Tekwasse**  
**HRD Project Coordinator**  
**EDM**

  
\_\_\_\_\_  
**Masayoshi ONO**  
**Team Leader of JICA Study Team**  
**TEPSCO**

# Overview of each manual



| Manual                     | Overview                                                                                                                         |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| O&M Guideline              | CTM organization, division of duties and responsibilities of each group, outline of each manual / regulation. etc.               |
| HSE Manual                 | Risk management, Health/ Safety/ Environment management, Compliance items for dangerous work and low, etc.                       |
| Emergency Response         | Emergency organization, typical emergency response, emergency response plan, etc.                                                |
| Legal Compliance           | Records and reports of power plant operations under the law.<br>Laws and regulations applicable to power plant operations , etc. |
| Troubleshooting Management | How to troubleshoot, Trouble Shorting Flow Diagram, etc.                                                                         |
| Operation                  | Daily Operation (Monitoring, Patrol, Testing, Switching, etc.)<br>Plant Start-up / Shut-down Operation, etc.                     |
| Maintenance                | Scheduled Maintenance and Equipment Improvement Plan<br>Maintenance Work , Spare Parts Management, etc.                          |
| Purchasing and Contract    | Structure of ordering specifications, points to note<br>Work Supervision, Work Cost Estimation System, etc.                      |
| Human Resource Development | Training, Training program, KPI for O&M and HRD, Skill Certification System , etc.                                               |

Attachment - (

HRD Report consists of the followings;

|    | Manual & List Number | Description                                                  |
|----|----------------------|--------------------------------------------------------------|
| 1  | CTM-4-001            | Human Resource Development Manual                            |
| 2  | CTM-4-002            | KPI for O&M and HRD                                          |
| 3  | CTM-4-003            | Training Record Notebook for HRD                             |
| 4  | CTM-4-004            | Training Management Check Sheet for CTM Operator             |
| 5  | CTM-4-005            | Training Management Check Sheet for CTM Maintenance Engineer |
| 6  | CTM-4-006            | Q&A of Examination for Skill Certification System            |
| 7  | CTM-4-007            | Questionnaires Survey Report                                 |
| 8  | CTM-4-008            | Inspection Report for Existing HRD Program                   |
| 9  | CTM-4-009            | Training List of Training Center                             |
| 10 | CTM-4-010            | List received from EDM and Website                           |





Appendix-8

Presentation Material of Work Shop





# Capacity Development in Management and Operation of Gas Fired Power Plant

## Work Shop



May 2022

Electricidade de Mocambique (EDM)  
Japan International Cooperation Agency (JICA)

## Table of Contents

1. Summary of the Project
2. Counterpart
3. Introduction of the JICA Expert Team
4. Outline of the Project
5. Work flow & Schedule
6. Handbook
7. O&M Guideline
8. HRD Manual

## 1. Summary of the Project

| Items          | Contents                                                                                                                                                                                                                                                                                                                            |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Project Name   | Capacity Development in Management and Operation of Gas Fired Power Plant                                                                                                                                                                                                                                                           |
| Country        | Republic of Mozambique                                                                                                                                                                                                                                                                                                              |
| Project Period | August 2020 – August 2022 (24months)                                                                                                                                                                                                                                                                                                |
| Background     | The GTCC power plant was constructed in Maputo, funded by a Japanese yen loan. However, most of the power plant staff had <u>little experience in operation and maintenance of power plants in the past, and it is necessary to strengthen the human resource development system for operation and maintenance of power plants.</u> |

## 2. Counterpart (EDM(1))



## 2. Counterpart (EDM(3))



Project Leader  
(Ms. Thandi)

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## 3. JICA Experts



| Name              | Area of charge                                                            |
|-------------------|---------------------------------------------------------------------------|
| Masayoshi Ono     | Chief of Operations / Thermal power plant operation management A          |
| Masaho Aoki       | Thermal power station maintenance (inspection/repair)                     |
| Hiroyuki Nemoto   | Human resources development A/ Thermal power plant operation management B |
| Takahiro Nakajima | Thermal power plant operation simulation A                                |
| Takashi Kuroishi  | Human resource development B (TV conference lecturer)                     |
| Tsutomu Tanaka    | Human resource development C (TV conference lecturer)                     |
| Masahiro Sado     | Economic and financial management                                         |
| Taisuke Koto      | Thermal power plant operation simulation B/ Operation Coordinator         |

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## 4. Outline of the Project



### Expected Goals

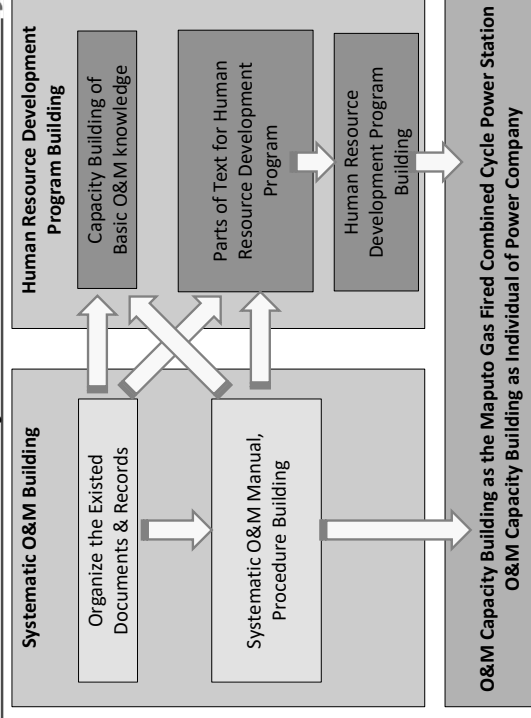
- Capable of sustainably O&M the Maputo Gas Fired Combined Cycle Power Plant

### Project Activities

- Implementation of **Systematic O&M Practice** by EDM
  - **Systematic plan** to evaluate, take countermeasures & develop preventive measures **for trouble including natural & human disasters** is established.
  - The established **systematic plan for trouble** is implemented.
  - Work flow for the utilization of **PMIS** is developed.
  - **Structure of O&M** implementation is developed.
  - The **HSE** for the power plant O&M is defined & introduced.
  - The **KPI** for the power plant O&M is defined & introduced.
  - Capacity of EDM for **contract management** (e.g. LTSA) is developed.
- Introduction of **Human Resource Development Program** by EDM
  - The existing **training system for new employee** is improved.
  - The existing **training program for the simulator system** is improved.
  - The plan & system for **human resource development & training** is introduced.

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## 4. Outline of the Project (cont'd)



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## 5. Work flow & Schedule (1)

### Project Period

■ Aug 2020 through to July 2022 (Approx. 24 months)

|         | Work flow                                                                                                                                                                                             | Schedule             |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| Stage 1 | <ul style="list-style-type: none"> <li>• <b>Clarification</b> the current situation of Power Station</li> </ul>                                                                                       | Sep to Dec 2020      |
| Stage 2 | <ul style="list-style-type: none"> <li>• Organize the Existed Documents and Records</li> <li>• <b>Framework Establishment</b> of Systematic O&amp;M and Human Resource Development Program</li> </ul> | Jan to Apr 2021      |
| Stage 3 | <ul style="list-style-type: none"> <li>• <b>Establishment</b> of Systematic O&amp;M and Human Resource Development Program</li> </ul>                                                                 | May 2021 to Jan 2022 |
| Stage 4 | <ul style="list-style-type: none"> <li>• <b>Implementation</b> of Systematic O&amp;M and Human Resource Development Program</li> </ul>                                                                | Feb to May 2022      |
| Stage 5 | <ul style="list-style-type: none"> <li>• <b>Evaluation and improvement</b> of Systematic O&amp;M and Human Resource Development Program</li> </ul>                                                    | May to July 2022     |

Subject to change depending on the COVID-19 conditions.

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## 6. The Handbook (Purpose)

### O & M Manual

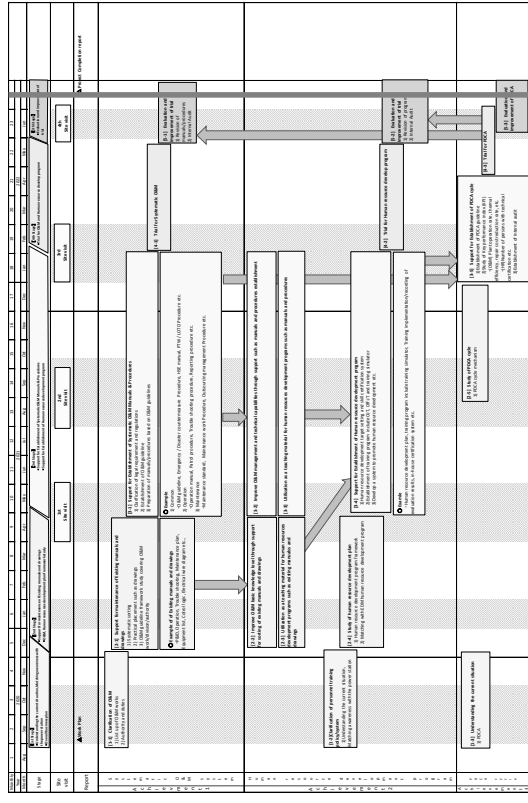


### Big Volume



11

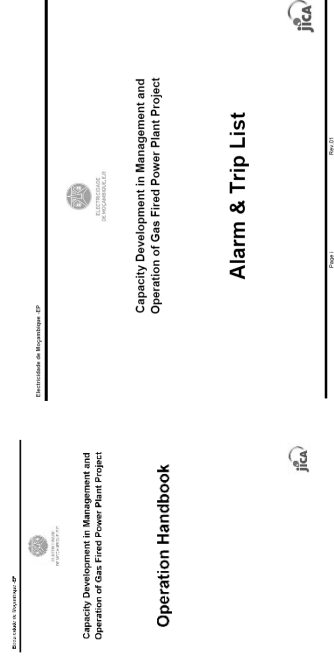
## 5. Work Flow & Schedule (2)



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## 6. Provided Handbook

The Operation Handbook and Alarm & Trip List, which is important for O&M, were provided.



### Operation Handbook

### Alarm & Trip List

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## 7. O&M Manual



### General

Created O&M Guideline as the basis for a manual on the overall operation and maintenance of CTM.

- Clarification of O&M tasks and roles
- Systematization of manuals including existing rules
- Basic guidelines for other detailed O&M documents

A separate manual was created based on O&M guideline.

The manual not only defines the work content, but can also be used as training material for the power plant staff to understand the overall work content.

The structure of the CTM Manuals are shown in the O&M Manual Documents Tree.

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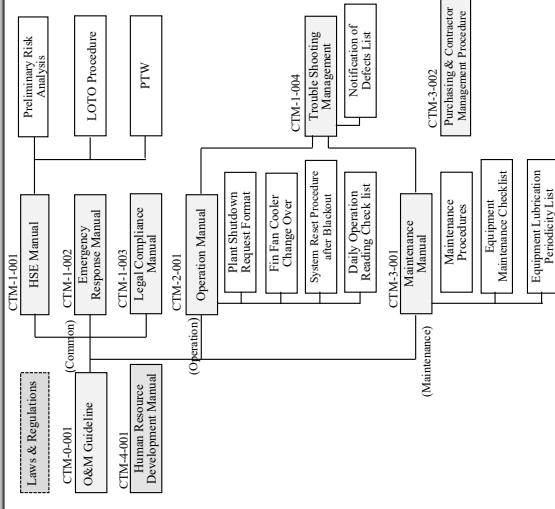
### Overview of each manual



| Manual                     | Overview                                                                                                                |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------|
| O&M Guideline              | CTM organization, division of duties and responsibilities of each group, outline of each manual / regulation. etc.      |
| HSE Manual                 | Risk management, Health/ Safety/ Environment management, Compliance items for dangerous work and low, etc.              |
| Emergency Response         | Emergency organization, typical emergency response, emergency response plan, etc.                                       |
| Legal Compliance           | Records and reports of power plant operations under the law. Laws and regulations applicable to power plant operations. |
| Troubleshooting Management | How to troubleshoot, Trouble Shorting Flow Diagram, etc.                                                                |
| Operation                  | Daily Operation (Monitoring, Patrol, Testing, Switching, etc.) Plant Start-up / Shut-down Operation, etc.               |
| Maintenance                | Scheduled Maintenance and Equipment Improvement Plan Maintenance Work , Spare Parts Management, etc.                    |
| Purchasing and Contract    | Structure of ordering specifications, points to note Work Supervision, Work Cost Estimation System, etc.                |
| Human Resource Development | Training, Training program, KPI for O&M and HRD, Skill Certification System , etc.                                      |

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## O&M Manual Document Tree



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## Manual Example : Emergency Response Manual



We have been developing manuals for CTM operation based on O & M guidelines.

Of these, so this time we will introduce the outline of the **Emergency Response Manual**.

| Rev  | Description   | By        | App.       | Date | Title                     |
|------|---------------|-----------|------------|------|---------------------------|
| 0    | First Issue   | HSE xxx   | INACIO xxx |      | Emergency response manual |
| Rev. | DOCUMENT No.: | CTM-1-002 |            |      | Rev. : 0                  |

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## Outline of Emergency Response Manual < GENERAL > jica

### 1. PURPOSE

Based on the O&M Guideline , This Emergency Response Manual is

- (1) Mitigate the consequences of potential emergencies.
  - (2) All staff must be familiar with emergency response procedures.
- These things are intended

### 2. APPLICATION

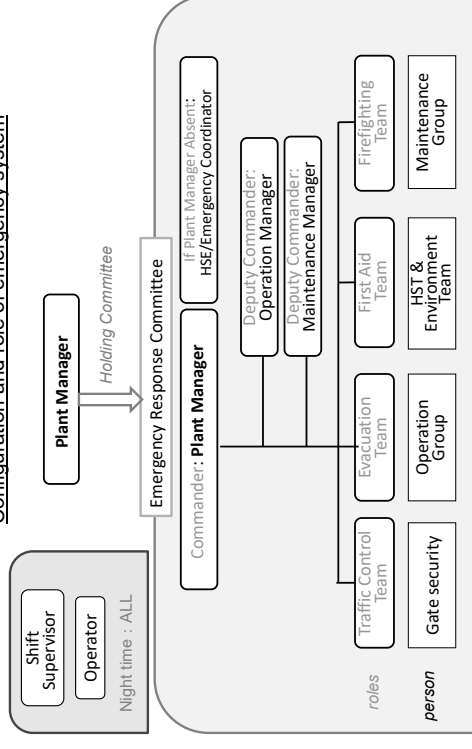
The Emergency Response Manual contains the following:

|                                                 |
|-------------------------------------------------|
| Fire and explosion                              |
| Cyclone                                         |
| Flood                                           |
| Toxic gas leakage                               |
| Chemical / Oil spill                            |
| Other risk which may threaten the safety of CTM |

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## Emergency Response < Roles and Responsibilities > jica

### Configuration and role of emergency system



## Outline of Emergency Response Manual < EMERGENCY STAGE > jica

|                                    | Alert Stage                                          | 1st<br>Emergency<br>Stage                                                         | 2nd<br>Emergency<br>Stage                                                                | Evacuation                                                                            |
|------------------------------------|------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Timing of<br>issuance              | when a disaster<br>is expected                       | when a disaster<br>is expected to<br>occur.                                       | 2nd emergency<br>stage is issued<br>exactly where<br>disaster strike.                    |                                                                                       |
| Preparation,<br>Action             | communication<br>system and<br>disaster<br>equipment | set-up disaster<br>equipment, lock<br>doors, provide<br>rain / wind<br>protection | set-up disaster<br>equipment, lock /<br>open doors,<br>provide rain /<br>wind protection |                                                                                       |
| Emergency<br>Response<br>Committee |                                                      | Incident Commander<br>Deputy Incident Commander<br>Emergency Coordinators         | Evacuate<br>(depending on<br>the disaster that<br>occurred)                              | immediately<br>leave the work<br>site, proceed<br>to designated<br>assembly<br>point. |
| Each Person                        |                                                      |                                                                                   |                                                                                          |                                                                                       |

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## Outline of Emergency Response Manual < Emergency Response Plan 1/2> jica

| STEP   | Fire                                                                                                                                                                                                                                                                                                                          | Injury                                                                                                                                                                                       | Entrapment                                                                                                                                                                                                                                                                                 |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STEP 1 | <ul style="list-style-type: none"> <li>➢ Raise the alarm, call help.</li> <li>➢ Call supervisor.</li> <li>➢ Attempt to extinguish the fire, if it is small, safe and possible to do so.</li> <li>➢ Stop all work, inform all personnel to evacuate</li> <li>➢ Secure the area when the fire has been extinguished.</li> </ul> | <ul style="list-style-type: none"> <li>➢ Raise the alarm, call help</li> <li>➢ Call supervisor</li> <li>➢ Render first aid treatment. Remove injured to safe area when necessary.</li> </ul> | <ul style="list-style-type: none"> <li>➢ Secure the injured and try to protect them from further injuries if possible.</li> <li>➢ Render first aid without endangering your own life.</li> <li>➢ Remove injured to safe area when necessary.</li> </ul>                                    |
| STEP 2 | <ul style="list-style-type: none"> <li>➢ Call the Fire Brigade and inform operator of the fire and its location.</li> <li>➢ Arrange to escort emergency service if required</li> </ul>                                                                                                                                        | <ul style="list-style-type: none"> <li>➢ Call the emergency services and inform operator of the incident location.</li> <li>➢ Arrange to escort emergency service if required</li> </ul>     | <ul style="list-style-type: none"> <li>➢ Call the Fire Brigade and inform operator of the situation and its location.</li> <li>➢ Call the emergency services and inform the operator of the incident &amp; location.</li> <li>➢ Arrange to escort emergency service if required</li> </ul> |
| STEP 3 | Hold roll-call of people present at the Emergency Assembly Point Number<br>Identify missing people.<br>Supervisor to contact: <ul style="list-style-type: none"> <li>• EHS Officer</li> <li>• Safety officer</li> </ul> Construction Manager or EHS Officer to inform EDM<br>Inform fire brigade of missing people.           |                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                            |
| STEP 4 | Safety department to start the incident investigation process                                                                                                                                                                                                                                                                 |                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                            |

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|        | Spillages                                                                                                                                                                                                                                                                                                                                                                                   | Falling From Heights                                                                                                                                                                                                                                                                             | Robbery / Hostage Situations / Riots                                                                                                                                                                                                                                                     |
|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STEP 1 | <ul style="list-style-type: none"> <li>Stop spillage at source.</li> <li>Raise the alarm, call help</li> <li>Call supervisor</li> <li>Contain the spillage</li> <li>Supervisor to contact:                             <ul style="list-style-type: none"> <li>EHS Officer</li> <li>Safety Officer</li> </ul> </li> </ul>                                                                    | <ul style="list-style-type: none"> <li>Raise the alarm, call help</li> <li>Call supervisor</li> <li>Ask the victim to remain calm.</li> <li>Supervisor to contact:                             <ul style="list-style-type: none"> <li>EHS Officer</li> <li>Safety Officer</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>Make / Raise the alarm if Possible</li> <li>Remain calm</li> <li>Co-operate with criminals at all times.</li> <li>Do not put your own safety or that of others at risk.</li> </ul>                                                                |
| STEP 2 | <ul style="list-style-type: none"> <li>Consult MSDS for action</li> <li>Add absorbent material on spillage.</li> <li>Determine the size of the spillage</li> </ul>                                                                                                                                                                                                                          | <ul style="list-style-type: none"> <li>Call the Fire and inform the operator of the emergency and its location.</li> </ul>                                                                                                                                                                       | <ul style="list-style-type: none"> <li>To contact any one of the following                             <ul style="list-style-type: none"> <li>EHS Officer</li> <li>Safety Officer</li> <li>Supervisor or EHS Officer</li> </ul> </li> <li>get to call the Police if required.</li> </ul> |
| STEP 3 | <ul style="list-style-type: none"> <li>Spillages to be cleaned according to best practice and MSDS guidelines</li> <li>EHS Officer and Safety Officer will authorize and co-ordinate catastrophic or large spillage clean-up.</li> <li>Construction Manager / EHS Officer get to call Emergency or other Services</li> <li>Construction Manager or EHS Officer get to inform EDM</li> </ul> | <ul style="list-style-type: none"> <li>The Fire Brigade will authorize and co-ordinate the rescue.</li> </ul>                                                                                                                                                                                    | <ul style="list-style-type: none"> <li>Stay calm and wait for rescue.</li> <li>Do not attempt to follow the criminals or try to apprehend them.</li> </ul>                                                                                                                               |
| STEP 4 | Safety department to start the incident investigation process                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                          |

## 8. Image of Activities – HRD

|         | Work flow                                                                                                                                                           | Schedule             |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| Stage 1 | <ul style="list-style-type: none"> <li><b>Clarification</b> the current situation of Power Station</li> </ul>                                                       | Sep to Dec 2020      |
| Stage 2 | <ul style="list-style-type: none"> <li>Organize the Existed Documents and Records</li> <li>Framework Establishment of Human Resource Development Program</li> </ul> | Jan to Apr 2021      |
| Stage 3 | <ul style="list-style-type: none"> <li><b>Establishment</b> of Human Resource Development Program</li> </ul>                                                        | May 2021 to Jan 2022 |
| Stage 4 | <ul style="list-style-type: none"> <li><b>Implementation</b> of Human Resource Development Program</li> </ul>                                                       | Feb to May 2022      |
| Stage 5 | <ul style="list-style-type: none"> <li><b>Evaluation and improvement</b> of Human Resource Development Program</li> </ul>                                           | May to July 2022     |

## Human Resource Development (HRD) 1/13



## Human Resource Development (HRD) – 2/13

HRD Report consists of the followings;

| Manual & List Number | Description                                                            |
|----------------------|------------------------------------------------------------------------|
| 1                    | CTM-4-001 Human Resource Development Manual                            |
| 2                    | CTM-4-002 KPI for O&M and HRD                                          |
| 3                    | CTM-4-003 Training Record Notebook for HRD                             |
| 4                    | CTM-4-004 Training Management Check Sheet for CTM Operator             |
| 5                    | CTM-4-005 Training Management Check Sheet for CTM Maintenance Engineer |
| 6                    | CTM-4-006 Q&A of Examination for Skill Certification System            |
| 7                    | CTM-4-007 Questionnaires Survey Report                                 |
| 8                    | CTM-4-008 Inspection Report for Existing HRD Program                   |
| 9                    | CTM-4-009 Training List of Training Center                             |
| 10                   | CTM-4-010 List received from EDM and Website                           |

Workshop Report consists of the followings;

|   | Description                          |
|---|--------------------------------------|
| 1 | Project Targets and Expected Results |
| 2 | New Employee Training -1, 2          |
| 3 | Skill Certification System           |
| 4 | Training System Organization         |
| 5 | Overall Technical Training Framework |

## 1. Project Targets and Expected Results

### What are the goals and objectives?

(1) Introduce a skills certification system for shift operators and maintenance engineers.  
It shall be consistent with the skills management plan prepared by EDM for 2020.

(2) Ensure that the number of employees taking and passing the intermediate (Level 2) and advanced (Level 3) examinations and the promotion of employees joining the company in March 2019, from elementary (Level 1) to intermediate (Level 2) are managed and implemented on a yearly basis.

### What achievements have been made?

(1) Conducted the development of a skills certification system, training schedule, training structure, training items, etc. and these training materials.

## 3. Skill Certification System

| 1 | Skill Certification System                  | (1) Skill Target Level (Refer to 6/13)                     |                                                            |
|---|---------------------------------------------|------------------------------------------------------------|------------------------------------------------------------|
|   |                                             | (2) Qualification examination methods (Refer to 7/13)      | (3) Skill Training (Refer to 7/13)                         |
|   |                                             | (4) Skill Qualification Process (Refer to 8/13)            | (5) Schedule of Skill Qualifications (Refer to 9-10/13)    |
|   |                                             | Eligibility Requirements                                   |                                                            |
| 1 | Operator skill certification level 1        | After 1 year experience of qualified operator              | After 1 year experience of qualified operator              |
| 2 | Operator skill certification level 2        | After 2 years experience of level 1                        | After 2 years experience of level 1                        |
| 3 | Operator skill certification level 3        | After 2 years experience of level 2                        | After 2 years experience of level 2                        |
| 4 | Transfer to maintenance section as required | After 1 year experience of obtained operator skill level 1 | After 1 year experience of obtained operator skill level 1 |
| 5 | Maintenance engineer skill level 1          | After 1 year experience of maintenance engineer            | After 1 year experience of maintenance engineer            |
| 6 | Maintenance engineer skill level 2          | After 2 year experience of level 1                         | After 2 year experience of level 1                         |
| 7 | Maintenance engineer skill level 3          | After 2 year experience of level 2                         | After 2 year experience of level 2                         |

## 2. Training schedule for new employee -1, 2

| Month                                          | 1st                                                                           | 2nd | 3rd  | 4th  | 5th  | 6th  | 7th  | 8th  | 9th  | 10th | 11th | 12th  |
|------------------------------------------------|-------------------------------------------------------------------------------|-----|------|------|------|------|------|------|------|------|------|-------|
| Month                                          | April                                                                         | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | March |
| Company-wide training                          | Training in the first stage                                                   |     |      |      |      |      |      |      |      |      |      |       |
|                                                | Training in the late stage                                                    |     |      |      |      |      |      |      |      |      |      |       |
| Department Training<br>(Thermal<br>Department) | Day shift introductory training                                               |     |      |      |      |      |      |      |      |      |      |       |
|                                                | Day shift training<br>(«Classroom training»<br>+ Training Simulator training) |     |      |      |      |      |      |      |      |      |      |       |
|                                                | Shift work introductory training                                              |     |      |      |      |      |      |      |      |      |      |       |
| Shift work Training                            | Shift work training with instructor                                           |     |      |      |      |      |      |      |      |      |      |       |
|                                                | Qualified Operator                                                            |     |      |      |      |      |      |      |      |      |      |       |
| OJT                                            |                                                                               |     |      |      |      |      |      |      |      |      |      |       |

## 3.1 Skill Target Level

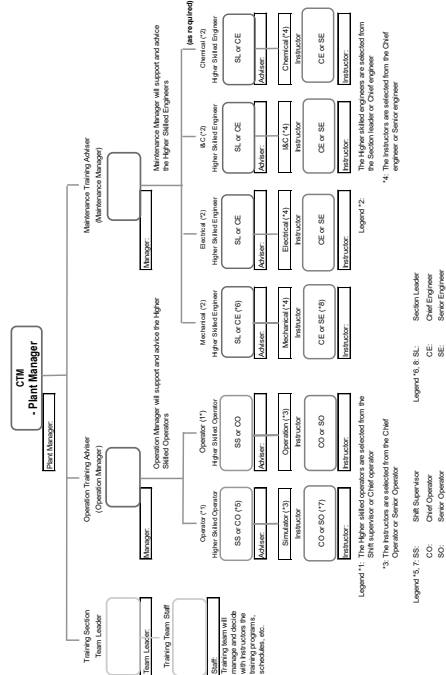
Classify the targets to be achieved in thermal power operation and maintenance work into three grades (Elementary, Intermediate, and Advanced) and certify the skills at each step.

| Grade                        | Operation Work                                                                                                             |  | Maintenance Work                                                                                                                                            |  |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|                              | Target level to be reached                                                                                                 |  | Target level to be reached                                                                                                                                  |  |
| Advanced Level (Level 3)     | Ability to make appropriate judgments and take actions in the event of unit and grid system abnormality                    |  | Acquire specialized knowledge, skills and techniques and be able to make appropriate judgments and actions for all equipment in one's field of expertise.   |  |
|                              | GT, HRSG, ST, Electrical accidents, etc.                                                                                   |  | Appropriate and advanced technical judgment                                                                                                                 |  |
|                              | Frequency fluctuation, voltage fluctuation                                                                                 |  | Appropriate measures to be taken in case of troubles                                                                                                        |  |
| Intermediate Level (Level 2) | Island operation for house load and grid island load                                                                       |  | Design and estimation of large repair and complex construction works                                                                                        |  |
|                              | Natural disasters such as typhoons, earthquakes and lightning                                                              |  | Construction planning, budget management, etc.                                                                                                              |  |
|                              | Ability to make judgments and take actions on unit start-up and shutdown operations and critical alarm response operation. |  | Acquire specialized knowledge, skills and techniques and be able to make appropriate judgments and actions for major equipment in one's field of expertise. |  |
| Elementary Level (Level 1)   | Unit start-up and shutdown operations                                                                                      |  | Routine disassembly and inspection, adjustment operations and judgment of the results                                                                       |  |
|                              | Critical alarm response operation                                                                                          |  | Repair work of minor accidents and troubles                                                                                                                 |  |
|                              | Important routine tests                                                                                                    |  | Standard repair work and design estimation                                                                                                                  |  |
| New Employee                 | Ability to make judgments and take actions on unit normal operation and monitoring, and minor alarm response operation     |  | Budget management                                                                                                                                           |  |
|                              | Monitoring and complementary operations for equipment                                                                      |  | Acquire basic knowledge, skills and techniques and be able to make judgments and actions for auxiliary equipment in one's field of expertise.               |  |
|                              | Start-up and shutdown operation for the auxiliary equipment                                                                |  | Routine disassembly and inspection, adjustment operations and judgment of the results                                                                       |  |
| New Employee                 | Normal alarm response operation                                                                                            |  | Repair work of minor accidents and troubles                                                                                                                 |  |
|                              | Normal routine tests                                                                                                       |  | Standard repair work and design estimation                                                                                                                  |  |
|                              | Understand equipment monitoring and inspection points and be able to perform simple routine tests.                         |  |                                                                                                                                                             |  |





## 4.1 Training System Organization



## 4.2 Training System Organization Explanation

- (1) Training Team.  
Training team will manage and decide with instructors the training programs, schedules, etc.  
➤ Team leader  
➤ Staff
- (2) Operation Group.  
Operation manager as operation training advisor will support and advise the higher skilled operators.  
The higher skilled operators are selected from the shift supervisor or chief operator to support the instructor.  
  
The instructors are selected from the chief operator or senior operator  
➤ Operation manager  
➤ Shift supervisor  
➤ Chief operator  
➤ Senior operator
- (3) Maintenance Group:  
Maintenance manager as maintenance training advisor will support and advise the higher skilled maintenance engineers.  
  
The higher skilled maintenance engineers are selected from the chief maintenance engineers or senior maintenance engineers to support the instructor.  
  
The instructors are selected from the chief maintenance engineer or senior engineer  
➤ Maintenance manager  
➤ Mechanical section leader  
➤ Mechanical chief engineer  
➤ Mechanical senior engineer
- The selection of instructors of Electrical, I&C, Chemical are the same as Mechanical section.

## 5. Overall Technical Training Framework

|   | Description                                                               |
|---|---------------------------------------------------------------------------|
| 1 | EDM Training Center Training                                              |
| 2 | OJT and Off-JT Training                                                   |
| 3 | Class room Training and OJT by LTSA Resident Engineer                     |
| 4 | Basic and Specialized Domestic Training for the future                    |
| 5 | Basic and Specialized Foreign Training for the future                     |
| 6 | Overall Training for Thermal Power Plant (e.g. JICA Japan) for the future |

