بسم الله الرحمن الرحيم

SUDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF GRADUATE SUTDIES

Quantifying the Cost of Unplanned Outage at Khartoum North Thermal Power Station

حساب تكاليف توقف محطة الخرطوم بحري الحرارية الغير مبرمج

The Thesis Submitted in Partial Fulfillment of the requirement for

The Master Degree of Science in Mechanical Engineering

Power Engineering

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الإستهلال

قال تعالى:

(وقل ربي زدني علما)

سورة طه الآيه (114)

قال الرسول (صلى الله عليه وسلم):

((ان الملائكة لتضع اجنحتها لطالب العلم رضا بما يصنع))

Dedication

To...

My mother

To...

My father

To...

All my brothers

To...

All my sisters

To...

All my suns

To...

My wife Salwa Babikir

Acknowledgment

First, I would like to express all my deepest thanks to Allah for his grate help in completing this thesis.

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Abstract

This research concerns with the energy resources in Sudan. It includes the steam plants, their unplanned outage problems. The study conducted on Dr. Sharief power station in Khartoum north.

The research is studied the station problems occurring during the period (Jan 2011 to Dec 2015), the maintenance program procedure and management method description.

Losses resulting from unplanned outage were calculated. The rest of maintenance was not calculated because there were no enough data about material at the time in the unplanned outage case, communication, cleaning, lubrication and transportation.

In conclusion recommendations to prevention or reduction in the unplanned outage has been represented, station should also be rehabilitated, this will improve the station efficiency.

ملخص البحث

إهتم هذا البحث بدراسة مصادر الطاقة في السودان. وقد شمل ذلك محطات البخار ومكوناتها وأهم المشاكل التي تواجه المحطات وهي التوقف غير المبرمج وقد تمت الدراسة على محطة د. شريف الحرارية في الخرطوم بحري.

تمت الدراسة لحالات الأعطال في المحطة في الفترة من يناير 2011 حتى ديسمبر 2015 وكذلك وصف برنامج الصيانة المعمول بها واجراءاتها وطريقة ادارتها.

تم حساب تكلفة الفقودات الناتجة من التوقف غير المبرمج ولعدم وجود بيانات عن الفاقد من المواد في حالات التوقف غير المبرمج واعمال النظافة والتزييت والاتصالات والمواصلات تعذر حساب باقي التكاليف المتعلقة باعمال الصيانة.

ختاما تم تقديم مقترحات لمنع او تقليل التوقف غير المبرمج وهي إعادة تأهيل المحطة مما يساعد على زيادة كفاءة المحطة.

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Table of Abbreviation

Abbreviation	Meaning
A/F	Air fuel ration
BFP	Boiler feed pump
BMD	Boiler maintenance department
BMS	Burner management system
CB	Circuit breaker
CDI	Control instrument
CEP	Condensate extraction pump
CO	Control oil
CT	Cooling tower
CWP	Cooling water pump
CV	Control valve
D/A	Desecrator
EMD	Electrical maintenance department
ESV	Emergency stop valve
FD	Force draught
E/F	Earth/ fault
FO	Fuel oil
FW	Feed water
FWDG	Forwarding pump
Gen	Generation
KNPS	Khartoum north power station
HPH	High pressure heater
LO	Lubrication oil
MFT	Main fuel trip valve
N/A	Not available
NRV	Non return valve
O/C	Over/ Current
O/L	Over / Load
PEW	Permit for work
S/H	Super heater
S/S	Sub station
TME	Turbine maintenance engineering
TX	Transformer
U/N	Under/Voltage
VT	Volt transformer
IVI	Level
Aux Bard	Auxiliary Board
CW	Cooling tower

Chapter one
Introduction

1-1 Introduction

Electrical is the main nerve for the modern life technology and it’s important for the life as it is the back bone civilization. The development of countries is measured through their power consumption. In nature there are different resources for energy like (sun, water falls, wind force and fossil fuel) Power system begins with a generation source. Electrical generators are devices that convert energy form a mechanical form to an electrical form.

Electrical power can be produced in many ways that including chemical reaction, heat, light or mechanical energy. Most electrical power is produced today through hydro-electrical plants, nuclear energy, natural gas or coal. Fossil fuel and nuclear fission plant use steam turbines to deliver the mechanical energy required to rotate a large three phase generator. Hydroelectric systems use hydraulic turbines which are mounted vertically that intercept the flow of water to produce electrical energy.

The most common thermal power plants are internal combustion engine (diesel engine) gas power plants and steam power plants. Electricity was first introduced in Sudan in 1908, when a small 100kw steam station employing reciprocating engines, and direct current generators was installed. In 1925 the plant capacity was increased to 3MW. In 1962 the first hydro-station was operated in Elgirba senar and Elrossieres, with a capacity of 12.6, 15 and 280 MW respectively.

In 1948 steam power station was operated in Khartoum north with an overall capacity of 60MW and then is replaced in 1994 by another station of 120MW.

The main power generation in the Sudan can be divided into four sectors: hydro-power stations, steam power stations, gas power stations and diesel power stations.

1-2 Problem Statement:

Due to increase of number and duration of unplanned outage of the plant failure leads mainly to:

- Deterioration of original performance (output & efficiency)
- Loss of availability of the station
- And higher production cost for (maintenance & operation)

1-3 Objectives of the study

The objective for the research is to study the station (Khartoum north power station) problem during the period from June 2011 to December 2015 which effect of unplanned outage of the unit and estimate the losses cost from unplanned outage.

1 -4 methodology of the study

In order to Guantifing the the cost of unplanned outage of power station it reguired data collection :

- field unit trip
- field unit human unplanned ontage .
- Data collection of training .
- calculation Kilo watt hour (KWH) cost
- calculation losses cost .

Chapter Two

Literature Review

2-1 Background

The power station is a simple superheat steam power station it is constructed for covering needs of electric energy in Sudan.

As a historical review the Khartoum North power station in March 1981is located at northeast North Khartoum Industrial Area is provide power for national public, industrial and civil use.

In May 1985 a request was made by National Electrical corporation project to Internal Combustion limited to carry out official acceptance test on.

Phase I consist of two units (No 1 & No 2) for each 30 MW steam turbine generator unit to energize the existing Blue Nile power system via 110KV transmission line were officially inaugurated in December 1985.

An existing to Khartoum North power station Know as phase II consist of two units (No3 & No 4) for each 60 MW steam turbine generator units to energize via another 110KV transmission line, it were officially inaugurated on July 1994.

This project is the expanded phase III including two sets of 100MW steam turbine generator units were officially inaugurated on March 2011 [4]

Therefore, the installed gross capacity of the plant is 380MW (2x30MW+2x60MW+2x100MW).

The newly increased capacity of the plant is connected with the local power system through the 4 circuit outgoing line. Established in phase I and phase II, the Main transformer in this phase uses 2 circuit incoming line … phase III line will finally incorporated into 110 KW national power system of Sudan.

Now the power stations (formerly Khartoum North Power Station) represent the major asset of National Electrical Corporation by with capacity of 380MW, it is the 3rd thermal station in generating power after garri combined power station and Kosti power station. [8]

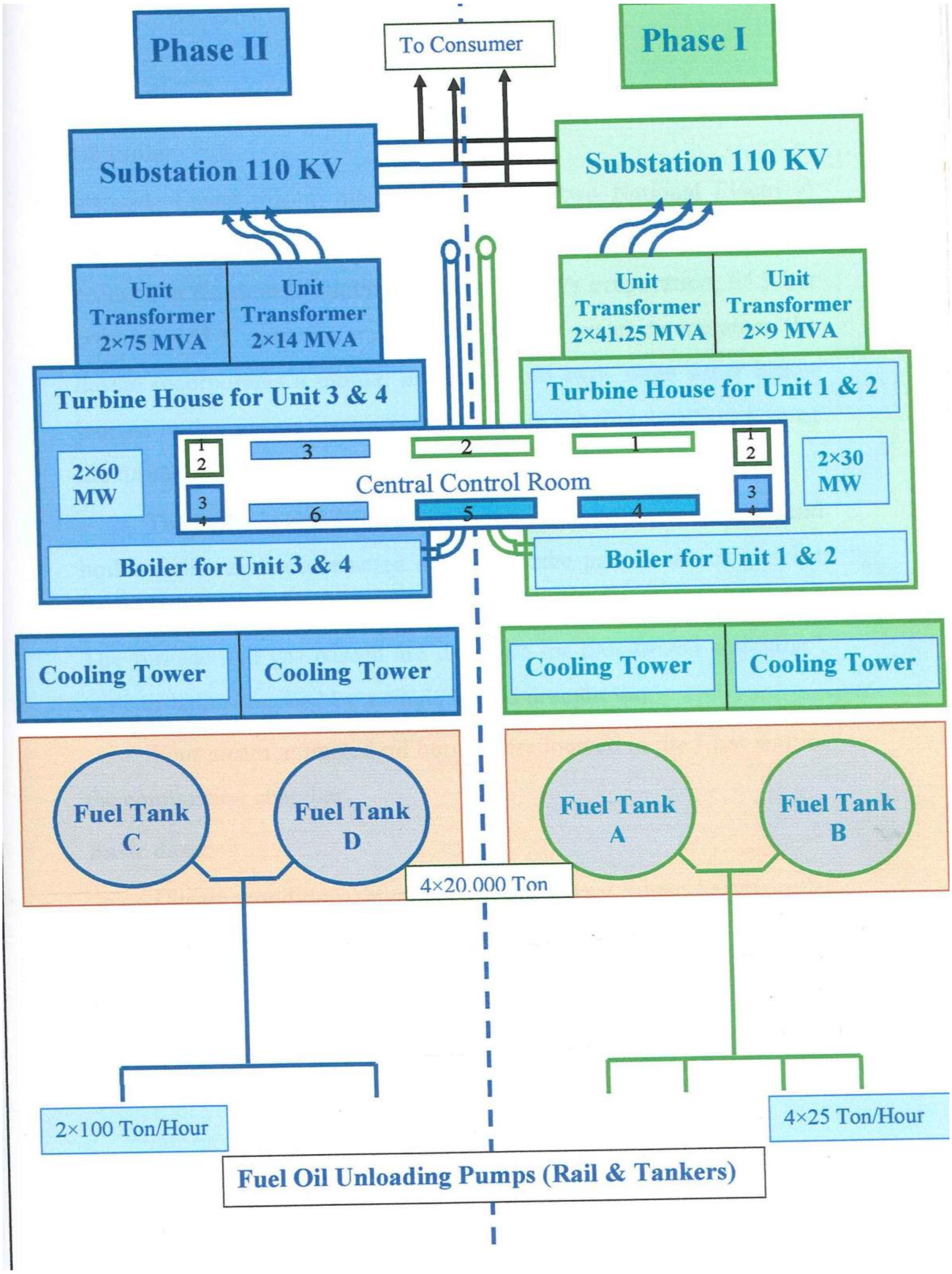


Figure (2-1) schematic diagram of the power station [2]

2-2 Steam System Operation:-

There is four areas follow the path of steam as it leaves the boiler and returns via the condensate return system this four areas (generation, distribution, end use and recovering of steam).

2-2-1 Boiler

The boiler used to convert the chemical energy in the fuel oil to heat energy by burning out the fuel on the boiler furnace; the generated heat converts the water to steam. The boiler of furnace, economizer, air preheater and super heater.

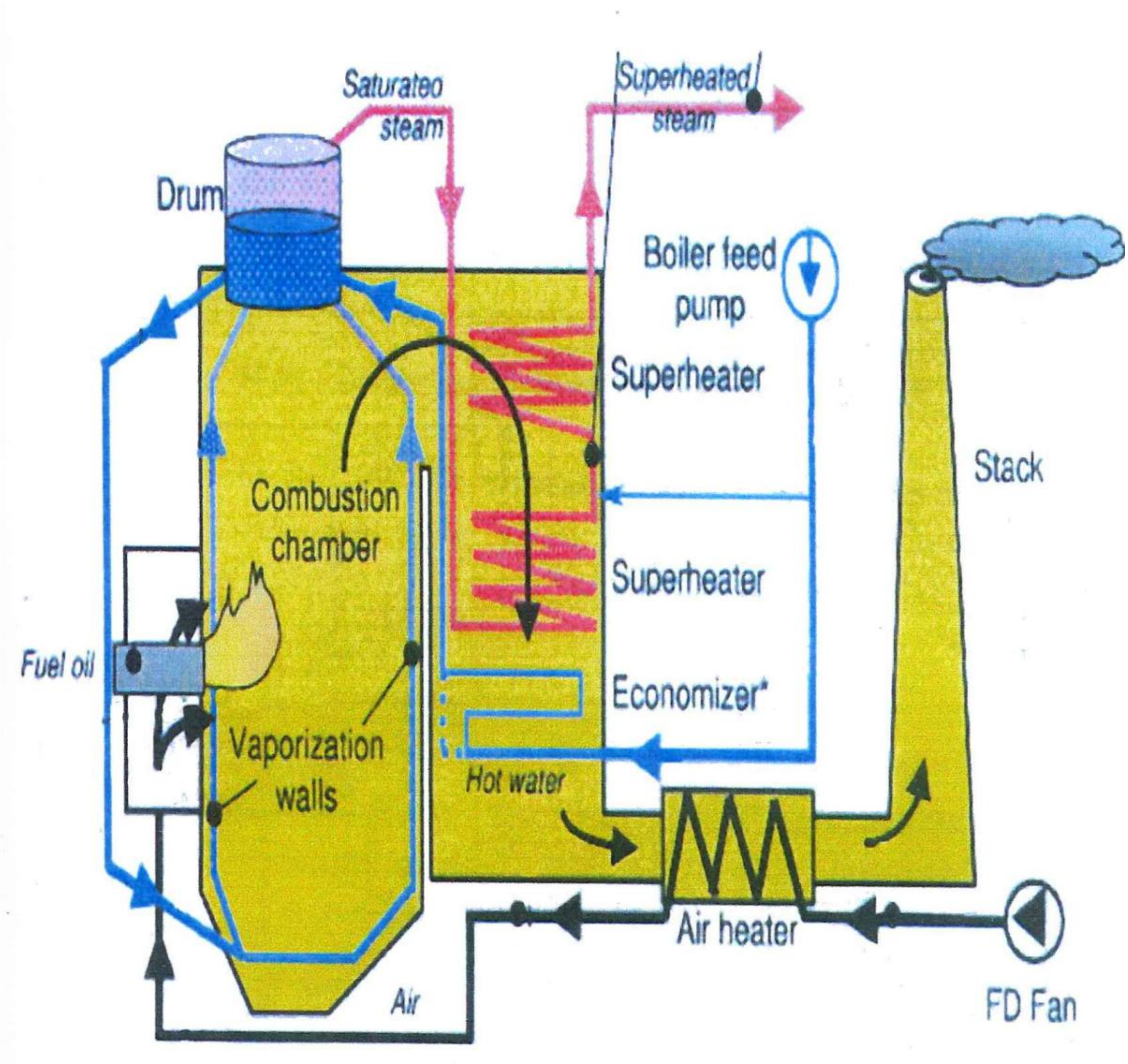


Figure (2-2) the boiler components [4]

2-2-2 Economizer

An economizer is a heat exchanger which acts to preheat the boiler feed water by transferring heat from the flue gases stream. Economizers provide effective methods of increasing boiler efficiency.

2-2-3 Air preheater

Air preheater are similar to economizer in that they transfer energy from the flue gases into the system in these device however the energy is transferred to the incoming combustion air then increasing boiler efficiency.

2-2-4 Super heater

Super heater add energy to steam, resulting in a steam temperature that exceeds the saturation temperature at a specific pressure. Super heater rely on the energy transferred directly from the steam while convective super heater rely on the transfer of additional energy from the flue gases to the steam.

2-2-5Forced Draft Fan

A forced draft fan is located at the inlet of a boiler and pushes ambient air into the burner region, ensuring that adequate air is delivered to the combustion process.

2-2-6 Valves

In steam systems the principle function of valves are to isolate equipment or system branches, to regulate steam flow, and to prevent over press ration. The principal types of valves used in steam system include gate, globe and swing check valves typically isolate steam pressure reducing valves controlling the amount of steam.

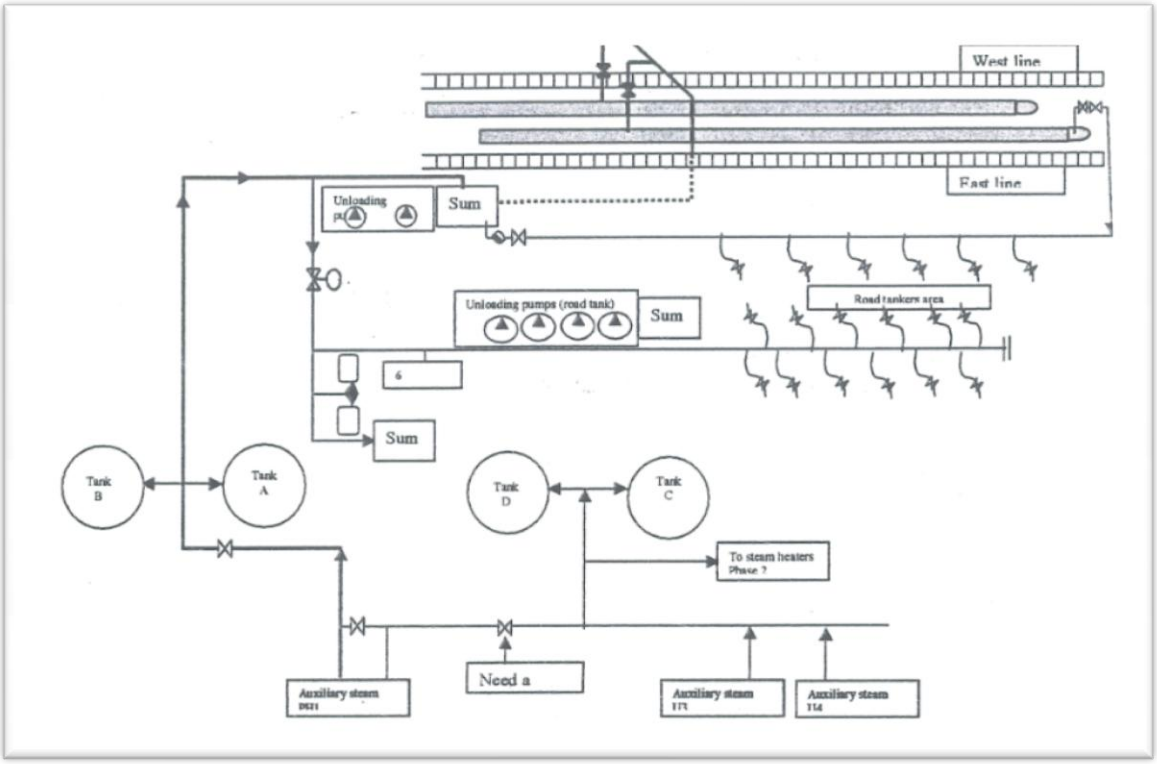


Figure (2-3) Fuel unloading system [5]

2-2-7 Turbine

A turbine is a device which converts theenergy of steam to a mechanical work by passing a fluid, such as steam, through a series of rotating blades. The blades are perpendicular to the flow direction of the steam. The steam expands in the turbine due to the pressure below the atmospheric created by a condenser attached to the turbine. The expansion of the steam results in the rotation of the turbine blades. The rotation blades are attached to a shaft; this shaft does mechanical work on the electrical generator.

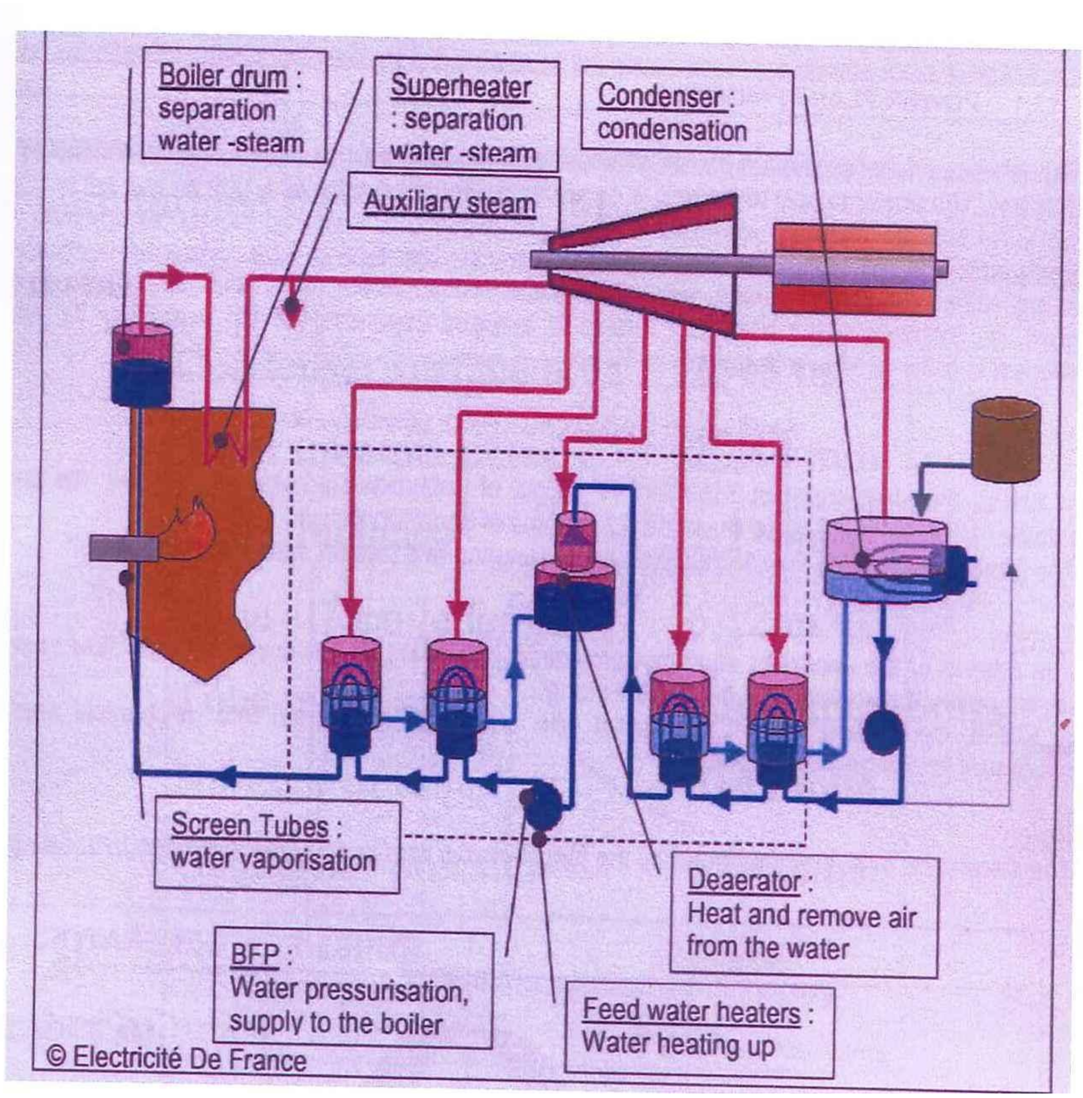


Figure (2-4) steam cycle [6]

2-2-8 Condenser

The condenser is a device which is used to convert the steam back to the liquid phase. A multiple pass shell and tube heat exchanger is used to minimize the amount of heat transfer with water from the cooling tower. The water circulated from the cooling tower returns to cooling tower to be atmospherically cooled. The liquid formed from the steam recycled back to the boiler feed water system. It should be noted that during the condensation process a number of gases become dissolved in the condensate. These dissolved gases are treated by the dearator.

2-2-9 Electrical generator

An electrical generator is a device which converts the Mechanical net work done by the turbine to electrical energy. Electrical generator consist of three windings having a magnetic field, the work done by the blades on the windings results in a motion which is perpendicular to the magnetic field a current is generated in due to this motion in a direction which predicated the right Hand Rule.

2-2-10Pumps

The boiler feed pump is a nine stage horizontal centrifugal pumps of the barrel casing design. The pump internal together with the discharge cover, suction guide, stuffing boxes, bearing housing and pump half coupling, from a cartridge which can be withdrawn from the pump casing as a complete unit for maintenance purpose, without disturbing the suction and discharge pipe work or the alignment of the prime mover the pump shaft is sealed at each and of the pump by Mechanical seals which are flushed with station cooling water. The mechanical seal stuffing boxes are also cooling with station cooling water.

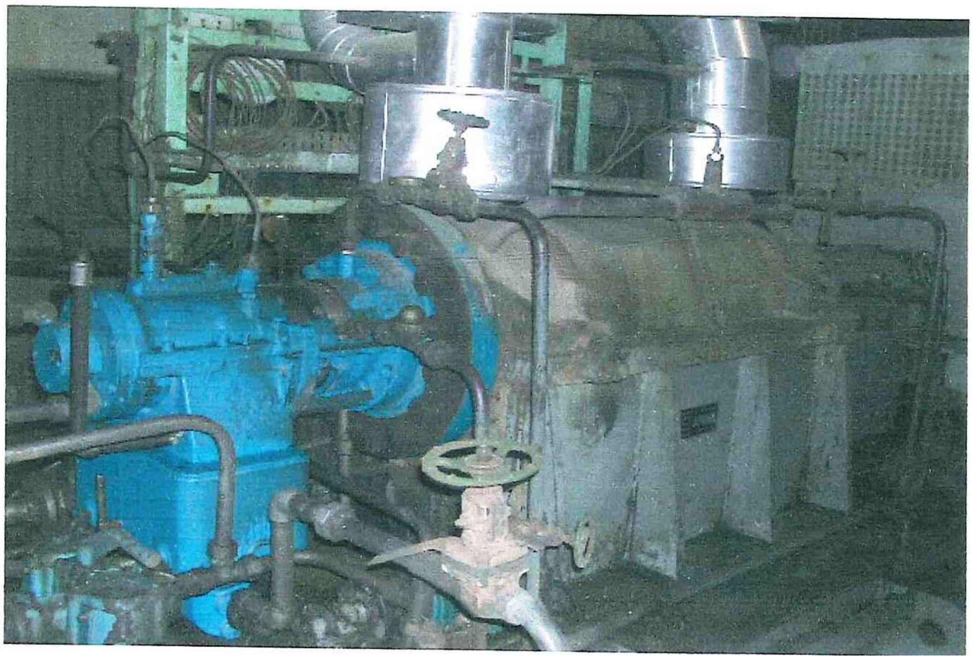


Figure (2-5) boiler feed pump [6]

2-2-11 Cooling Tower

Cooling Tower it is mechanically induced drought crosses flow cooling lower. Air inlet cover is designed to retain water drop lets within the confines of the cooling tower and is positioned to direct the air entering the cooling tower.

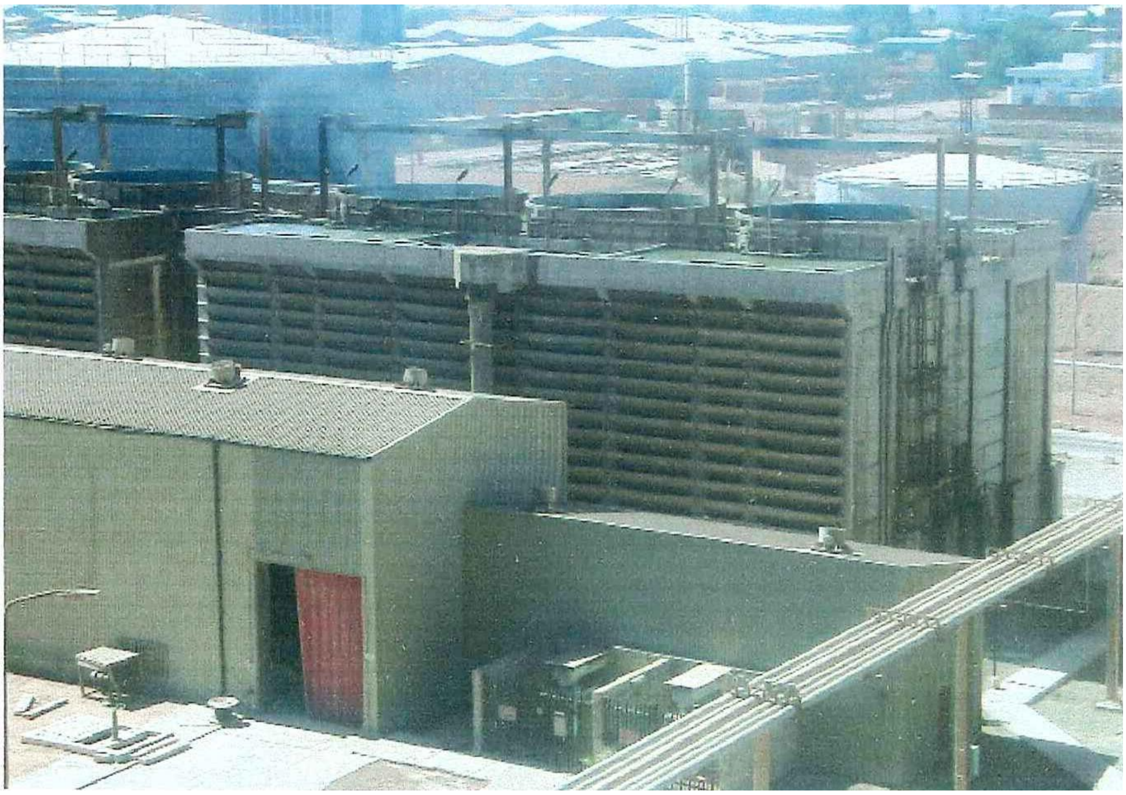


Figure (2-6) cooling tower with cooling fans [6]

2-2-12 Cooling water pump

Cooling water pumps are supplied per unit but the system is arranged so that any two pumps can be used to supply both cooling water circuits located in a pump house on the east side of the cooling towers. The pumps are mounted on plinths below grade level. The arrangement ensures that the pumps minimum suction head is always available an enables the pump suction and discharge headers and the underground pipe work to the turbine generator area to be flooded, prior to starting pump.

2-3 River side

The riverside work is approximately 4.5 km from the main power station site. It is bounded on the north by the kuku Kassala road approximately 0.5 km to the south, the intake life pump structure is located on the Blue Nile. Approximately 0.5 km west and downstream of the intake structure is the clean dram out fall. The main function of the plant are to extract raw water from the river, to treat the water to remove the majority of the suspended solid and to present algae growth, to store the resultant clarified water and to supply it to the main station as required.

The main uses for the clarified water are as make-up for the cooling water system, and as raw water supply to the demineralization plant.

To fulfill these functions, the plant comprises four in take lift pumps, a pre-settlement tank, two clarifiers and two clarified water storage tanks, each of which is fitted with two clarified water forwarding pumps. Associated with the treatment plant are various systems for the handling of chemicals and for the disposal of sludge.

The clean drain out fall permits the disposal of non- toxic waste water from the power station and river side work. From the main power station site, the waste is mainly from boiler blow down and cooling water purge. From the river side work, the waste is chiefly sludge resulting from the clarification process. Electrical supplies for the river side work are obtained from the adjacent kuku 33kv substation.

A local control room provides monitoring and controlling I facilities for the intake lift pumps and the river side work. [6]

2-3-1 Intake lift pump

Four in take lift pumps are provided to supply water from the River Nile to the river side works, thus normally only one or two pumps are in operator each pump is located on a platform which may be raised and lowered to any one of four positions to cater for the seasonal variations in river level. The levels are 2.75m a part. The plat form is moved vertically in guide rail using one of two specially provided hoists.

The pumps are vertically mounted on two stages centrifugal pump driven at 1470 rev/mitt, by 41 5v motors rated at 37 KW. The steel supporting structure, platform and pipe work is protected against corrosion by impressed current catholic production two underground glass reinforced plastic pipe connect the discharge pipe work to the riverside works, where the water enters the pre-Settlement tank via a concrete flume. [6]

the dynamically balanced rotating assembly is supported at the drive end non-drive end of the shaft by plain thin wall white metal lined journal bearings .Axial location of the rotating assembly is maintained by double tilting pad thrust bearing mounted at the non-drive end of the shaft.

The discharge cover is spigot located to the pump casing and is secured a ring of studs, washers and nuts, sealing being effected by a ‘0’ ring located between the cover and the casing. A balance chamber is formed between the discharge cover and the non-drive end stuffing box. The balance chamber leakage returned to the pump suction branch through a pipe welded to a passage drilled in the pump casing. A similar passage is drilled in the discharge cover and sealing between the discharge cover and pump easing connection, where the balance chamber return passes through each component, is effected by an ‘0’ ring .Provision is made in the pump casing for two drain connection. [6]

2-4 Lubricating oil system

The bearings in the boiler feed pump are supplied with lubricating oil from the lubricating oil system incorporated in the pump set. The oil system comprises a main gear type oil pump directly driven from the non-drive end of the pump shaft, a motor driven auxiliary gear type oil pump for starting, standby and emergency duties, two non-return valves, an oil filter and oil cooler.

During auto start-up , the lubricating oil is drawn from the non- drive end bearing sump by the motor- driven auxiliary oil pump and is passed through the oil cooler and the oil filter to the bearings of the boiler feed pump. A pressure switch in the bearing supply manifold clears a starting interlock in the boiler feed pump driving motor circuit and allows the boiler feed pump to be started. Once the has started, the main oil pump driven from the non-driven end of the pump shaft takes over the supply of lubricating oil and at a pre-set pressure a pressure switch will shut down the motor. Driven auxiliary oil pump if the oil pressure falls below a preset pressure, the pressure switch will also automatically start up the motor Driven auxiliary oil pump.[6]

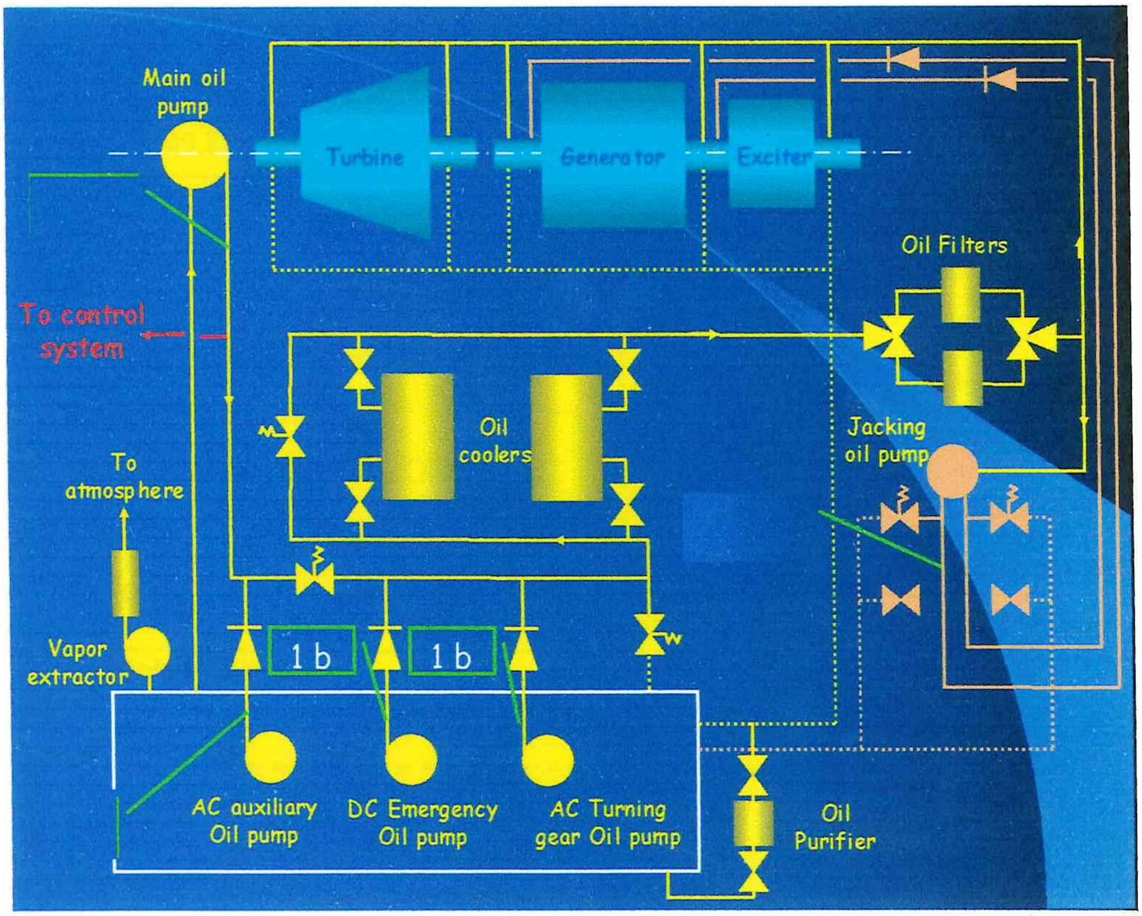


Figure (2-7) lubrication oil system [6]

2-5 Unplanned Outage

It is divide to two type‘unit’s trip and human unplanned outage.

2-5-1 Unit trip

The unit trip means that a unit load lost suddenly (load lost more than 50% of design capacity of unit).

Unit trip may be due to: human error, plant failure and external faults (refer to Appendix (1)) making use appendix (1) from the down time to calculation losses cost.

2-5-1-1 Plant failure:

Plant failure is a problem in any component or cycle operation system, in the station. This problem effect the unit and trip unit.

Parameter	Way of controlling	If	Action	To prevent
O_2: Air excess	• FD Fan speed	Low	Air/Oil ratio trip	Fire out of furnace
		High		Bad efficiency
T: Steam temperature	• Attemperator CV	High	CV Open	Metal stresses
		Low	CV close	Water in turbine
P: Steam Pressure	• Fuel Oil CV	Low	Load drop	Bad boiler circulation
		High	Safety V/v	Pipe distortion
L: Drum level	• Feed regulating CV	Low	Boiler trip	Tubes overheat
	• BFP speed	High	Turbine trip	Water in turbine

CV: Control valve

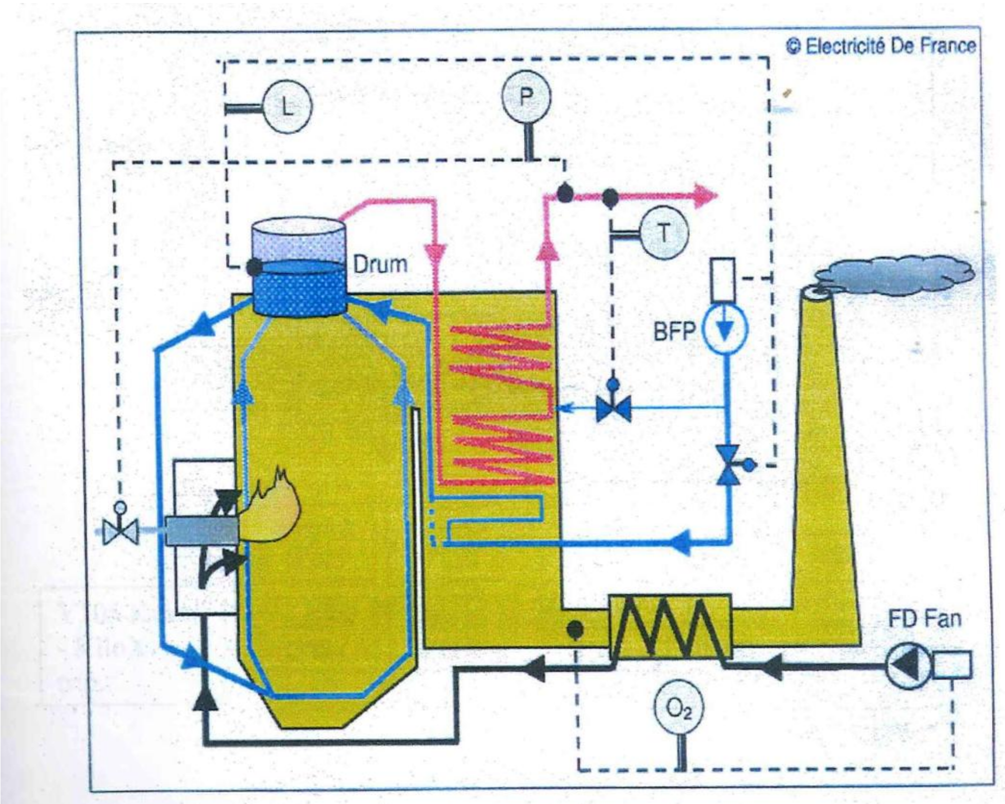


Figure (2-8) boiler control loop and protection [2]

2-5-1-2 External fault

It is a problem of national grid out of station this problem effect in station and trip the station show the fig (2-9),fig (2-10)

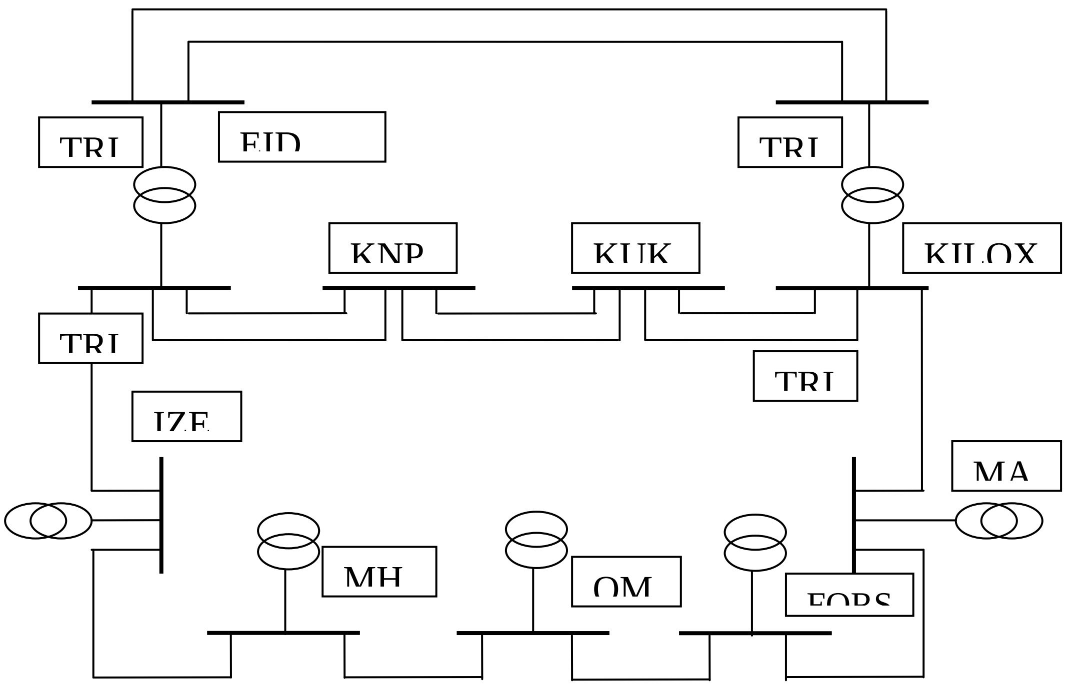


Fig (2-9) Trip of Cycle of National grid [4]

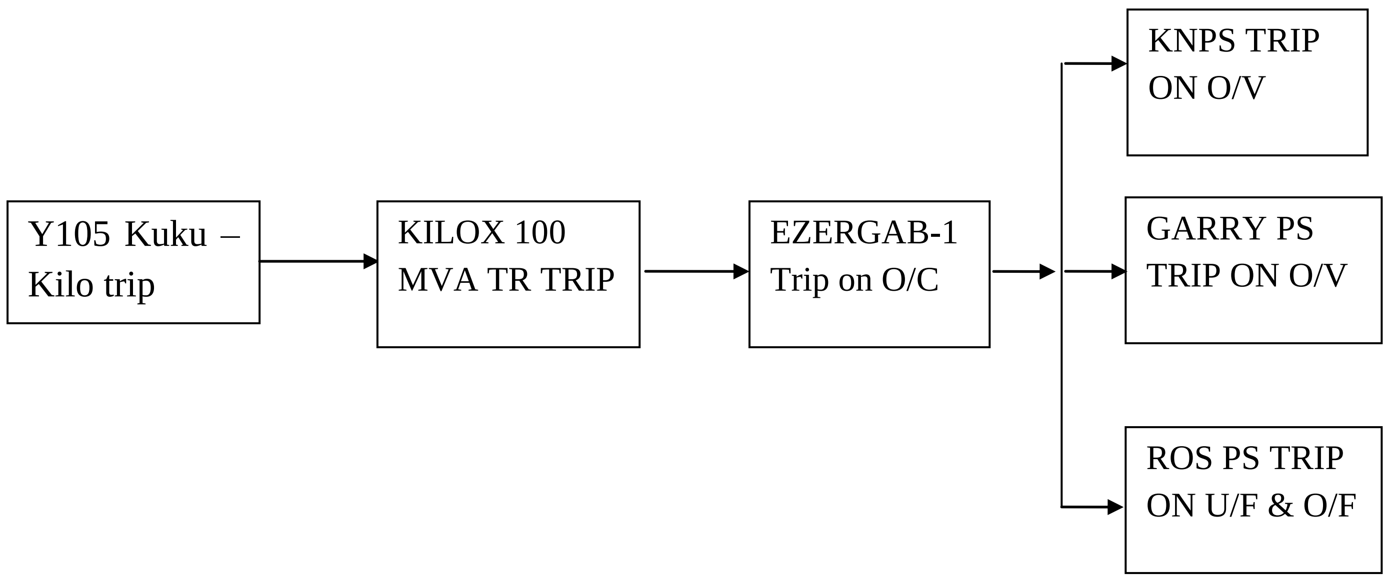


Fig (2-10) Analysis the trip of National grid[4]

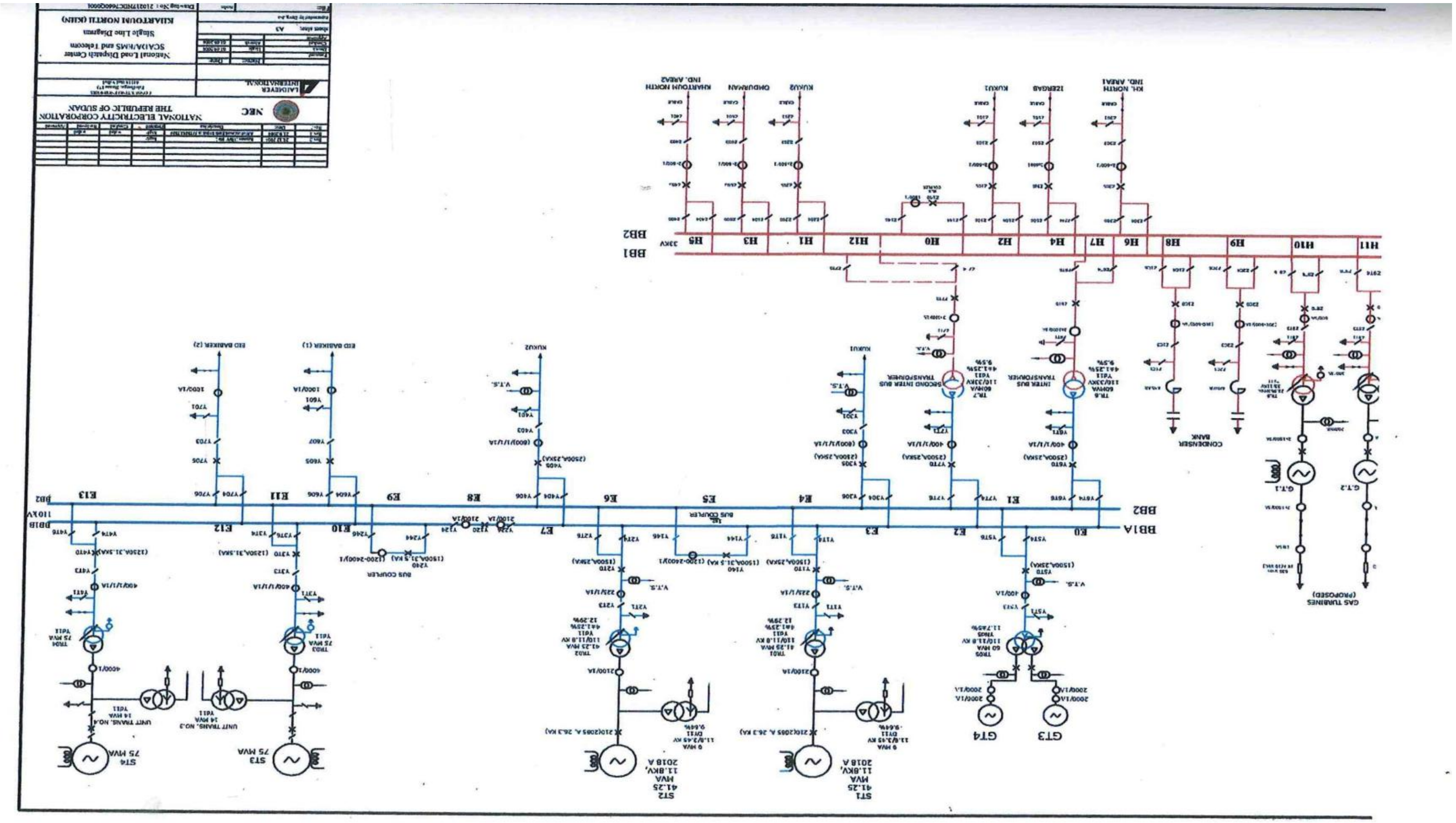


Figure (2-11) single line diagram Khartoum Power station

2-5-1-3 Summary of Definitions

- **Active error Failure**: an active human error is an unintended action or an intended action based on a mistaken diagnosis, interpretation, or other failure, which is not recovered and which has significant negative consequences for the system.
- **Latent Human Error / failure (operation level)**: A latent human error is similar to an active error, but the consequences of the error may only become apparent after a period or when combined with other error or particular operational conditions.
- **Latent Human error/Failure (management Level):**

A management level human error is an inadequate or nonexistent management policy, which creates the preconditions for active latent human, hardware, or software failure.

- **Violation Error I Failure:** A violation error occurs when an intended action is made which deliberately ignores known operation rules, restrictions, or procedures. However, this definition excludes actions that are deliberately intended to harm the system, which come within the category of sabotage.
- **Recovery Error / Failure**: A recovery failure occurs if a potentially recoverable active or latent error is not detected or remedial action is not taken before the negative consequences of the error occur.

2-5-2 Human Unplanned Outage

Human unplanned outage means the unit is shut down by operator due the operation condition of the unit is not proper for equipment safety and efficiency.

2-6 Maintenance

Maintenance is activity performed in order to maintain certain breakdown on equipment and plant.

Technical Definition of maintenance is to keep or restore an asset to an acceptable standard at acceptable cost. [7]

2-6-1 Maintenance objective

Extended and useful life of the assets, maintain the plants equipment using technical performance for production company desires (higher productivity), Decrease the time loss of the production due to the plants equipment failure, Ensure the safety of the personnel using the machinery and equipment and Perform the maintenance operation at lowest cost.

2-6-2 Maintenance type

Can be used into two types: planned maintenance and unplanned maintenance.

2-6-2-1 planned maintenance:

Maintenance, which is known to be necessary sufficiently in advance for normal planning and preparing procedure to be followed it has three major forms:

- **Design-Out maintenance**: This is also known as plant improvement maintenance, and its object is to improve the operation, reliability or capacity of the equipment in place. This sort of work usually involves Studies, Construction Installation Start- up, and running.
- **Preventive maintenance**: t was divided into Systematic and condition based maintenance
    - **Systematic maintenance**: It is attending to serve equipment either according to time schedule or basis of predetermined units of use preventive maintenance is to detect the failure or premature wear to correct before breakdown it is also called the periodic maintenance.
    - **Condition-based maintenance**: it is also called the predictive or auscultative maintenance; it is preventive techniques based on inspection. It depends on continuous observation of an item of equipment to detect possible faults or monitor its condition.

This is the main point of annual preventive maintenance plan Application in the Power Station:

- **Preparation:** evaluation of the current status, efficiency of the main equipment's / parts. List of work order, spare-parts arrival, equipment's/ tools needed, manpower requirement, sub-plans for each section, safety documents &tools, targetsand priorities.
- **Final Plan approval:** meeting, software planning communications, announcement, shutdown test & measurement.
- **Execution:** Daily follow-up meeting weekly management meeting, walk around, safety visit, critical tasks follow up testing.
- **Commissioning:** Final testing, preparation for re-starting first starting & rim-up trails re adjusting - when-where necessary, evaluation for approval & deviations measure.

- **Corrective maintenance:** Also called break down maintenance, Palliative or corrective maintenance this form of maintenance Consists of: Troubleshooting on Machines whose poor condition result in Stoppage or in operation under in tolerable Condition, repairs

2-6-2-2 unplanned maintenance

It is called unscheduled maintenance, by other word can say it is not carried out regularly. This can be represented by emergency maintenance (Work caused by unforeseen break down or damage).

Design-out maintenance, Preventive maintenance and Corrective maintenance are the main Type Used in practice.

Other People were added to type of maintenance to planned maintenance as below:

Running maintenance: Is the work carried out with asset remaining use. Shutdown maintenance: The work carried out when the asset is out of service.

Break down maintenance: Means the work carried out after failure of an asset. Figure (2-12) and Figure (2-13) are showing the forms of maintenance and planned and unplanned maintenance respectively.

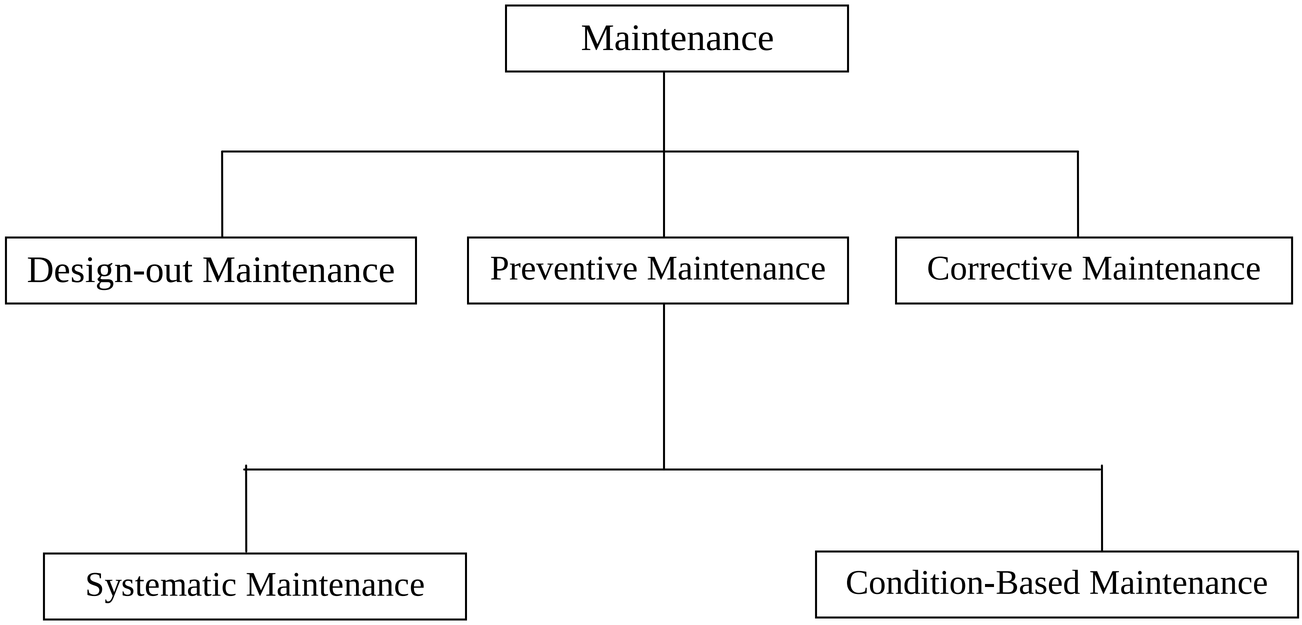


Fig (2-12): The form of the Maintenance [7]

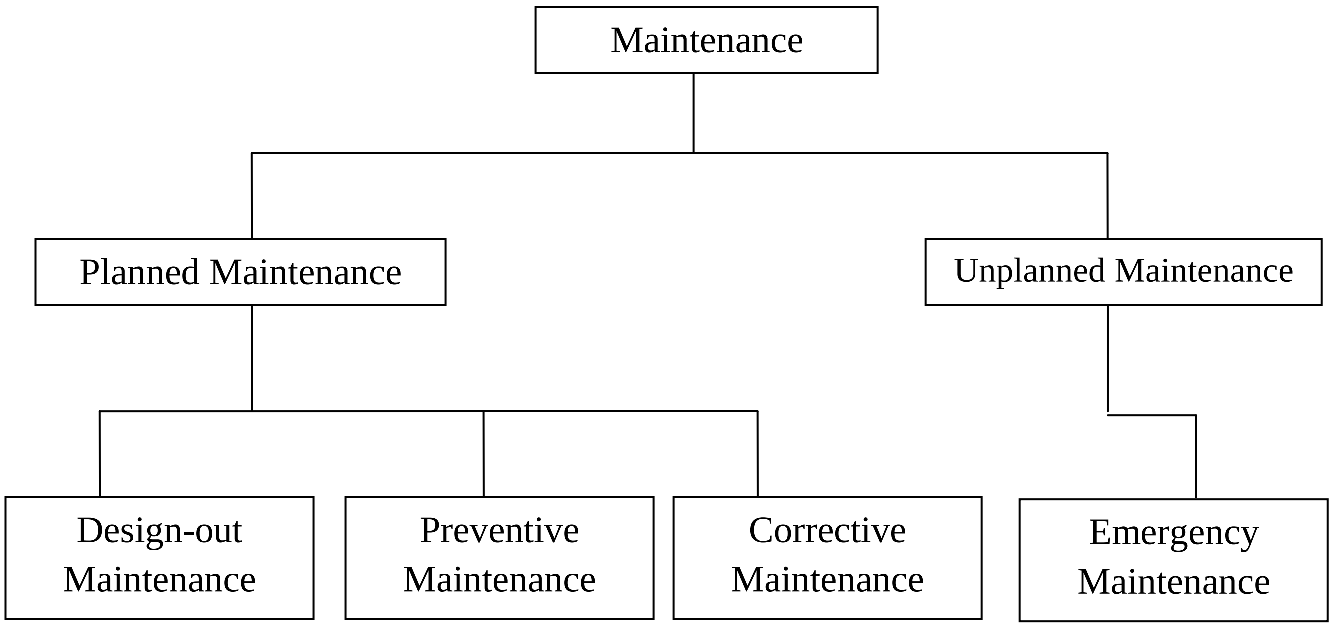


Fig (2-13): Planned and Unplanned Maintenance [7]

2-6-3 Maintenance Planning

Maintenance Planning is the function which concern with daily maintenance. The repair schedule, preventive and design out maintenance periodic overhauls, planned replacement and activities of Control Station.

In establishing planning system, in the power station concern with identify and list all items (building, transport item, auxiliary equipment), arrange in Convenient Section to provide plant inventory (according to process , Type of equipment), each item of equipment or plant chooses between planned maintenance or emergency maintenance or both, List maintenance-work to be done according to time scheduling Master Plan maintenance (maintenance chart for whole plant or section of plant), prepare the details of maintenance instruction sheet sheets or schedules for every item, organize the team of maintenance Organize the documentation system to run maintenance System run Smoothly, Check and develop the planned maintenance program from time to lime and organized the spare parts system (Supply time life and ordering).

2-6-4 Maintenance Organization:

Maintenance organization is not easy in designing, because it is difficult to say this is the optimum organization, so there are points for helping in designing maintenance organization:

Engineers in maintenance department have to study all proposal organization and prepare operation procedure.

The workshop equipment must be prepared early before machines are installed.

The maintenance office must set up in order to be in Operation when equipment arrives. Method offers should start preventive maintenance, Lubrication file checking the technical documentation complete spare part forecasts.

Central maintenance planning office (CMPO) should be gradually put in action, at least one year before start up.

Spare part maintenance section (SPMS) put in action gradually once the equipment and extra parts start arriving.

After start-up, mechanical and electrical services should insure availability of machine and give a priority to preventive maintenance.

When in the power station is operating the priority of the following points should be considered:

- Evaluation of machine data by updating of preventive program.
- Maintenance management performance indicators.
- Stock management.
- Improvement of work method and planning.
- Good in award receiving and safe keeping of all supplies.

Contract maintenance services: This can be used in the following condition:

Work for specialist skill land available in market or required on the routine basis (fire sprinkler system, heating system, air condition).

Work which can be done by others with lower cost.

Fire appliance and safety revaluation and Precaution firefighting appliances should be the responsibility of maintenance department (Usually be maintained by an outside contractor). Maintenance department must consider of labor safety, accident cause and damage of plant and equipment.

2-6-5 Maintenance Analysis

There are two sorts of cost, direct cost and indirect cost direct maintenance cost:

It is determine actual maintenance practice and all quantifiable work the list below shows various components:

Regular maintenance (Controls and checks), Labor, Equipment, Consumables (spare part and stock management), Training, Sub contracting and Technological Updating

Failure cost (Indirect cost): it is a result of unavailability of equipment and causes losses of production. The list of failure cost shows as blows:

Losses of production or service, Alternative in the quality or service, delivery delays, depreciation, work accident, deterioration in the work place and environment and Station image.

2-7 Maintenance Management

All activities of maintenance should be managed in proper way Maintenance management need to adopt their language (Technical), so that the executives and decision makers will understand.

2-7-1 Maintenance Management Function

It is Summarize of most important point as shown below:

- To optimize the reliability of equipment and infrastructure. To make the equipment and infrastructure in a good condition. To carry out the emergency repair of equipment and infrastructure for best possible availability for production. To enhance the modification and the extensions with new low cost items.
- To monitor and ensure the operation of equipment for production and for distribution of energy and fluids.
- To improve safety operation, too train personnel in specific maintenance skills, to advise on acquisition, Installation and machine Operation of, to contribute to finished high generation, to ensure the environmental protection.

2-7-2 Management tools for maintenance

Performance indicators are generally presented in coefficient form or relation between two absolute values (ration). The ratios are the tools for monitoring maintenance system.

Performance indicators are divided in to two categories of ratio:

- **Economic ratio**: which evaluated the internal result and allow Comparison between maintenance services of similar plant.
- **Technical Ratio**: which checking technical performance of installation.

2-7-3 Management and Charts

The principle objective of chart are:

- To serve as a warning if something goes wrong in maintenance Practice.
- To allow systematic comparison with previous result and establish the evaluation of parameter and trends.
- To judge the performance of different maintenance Service (with, the limits of ratio).
- Experience proves that a good maintenance management is only possible if the manager is correctly informed.

This is much Type of charts and graphs to assist maintenance function.

2-7-4 Maintenance departments:

Maintenance department must consist of plan and making possible preparation for main work through suitable techniques and appropriate resource.

2-7-4-1 maintenance Department Structure

The simplest organization chart of maintenance department contains the following function:

Maintenance management: Is responsible for technical and administrative management. The particular concerns with supervisor work, interpreting technical failure, giving instruction for maintenance program, recruiting personnel, Taking part in a board meeting and advising on equipment.

Planning: It is responsibility for methods (Preventive program, work Preparation) and work planning (programming scheduling) section also responsible selecting part to store and administration the stores. Intervention for preventive maintenance and Corrective maintenance Spare part Storage: It is responsible for stock keeping (registration Conservation, Storage) and issuing of spare parts.

Workshops: It is responsible for minor jobs to repair in mechanical and electrical department.

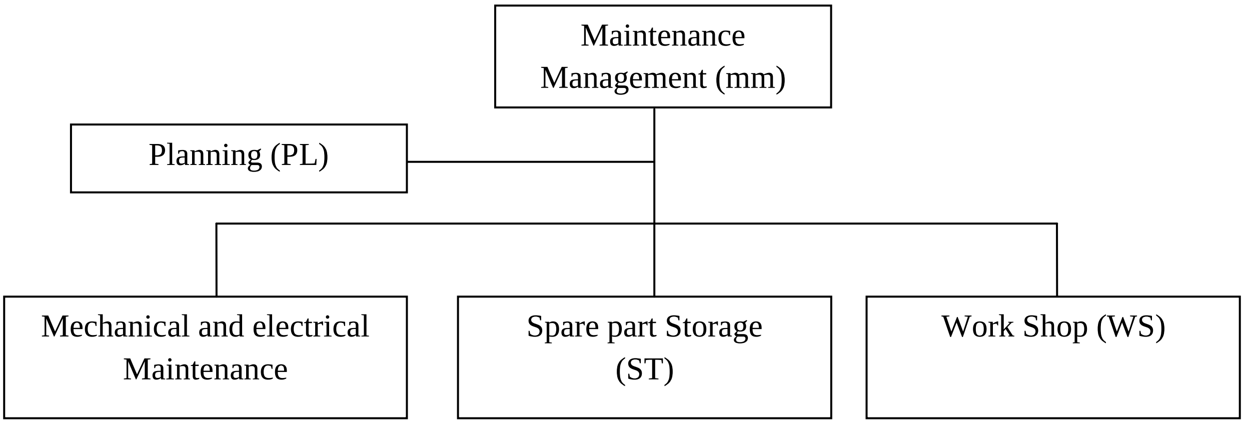


Fig (2-14): Simple maintenance Department chart [7]

2-7-4-2 Activities of maintenance Department

Maintenance department activities can divide in to activities, but these activities can be decrease or increase or maintenance operation The Activities are summarized below:

- **Engineering**: It concern with study and design of modification existing equipment (improving capacity, quality of production, operation safety maintainability and environment impact). Also Concern with monitor work executed by maintenance team.
- **Job preparation**: It concern with studies, job specification, material resources time allocation and workload.
- **Work program**: it determines by work scheduling assembly the required material, human resources, rowing program and setting time limits.

Chapter three

Material and method

3-1 The study site

The field is located at Khartoum north power station, the power station lies on the eastern edge of an industrial zone hence is bounded to the east and south by kafori district and to the west and south by businesses.

Arail way line was connected from Khartoum north rail way station to the power station to deliver furnace fuel via rail tankers. Also an asphalted road connected omer elmukhtar Main Street to the power station to diesel and furnace fuel via road tankers and to use for transportation especially during rainy season.

From this description is been that the station is near to the transportation, distribution station and is near to the consumer regions.

3-2 Data collection

3-2-1 Field unit trip

Field unit trip of power station collection of data in power station by efficiency office it registers in computer by the staff in the station.

Table (3-1) unit trip statistics January 2011 to December 2015 Appendix (8)

Year	Total no. of unit trips		
	Human error	**Plant failure**	**External faults**
2011	12	42	10
2012	7	42	8
2013	3	58	2
2014	5	18	2
2015	5	54	6
Total	32	214	28

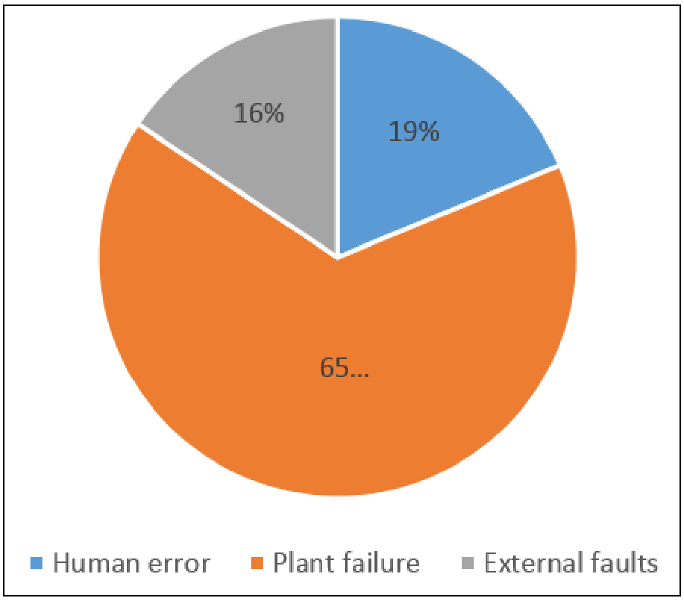


Figure (3-1) show unit trip statistics year 2011

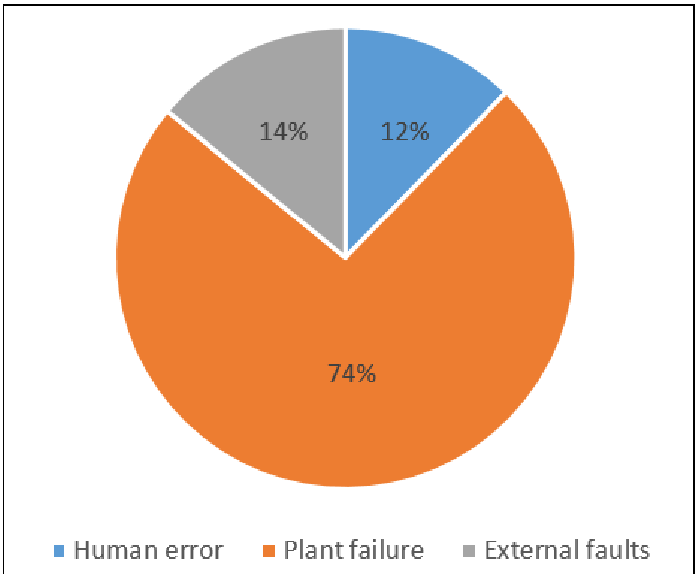


Figure (3-2) show unit trip statistics year 2012

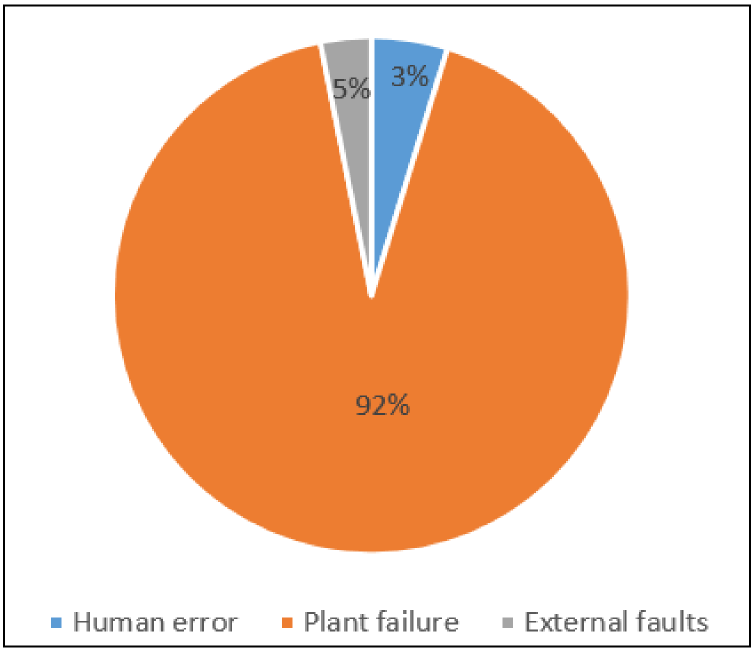


Figure (3-3) unit trip statistics year 2013

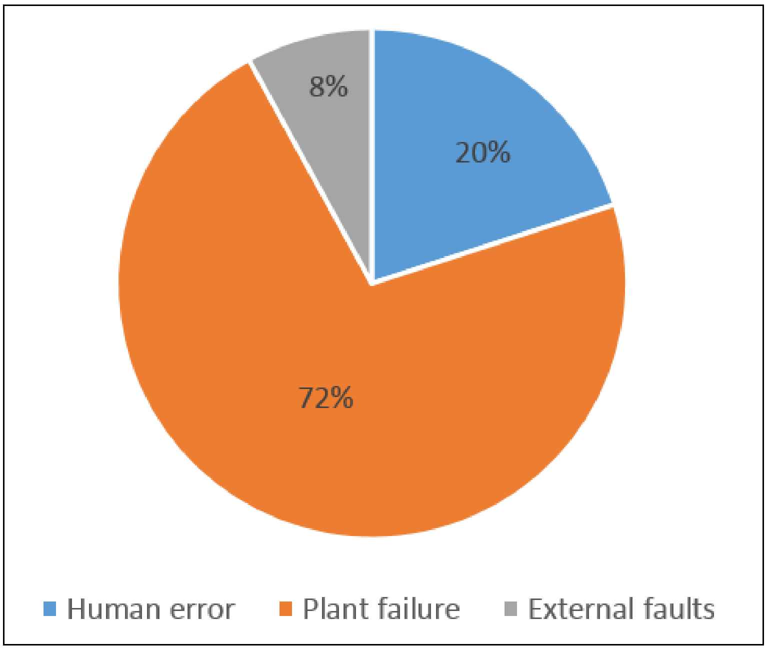


Figure (3-4) unit trip statistics year 2014

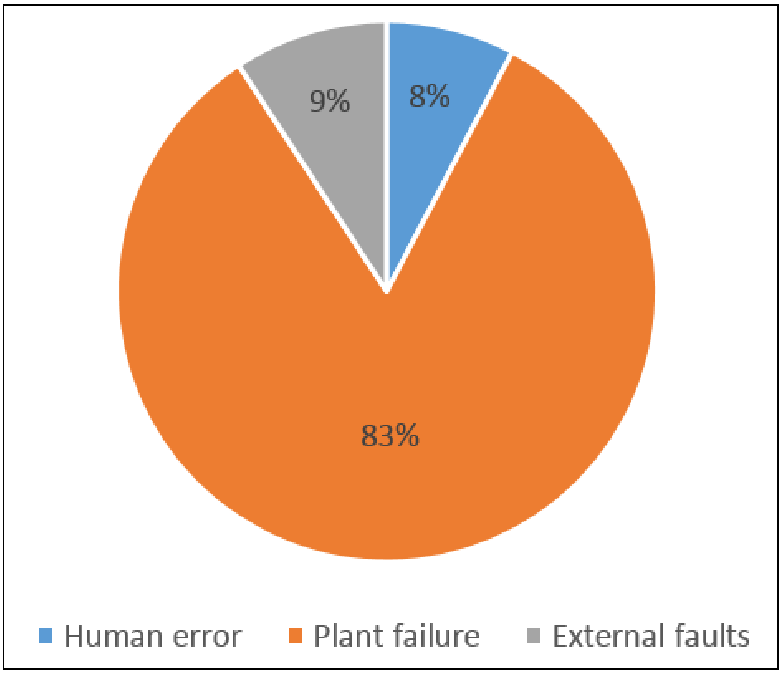


Figure (3-5) unit trip statistics year 2015

3-2-2 Field unit's human unplanned outage

Field unit's human unplanned outage collection of data by efficiency office it registers in computer by staff in the station

Table (3-2) shows units human unplanned outage statistics from January 2011 to December 2015

Table (3-2)

Year	Total human unplanned outage
2011	25
2012	25
2013	58
2014	40
2015	33
total	**181**

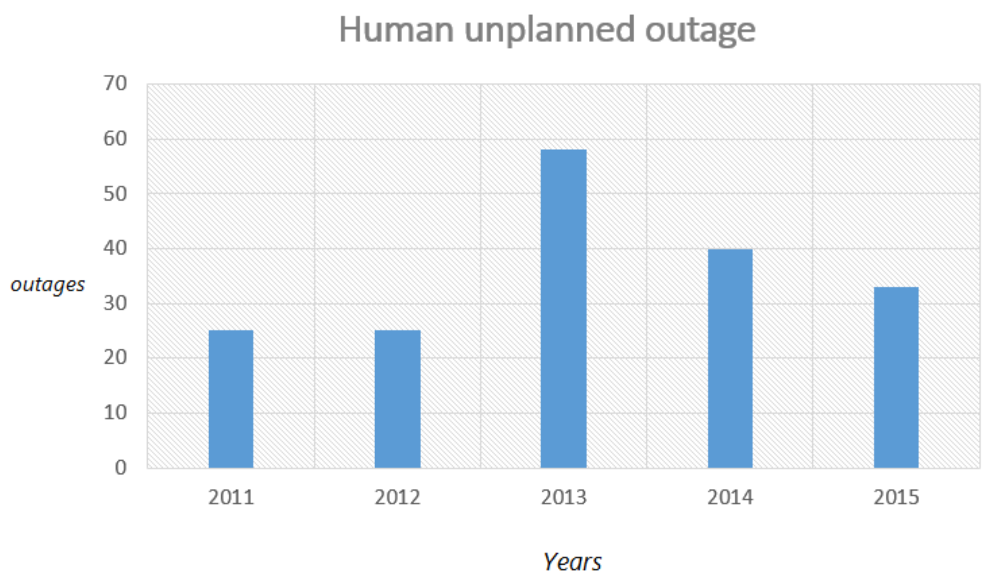


Figure (3-6) units unplanned outage statistics

3.2.3 Data collection of training

Collection data of training in the all power stations in the Sudan from the training center Abu haraz of electricity (refer to appendix (5)).

Collection of data in the power station has passed its designed lifetime collected from internet.(refer to Reference(10)).

3.3 Calculation Losses Cost:

The equation of losses cost is depended to down time, load of unit and cost kilo watt hour.

3.3.1 Calculation kilowatt hour (kWh) Cost:

The equation of kilo watt hour is depended to salaries& wages, operation cost, maintenance cost, generation expenditure Depreciation and insurance, (refer to Appendix (6)).

Dr=TAV

Where

Dr = Depreciation Rate per Month (1)

TAV = Total Assets Value

IRPM=TAV × 1.8 × 1\12 (2)

Where

1RPM = Insurance Rate per Month

Cost of kWh= **Tota1** Cost \ **Tota1 Generation power** (3)

Tota1Gnen'uionPower

Losses Cost down time load of unit ***x*** Cost KWH (4)

Phase (1) down time of two unit =

down time of unit (1.) **+** down time of unit2 (5)

Phase (2) down time of two unit =

down time of unit (3) +down time of unit 4 (6)

Chapter four

Results and Discussion

4-1 losses cost

This calculation of losses cost from period (January 2011 to December 2015) and it calculation on power generation losses cost by down time because no data about losses of materials, time in case of maintenance, clean, lubrication, communications and transportation.

4-1-1 Calculation of kilo watt hour cost

Calculation of kilo watt hour cost the kWh cost from total cost of salaries wages, operation cost, maintenance cost, generation expenditure depreciation and insurance.

Kilo watt hour different from month to month because it depended on an operation and maintenance cost

4-1-2 load of unit

Load of unit is the different between (I), (II) and phase (III)

Phase I

Unit (1) = 30 MW

Unit (2) = 30 MW

Phase II

Unit (3)=60 MW

Unit (4) = 60 MW

Phase III

Unit (5)=100 MW

Unit (6) = 100 MW

Table (4-1) Cost of kilo watt (SDG) from 2011 to 2015: Appendix (6)

Year	Average cost of kwh (SDG)
2011	0.2
2012	0.22
2013	0.18
2014	0.17
2015	0.21

4-1-3 Calculation of losses cost of unit trip year 2011

Losses cost = losses of unit x cost of kWh

Table (4-2) losses cost of units trip year 2011

Units	**Trip losses 10^6 kwh**	**Cost of kwh (SDG)**	**Losses cost 10^6(SDG)**
Unit 1	0.85	0.2	0.17
Unit 2	0.0	0.2	0
Unit 3	5.4	0.2	1.08
Unit 4	8.1	0.2	1.62
Unit 5	1.2	0.2	0.24
Unit 6	4.5	0.2	0.9
Total losses cost			**4.01**

4-1-4 Calculation of losses cost of unit trip year 2012

Table (4-3) losses cost of unit trip year 2012:

Units	**Trip losses 10^6 kwh**	**Cost of kwh (SDG)**	**Losses cost 10^6(SDG)**
Unit 1	2.7	0.22	0.594
Unit 2	0.0	0.22	0
Unit 3	2.2	0.22	0.484
Unit 4	5.1	0.22	1.122
Unit 5	15.3	0.22	3.366
Unit 6	19.5	0.22	4.29
Total losses cost			**9.856**

4-1-5 Calculation of losses cost of unit trip year 2013

Table (4-4) losses cost of unit trip year 2013:

Units	Trip losses 10^6 kwh	Cost of kwh (SDG)	Losses cost 10^6(SDG)
Unit 1	3.5	0.18	0.63
Unit 2	0.0	0.18	0
Unit 3	2.92	0.18	0.526
Unit 4	1.63	0.18	0.293
Unit 5	20.2	0.18	3.64
Unit 6	35.8	0.18	6.444
Total losses cost			**11.53**

4-1-6Calculation of losses cost of unit trip year 2014

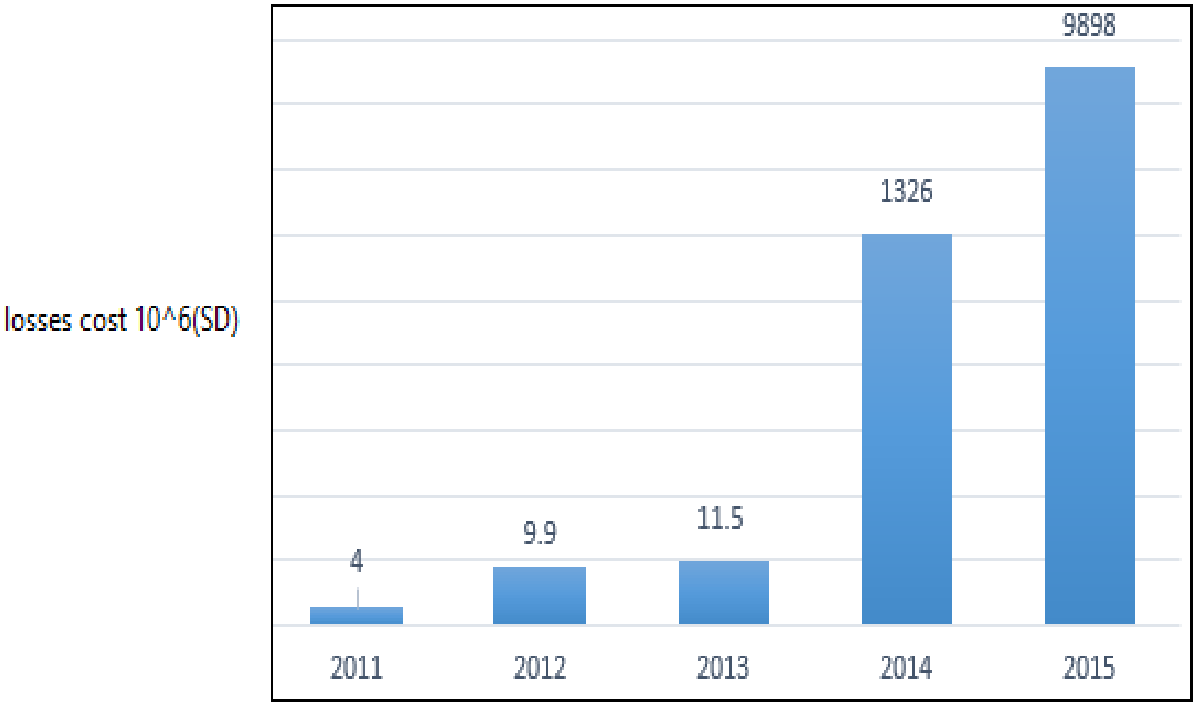
Table (4-5) losses cost of unit trip year 2014:

Units	Trip losses 10^6 kwh	Cost of kwh (SDG)	Losses cost 10^6(SDG)
Unit 1	315.9	0.17	53.7
Unit 2	0.0	0.17	0
Unit 3	2869	0.17	487.73
Unit 4	2367	0.17	402.39
Unit 5	_	0.17	_
Unit 6	2248.3	0.17	382.2
Total losses cost			**1326**

4-1-7 Calculation of losses cost of unit trip year 2015

Table (4-6) losses cost of unit trip year 2015:

Units	Trip losses 10^6 kwh	Cost of kwh (SDG)	Losses cost 10^6(SDG)
Unit 1	1466	0.21	307.86
Unit 2	0.0	0.21	0
Unit 3	2291	0.21	481.11
Unit 4	3061	0.21	642.81
Unit 5	22826	0.21	4793.46
Unit 6	17488	0.21	3672.5
Total losses cost			**9897.7**



Year

Figure (4-1) unit trip statistics from 2011 to 2015:

4-1-8Calculation of losses cost of human unplanned outage year 2011

Table (4-7) losses cost of unit unplanned outage year 2011:

Units	**Unplanned outage losses(10^6kwh)**	**Cost of kwh (SDG)**	**Losses cost 10^6(SDG)**
Unit 1	47.7	0.2	9.54
Unit 2	110.16	0.2	22.032
Unit 3	16.1	0.2	3.22
Unit 4	30.3	0.2	6.06
Unit 5	33.1	0.2	6.62
Unit 6	33.6	0.2	6.72
Total losses cost			**54.2**

4-1-9 Calculation of losses cost of human unplanned outage year 2012

Table (4-8) losses cost of unit unplanned outage year 2012:

Units	Unplanned outage losses(10^6kwh)	**Cost of kwh (SDG)**	**Losses cost 10^6(SDG)**
Unit 1	43	0.22	9.46
Unit 2	264	0.22	58.1
Unit 3	66	0.22	14.52
Unit 4	104	0.22	22.88
Unit 5	142	0.22	31.24
Unit 6	193	0.22	42.46
Total losses cost			**178.66**

4-1-10 Calculation of losses cost of human unplanned outage year2013

Table (4-9) losses cost of unit unplanned outage year 2013:

Units	Unplanned outage losses(10^6kwh)	**Cost of kwh (SDG)**	**Losses cost 10^6(SDG)**
Unit 1	79	0.18	14.22
Unit 2	-	0.18	-
Unit 3	49	0.18	8.82
Unit 4	170.3	0.18	30.65
Unit 5	300	0.18	54
Unit 6	500	0.18	90
Total losses cost			**197.7**

4-1-11Calculation of losses cost of human unplanned outage year2014

Table (4-10) losses cost of unit unplanned outage year 2014:

Units	Unplanned outage losses(10^6kwh)	**Cost of kwh (SDG)**	**Losses cost 10^6(SDG)**
Unit 1	60544	0.17	10292
Unit 2	-	0.17	-
Unit 3	98996	0.17	16829
Unit 4	63548	0.17	10803
Unit 5	-	0.17	-
Unit 6	-	0.17	-
Total losses cost			**37924**

4-1-12 Calculation of losses cost of human unplanned outage year 2015

Table (4-11) losses cost of unit unplanned outage year 2015:

Units	Unplanned outage losses(10^6kwh)	**Cost of kwh (SDG)**	**Losses cost 10^6(SDG)**
Unit 1	9964	0.21	2092
Unit 2	236520	0.21	49669
Unit 3	84492	0.21	17743
Unit 4	32677	0.21	6862
Unit 5	188846	0.21	39658
Unit 6	259652	0.21	54527
Total losses cost			**170551**

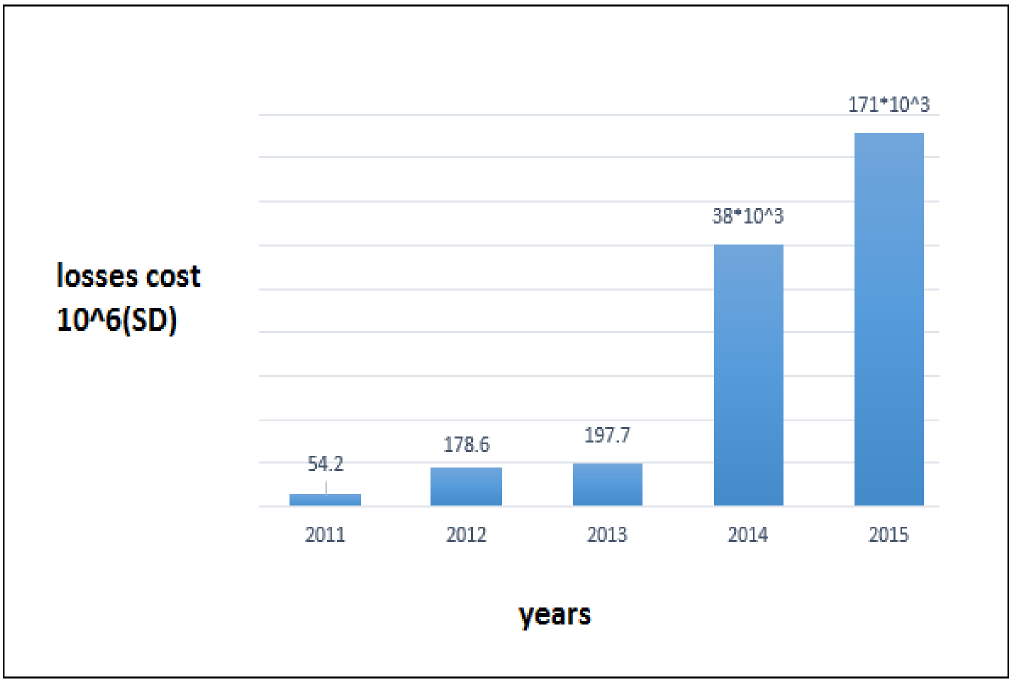


Figure (4-2) unit unplanned outage statistics from 2011 to 2015:

Table (4-12) show total losses cost for years 2011 till 2015:

Year	**Losses cost of unit trip**	**Losses cost of human unplanned outage(10^6 SDG)**	**Total 10^6 (SDG)**
2011	4.01	54.2	58.21
2012	9.856	178.66	188.516
2013	11.53	197.7	209.23
2014	13.26	37924	39250
2015	9897.7	170551	180448.7
Total	11249.1	208905.6	220154.7

With reference to table (4-12), it can be noticed that losses cost due to unit trip increases cost from year to year, human unplanned outage of losses cost is increase from year to year.

All this problem the main case is the power station (phase I, phase II) are passed its design life time. The solution of this problems are rehabilitation the power station (phase I, phase II), training and improvement performance power station.

4-2 Rehabilitation

Steam power units more than 25 years in operation are facing serious threats in view of their remaining lifetime. Even in case of proper operation & maintenance, the ageing of power plant leads to higher production cost mainly due to:

- Deterioration of original performance (output & efficiency).
- Loss of availability by increased number and duration of forced outages.

Steam power plant rehabilitation is a cost-effective method to regain competitive electricity production cost of older power plant units.

The result of a successful rehabilitation are reduced electricity production cost achieved by output increase, and prevent the unplanned outage of the plant failure, heat rate improvement, and availability enhancement while at the same time extending life time and complying with stricter environmental standards. These targets are reached by a complete plant approach using plant system engineering and project management tools.

Rehabilitation of and older power plant means to introduce and overall technical concept in order to recapture or exceed the original performance and availability while complying with environmental requirements and extending the remaining service live. Rehabilitation is involving either the total plant or major plant systems.

Rehabilitation usually includes the refurbishment of component and / or ordinary service work.

4-2-1 Rehabilitation objectives

1. Recapture or exceed original plants performance.
2. Improve availability reliability.
3. Comply with environmental standards.
4. Increase plant failure.

4-2-2 Improving the plant heat rate

Optimizing the heat rate of generating units requires careful balancing of the boiler and steam turbine generator / condenser performance.

In the case of the boiler, a rehabilitation project must begin with a complete analysis of the existing operational issues, including emission limits, and identification of available solution, this must include evaluation of any changes brought about by the modifications to the steam turbine, such as different reheat steam flow and inlet temperature. Boiler efficiency improvement can be realized through upgrading components with better designs optimizing system performance, and eliminating conditions that degrade efficiency between maintenance outages. primary areas to be considered is this review are fuel preparation and transport firing system design furnace wall cleaning convective heat transfer surface arrangement, and air pre-heater heating element and seal design.

Retrofitting of rotors diaphragms or more commonly of complete stator\rotor modules(inner block)is now well proven way of significantly improving the heat rate of steam turbine The new design of steam turbine blade is quite distinct from its popular two-dimensional predecessor. Thefully three dimensional blade profiles enable a step change in efficiency in a cylinder to be made.

Another very effective means of improving the unit efficiency is to improve vacuum or back pressure Condenser tube bundle design 25 year ago was largely focused on packing as many tube in the available volume as possible. As a result some tubes condensed very little steam.

Are designed state of the art tube bundle pattern will allow steam to access all the tube and an improvement in condensing pressure is achieved cooling towers can also be retrofitted with modern packing to give an improvement in cooling water temperature and hence an lower condensing pressure and ultimately a higher power output.

4-2-3 Maximizing the output

As is the casewithoptimizing the plant heat rate, maximizing the plant output can be best approached by balancing boiler and steam turbine performance. Many 20 year old steam turbines have a design margin which is unused with the Boiler Maximum Continuous Rate often *3%* higher than the Valves Wide open turbine steam flows. Modifying the unit to run at Boiler Maximum Continuous Rate conditions is possible and will yield valuable megawatts. In addition, by considering both boiler and turbine, it is often possible to redesign the steam conditions to further increase the output of the plant.

The boiler feed system is usually designed for Boiler Maximum Continuous Rate condition and should not need up-rating. Plant such as the condenser and condensate extraction pumps, however would be designed around valves wide open condition. The pumps would be specified with a margin (10%) and can usually a accommodate Boiler Maximum Continuous Rate conditions once fully refurbished, however due to the size and cost of a condenser there is usually on margin.

In the boiler two change from the original design are typically encountered. First, higher main steam flow is required because of improvements to the HP section, higher reheat steam flow is sent back to the boiler at a lower temperature. The main steam changes can be accommodated by improve steam drum separation and minimizing pressure drop through the super heater. Reheat change are more complex and typically involve new tube surface to increase heat absorption with the minimal effect on system pressure drop. Other key changes are the requirement for greater heat input to the boiler and regulatory pressure to maintain or reduce emission within established limits. Steam turbine blading can be replaced or modified to accommodate the increase steam flow with only selected rows having to be changed.

However, the increased heat rejection to consider will give rise to a higher condensing pressure and worsen the heat rate due to the limited margin in it. This is where the trade of comes, and it is easy to see from a chart of electricity pool price why extra megawatt at the expense of heat rate might be more beneficial.

Electrical generator also tends to have design margin that will accommodate the extra megawatts.

4-2-4 Achieving a higher reliability / Availability

Curing forced outage causes improves reliability. Reducing the time spent on planned outages, in combination will the improved reliability will improve availability. Here there is scope to re-engineer high maintenance area, again with the input of the operations and maintenance staff at the station, and review the planned outage regime.

As noted earlier, the primary cause of forced outages of a boiler are tube leaks and fouling. Programs to a aggressively manage boiler tube leaks should include maintenance of accurate records of forced outage events, closed attention of feed water treatment, and use of weld over lays and coating in high wear / corrosion areas. Fouling can be addressed through proper design of heat absorption surface clear spacing improved clean equipment, and well-tuned firing systems.

With accurate instrumentation, with continuously monitor key parameters of the plant and enable outages to be planned when they are needed, thereby allowing the plant to generate for longer periods between shutdowns.

4-2-5 Aiming at lifetime extension

Life extension is a reasonably well established principle, which is starting together momentum in the global power generation market.

The residual life time assessment will focus on these components which have creep life or fatigue life limitations. To the operator-these mean running hours and controlled (and forced) stop / starts respectively. When much of the 20-25 Years old plant was originally designed, the plant was expected to run base load and the only thermal limited applied in the design was creep. Thermal fatigue resulting from frequent stop/ start was not anticipated.

Electrical generators are also examined thoroughly due to the nature of the loading on the winding and the material of the end caps or retaining rings, and the fact that the insulation is deteriorating with time, temperature and fatigue.

Obsolescence, particularly in control systems and switchgear area, can be a major problem, ultimately leading to a situation where replacement of major portions evens the complete system is required.

Steam power plant rehabilitation is a feasible solution for older unit having achieved more than 200.000 operation hours. Rehabilitation keeps valuable generation capacity in service will increase a viability level while meeting enhanced environmental standards.

Competitive electricity production costs are regularly achieved with significantly less capital investment compared to building a new station.

A standardized process of rehabilitation project development including assessment of plant condition and residual life time ensures reliable feasibility results for decision making taking into account technical and economic factors.

Rehabilitation in the power stations is preventing the unplanned outage.

4-3 Training and performance:

Training:

Training requires much more than simply following: and practicing the procedures. It requires understanding the reasons for the procedures, the consequence of deviations from these procedures and recognition and accommodation for the fact that actual performance will differ from that observed in training sessions. The training should as for as is possible, reduce their differences, or at least the significance of such differences. It is essential that operating procedures and training be closely integrated.

Training should in no way be considered as a substitute or remedy for poor design. Although poor training is frequently given as the reason for people making mistakes, we must emphasize that working in an error - likely situation is probably a more valid reason. Good training will have considered the relevant human factors elements.

Training can be considered to take place at two levels:

- The general (appreciation, overview, awareness), education level**.**
- The detail level of being able to perform tasks, functions or acquire skills.

While it is impractical to provide employees with detailed human factors training, process safety, and management training should provide an overview of the subject. The detailed training in operations, maintenance inspections, and tests. Must include reference to specific and readily applicable human factors issues. An integral part of training is the existence of quality procedures to follow. Writing quality procedures is not a casual skill; it requires proper consideration of all the ways the user interacts with the procedure.

In all training programs, the importance of identifying, reporting, and eliminating error-likely situations, reporting mistakes and near misses and looking for ways to prevent error should be emphasized. Once again, this requires a blame-free environment.

The following are some human factors aspects relevant to training but they are mean only as a stimulus to further study and consideration and not as an authoritative and exhaustive checklist:

- The trainer must understand human factors principles.

- The training environment should be noise-free, with proper lighting and a comfortable temperature provided. Good audio-visual aids should be used.
- Lines of communication should be kept short. Transfer of information is probably least accurate by a work of mouth. Avoid superfluous information.
- Understanding the objectives of a procedure and the consequences of deviation are a vital part of learning how to perform the procedure knowing process limitations and tolerances is also important.
- Choosing the tasks best suited to equipment and allowing people to do the task they are best suited to, is better than training people to do jobs which they are ill-suited. Practice need to be carried using training situations similar to the active tasks and the differences between the real and artificial situation need to be appreciated.

All activities are based on various levels of ability, skill based actions are virtually automatic and may fail due to distractions and change. Rule based actions require good procedures and adequate time. Knowledge based actions require technical knowledge and organized thinking. Different types and levels of training and practice are required for these different abilities. Recognize the effects of stress in case of emergencies. The actual emergency probably will differ considerably from those practiced. The reluctance to acknowledge that the emergency practiced. The reluctance to acknowledge that the emergency exists is a well-known cause of delayed response. Complex decisions are doomed to failure under stress.

People develop bad habits and take things for granted. Processes equipment, and technology change, so retaining is essential at appropriate intervals.

Develop realistic evaluation exercises to verify that effective learning of skills has occurred.

Performance:

In addition to proper training and quality procedures, good performance requires a supportive culture and working environment. The procedures provides the how to the training reinforces this with the background, the understanding, and the practice to develop the necessary skills; the environmental must support their quality execution.

An encouraging, motivational environment is likely to evoke better performance than a threatening one, it is generally accepted that results are better where employees are empowered to contribute and participate rather just follow. Training and performance is preventing the human error.

Chapter five

Conclusion and recommendation

5-1 Conclusion

1. The main causes of all plant failure in the power station are due to that is the power station has passed its designed life time (phase one and phase two)
2. The deficiency of training maintenance and operation plays the main role in increasing the down time
3. The study could cover the station problem during the period (Jan 2011-Dec 2015)
4. The cost of stoppage in the power station is about $220*10^9$(SDG).
5. From the information mentioned above , it can be noticed thatif the rehabilitation of the station and good training maintenance and operation they will save more than $220*10^9$(SDG).

5-2 Recommendations

a) Rehabilitation of the power station, including the refurbishment of components and ordinary service work in advance technical standard.

b) Formulating corporate maintenance management plan, including the maintenance concept and relevant training.

c) Maintenance specialists should take part in all negotiations during the acquisition of new equipment.

d) In the development of human resources, there are two urgent priorities motivation and training. One of the problem is to attract highly qualified personnel to field which traditionally offers rather poor career prospects. The company should provide better career opportunities for maintenance personnel.

e) To keep the spare part level in perfect quantity.

f) Observation on the cables of electrical from column between station and substation, and concern rampart to protect the column of electrical on main roads.

g) The health and safety of both men and machines have to be carefully looked after. The order line of work place has to be assured to improve total productivity and the labor force, and to avoid accident.

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Appendix

Appendix (1)

KNPS unit trip statistic year 2011

Losses Classifications

GWH	Unplanned Out	Planned Out.	Trips	Others	Total Losses	Remarks
UNIT1	47.7220	45.3600	0.8515	8.5554	102.4889	
UNIT2	110.1600	152.6400	0.0000	0.0000	262.8000	
UNIT3	16.0489	0.0000	5.4366	43.0828	64.5683	
UNIT4	30.2936	6.6230	8.0702	52.4462	97.4330	
UNIT5	33.0840	53.7600	1.1690	9.6988	97.7118	
UNIT6	33.6100	63.1750	4.5108	9.6558	110.9516	
Station	270.918	321.5580	20.0381	123.4390	735.9535	

Outages Losses

Uplanned Outage	Energy losses	frequency of
Cause	(GWh)	Occurance
Water/steam leak	64	4
Boiler tube failure	25	4
Turbine outages	17	3
Boiler outages	11	3
Gov.devects	36	3
FDF defect	0	0
RAH defect	1	1
UPS outages	2	2
MFT replacement	0	0
Generator Work	0	0
Others	115	5
total forced outage	270,918	25

Appendix (1)

KNPS unit trip statistic year 2012

Loss Classifications

GWH	Unplanned Out	Planned Out.	Trips	Performance & Others	Total Losses	Remarks
UNIT1	42.9664	1.4400	2.7236	21.2818	68.4118	
UNIT2	263.5200	0.0000	0.0000	0.0000	263.5200	U2 N/A all year
UNIT3	65.8470	84.3900	2.1940	78.1880	230.6189	
UNIT4	103.6820	60.4800	5.0899	79.9219	249.1738	
UNIT5	141.9937	0.0000	15.3167	53.5613	210.8716	
UNIT6	193.2050	0.0000	19.4597	45.5920	258.2567	
Station	811.214	146.310	44.784	278.545	1280.853	

Outage Losses

Uplanned Outage Cause	Energy losses (GWh)	frequency of Occurance
Water/steam leak	0	0
Boiler Outages	169	13
Turbine outages	145	8
110 kv CB outages	0	0
BFP Defect	0	1
FDF defect	0	0
RAH Defect	5	3
Cooling water leak	0	0
CT Fans	0	0
MFT replacement	0	0
Generator Work	5	2
Others	267	9
total forced outage	270.918	25

Appendix (1)

KNPS unit trip statistic year 2013

Loss Classifications

GWH	Unplanned Out	Planned Out	Trips	Performance & Others	Total Losses	Remarks
UNIT1	79.2347	33.6960	3.5068	7.1080	123.5455	
UNIT2	0.0000	0.0000	0.0000	0.0000	0.0000	U2 N/A all year
UNIT3	48.5183	9.6000	2.9191	23.4844	84.5219	
UNIT4	170.3258	49.9792	1.6250	78.1185	300.0485	
UNIT5	299.7733	0.0000	20.1532	46.5515	366.4780	
UNIT6	498.5699	50.4000	35.7562	37.1716	621.8976	
GT1	0.0000	0.0000	0.0000	0.0000	0.0000	GT1 N/A all year
GT4	0.0000	0.0000	0.0000	0.0000	0.0000	GT4 N/A all year
Station	1096.422	143.675	63.960	192.434	1496.491	

Outage Losses

Uplanned Outage Cause	frequency of Occurance	Energy losses (GWh)
Others	11	149
TV Problems (PH3)	7	586
T/A ESV Relay/Bled st	6	14
Boiler Tube Failure	5	10
Annual O/H Unplanned	5	85
T/A oil system Defects	4	16
Boiler water Contaminc	3	85
Furnace Defects	3	25
Transformer Defects	3	16
Barring Gear Defects	2	11
Boiler Acid Cleaning	2	19
RAH Defects	2	35
Safety Valve Defects	2	6
Trip Investigation	2	16
T/A bearing vibration	1	22
total forced outage	58	1096.422

Appendix (1)

KNPS unit trip statistic year 2014

Loss Classifications

GWH	Unplanned Out	Planned Out.	Trips	Performance & Others	Total Losses	Remarks
UNIT1	60544.3394	15573.6000	315.8991	######	######	
UNIT2	236520.0000	0.0000	0.0000	0.0000	######	U2 N/A all year
UNIT3	98995.8385	40862.5000	######	######	######	
UNIT4	63547.4932	40800.0000	######	######	######	
UNIT5	789600.0000	86400.0000	0.0000	0.0000	######	U5 N/A all year
UNIT6	582428.3033	0.0000	######	######	######	
GT1	0.0000	0.0000	0.0000	0.0000	0.0000	GT1 N/A all year
GT4	0.0000	0.0000	0.0000	0.0000	0.0000	GT4 N/A all year
Station	1831635.974	183636.100	7800.864	######	######	

Outage Losses

Uplanned Outage	Energy losses	frequency of
Cause	(GWh)	Occurance
Boiler water contamination	542,9	8
Boiler tube failure	250,4	5
Annual O/H extension	255,5	4
Miscellaneous	40,4	5
Burners Defects	25,7	3
Turbine defects	12,8	3
Boiler front fire incident	15,1	2
Boiler water leak	12,4	2
ESV/TV defects	47,4	2
HPH leakages	3,2	2
Boiler 5 tube distortion	580,8	1
Fuel oil header press. Low	8,1	1
Furnace gas leak	27,1	1
Steam leakage	3,9	1
total forced outage	1825,661	40

Appendix (1)

KNPS unit trip statistic year 2015

Loss Classifications

GWH	Unplanned Out	Planned Out.	Trips	Performance & Others	Total Losses	Remarks
UNIT1	9964.8000	0.0000	1466.1100	47042.5900	58473.5000	
UNIT2	236520.0000	0.0000	0.0000	0.0000	########	U2 N/A all year
UNIT3	84492.4972	12000.0000	2291.6685	130061.6293	########	
UNIT4	32677.4985	31544.9850	3061.6517	100512.7861	167796.9213	
UNIT5	188846.2837	419336.6330	22826.6443	73608.4390	########	SAACKE project
UNIT6	259651.6670	346281.6670	17488.3213	43484.3447	########	AACKE project
GT1	0.0000	0.0000	0.0000	0.0000	0.0000	GT1 N/A all year
GT4	0.0000	0.0000	0.0000	0.0000	0.0000	GT4 N/A all year
Station	812152.746	809163.285	47134.396	394709.789	2063160.216	

Outage Losses

Uplanned Outage	Energy losses	frequency of
Cause	(GWh)	Occurance
Boiler water contamin	157753,4	5
Boiler tube failure	14305,1	4
Annual O/H extension	297467,2	5
Miscellaneous	41305,2	8
Burners Defects	0,0	0
Turbine defects	3925,0	1
Boiler front fire incid	0,0	0
Boiler water leak	3087,0	2
ESV/TV defects	45583,3	4
HPH leakages	6050,8	2
Boiler 5 tube distortic	0,0	0
Fuel oil header press.	0,0	0
Furnace gas leak	6155,5	2
Steam leakage	0,0	0
total forced outage	575632,459	33

Appendix (2)

NATIONAL ELECTRICITY CORPORATION

KHARTOUM NORTH POWER STATION

Department: OPERATION

Date: 5/04/2012

INCIDENT REPORT

TRIP ON UNIT (1) 5/ 04 / 2013

Ref. DOC Number :

SUMMARY: This report is about the incident happened on unit (1) 5 / 04 / 2013 Boiler trip

Index	WRITER		CHECKER	
	Name	Sign	Name	Sign
A	Tariq Abbadi Ali	Abadi	Nasor Ahmed Nasor	

FOLLOW-UP OF THE EVOLUTIONS

INDEX	NATURE OF THE MODIFICATIONS	JUSTIFICATIONS	DATE
A	Creation of the document		4/05/2013

Appendix (2)

STPG KHARTOUM NORTH POWER STATION	INCIDENT REPORT TRIP ON UNIT (1) 5/04/2013	Ref DOC NUMBER OPE/IR/

1. GENERAL INFORMATION

GENERALITY

	1	2	3	4
UNIT	X			

		D	M	Y		H	M
TRIP	Date	05	04	13	Time	09	40
SYNCHRONIZING	Date	18	04	13	Time	16	51

PARTS OF UNIT CONCERNED: Boiler

NATURE OF THE INCIDENT

Black out		*	Internal trip		*
Delay on grid program	X	*	No-load without separation		*
			Voluntary trip		*

SUMMARY DESCRIPTION

Heavy grid disturbance caused the F.O FWDG pump to trip by overvoltage .No fuel to boiler Steam pressure decreased and turbine shutdown.

COMPLEMENTARY DOCUMENT (Others incident report)

PROGRESS	Y	
Finished	X	

2. REPERCUSSION

IMPACTS ON THE UNIT

Unavailability	27	MW	During	2	15

IMPACTS ON THE PERFORMANCES (others units)

Unit 1	Unit 2	Unit 3	Unit 4
60 MWH	-	-	-

IMPACTS ON THE MATERIALS

Outage prolonged after trip due to barring gear defect which caused a total loss of 8400 MWH

TEMPORARY MEASURES (temporary instructions, bridges …)

3. INCIDENT ANALYSIS

SITUATION OF THE UNIT BEFORE THE INCIDENT

Load	26	MW	Reactive load	08	MVAR

Regulation operated manually X * Which one? :

State of materials before the incident

N.OK NO available s/by F.O FWDG pumps

Appendix (2)

STPG KHARTOUM NORTH POWER STATION	INCIDENT REPORT TRIP ON UNIT (1) 5/04/2013	Ref DOC NUMBER OPE/IR/

Facts in chronological orders (before the trip)

TIME			PHYSICAL PHENOMENA APPEARED	BEHAVIOR OF ALARMS & PROTECTIONS			
H	M	S		Title	OK	IA	OO
09	40	00			X		
					X		
					X		

OK : Correct / IA : Improperly adjusted (doorstep and temporizing) / OO : Out of Order

Final state of the unit and materials (after the trip)

- 12:27Unit Synchronized (LDCI).

Chronology of the startup (after synchronizing)

OK

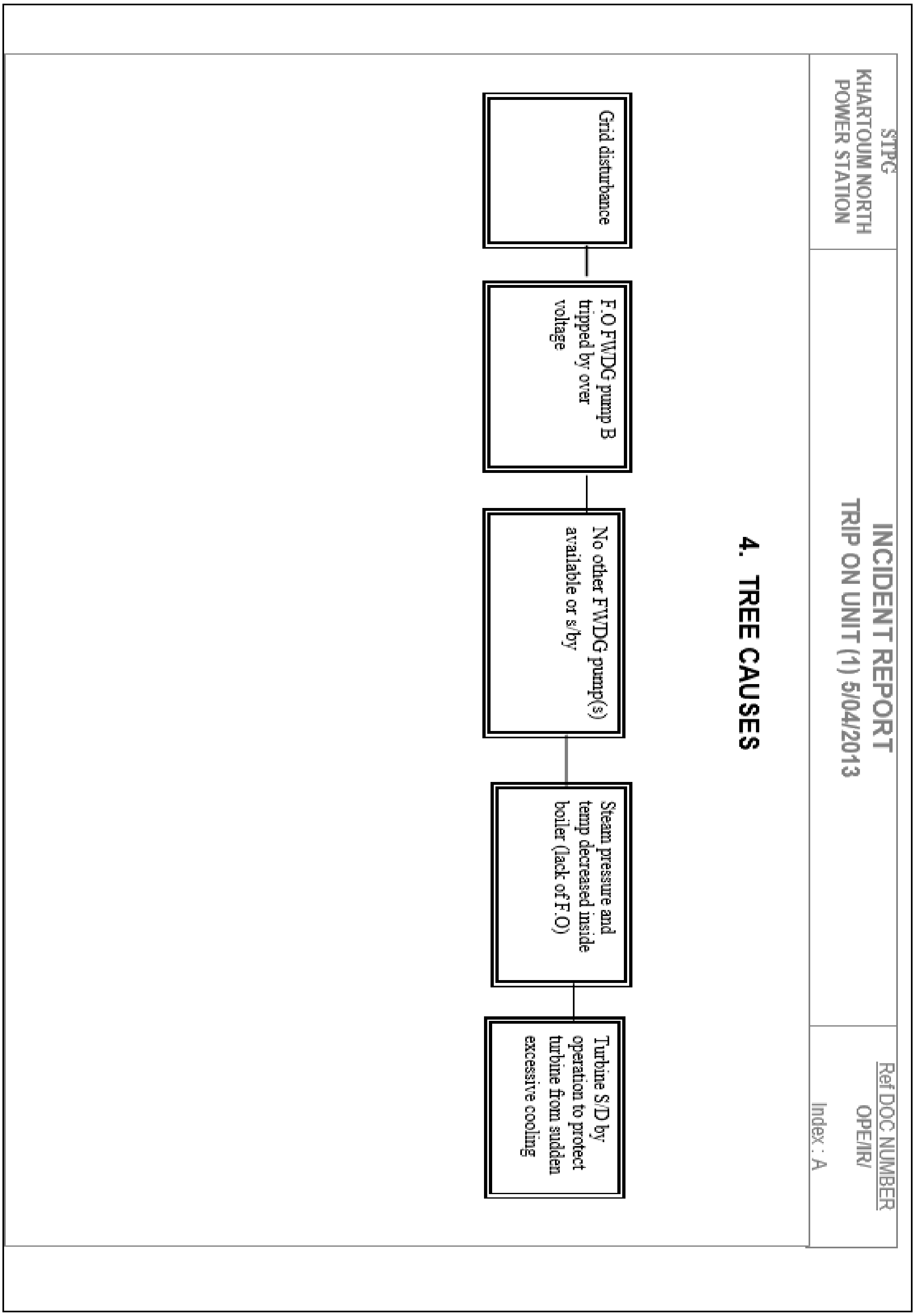
Behavior of the shift	Behavior of the material
O.K.	NO.K.
Behavior of the regulation	**Behavior of the protection (alarm & trip)**
N.OK.	N.O.K.

CAUSES OF THE INCIDENT

	A	B
1. EXTERNAL CAUSES		
1.1 - Grid defect	X	
1.2 - Others		
2. HUMAN CAUSES		
2.1 - Tests		
2.2 - Operation		
2.3 - Permit for work		
2.4 - Works		
2.5 - Others		
3. TECHNICAL CAUSES		
3.1 - Damages main material		
3.2 - Defect protection		
3.3 - Defect regulation		
3.4 - Defect actuators		
3.5 - Defect sensors		
3.6 - Fire		
3.7 - Electrical defect (contact, short-circuit)		
3.8 - Mechanical defect (vibration, expansion)		
3.9 - Exploitation problem (clogging)		
3.10 - Other defect unexplained		
3.11 - Others		

A : Origin of the first defect
B : First defect

Appendix (2)


STPG
KHARTOUM NORTH
POWER STATION
INCIDENT REPORT
TRIP ON UNIT (1) 5/04/2013
Ref DOC NUMBER
OPE/IR/
Index : A
4. TREE CAUSES
Grid disturbance
F.O FWDG pump B tripped by over voltage
No other FWDG pump(s) available or s/by
Steam pressure and temp decreased inside boiler (lack of F.O)
Turbine S/D by operation to protect turbine from sudden excessive cooling

Appendix (2)

STPG KHARTOUM NORTH POWER STATION	INCIDENT REPORT TRIP ON UNIT (1) 5/04/2013	Ref DOC NUMBER OPE/IR/ Index : A

5- ACTION PLAN

ACTIONS	WHO	WHEN	REMARKS
Boiler failed to trip by F.O pressure low	C&I (W.O ISSUED)		
No S/by FWDG pumps available	MAINTENANCE DEPT		

Appendix (3)

Year 2011 KNPS human unplanned outage

No	Date	Month	Unit	Phase	Cause	Duration
1.	23	Jan	2	1	Boiler gas leak	32.5
2.	2	Feb	4	2	T/A defect	66.8
3.	18	April	1	1	Boiler tube leak	19.1
4.	18	April	2	1	Drum door leak	18.0
5.	26	May	2	1	Boiler gas leak	42.0
6.	30	May	3	2	Transmission job	20.00
7.	13	June	4	2	Feed water leak	10.8
8.	24	July	1	1	Boiler gas leak	66.2
9.	27	July	2	1	Boiler gas leak	38.2
10.	28	July	1	1	Boiler gas leak	13.0
11.	4	Aug	3	2	Boiler tube leak	43.4
12.	10	Aug	3	2	Feed water leak	17.4
13.	16	Aug	2	1	Boiler tube leak	17.1
14.	21	Aug	4	2	T/A defect	104.3
15.	19	Sept	3	2	BFP defect	8.6
16.	20	Sept	2	1	Drum door leak	20.1
17.	23	Sept	2	1	Gen air cooler failed	11.3
18.	3	Oct	4	2	Drum door leak	9.6
19.	6	Oct	2	1	BMS power failed	27.6
20.	9	Oct	2	1	Boiler tube leak	30.6
21.	17	Oct	3	2	Cooling water pump A dish leak	6.9
22.	30	Oct	3	2	Cooling water pump A dish leak	4.7
23.	2	Nov	3	2	Boiler tube leak	26.5
24.	10	Nov	3	2	Boiler tube leak	45.2
25.	22	Nov	3	2	Feed water leak	7.1
26.	26	Nov	1	1	Fuel oil heaters leak	12.9

Appendix (3)

Year 2012 KNPS human unplanned outage

NO	Date	Month	Unit	Phase	Cause	Duration
1.	5	Jan	2	1	Water leak (Fittings)	19.3
2.	29	Jan	2	1	Water leak (Fittings)	27.9
3.	29	Jan	3	2	Electrical defect	12.7
4.	21	Feb	3	2	Electrical defect	3.6
5.	25	Feb	3	2	Electrical defect	24.5
6.	18	Mar	2	1	Condenser tube failure	41.2
7.	22	Mar	3	2	Cooling water leak	78.0
8.	28	Mar	1	1	FDF defect	32.0
9.	9	April	1	1	Condenser tube failure	33.6
10.	11	April	1	1	Condenser tube failure	63.5
11.	14	April	1	1	Turbine defect	42.7
12.	23	April	4	2	Transmission job	15.6
13.	25	May	1	1	Boiler tube failure	21.5
14.	4	Jun	1	1	Boiler tube failure	49.5
15.	9	Jul	2	1	Gas leak	29.2
16.	26	Jul	1	1	Condenser tube failure	41.1
17.	6	Aug	3	2	Boiler tube failure	49.7
18.	25	Sep	1	1	Condenser tube failure	35.9
19.	27	Sep	1	1	Boiler tube failure	26.5
20.	8	Oct	2	1	Condenser tube failure	59.7
21.	28	Oct	4	2	Boiler tube failure	56.0
22.	2	Nov	2	1	BFP defect	83.1
23.	8	Nov	1	1	BFP defect	6.1
24.	29	Nov	2	1	BFP defect	12.3
25.	13	Dec	2	1	Condenser tube failure	64.9
26.	29	Dec	2	2	Turbine defect	2.7

Appendix (3)

Year 2013 KNPS human unplanned outage

NO	Date	Month	Unit	Phase	Cause	Duration
1.	16	Jan	3	2	Condenser tube failure	44.75
2.	23	Jan	4	2	T/A defect	19.62
3.	16	Feb	4	2	Others	42
4.	23	Feb	1	1	T/A defect	8.15
5.	2	Mar	2	1	Boiler tube failure	21.35
6.	13	May	4	2	FDF defect	63.15
7.	20	May	2	1	Electrical defect	21.17
8.	23	May	1	1	Condenser tube failure	62
9.	5	Jun	1	1	Condenser tube failure	1.8
10.	14	July	4	2	T/A defect	44.17
11.	28	July	2	1	MFT replacement	4
12.	10	Aug	2	1	Cooling water leak	113.1
13.	12	Aug	4	2	T/A defect	3.87
14.	18	Aug	2	1	BFP defect	28.25
15.	10	Sep	2	1	Boiler tube failure	18.25
16.	25	Sep	1	1	Electrical defect	9.1
17.	14	Oct	2	1	MFT replacement	2.75
18.	4	Nov	1	1	Condenser tube failure	67
19.	24	Nov	1	1	Condenser tube failure	13.9
20.	6	Dec	1	1	Condenser tube failure	47.78
21.	15	Dec	1	1	Condenser tube failure	80.82

NO	Date	Month	Unit	Phase	Cause	Duration
1.	14	Feb	2	1	MFT replacement	2.52
2.	24	Feb	2	1	MFT replacement	3.75
3.	20	Apr	1	1	BLR main steam line defect	63.6
4.	25	Apr	1	1	HP heater drain line to D/A flange leak	5.6
5.	24	May	3	2	Outage for D/A level transmitter leakage	4.87
6.	4	May	1	1	Gen protection & BFP /PB Mechanical seal	28
7.	11	May	1	1	BLR contamination	97
8.	17	May	2	1	To fix 100 KV VT leakage	5.25
9.	25	May	3	2	To replace MFT	5.38

Appendix (4)

The main point of Annual Preventive Maintenance Program

Task Name	Start	Duration
Main TMID activities: 1. (Feed water valve) and equipment's 2. Air ejector valve & equipment 3. Line steam drain v/v 4. T/A oil system (P/P+ cooler … others) 5. GOV and ESV system 6. Condensate V/V & equipment CWPs 7. Cooling water system and equipment CWPs 8. Gen air cooler 9. Condenser tube cleaning	27/12/2011	13.63
Main BMD activities: 1. Furnace and super heater 2. Oil Burners and air heater washing 3. FD fan & suit blower 4. Boiler v/v + press parts FDRs 5. Boiler v/v (safety v/v +fuel oil v/v +NRV+ Attemperator v/v)	27/12/2011	13.25
Main EMID activities: 1. Gen& unit transformer 2. Gen C.B & tap changer 3. Cooling tower Aux transfer & Board 4. Tank form Aux tans & board 5. 33 or 6.6 KV motors & starters 6. 415V motors & starters **7.** Control v/v & electrical v/v + damper	27/12/2011	13
Main C&ID activities: 1. Transmitters& press interlocks 2. Gauges (temperature , pressure) flow calibration 3. T/A protection & level switches 4. BMS & tapping points	27/12/2011	13.25

5.Burners management system check(v/v) 6.Control v/v+ loop (press & temp + c/v level)	27/12/2011	
Main chemical activities: 1. Gen cooler inspection 2. T/A condenser inspection 3. D/A shell deposit inspection 4. BLR press side inspect &samp + mud drum 5. Boiler firing side inspection & sampling 6. Cooling tower inspection	27/12/2011	13.63
Main service activities: 1. CT cell south side wooden door leak 2. CT bond & area cleaning 3. Heaters area cleaning 4. Lube oil coolers area cleaning 5. Condenser area cleaning 6. Turbine area cleaning 7. BFPs area cleaning 8. Gen air cooler area cleaning 9. Boiler air cooler area cleaning	28/12/2011	13.25
Main operation activities: **a. PFW cancellation** 1. Gen & unit TX 2. Transmitters & press interlocks (DOC only) 3. Turbine production (DOC only) 4. Tapping point (DOC only)& BMS 5. Condenser & DE aerator 6. Feed system , air ejectors & gen air cooler 7. T/A steam spaces & soot blowers 8. Boiler gas passes & press parts 9. EMD valves (Necessary idol for EMD list) 10. FD fan (for EMD) , CW system & 3.3 KV board 11. T/A rotating parts & 415v unit aux board	28/12/2011	13.25
b. Commissioning	2/1/2012	7 days
c. T/A protection test		
d. synchronizing		

Appendix (5)

National Electricity Corporation

Training program of all power station year 2011

No	Name of cycle	Type of learners	No of equitable	Week period	Begin date	End date
1.	Drawing Electrical	Technical	8	3	4Jan	23 Jan
2.	Gases plant	Technical	8	2	4Jan	16 Jan
3.	Weld	Technical	8	4	4Jan	30 Jan
4.	Turning	Technical	8	4	4Jan	30 Jan
5.	Filings	Technical	8	4	4Jan	30 Jan
6.	Gen electricity	Technical	12	3	25Jan	13 Feb
7.	Energy transformers	Technical	10	3	25Jan	13 Feb
8.	Bearing	Engineer	8	2	25Jan	6 Feb
9.	Stream Gen maintenance	Technical	8	2	25Jan	6 Feb
10.	Sweeping Quality	All sections	12	2	25Jan	6 Feb
11.	Mechanical measurement	Engineer	8	2	15Feb	27 Feb
12.	Electrical generation	Technical	8	3	15Feb	6 Mar
13.			12	2	15Feb	27 Feb
14.	Distribution safety	Technical	12	2	15 Feb	27 Feb
15.	Electronic	Technical	8	3	15 Mar	3 Apr
16.	Aerobic lines	Technical	12	2	15 Mar	27 Mar
17.	Gases operation	Technical	8	2	15 Mar	27 Mar
18.	Compressors	Technical	8	2	15 Mar	27 Mar
19.	MS project	Technical	12	2	15 Mar	27 Mar
20.	Gen safe	Technical	12	2	15 Mar	27 Mar
21.	Motors electricity	Technical	10	3	5 Apr	17 Apr
22.	Diesel operation	Technical	12	2	5 Apr	17 Apr
23.	Workshop equipment	Technical	8	4	5 Apr	1 May

24.	Sweeping quality	All sections	15	2	5 Apr	17 Apr
25.	Work team leading	Top leading	15	2	5 Apr	17 Apr
26.	Cable problem defining	Engineer	10	2	19 Apr	1 May
27.						
28.	Technical safety	Technical	8	2	19 Apr	1 May
29.						
30.						
31.	ENG Drive	Technical	12	2	19 Apr	1 May
32.	Equipment measurement electricity	Technical	10	2	19 Apr	1 May
33.	Energy counters	Technical	10	2	10 May	22 May
34.	Tower constructing	Technical	12	2	10 May	22 May
35.	Grid operation	Technical	10	2	10 May	22 May
36.	Safety valves	Technical	12	2	10 May	22 May
37.	Mechanical measurement	Technical	8	2	10 May	22 May
38.	Report writing	Intermediate leading	12	1	21 May	22 May
39.	Schematizing grids	Technical	10	2	24 May	5 Jun
40.	Electricity drawing	Technical	8	2	24 May	5 Jun
41.	Diesel maintenance	Technical	12	2	24 May	5 Jun
42.	Bearing	Technical	8	2	24 May	5 Jun
43.	Engineering safe	Engineers	8	2	7 Jun	19 Jun
44.	Forth – going electronics	Engineers	8	2	7 Jun	19 Jun
45.	Diesel operation	Technical	12	2	7 Jun	19 Jun
46.	Steam operation	Technical	8	2	7 Jun	19 Jun
47.	Mechanical drawing	Technical	8	2	21 Jun	17 Jun
48.	Weld	Technical	8	4	21 Jun	17 Jun
49.	Turning	Technical	8	4	21 Jun	17 Jun

50.	Filings	Technical	8	4	21 Jun	7 Aug
51.	Grids technical	Engineers	10	2	26 Jul	7 Aug
52.	Mechanical drawing	Technical	8	2	26 Jul	7 Aug
53.	Maintenance Schematizing	Engineers	10	2	26 Jul	7 Aug
54.	Sweeping quality (equipment)	Intermediate leading	12	2	26 Jul	7 Aug
55.	Electronics	Technical	12	3	26 Jul	7 Aug
56.	Equipment measurement electricity	Technical	10	2	16 Aug	28 Aug
57.	Safety valves	Technical	8	2	16 Aug	28 Aug
58.	Aerobic lines	Technical	12	2	16Sep	18 Sep
59.	Commonalty electrical	Technical	12	3	16Sep	25 Sep
60.	MS project	Engineers	12	2	16Sep	18 Sep
61.	Mechanical measurement	Technical	8	2	16Sep	18 Sep
62.	Energy transformers	Technical	10	2	27Sep	9 Oct
63.	Generators	Technical	10	3	2Ssep	16 Oct
64.	Diesel operation	Technical	12	2	27Sep	9 Oct
65.	General safety	Technical	12	2	27Sep	9 Oct
66.	Cables type and sizes	Technical	10	2	18 Oct	30 Oct
67.	Hydro plants maintenance	Technical	10	2	18 Oct	30 Oct
68.	Floor lines	Technical	12	2	1 Nov	13 Nov
69.	Mechanical drawing	Technical	10	2	1 Nov	13 Nov
70.	Workshop equipment	Technical	12	4	1 Nov	27 Nov
71.	Sweeping quality	All sections	12	2	1 Nov	13 Nov
72.	The safe (distribution)	Technical	12	2	29 Nov	11 Dec
73.	Commonalty	Technical	12	3	29 Nov	18 Dec
74.	Maintenance Schematizing	Engineers	10	2	29 Nov	11 Dec

Appendix (6)

Calculation KWh Cost year 2011

FUEL OIL MANAGEME	Fuel Oil Consumption (Tonnes)	
Fel Oil Consumption	HFO	HCGO
Unit1	0	24968
Unit2	0	0
Unit3	16123.009	41468.9238
Unit4	15431.678	37313.25735
Unit5	92061.03	0
Unit6	89053.27	0
Station	212669	103750

	Fuel Oil Delivery (Tonnes)		Remarks
Month	HFO	HCGO	
Jan.	3239.67	0	
Feb	1275.08	0	
Mar	18677.75	0	
Apr	17454.988	0	
May	27321.76	22337.186	
Jun	31912.5	25324.13	
Jul	30831.66	16758.5	
Aug	27215.56	18017.9	
Sep	16066.514	12262.54	
Oct	16281.08	4945.84	
Nov	1899.74	1883.7	
Dec	36.35	2212.82	
Total	192213	103821	

KWh Cost

month	cost	Cost with fuel &lube oil
January	0.11	0.28
February	0.08	0.26
March	0.03	0.16
April	0.02	0.14
May	0.02	0.14
June	0.02	0.15
July	0.02	0.14
August	0.02	0.16
September	0.03	0.16
October	0.04	0.17
November	0.26	0.42
December	0.06	0.19
Average KWh cost	0.06	0.20

	Tot.Cost	
Item	(1000 SDG)	%age of Cost
Operational cost	1,541,677.70	4.9%
Depereciation	-	
Insurance	-	
Maintenance cost	16,323,307.68	51.6%
Salaries & wages	11,209,239.12	35.4%
General expenditure	2,561,481.09	8.1%
Total cost	31,635,705.59	

Appendix (6)

Calculation KWh Cost year 2012

FUEL OIL MANAGEME	Fuel Oil Consumption (Tonnes)	
Fel Oil Consumption	HFO	HCGO
Unit1	0	46475
Unit2	0	28
Unit3	2489.779	61029.40554
Unit4	11020.135	55522.9698
Unit5	48585.73	0
Unit6	54493.42	2.7
Station	116589	163057

	Fuel Oil Delivery (Tonnes)		
Month	HFO	HCGO	LDO
Jan.	1403.25	0	0
Feb	491.42	2384.62	0
Mar	9274.11	18097.1	0
Apr	8887.61	16984.38	0
May	20874.738	20095.93	0
Jun	7872.36	14555.72	0
Jul	3047.4	27674.917	1527.241
Aug	8368.668	20377.49	0
Sep	14320.985	22723.23	0
Oct	8515.81	18639.784	0
Nov	8589.81	6456.06	0
Dec	4233.12	12217.81	0
Total	95945	180207	1527

KWh Cost

month	cost	Cost with fuel &lube oil
January	0.05	0.20
February	0.04	0.18
March	0.02	0.15
April	0.03	0.15
May	0.02	0.15
June	0.03	0.16
July	0.03	0.16
August	0.05	0.18
September	0.05	0.19
October	0.10	0.25
November	0.08	0.23
December	0.45	0.64
Average KWh cost	0.08	0.22

	Tot.Cost	
Item	(1000 SDG)	%age of Cost
Operational cost	2,390,615.62	6.2%
Depereciation	-	
Insurance	-	
Maintenance cost	17,825,187.54	46.1%
Salaries & wages	14,266,706.15	36.9%
General expenditure	4,172,948.61	10.8%
Total cost	38,655,457.91	

Appendix (6)

Calculation KWh cost year 2013

FUEL OIL MANAGEME	Fuel Oil Consumption (Tonnes)	
Fel Oil Consumption	HFO	HCGO
Unit1	0	33859
Unit2	0	0
Unit3	9720.295	71007.1098
Unit4	3871.915	33580.31435
Unit5	83962.49	7191.15
Unit6	46760.7	2629
Station	144315	148267

	Fuel Oil Delivery (Tonnes)		
Month	HFO	HCGO	LDO
Jan.	11623.25	5001.78	0
Feb	10643.49	5303.16	0
Mar	13371.82	8139.04	0
Apr	18181.508	13740.408	0
May	20189.06	10094.62	0
Jun	15408.55	12761.59	0
Jul	3279.85	1671.24	0
Aug	13507.86	18287.74	0
Sep	10894.53	12864.792	0
Oct	13094.72	6814.88	0
Nov	6432.68	13859.18	0
Dec	10067.31	8162.68	0
Total	146695	116701	0

KWh Cost

month	cost	Cost with fuel &lube oil
January	0.06	0.20
February	0.04	0.20
March	0.01	0.15
April	0.05	0.20
May	0.02	0.17
June	0.02	0.16
July	#N/A	#N/A
August	#N/A	#N/A
September	#N/A	#N/A
October	#N/A	#N/A
November	#N/A	#N/A
December	#N/A	#N/A
Average KWh cost	**#N/A**	**#N/A**

	Tot.Cost	
Item	*(1000 SDG)*	*%age of Cost*
Operational cost	2,742,416.39	#N/A
Depereciation	-	
Insurance	-	
Maintenance cost	#N/A	#N/A
Salaries & wages	14,292,108.19	#N/A
General expenditure	2,952,905.85	#N/A
Total cost	#N/A	

Appendix (6)

Calculation KWh cost year 2014

FUEL OIL MANAGEMENT

Fel Oil Consumption	Fuel Oil Consumption (Tonnes) HFO	HCGO
Unit1	0	45737
Unit2	0	0
Unit3	23428	39082
Unit4	14060	58302
Unit5	122	0
Unit6	46975	7336
Station	84585	150457

	Fuel Oil Delivery (Tonnes)		
Month	HFO	HCGO	LDO
Jan.	13221.63	15076.14	0
Feb	10002.86	5197.06	0
Mar	6874.56	13905.33	0
Apr	599.9	22118.982	0
May	830.6	16301.268	0
Jun	162.53	11675.3	0
Jul	2953.57	9928.95	0
Aug	3531.74	14938.85	0
Sep	0	16570.28	0
Oct	12084.42	3879.43	0
Nov	22892	4420.178	0
Dec	4602.69	28329.62	0
Total	77757	162341	0

Human Resource

No of Employee(2013)	No of Employee(2014)	Intrance	outlaws	training days
396	396	51	19	303

KWh Cost

month	cost	Cost with fuel &lube oil
January	0.02	0.15
February	0.04	0.18
March	0.01	0.15
April	0.03	0.16
May	0.02	0.16
June	0.03	0.17
July	0.01	0.18
August	0.02	0.16
September	0.03	0.18
October	0.03	0.19
November	0.04	0.22
December	0.10	0.10
Average KWh cost	**0.03**	**0.17**

Item	Tot.Cost (1000 SDG)	%age of Cost
Operational cost	100,492,898.11	85.5%
Depereciation	-	
Insurance	-	
Maintenance cost	12,678,705.92	10.8%
Salaries & wages	1,172,251.98	1.0%
General expenditure	3,243,116.73	2.8%
Total cost	117,586,972.73	

Appendix (6)

Calculation KWh cost year 2015

FUEL OIL MANAGEME	Fuel Oil Consumption (Tonnes)	
Fel Oil Consumption	HFO	HCGO
Unit1	0	60067
Unit2	0	0
Unit3	11277	57599
Unit4	9489	69516
Unit5	50734	0
Unit6	55286	0
Station	126786	187183

	Fuel Oil Delivery (Tonnes)		
Month	HFO	HCGO	LDO
Jan.	3223.25	22369.88	0
Feb	155.52	9391.7	0
Mar	4606.4	21519.34	0
Apr	10411.01	16212.73	0
May	10195.43	13747.38	0
Jun	6043.84	14535.04	0
Jul	17890.746	16104.45	0
Aug	24779.362	23979.56	0
Sep	21062.8	17690.688	0
Oct	27650.371	19736.64	0
Nov	14617.26	8421.48	0
Dec	3556.33	5719.858	0
Total	144192	189429	0

KWh Cost

month	cost	Cost with fuel &lube oil
January	0.06	1.10
February	0.08	1.13
March	0.05	1.15
April	0.06	1.14
May	0.03	1.09
June	0.03	1.06
July	0.03	1.07
August	0.04	1.12
September	0.09	1.23
October	0.06	1.24
November	0.09	1.39
December	0.42	1.84
Average KWh cost	0.09	1.21

	Tot.Cost	
Item	(1000 SDG)	%age of Cost
Operational cost	1,022,246,301.21	95.0%
Depereciation	-	
Insurance	-	
Maintenance cost	17,585,454.54	1.6%
Salaries & wages	28,162,143.49	2.6%
General expenditure	8,494,241.11	0.8%
Total cost	1,076,488,140.34	

Appendix (7)

Trips classification year 2011

Trip Catagery	No
External	14
Plant Failure	74
Human Error	12

Trips Classifications

Trip Cause	frequency	Remarks
Blackout	1	
FD Fan Trips	3	
Fuel oil press. Low Count	5	
Condenser Water Level High	11	
At least one BFP run Count	3	
Drum Water Level very high	4	
Winding temp very high Count	4	
Generator Protection	11	
F.O Ratio	2	
MFT valve closed	3	
Others	17	
Total	64	

Appendix (7)

Trips classifications year 2012

Trip Catagery	No
External	8
Plant Failure	42
Human Error	7
Total	57

Trips Classifications

Trip Cause	frequency	Remarks
System Black out/Disturbance	8	
Fault signal	7	
Electrical Failure	7	
Human Error	6	
BFP trip	4	
High vibration	4	
F.O. FWDG pump control problem	3	
Boiler tube failure	2	
Cond level control v/v undersized	2	
Loose connection	2	
MFT defect	2	
Passing valve	2	
100%FRV poor response	1	
FDF trip	1	
Fuel oil temperature very low	1	
Malfunction of lube oil thermostatic valve	1	
no analysis	1	
Poor installation (PH3)	1	
Winding temperature high	1	
Total	56	

Appendix (7)

Trips classification year 2013

Trip Catagery	No
External	2
Plant Failure	58
Human Error	3
Total	63

Trips Classifications

Trip Cause	frequency	Remarks
Unknown	26	
TV Defects	12	
False signal	3	
Human Error	3	
FO FWDG pump regulation troubles	2	
Vibration	2	
System Disturbance	2	
Pumphouse flooding	2	
Electrical fault	2	
CW pump trip	2	
Signal/Power cables burnt	1	
Poor air conditioning of eqpt room	1	
Passing valve	1	
Boiler 4 fire incident	1	
BFP defects	1	
Bearing Damage	1	
Air ingress	1	
Total	63	

Appendix (7)

Trips classification year 2014

Trip Catagery	No
External	2
Plant Failure	18
Human Error	5
Total	25

Trip Classifications

By Trip Cause	frequency
Unknown	7
Human Error	5
False trip signal	3
External: System disturbance	2
Drum level transmitter defect	2
Condenser level C.V. stuck at 23%	1
Logic fault during change over of U4 BFPs	1
LP seal CV failure	1
Main damber A/H closed	1
Unavailability of flame scanners	1
FO FWDG P/P supply lost due to fire incident in U2 G	1
Total	25

By Trip Alarm	frequency	Remarks
Unknown	3	1 of them as ahuman error
At least one BFP not running	2	1 of them as ahuman error
Condenser level very high	2	
Control oil press low	1	human error
Drum level very high	2	
Fuel press. low	3	External
Gen. Winding temp high	2	
last burner flame failed	5	2 of them as ahuman error
Over voltage	1	External
Power failed	1	
Radial bearing temp v. high	1	
T/A bearing temp high	1	
Reverse power	1	
Total	25	

Appendix (7)

Trips classification year 2015

Trip Catagery	No
External	6
Plant Failure	54
Human Error	5
Total	65

Trips Classifications

Trip Alarm	frequency	Remarks
Blackout	3	3 extternal
Unknown	2	1 extternal
At least one BFP not running	6	
Condenser level very high	3	
Control oil press low	5	2 of them as ahuman error
Drum level very high	5	
Fuel press. low	7	3 of them as ahuman error
Gen. Winding temp high	2	
last burner flame failed	1	
Radial bearing temp v. high	2	
T/A bearing temp high	4	
Drum level low	11	
Air fuel ratio	6	
T.V closed	4	
other	4	2 of them external
Total	65	

Appendix (8)

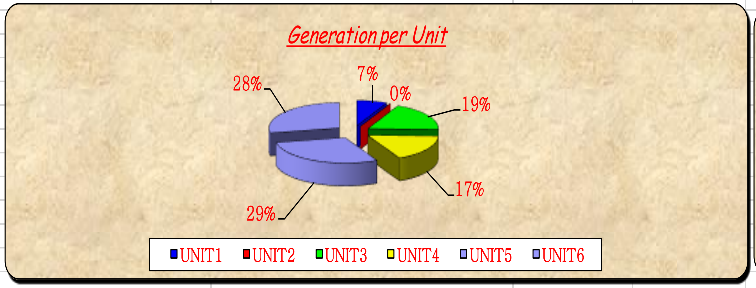
Annual report for year 2011

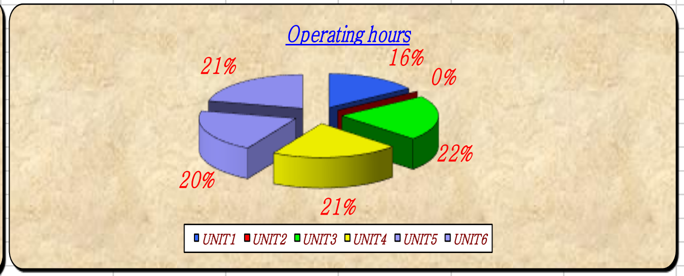
Dr.Sharief Thermal Power Station

Annual report for Year 2011

Summary

		UNIT1	UNIT2	UNIT3	UNIT4	UNIT5	UNIT6	STATION
Energy generated	MWh	80550	0	213162	197532	337517	324696	1153457
Unit Generated percentage	%	7%	0%	18%	17%	29%	28%	
Target Generation	MWh	136362	0	276552	289709	390899	416194	1509717
Auxiliaries consumption	MWh	9932	1078	16705	14334	27138	27484	96671
Units sent out	MWh	70618	0	196457	183198	310379	297212	1057864
Tot.opeating time	Hrs	3943	0	5462	5449	5198	5460	25512
Unit Availability factor	%	45.01%	0.00%	62.35%	62.20%	59.34%	62.33%	48.54%
Unit Capability factor (Ka)	%	59.07%	-	77.08%	68.18%	86.34%	78.02%	73.74%





Monthly Statistics	Energy Gen.	LDC Req.	Generated Time	Fuel Oil Cons (Tonnes)		Fuel Oil Delivery		Tot.No.Of Trips	Capability Fact.	emarks
	MWh	MWH	Hrs	HFO	HCGO	HFO	HCGO		%	
Jan.	22463.0	0.0	0	7223.376	3	3239.67	0	0	-	
Feb	28048.0	50057.0	512.6196693	8881.436	0	1275.08	0	4	56.03%	
Mar	138746.0	208647.0	2618.453356	35568.848	3276	18677.75	0	5	66.50%	
Apr	150990.0	203016.6	2759.453284	23912.63	16280.169	17454.988	0	12	74.37%	
May	159835.0	187017.1	3492.400033	21744.3	20915.865	27321.76	22337.186	14	85.47%	
Jun	125263.0	171543.8	3033.199703	17700.13	16334.525	31912.5	25324.13	6	73.02%	
Jul	148482.0	185616.3	3331.916636	21268.58	18322.80715	30831.66	16758.5	3	79.99%	
Aug	129306.0	161233.7	3433.58345	31343.022	4890.771	27215.56	18017.9	8	80.20%	
Sep	106525.0	150250.0	3029.546333	14739.826	15125.264	16066.514	12262.54	9	70.90%	
Oct	87047.0	105366.1	2262.84263	16704.4	7125.894	16281.08	4945.84	1	82.61%	
Nov	9954.0	41037.2	167.9166333	2595.77	80.363	1899.74	1883.7	0	24.26%	
Dec	46798.0	45931.8	847.7630211	10986.669	1395.523	36.35	2212.82	2	101.89%	
TOTAL	1153457	1509717	25490	212669	103750	192213	103743	64	72%	

Appendix (8)

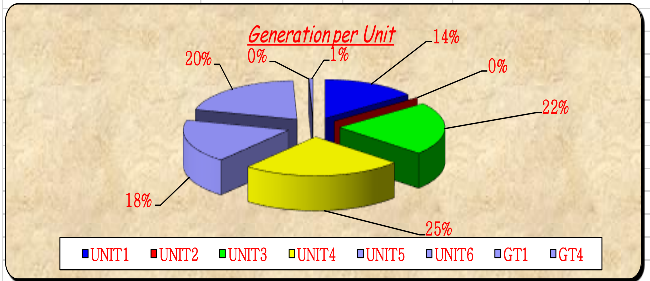
Annual report for year 2012

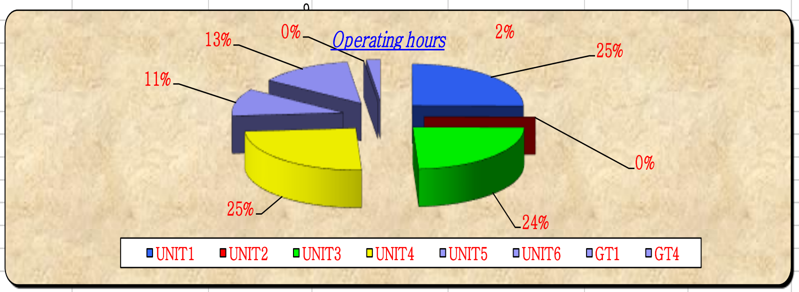
Dr.Sharief Thermal Power Station

Annual report for Year 2012

Summary

		UNIT1	UNIT2	UNIT3	UNIT4	UNIT5	UNIT6	GT1	GT4	STATION
Energy generated	MWh	145782	0	221316	246559	181274	203893	0	5992	1004816
Unit Generated percentage	%	67%	-	55%	54%	57%	35%			
Target Generation	MWh	196416	0	314975	397811	380909	419879	0	9229	1719220
Auxiliaries consumption	MWh	14372	1118	17314	16939	15173	19432	0	65	84413
Units sent out	MWh	131410	-1118	204002	229620	166101	184461	0	5927	920403
Tot.opeating time	Hrs	6081	0	5832	5960	2570	3294	0	493	24230
Unit Availability factor	%	83.90%	0.00%	87.72%	77.84%	80.52%	56.02%			
Unit Capability factor (Ka)	%	74.22%	-	70.26%	61.98%	47.59%	48.56%	-	64.92%	58.45%





Monthly Statistics	Energy Gen.	LDC Req.	Generated Time	Fuel Oil Cons (Tonnes)			Fuel Oil Delivery			Tot.No.Of Trips	Capability Fact.
	MWh	MWH	Hrs	HFO	HCGO	LDO	HFO	HCGO	LDO		
Jan.	53631.0	130952.8	1456.9369	11889.831	3540.5	0	1403.25	0	0	6	40.95%
Feb	65459.0	173325.0	1621.136767	6864.401	11698.739	2.52	491.42	2384.62	0	3	37.77%
Mar	128074.0	229073.0	2664.100727	17050.281	17461.919	0.84	9274.11	18097.1	0	10	55.91%
Apr	134802.0	185408.4	2787.94903	15969.8	19964.733	0	8887.61	16984.38	0	9	72.71%
May	153907.0	207334.4	3043.76727	17161	23791.024	0	20874.738	20095.93	0	7	74.23%
Jun	131844.0	227343.3	3279.24644	15496.541	19699.795	1884.12	7872.36	14555.72	0	8	57.99%
Jul	94605.0	149760.7	2596.99667	5126.26	22139.237	451.08	3047.4	27674.917	1527.241	3	63.17%
Aug	70316.0	97862.0	2270.847	1129.3	19871.343	0	8368.668	20377.49	0	1	71.85%
Sep	72077.0	145247.5	1947.5	9334.13	12070.81139	5.04	14320.985	22723.23	0	4	49.62%
Oct	50964.0	90841.7	1182	8726.14	5743.933	0	8515.81	18639.784	0	0	56.10%
Nov	40174.0	64538.5	1000.9	7192.41	4604.65595	0	8589.81	6456.06	0	4	62.25%
Dec	8963.0	17532.5	378.683	648.97	2470.7	0	4233.12	12217.81	0	2	51.12%
TOTAL	1004816	1719220	24230	116589.064	163057	2344	95879	180207	1527	57	58.45%

Appendix (8)

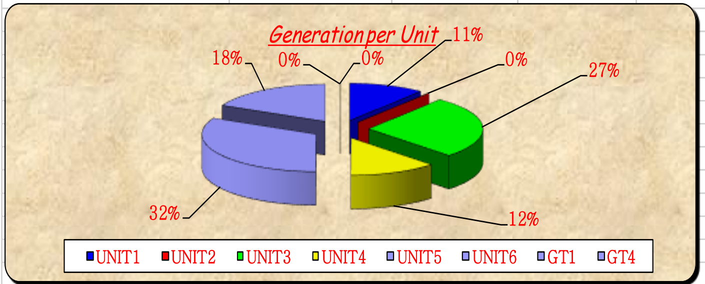
Annual report for year 2013

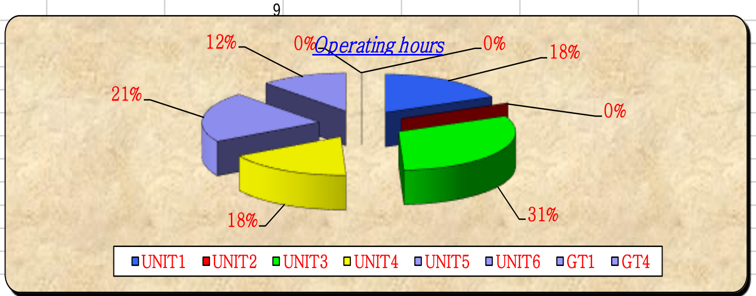
Dr.Sharief Thermal Power Station

Annual report for Year 2013

Summary

		UNIT1	UNIT2	UNIT3	UNIT4	UNIT5	UNIT6	GT1	GT4	STATION
Energy generated	MWh	109283	0	276084	126852	328655	182936	0	0	1,023,810
Unit Generated percentage	%	46%	-	63%	29%	39%	21%			
Target Generation	MWh	155519	0	339756	395557	664883	655692	0	0	2,211,407
Auxiliaries consumption	MWh	10847	1508	20930	12030	25174	19221	0	32	89,742
Units sent out	MWh	98436	-1508	255154	114822	303481	163715	0	-32	934,068
Tot.opeating time	Hrs	4448	0	7539	4230	5187	2913	0	0	24,317
Unit Availability factor	%	50.77%	0.00%	86.06%	48.80%	61.85%	33.25%			
Unit Capability factor (Ka)	%	70.27%	-	81.26%	32.07%	49.43%	27.90%	-	-	46.78%





Monthly Statistics	Energy Gen.	LDC Req.	Generated Time	Fuel Oil Cons (Tonnes)			Fuel Oil Delivery			Tot.No.Of Trips	Capability Fact.
	MWh	MWH	Hrs	HFO	HCGO	LDO	HFO	HCGO	LDO		
Jan.	37079.0	79681.0	899.2833667	4	11411.515	0	11623.25	5001.78	0	1	46.53%
Feb	59876.0	93290.0	1603.566633	11927.03	5805.069	0	10643.49	5303.16	0	2	64.18%
Mar	107129.0	188404.1	2462.03026	14659.47	15018.69695	1.68	13371.82	8139.04	0	8	56.86%
Apr	93462.0	198945.0	1959.437423	16501.62	9711.558	0	18181.508	13740.408	0	10	46.98%
May	127844.0	172307.1	3298.05372	23298.998	13205.932	0	20189.06	10094.62	0	6	74.20%
Jun	133730.0	207656.9	3190.83433	18538.4	18720.265	0	15408.55	12761.59	0	6	64.40%
Jul	177493.0	228640.6	3407.450353	27272	21567.997	0	3279.85	1671.24	0	12	77.63%
Aug	106798.0	210657.6	2565.81776	11616	19029.408	0	13507.86	18287.74	0	8	50.70%
Sep	88107.0	200841.5	2145.533397	11849	13331.1066	0	10894.53	12864.792	0	3	43.87%
Oct	40058.0	191274.3	1217.283333	4827.935	7428.0436	0	13094.72	6814.88	0	1	20.94%
Nov	23782.0	204887.5	722.85	3701.947	3829.411	0	6432.68	13859.18	0	0	11.61%
Dec	28452.0	234821.3	844.6849967	119	9207.972	0	10067.31	8162.68	0	6	12.12%
TOTAL	1023810	2211407	24317	144315.400	148267	2	146695	116701	0	63	46.30%

Appendix (8)

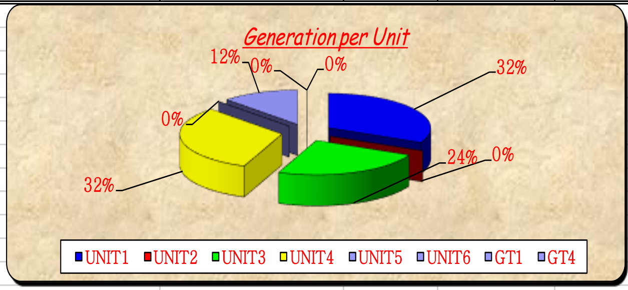
Annual report for year 2014

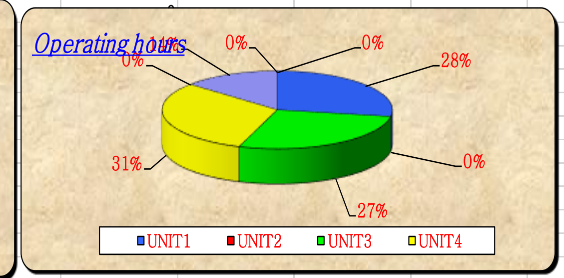
Dr.Sharief Thermal Power Station

Annual report for Year 2014

Summary

		UNIT1	UNIT2	UNIT3	UNIT4	UNIT5	UNIT6	GT1	GT4	STATION
Energy generated	MWh	142036	0	196273	243669	0	196168	0	0	778,146
percentage	%	64%	0%	48%	64%	0%	24%			
Target Generation	MWh	220921	0	407407	381350	876000	802756	0	0	2,688,434
Auxiliaries consumption	MWh	13900	689	16570	19532	2981	17852	0	30	71,554
Units sent out	MWh	128136	-689	179703	224137	-2981	178316	0	-30	706,592
Tot.opeating time	Hrs	5929	0	5905	6626	0	2914	0	0	21,374
Unit Availability factor	%	67.68%	0.00%	67.41%	75.64%	0.00%	33.26%			
(Ka)	%	64.29%	-	48.18%	63.90%	0.00%	24.44%	-	-	29.92%





Monthly Statistics	Energy Gen.	LDC Req.	Generated Tim	Fuel Oil Cons (Tonnes)			Fuel Oil Delivery			Tot.No.Of Trips	Capability Fact.
	MWh	MWH	Hrs	HFO	HCGO	LDO	HFO	HCGO	LDO		
Jan.	43630.0	220894.0	1053.534033	0	12532.406	0	13221.63	15076.14	0	2	19.75%
Feb	47768.0	217678.8	1107.1833	6762.0861	6935.919605	0	10002.86	5197.06	0	1	21.94%
Mar	74623.0	243183.7	1841.367	5835	15554.74805	0	6874.56	13905.33	0	3	30.69%
Apr	105447.0	235440.0	2479.2837	7353	22779.099	0	599.9	22118.982	0	2	44.79%
May	82491.0	228023.9	2290.716693	3529	21077.03565	0	830.6	16301.268	0	1	36.18%
Jun	73017.0	219867.8	1971.81666	4628	17448.1846	0	162.53	11675.3	0	2	33.21%
Jul	86460.0	239554.8	2285.96667	19036.0705	7698.439	0	2953.57	9928.95	0	4	36.09%
Aug	66750.0	241425.8	2034.616703	1684.4477	19124.96825	0	3531.74	14938.85	0	4	27.65%
Sep	80279.0	226621.3	2414.400034	10842.653	13960.66205	0	0	16570.28	0	3	35.42%
Oct	52529.0	234484.1	1908.899897	8550.596	8332.7749	0	12084.42	3879.43	0	2	22.40%
Nov	41179.0	180072.0	1081.2167	12624.8042	0	0	22892	4420.178	0	1	22.87%
Dec	23973.0	201188.0	905.033367	3739.26	4293.6939	0	4602.69	28329.62	0	0	11.92%
TOTAL	778146	2688434	21374	84584.918	149738	0	77757	162341	0	25	28.94%

Appendix (8)
Annual report for year 2015

Dr.Sharief Thermal Power Station
Annual report for Year 2015

Summary

		UNIT1	UNIT2	UNIT3	UNIT4	UNIT5	UNIT6	GT1	GT4	STATION
Energy generated	MWh	178063	0	202497	263063	171540	209201	0	0	1,024,364
Unit Generated percentage	%	75%	0%	48%	61%	20%	24%			
Target Generation	MWh	236520	0	419341	430388	876000	876000	0	0	2,838,249
Auxiliaries consumption	MWh	18218	0	16453	22584	13210	17426	0	0	87,891
Units sent out	MWh	159845	0	186044	240479	158330	191775	0	0	936,473
Tot.opeating time	Hrs	8337	0	6784	7414	2450	2526	0	0	27,511
Unit Availability factor	%	95.17%	0.00%	77.45%	84.64%	27.97%	28.83%			
Unit Capability factor (Ka)	%	75.28%	-	48.29%	61.12%	19.58%	23.88%	-	-	36.24%

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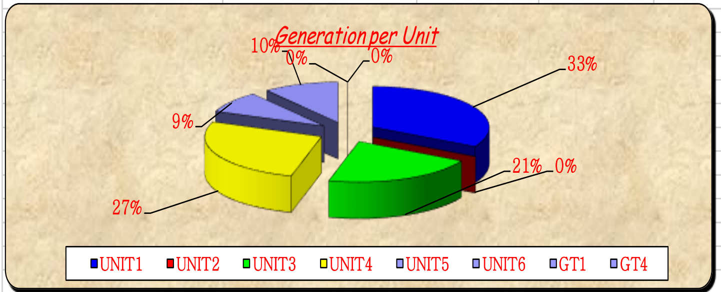

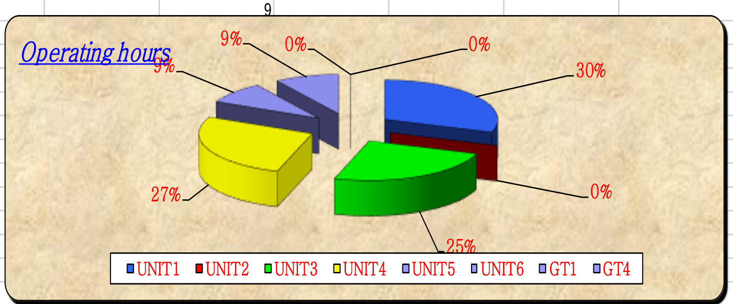

Monthly Statistics	Energy Gen.	LDC Req.	Generated Time	Fuel Oil Cons (Tonnes)			Fuel Oil Delivery			Tot.No.Of Trips	Capability Fact.
	MWh	MWH	Hrs	HFO	HCGO	LDO	HFO	HCGO	LDO		
Jan.	46204.0	228870.8	1443.13333	45.406	13376.83175	0	3223.25	22369.88	0	0	20.19%
Feb	62382.0	219619.0	1832.466597	1809.979	16680.47995	0	155.52	9391.7	0	5	28.40%
Mar	71777.0	243288.0	2003.766729	13	22108.3916	0	4606.4	21519.34	0	4	29.50%
Apr	94394.0	232427.1	2450.383357	5907	23107.7732	0	10411.01	16212.73	0	10	40.61%
May	129328.0	240046.4	2930.35056	16325	22134.246	0	10195.43	13747.38	0	10	53.88%
Jun	154694.0	229965.5	3244.636827	24563	20612.1299	0	6043.84	14535.04	0	8	67.27%
Jul	148979.0	243288.0	3138.66676	23355	20422.53101	0	17890.746	16104.45	0	14	61.24%
Aug	109036.0	243288.0	2625.099993	21035	12595.02525	0	24779.362	23979.56	0	5	44.82%
Sep	64938.0	235440.0	1884.916997	10994	9291.5636	0	21062.8	17690.688	0	5	27.58%
Oct	66083.0	243288.0	2394.983333	8073.1328	13456.0066	0	27650.371	19736.64	0	0	27.16%
Nov	46608.0	235440.0	2062.267	11952.501	4758	0	14617.26	8421.48	0	2	19.80%
Dec	29941.0	243288.0	1500.2833	2712.932	8639.533	0	3556.33	5719.858	0	2	12.31%
TOTAL	1024364	2838249	27511	126785.951	187183	0	144192	189429	0	65	36.09%