



# Curriculum on Monitoring and Compliance of Thermal Power Plants

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## **ABOUT CAG**

Citizen consumer and civic Action Group (CAG), is a 32 year old non-profit, non-political and professional organisation that works towards protecting citizens' rights in consumer and environmental issues and promoting good governance processes including transparency, accountability, and participatory decision making.

## **ABOUT THE PROJECT**

The objective of CAG's Thermal Watch Initiative is empowering local communities on the Environmental Impact Assessment (EIA) process with specific reference to thermal power plants. As part of this initiative, CAG aims to educate local communities on the EIA process to empower and enable them to monitor the activities of upcoming and existing coal based thermal power plants to understand the violations in the process of its establishment and operation, and adherence to standards as set by government agencies.

For more details, visit [www.thermalwatch.org.in](http://www.thermalwatch.org.in)



## **ACKNOWLEDGEMENT**

CAG would like to express its gratitude to a group of individuals without whose support and guidance it would not have been possible to design and develop an easy to understand curriculum on monitoring and compliance of thermal power plants.

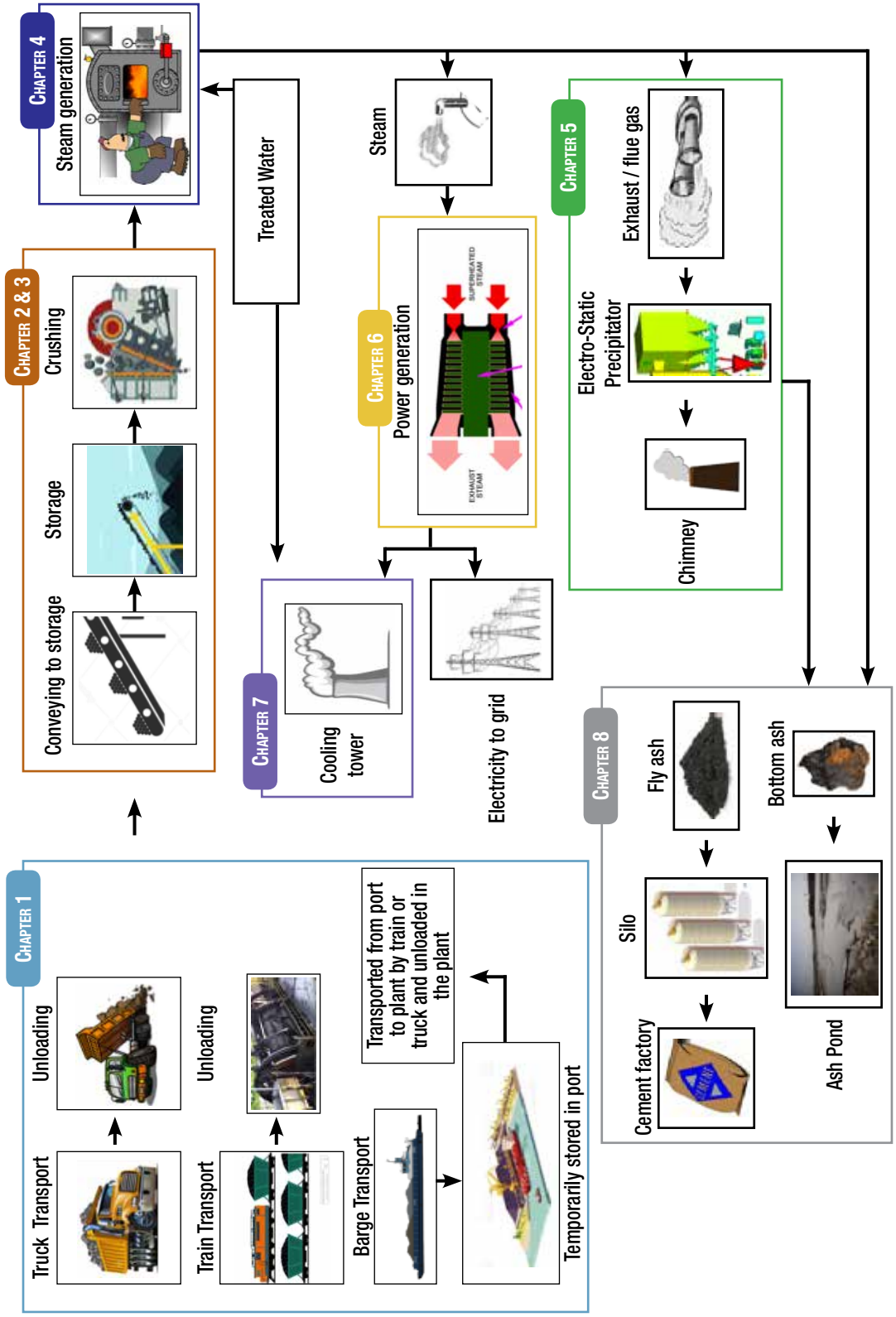
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## GLOSSARY

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MoEF & CC	Ministry of Environment, Forest and Climate Change
ToR	Terms of Reference
EC	Environmental Clearance
ES	Environment Statement
CTE	Consent to Establish
CTO	Consent to Operate
SO <sub>2</sub>	Sulphur di-oxide
NO <sub>x</sub>	Oxides of Nitrogen
PM	Particulate Matter
ESP	Electro Static Precipitator
FGD	Flue Gas Desulphurization
AAQ	Ambient Air Quality

‘Fugitive dust’ - very small particles which can easily suspend into the air

<sup>1</sup>‘atm’ – unit of pressure

‘ash dyke’ – pond where ash is stored and dried

‘hopper’ – funnel shaped passage for coal to pass

‘Carpet Loss’ – the loss of material stored on the unprepared ground. The soil and clay matter mix up with coal and some quantity of coal is lost

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<sup>1</sup> <https://www.asknumbers.com/pascal-to-atm.aspx>



## INTRODUCTION

This curriculum, a part of a series of educational materials developed by CAG, covers best practices a thermal power plant should follow for protecting the local environment. Best practices can be observed starting from transportation of coal, production of electricity to management of residual outputs, such as ash. The curriculum seeks to demystify regulatory standards and apply simple techniques to the thermal power plant production cycle, to prevent and mitigate environmental damage. Further, the curriculum will list the appropriate authorities and agencies to approach in case of violations and to seek remedial measures. It also explains about the Environment Clearance process, and the process of seeking relevant documents under Right to Information Act (Environment Statement, fly ash utilization report etc.).

This curriculum has been designed for communities living in the vicinity of thermal power plants. It follows a simple methodology wherein the communities can use the content a) to identify violations through e.g. coal trucks without cover, colour of the smoke from the stack etc., b) make inferences on the type of violation, c) take action through filing of RTIs and writing letters to concerned authorities, d) monitor the action taken by the erring thermal power plant, and local pollution control board authorities to remedy the situation.

Further, the curriculum also encourages analysing unobservable facts which may pertain to fly ash utilisation and water consumption, by linking it to other aspects such as groundwater depletion, fall in agricultural productivity etc. as a result of activities of thermal power plants. Briefly, the production cycle of a thermal power plant is as follows

- Transportation of coal: the coal is transported from the mines to the power plant by train, slurry pipeline, truck or barge. The coal reaches the

coal handling plant, which takes care of unloading, processing (grinding/crushing) and stacking of the coal in piles in the coal storage area.

- Coal can be stored either as open stockpile or closed stockpile depending on the land, environment and financial conditions of that area and plant.
- The stored coal will be taken to the boiler-furnace area for combustion where steam comes out as product, ash as by-product and exhaust gas exits into the atmosphere through the chimney/stack. The steam reaches the turbine area for producing electricity.
- The exhaust gas/flue gas passes through the electro static precipitator for fly ash collection and flue gas desulphurization unit for sulphur reduction i.e., cleansing the exhaust gas for its impurities and reducing the emission to within prescribed limits.
- In the total ash content, fly ash content is 80% and bottom ash is 20%; fly ash from the ESP and FGD system will be taken to the ash silos and stored there for distribution to cement industries situated within 100 Km area of the plant. The bottom ash is taken to the ash pond and treated.

Apart from coal, water is another raw material used for electricity generation. Water, before entering the boiler and the cooling system, is physically and chemically treated while the waste water exiting the plant will be taken to the treatment plants. Water treatment is required for maintaining the boiler while wastewater treatment is essential for protecting the environment.

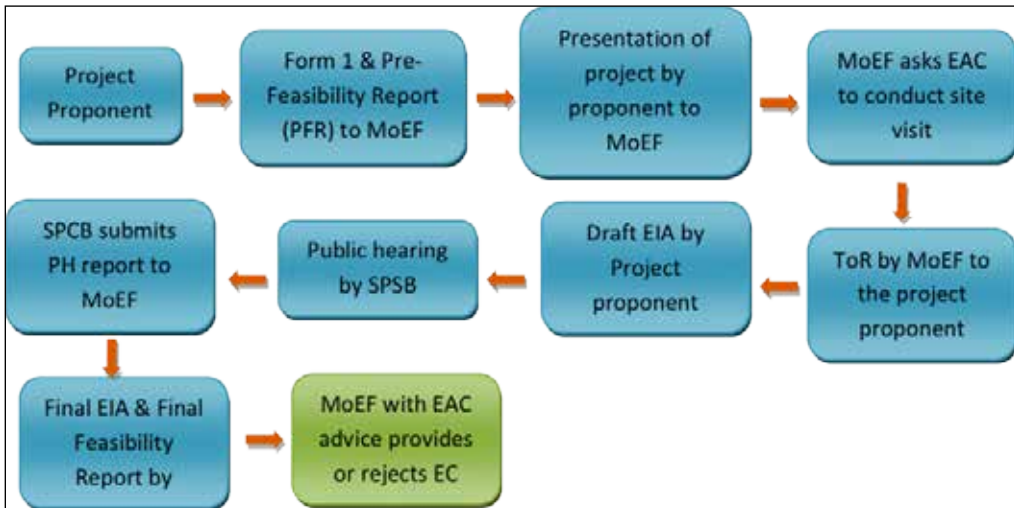
The above processes can adversely impact land, water and air resources. Hence there is a need to periodically monitor the processes of the thermal power plant.

To regulate the above, Ministry of Environment, Forest & Climate Change brought about the Environmental Impact Assessment Notification in 2006, under the Environmental Protection Act, 1986. This Notification mandates procedures for establishing 39 kinds of industries, including thermal power plants. Accordingly, the onus is on the project proponent to ensure that the project does not affect the socio-economic status of the communities and will protect the environment. This Notification, through an Environment Clearance (EC), gives permission for the establishment of these industries.

In the thermal power sector, power plants having a production capacity of more than 500 MW come under 'Category A' projects and power plants with less than 500

MW come under ‘Category B’. The former will get EC from Central Government, from MoEF & CC, whereas the latter gets EC from State Environment Impact Assessment Authority (SEIAA). Project-related work, including construction activity, should not commence until EC is granted. After the EC is obtained, the power plant has to get Consent to Establish (CTE), from State Pollution Control Board (SPCB), and Consent to Operate (CTO) thereafter from the same authority. CTE and CTO have to be renewed from time to time.

The following chart explains the process for obtaining EC:



EIA process for Issuing EC

Further, after commencement of operations, the project proponent is mandated to file compliance reports such as the annual Environmental Statements, Fly Ash Utilization and water consumption statements with the respective authorities. These compliance documents contain information on air, water, land and noise emission and highlight the steps to be taken by the proponent to reduce environmental impact, etc.

### **CTE**

- Site visit by SPCB before issuing CTE
- Start Construction activities
- Proponent to comply with CTE conditions

### **CTE**

- To start operational activities
- Issued for a particular period and needs to be renewed.
- Red category – annual renewal
- Orange & Green category – once in two years renewal

### **Documents apart from EC**

#### **MoEF & CC**

- Six monthly compliance report
- Annual declaration of Fly ash utilization report to CEA (Central Electricity Authority) with copies to MoEF & CC and SPCB

#### **SPCB**

- Monthly water cess report (water tax)
- Annual Environment Statement (ES)
- Hazardous waste declaration
- Renewal of consent

### **Compliance reports**

#### **ES**

- General information of the plant
- Water and raw material consumption
- Air & water pollution data
- Hazardous waste data
- Solid waste data
- Additional pollution preventive measures

#### **Fly ash utilization report**

- General information of the plant
- Ash generation and ash utilized data
- Bottom ash quantity, Ash pond quantity details
- Fly ash collection, storage and transportation details

## Monitoring reports

The documents mentioned above can be accessed by the public by filing of RTI requests to the Central/State Public Information Officer of the concerned department.

### How & with whom to file RTI request?

- An application seeking details addressed to the Central Public Information Officer (CPIO) in the case of Central Government or the State Public Information Officer (SPIO) in the case of State Government, of the respective department.
  - If it is a government operated thermal power plant, then the respective CPIO/SPIO.
  - If the thermal power plant belongs to a private company, then RTI cannot be filed to the power plant and should be sent only to the government department.
- Application has to be sent along with a fee of ₹10.
- Application can be in English, Hindi or any regional language.
- Any Indian citizen of any age group can file RTI request.
- RTI responses take 30 days. But in case of life and security situations, RTI information should be given within 48 hours.
- If there is no reply or if the response provided is not satisfactory, then within 30 days the applicant can make the first appeal to the Appellate Authority of the same department.
- Second appeal lies with the Central/State Information Commission and should be filed within 90 days.





# CONTENTS

18	CHAPTER 1 <b>COAL TRANSPORT</b>
33	CHAPTER 2 <b>COAL STORAGE</b>
43	CHAPTER 3 <b>COAL HANDLING</b>
48	CHAPTER 4 <b>COMBUSTION AND STEAM GENERATION</b>
53	CHAPTER 5 <b>FLUE GAS</b>
61	CHAPTER 6 <b>POWER GENERATION</b>
65	CHAPTER 7 <b>COOLING SYSTEM</b>
70	CHAPTER 8 <b>ASH</b>
78	CHAPTER 9 <b>WATER AND WASTE WATER</b>

# CHAPTER 1

## COAL TRANSPORTATION

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Coal is largely transported from coal mines in remote locations to thermal power plants. Coal transportation involves transporting coal from mines to intermediate processing plants, and finally to thermal power plants for producing electricity. Various modes of transportation are deployed for this purpose, which have implications on the energy, economics and environment of the nation. Coal transportation through train, barge/ship and truck contributes to the particulate matter pollution from raw coal.

The environmental impacts of coal transportation include air pollution, water pollution, solid wastes, noise levels, safety and traffic hazards. This can cause either direct or indirect environmental impacts.

- Direct impacts occur during loading of coal at supply point, during transfer and unloading of coal at thermal power plants.
- Indirect impacts are mostly contributed by vehicular movement and fuel usage.

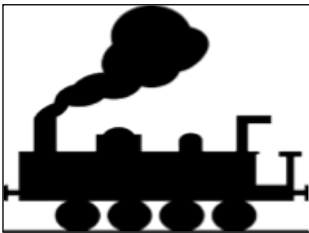
### **Transport mode depends upon**

- **The amount of coal to be transported**
- **The distance to be travelled**
- **Capital & operating costs**
- **Flexibility, reliability, and responsiveness to changes in end-user demand**

## Coal can be transported by



## Train



Coal can be carried in freight train or designated unit coal trains.

Freight trains are those which cover small distances and carry comparatively less coal, and travel at a speed of 20 to 70 miles per hour.

Unit trains transport coal for long distances and carry high loads of coal and thus travel at a speed of 35 to 40 miles per hour in order to reduce wear and tear of railway tracks etc.

## Problems:

- Impacts land use if new tracks are to be laid
- The wind will cause locomotive fugitive emission during transit (pic below). This happens due to transportation of coal without covering the loaded rail cars. Coal dust coming out of railcars get deposited on the tracks, and corrode the rails that may lead to train derailments



**Pic 1.1: Coal particles flying off into the air due to wind**

- Noise during transit is mainly due to powerful horns, empty cars and non-electric train transportation
- During loading and unloading of coal in and out of cars, dust may escape into the atmosphere



**Pic 1.2: Loading of coal into truck**

- Spillage may occur while transporting due to bumping of improper container cars, over filling of the cars and bolted rail lines



**Pic 1.3: Overfilled cars**



**Pic 1.4: Spillage**

- Fires may either occur as dry coal escapes into air or if pulverised coal is transported without prior water sprinkling over the coal.



**Pic 1.5: Fire sparks**



**Pic 1.6: Putting off fire**

### Pollutants:

- Coal particulate matters can be both  $PM_{2.5}$  and  $PM_{10}$   
( $PM_{2.5}$  is an atmospheric particulate matter of diameter of fewer than 2.5 micro meters, which is around three per cent the diameter of a human hair. It causes respiratory problems and reduces visibility.  
 $PM_{10}$  are 2.5 to 10 micrometers in diameter. Sources include crushing or grinding operations and dust stirred up by vehicles on roads.)
- Leaching of chemicals (chromium, lead, mercury) from coal during rain/ high moisture content.

### Effects:

- Windblown coal covers the leaves and reduces photosynthetic capacity of plants, indirectly affecting the grazing animals. Coal dust can deposit on the soil and clog soil pores, which in turn prevents water from entering the soil and stops groundwater recharge.



**Pic 1.7: Leaves covered with coal particles**

- Brush fires from train may cause sparks due to heat produced by the frictional force between the metal body parts of the train car.



**Pic 1.8: Brush Fires**

- Indirect pollution is caused by diesel trains emitting smoke.



**Pic 1.9: Diesel train**

**Remedies:**

- Use of electric trains not only reduces air pollution but also results in less noise.



**Pic 1.10: Electric train**

- Bottom unloading from railcars reduces fugitive dust emission as the space for the dust to escape is limited



**Pic 1.11: Bottom Unloading**

- Negative pressure bag loaders can be used. These bags use vacuum pressure to suck in the coal and load it onto the rail cars. Since it is a vacuum, it has to be completely enclosed to ensure no dust particles escape outside.

- Providing wind guards for protecting the coal from wind. The wind guards can be either thick plastic covers or covered type rail cars with steel covering on top.



**Pic 1.12: Tarpaulin covered train**



**Pic 1.13: Train cars with steel enclosure**

Washing of coal increases the density of coal particles, thus making it heavy for wind to carry. This will reduce the emission of dust particles due to wind.



**Pic 1.14: Coal washing**

- However, due to the velocity and depending on the distance covered by the train, the moisture will reduce, resulting in coal becoming dry. In such cases, sealing the coal surface with latex polymer/asphalt emulsion or dust proof coating with oil/ $\text{CaCO}_3$  should be considered. The latter needs to be done while the coal is in process of being loaded on to the rail car.
- Brush fires can be reduced by using appropriate rail materials.
- After loading, bumping of cars is necessary, as this will help in compacting the coal, thereby reducing spillage during transportation.
- Spillage by the bumps during transportation can be reduced by using welded rails instead of bolted rails.





**Pic 1.15: Bolted joints**



**Pic 1.16: Welded Joints**

Trucks are the most versatile of all transportation modes for coal hauling as road connectivity is better than rail. However, trucks do have drawbacks.



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#### **DISADVANTAGES OF TRUCK TRANSPORT**

- **High unit energy consumption;**
- **High operation & maintenance costs; and**
- **Damage to roads.**

#### **Problems:**

- Haulage dust i.e. dust occurring during transport, is caused due to movement of heavily loaded vehicles. Haulage dust will be higher in the case of damaged roads and improperly paved roads.



**Pic 1.17: Haulage dust**



- As with the train transportation, wind again acts as a major cause for fugitive dust emission
- Spillage on to the road also occurs due to overloading of trucks



**Pic 1.18: Spillage**

- Noise emanating from engine, exhaust, cooling fans and tires
- Dust escaping from trucks while emptying into the feeder at the power station/coal stock yard is another issue.



**Pic 1.19: Without water spray**

**Pic 1.20: With water spray**

### **Pollutants:**

Transport emissions (SO<sub>2</sub>, NO<sub>x</sub>, CO) and particulate matters

### **Effects:**

- Windblown coal covers the plant leaves and reduces photosynthetic capacity, affects grazing animals and clogs soil pores affecting seepage of water into the ground
- Respiratory problems to the public in the vicinity of haul road and also workers involved in loading and unloading of trucks



**Pic 1.21: Manual loading of coal**

- Trucks release pollutants into atmosphere further damaging the environment
- Spillage due to over loading of trucks impacts the soil and groundwater in the nearby areas



**Pic 1.22: Truck pollution**

- Roads are damaged by frequent movement of trucks causing inconvenience and accidents

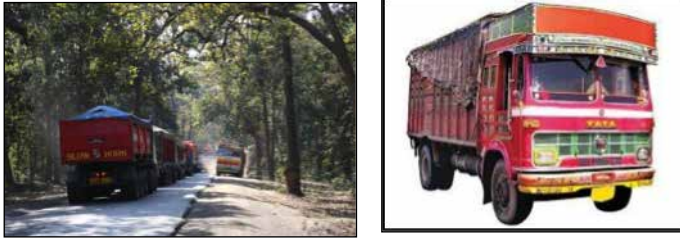


**Pic 1.23: Road damage**

### **Remedies:**

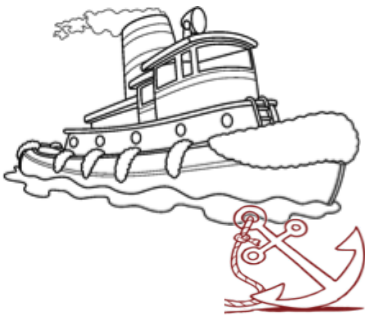
- Water should be sprayed or chemical should be applied (refer to remedies section in train transport), over coal heap before transportation

- Covering the trucks with aluminum, plastic covers will reduce the effect of wind on coal and prevent fugitive emission during transportation



**Pic 1.24: Covered trucks**

- Mufflers, resonators or exhaust pipe wraps can be used to reduce exhaust noise, engine covers and panels can be used to reduce engine noise



### **BARGE / SHIP**

Here, coal is normally moved in open barges or ships which range in capacity from 1,000 to 3,000 net tons. Ten to fourteen barges are normally connected in series. From barge, coal will be stored

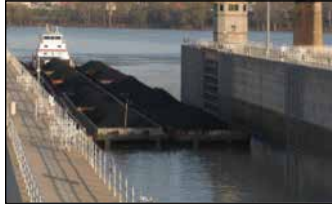
in the port storage area and then transported by train, truck or conveyor. As the first two are discussed above, transport through conveyor is discussed in the following section.

### **DID YOU KNOW**

The Jetty or Port must have Environmental Clearance for the coal quantity handled (new or existing one going for expansion)

### **Problems:**

- Primary impact due to fugitive dust and spillage at loading, transfer and unloading points



**Pic 1.25: Uncovered barge**

- Loss of coal due to wind (long distance conveyor), mud and water drippings during transfer

### **Pollutants:**

Transport emission (SO<sub>2</sub>, NO<sub>x</sub>, CO) occurs due to barge movement and coal particulate matters, and contamination of water bodies in case of barge wreckage

### **Effects:**

- In case of wreckage, thousands of tons of coal will get deposited and pollute the water bodies



**Pic 1.26: Wreckage**

- Movement of barge will disturb free flow of water
- Pillars supporting belt conveyors, going over roads could become dangerous, if not maintained properly

### **Remedies:**

In the unloading stations, clamshells help in reducing fugitive dust while the receiving bin with extended edges will capture suspend-able particulate matters.



**Pic 1.27: Clamshell unloaders**



**Pic 1.28: Extended edge receiving bin**

- Water sprayers should be equipped for moistening the coal to prevent fire accidents, and also to control dust emission caused by the movement of belt



**Pic 1.29: Water sprinkling on conveyors**

- Conveyor belts should be covered to protect from rain, and from the wind to prevent overturning of the conveyor belts
- Drip pans to collect the coal spillage should be provided when the conveyor belts cross highways, walkways etc.
- Coal pile should be covered with tarpaulins



**Pic 1.30: Covered Barge**

- Residue, as a result of spillage, should be collected and put on the trucks
- Conveyor belt pillars have to be removed and should not be abandoned after the project is over

### **Slurry pipeline\***

The slurry pipeline requires coal to be ground to uniform size through successive crushing and pulverisation process. The coal is then made into a liquid form, by agitating and mixing with water, chemicals, methanol or crude oil. The chemicals are used for maintaining the velocity, pH and prevent corrosion. Thereafter, it is passed through the pipeline to the end-use point.

\*This type of coal transport is not followed in India till now.

### **Problems:**

- Land is affected e.g. destruction of vegetation
- Dewatered liquid from slurry, i.e. water removed from slurry, is high in chemical content

### **Pollutants:**

Slurry water contains chromium, phosphate and organic compounds with dosage as high as 1000 ppm (mg/l)

### **Effects:**

Dewatered liquid if used, in the cooling tower in thermal power plants can release pollutants into the atmosphere, and will also leach into the groundwater, if used as blow down water.

### **Remedy:**

Slurry water can be re-circulated into the pipeline.

## REFERENCE TO EIA DOCUMENTS

<b>Form 1</b>	<p>Sections:</p> <ul style="list-style-type: none"> <li>2. Activity details</li> <li>4. Storage, transport, handling or protection of substances harmful to human health or environment</li> <li>6. Release of pollutants or any hazardous; toxic or noxious substances to air</li> <li>7. Generation of noise and vibration and emission of light and heat</li> <li>8. Risk of contamination of land or water</li> <li>9. Risk of accidents during construction or operation which could affect human health or environment and</li> <li>11. Environmental sensitivity</li> </ul>
<b>ToR (Terms of Reference)</b>	<p>Sections:</p> <ul style="list-style-type: none"> <li>10. Distance between the roadway/railway and the plant boundary</li> <li>21. Quantity of fuel to be transported</li> <li>41. Cumulative impacts including handling and storage</li> <li>44. Impact on ambient air quality due to transport of fuel</li> <li>45 and 46. Approvals from port, rail and road authorities</li> </ul>
<b>Executive Summary</b>	<p>Sections:</p> <p>“Baseline Environmental Studies” – Land use; transport; noise monitoring; traffic noise level monitoring data</p> <p>“Anticipated adverse environmental impacts in the construction phase”</p>
<b>EIA Report</b>	<p>Under Chapter:</p> <p>Chapter – 5: analysis of alternatives – Site &amp; Technology and Chapter – 7 Additional Studies to cover Risk Assessment &amp; Disaster Management</p> <p>Modes of transportation are mentioned in:</p> <p>“Details of proposed project” &amp; “Coal transportation” – construction activities for mode of transport /existing / modes transportation information</p> <p>“Mechanical system” – how coal is transported</p> <p>“Impact during operational phase” – transportation impacts</p> <p>“Noise impacts” – transportation noise control</p> <p>“Mitigation measures” – mitigation measures for controlling transport emission</p>
<b>EC</b>	<p>“Raw material” – proper transportation of coal without impacting the environment</p>

<b>CTE</b>	General conditions - information on transportation without damaging the environment
<b>CTO</b>	Specific conditions - information on concrete pavement inside the campus, water sprinkling for dust suppression and the speed of vehicles



# CHAPTER 2

## COAL STORAGE

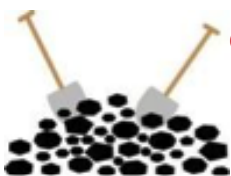
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Coal is transported from coal mines and unloaded in coal yards, then stored in stockpiles at the power plant. In case of barge transport, the coal is first unloaded in the port and stored in the port storage area and then taken to the plant by train, truck or conveyor.

### **Coal storage facilities depend on:**

- Availability of capital for storage;
- Capacity of the power plant;
- Open or closed storage depending on moisture content of the coal;
- Level of dust control; and
- Potential effects of freezing when stored in cold weather.

Coal can be stored either as open stockpiles or closed stockpiles. Industry practice has been to use open type coal storage due to cost considerations, although closed stockpiles are environmentally friendly. The latter is mainly used by captive thermal power plants and power plants with lesser capacity.



### **Coal storage consists of two major systems:**

- Wagon unloading system
- Stacking system



**Pic: 2.1 Open stockpile**



**Pic 2.2: Closed stockpile**

### **Wagon unloading system:**

Coal is fed into the hopper by wagon unloading system, in case of train transportation. In the case of trucks, the tipper trucks directly unload into the hopper. The hopper has a metal net/mesh so as to ensure primary size grading. If bigger coal particles/nuggets stay on the mesh, they will be broken down manually or mechanically.



**Pic 2.3: Wagon unloading**

### **Stacking system:**

The stacking system is one of the most automated and helpful technologies in the coal handling system. The stacking system has a stacker (forms pile) and a reclaimer (reclaims coal whenever needed). These structures are rail mounted. They can move back and forth, and can rotate from left to right and vice versa. The conveyor collecting the unloaded coal from the wagon unloading station ends at the stacking system, which empties the coal from the conveyor at the storage yard.



**Pic 2.4: Stacking system**

**Problems:**

- During the storage process, fugitive dust and coal particles will escape and get deposited inside and outside the plant. For example, when the coal is crushed in the hopper, the possibility of the coal particles being carried by wind is high.
- Effect of wind on the coal stock pile in the storage area will result in blowing of fugitive dust into the atmosphere.



**Pic 2.5: Pile formation**

- Coal is prone to heating up due to its chemical composition. Thus improper maintenance can build up pressure, which will lead to fire accidents.
- Wind and moisture play a major role in spontaneous combustion. Wind supplies oxygen for combustion and the absorbed moisture in the pile increases the temperature. This combustion releases toxic gases into the atmosphere causing air pollution.



**Pic 2.6: Spontaneous combustion**



**Pic 2.7: Fire**

- Leachate from the coal storage pile occurs due to rain and also spraying of water on the stock pile. This has high amounts of dissolved solids which can enter into the nearby water bodies and even percolate into the ground, contaminating groundwater and the surrounding soil.



**Pic 2.8: Leachate from pile**

### **Pollutants:**

Particulate matter, dissolved chemicals, low pH and high conductivity, and combustion of coal piles release CO<sub>2</sub>, SO<sub>2</sub> and NO<sub>x</sub>.

### **Effects:**

- Dust suspended in air reduces visibility
- Health is affected by direct inhalation of coal particulates by both workers and public
- Particulate matters escaping from the coal pile causes respiratory problems
- Fugitive dust gets deposited on the plantations nearby, thus reducing the photosynthetic activity of the flora and reduces the agricultural productivity.
- Water pollution caused by the leachate acidifies the water making it unfit for consumption

- Rain may leave lumps in the coal thereby increasing the process of breaking them down into uniform sized particles



**Pic 2.9: Lump formation**

- Excessive water in coal makes it stick to the conveyor belt. On its return, it will dry up and cause air pollution,



**Pic 2.10: Coal wastage under conveyor**

- Fire accidents not only increase the temperature of the surroundings, but also release combustion gases into the atmosphere which mostly include CO<sub>2</sub>, SO<sub>2</sub> and NO<sub>x</sub>. These are some of the greenhouse gases that result in global warming.



**Pic 2.11: Combustion of coal pile**

## Remedies:

- Closed storage facility is the best option
- The mouth of the hopper – the funnel shaped coal receiver - can be provided with extended edges so as to control escaping dust. In addition, water can be sprinkled at the mouth.



**Pic 2.11: Unloading station dust suppression**

- The conveyor should be shielded in order to reduce the effect of wind
- Water can be sprayed over the loaded conveyors to ensure no coal particle escapes into the air
- Proper scrapping of the coal from the conveyor should be ensured. The recovered coal should be repurposed.
- Coal piles should be covered with huge plastic covers for protection from rain and win, and preventing fires due to oxidation of coal.



**Pic 2.12: Covered coal piles**

- In case of rain, excessive water will get drained from the coal pile. This has to be collected in the coal pile runoff pit through garland drains and allowed

to settle. The coal particles should then be separated from the water in the pit. The water should be treated and reused for watering the pile once again.

- For dust control and firefighting, plain water type sprinkling system should be engineered. Sometimes hundreds of liters of water will be poured over the piles to suppress spontaneous combustion. However, this should not be entertained because excessive moisture will result in warming and heating up of the coal.



**Pic 2.13: Water spraying over piles**



- Coal heaps should not exceed five meters in height. The distance between two heaps at ground level should be five meters. This helps segregate the coal piles while providing for easy access in case of fire.





**Pic 2.14: Coal pile formation**

- Given the disadvantages of open stockpile storages, closed coal storage options must be considered. They are a) longitudinal covered shed; b) dome type structural storage shed; c) wind barriers around the stockpiles; and d) large capacity silos must be considered

## Closed coal storage:

Type	Description	Image
Longitudinal covered shed	As with open coal storage, the stockpile will have a rail-mounted stacker cum re-claimer. Here stockpiles, stacker cum re-claimer will be covered inside the shed	
Dome type covered shed	The shape of the cover is in the form of a hemisphere. The coal will be sheltered from wind, rain and other elements. Large quantities of coal can also be stored by altering the height of the dome. The dome structure will be erected on a concrete wall of required height depending on the amount of coal to be stored.	
Wind barriers around the stock pile	Wind barriers can be provided to an open stock pile. It will be made of steel to withstand wind speed of that	



	<p>particular site. This reduces problems like spontaneous combustion and dust being blown away.</p>	
<p>Large capacity silos</p>	<p>Silos are preferred where land availability is a problem. It reduces effects of wind and rain on the coal pile. Blending of different types of coal becomes easy and accurate. As it is fully covered, contact with atmospheric oxygen is negligible and heating issues are largely reduced. But, the emission of gases like CO, ammonia etc., should be monitored.</p> <p>It is expensive, hence cost benefit analysis of such storages should be considered.</p>	

<b>REFERENCE TO EIA DOCUMENTS</b>	
<b>Form 1</b>	<p>Sections:</p> <p>2. Activity details</p> <p>4. Storage, transport, handling or protection of substances harmful to human health or environment</p> <p>6. Release of pollutants or any hazardous; toxic or noxious substances to air</p> <p>8. Risk of contamination of land or water and</p> <p>9. Risk of accidents during construction or operation which could affect human health or environment</p>
<b>ToR</b>	<p>Sections:</p> <p>43. Storage of fuel and auxiliary fuel, EMP to mitigate adverse impacts</p> <p>48 &amp; 49. Disaster Management Plan in storage area including the fire and explosion issues with the risk contours properly mentioned in the plant layout and safeguard measures for the same</p>
<b>Executive Summary</b>	<p>Sections:</p> <p>9. Risk and Disaster Management includes the details on safe storage of the fuel and auxiliary fuel;</p> <p>10. Cost provision will give the split up for air pollution control, which will include fugitive dust suppression cost</p> <p>Under anticipated adverse Environmental impacts in operational phase, dust suppression measures will be provided</p>
<b>EIA Report</b>	<ul style="list-style-type: none"> <li>• “General layout plan” – coal storage yard capacity</li> <li>• “Impact on air quality” – fugitive dust emission from coal yard</li> <li>• “Potential risk areas” and “Waste Water Management” - storage yard information</li> </ul>
<b>EC</b>	<ul style="list-style-type: none"> <li>• “Raw material” – storm water drain from coal yard through garland drain, soil and groundwater characteristics of the storage yard</li> <li>• “Water pollution” – proper storm water drain</li> </ul>
<b>CTE</b>	General conditions - proper ways of storing coal without impacting the environment
<b>CTO</b>	Specific conditions - coal storage flooring, wind barrier and coal pile heights

# CHAPTER 3

## COAL HANDLING

---

Coal handling is the first step in the process of power generation. Coal is stored in the storage yard either as open or closed stockpiles, as discussed in Chapter 2. Before being sent to the boiler, the coal passes through the coal processing plant for more efficient power generation. The coal is ground and converted into uniformly sized particles so as to achieve even burning in the furnace and for maximum utilisation of coal. The coal is then taken to the boiler for burning.

Coal handling has the following processes:

- a. Conveyor system
- b. Crushing unit
- c. Feeding system

### **Conveyor system:**

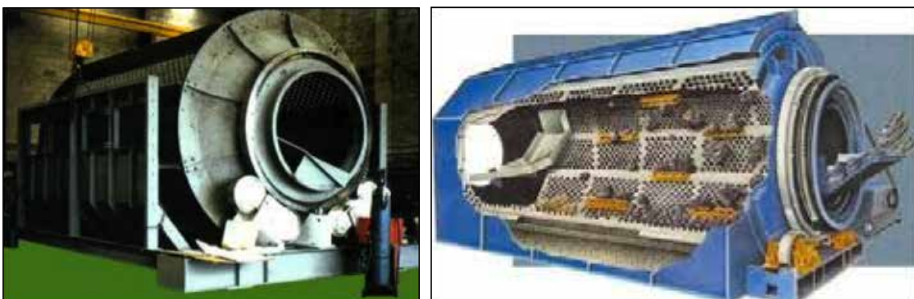
The coal is taken from the storage site to the crusher through conveyors. These conveyors are enclosed to prevent dust from flying. This conveyor passes through a metal detector to remove any metallic components present in the coal.



**Pic 3.1: Enclosed coal conveyors**

### **Crushing system:**

The crushing unit is necessary in a power plant to crush or evenly pulverize the coal, depending on the type of boiler used. The coal particles should be of uniform size for efficient performance of the boiler (Refer Chapter 4 for Boiler).



**Pic 3.2: Crusher unit**

### **Feeding system:**

Processed coal from the crushing system is directly fed into the boiler through the feeder.



**Pic 3.3: Feeder**

The feeding process happens under a closed system and hence only minor impact is felt on the surrounding environment.

### Problems:

- Fugitive dust emission is a major problem
- If conveyors are not closed or crushing, and feeding units improperly maintained, coal dust particles will escape and cause air pollution
- Indoor dust pollution

### Effects:

Dust emission, from the above systems, is a health hazard for site workers and local population.

### Remedies:

- Equipments should be maintained properly to prevent leaks and gaps
- Workers should be provided with high quality masks to prevent coal dust inhalation
- Dust suppression system: Dust suppression systems mostly employ water jets to suppress escaping dust or fugitive emission. Water jets with fine droplets, having high velocity, with high surface coverage should be employed. This will allow the water drops to come in contact with dust particles easily, to suppress the escaping dust, thus allowing it to settle faster.



**Pic 3.4: Water sprayers**

- Dust extraction system: Bag filters should be used to extract dust particles. Bag filters consist of vacuum suckers that suck the floating dust particles. The dust particles get collected in a bag from which they can be removed.

The collected coal dust should either return to the feeding/coal yard or disposed along with solid waste i.e. ash (to know more about Fly Ash, refer chapter 8).



**Pic 3.5: Bag Filter**

- Metal detector system: Metal detectors are important as the presence of metal in the pulverized coal will tend to reduce the efficiency of the boiler.



**Pic 3.6: Metal detector**

<b>REFERENCE TO EIA DOCUMENTS</b>	
<b>Form 1</b>	<p>Sections:</p> <p>4. Storage, transport, handling or protection of substances harmful to human health or environment;</p> <p>6. Release of pollutants or any hazardous, toxic or noxious substances to air;</p> <p>8. Risk of contamination of land or water; and</p> <p>9. Risk of accidents during construction or operation, which could affect human health or environment</p>
<b>ToR</b>	<p>Section:</p> <p>41. Cumulative impacts including handling and storage</p>
<b>Executive Summary</b>	<p>Sections:</p> <p>9. “Risk and Disaster Management” - details on safe handling of the fuel and auxiliary fuel;</p> <p>10. “Cost provision” - split up for air pollution control, this will include fugitive dust suppression cost; and</p> <p>“Anticipated adverse Environmental impacts in operational phase” - dust suppression measures</p>
<b>EIA Report</b>	<p>Sections:</p> <ul style="list-style-type: none"> <li>• “Fuel source and quality” - coal handling details</li> <li>• “Process description” – coal handling</li> <li>• “Water pollution control” - details on waste water from coal handling plant</li> </ul>
<b>EC</b>	“Raw material and air pollution control measures” - Fugitive dust control mechanisms
<b>CTE</b>	“General conditions” and “Air pollution control” -Fugitive dust emission by spraying of waters
<b>CTO</b>	<p>“Specific condition”</p> <ul style="list-style-type: none"> <li>• Details on when the plant should complete setting-up of the coal handling system; and</li> <li>• Details of dust collection system cum water sprinkler arrangement for fugitive dust suppression and bag filter and cyclone separator requirement at coal handling and pulverizing unit</li> </ul>

# CHAPTER 4

## COMBUSTION AND STEAM GENERATION

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Combustion and steam generation, where combustion leads to steam generation, are the initial processes for producing electricity.

In a coal based thermal power plant, pulverised coal from the coal handling plant is fed into a giant furnace for burning (burning, technically, can be described as combustion/oxidation) resulting in heat production. The aim of the combustion process is to transfer heat energy from the fuel to boil the water to generate steam at a certain temperature and pressure in a boiler.

For this purpose, water is required for steam generation and is brought through pipes from various ground and surface sources. The steam is then transferred to the turbines linked with generator to produce electricity. The steam from the turbine is then condensed into water, and returned to the boiler for reheating.

Combustion is achieved by 3 Ts’:

- **Temperature:** A high temperature is required to burn the coal while retaining its ability to maintain the heat constantly inside the furnace.
- **Turbulence:** Coal is heavy and has a tendency to settle to the surface. In order to ensure that uniform and complete burning takes place, air is injected into the furnace. Coal is mixed with hot air to create turbulence resulting in complete combustion.



During combustion, oxygen from air combines with combustible elements such as carbon, sulfur, hydrogen, and nitrogen, to produce their respective oxides.

- **Time:** Time plays an important part in the combustion process. This depends on the steam generation technology and also quantity and quality of coal. For example, it takes 10 minutes to burn 1 kg of coal completely. If a new batch of coal is put into the furnace, within 5 minutes of putting the previous batch, there is a possibility that complete combustion will not take place. This will lead to inefficiency in electricity production and wastage of coal.

**Steam generation system:** Steam generator consists of furnace, economizer, boiler and super heater.

a) **Furnace:** The furnace helps in combustion of coal in order to produce heat for boiling the water to generate steam.



**Pic 4.1: Coal burning**

b) **Economizer:** This component pre-heats the water entering the boiler to maintain its uniform temperature. Economizer is a type of heat exchanger that is installed to transfer additional heat from the flue gas (refer Chapter 5 for Flue Gas) to the inlet water, thus pre-heating the water entering the boiler. This is used to improve the efficiency of a boiler.



**Pic 4.2: Economizer**

c) **Boiler/steam generator:** A steam generator is a huge closed vessel used in thermal power plants to produce steam by heating water. It produces steam at a certain threshold or critical pressure, depending on the boiler technology. This critical pressure is the pressure where liquid and gas co-exist – if the pressure increases the rotation in the turbine increases. More power will be produced for the same amount of coal consumed compared to the boiler with pressure lower than critical pressure.



**Pic 4.3: Boiler**

**Boiler technology:**

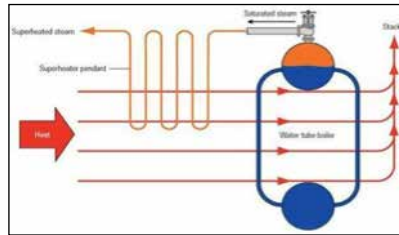
Boiler technology will influence the raw material usage, and have an important effect in reducing the amount of pollution being let out into the environment.

There are three types of boiler technologies: sub-critical, super critical, and ultra-super critical depending on their respective pressure.

Critical pressure of water under Standard Temperature and Pressure is 225 atm.

Technology	Operating Pressure	Efficiency	Advantages	Disadvantages
Sub-critical, it operates below the critical pressure	< 225 atm	35 – 38 %	Cost effective	High coal consumption, More CO <sub>2</sub> emission
Super critical, it operates above the critical pressure	> 240 atm	42 – 47 %	Lower coal consumption, low PM, NO <sub>x</sub> and SO <sub>2</sub> emissions; lower land requirement, reduced water consumption in ash dyke.	High cost of Construction, High levels of corrosion, and boiler accidents due to high pressure
Ultra-super critical, it also operates above the critical pressure, which is much higher than the supercritical pressure	>270 atm	48 – 55%		

d) **Super heater:** This heats the steam to a temperature above its saturation point to produce dry steam i.e., steam with zero moisture. This dry steam is sent to the turbine to produce electricity.



**Pic 4.4: Super heater**

### Problems:

- Ash becomes a residue of burning of coal. This is divided into fly ash and bottom ash (refer Chapter 8 for Ash);
- If the super heater does not work properly, then moisture in the steam will corrode metal parts of the boiler
- Flue gas (refer Chapter 5 for Flue Gas) containing  $\text{CO}_2$ ,  $\text{SO}_2$ ,  $\text{NO}_x$  and Particulate Matter
- Clinker or molten ash is formed inside steam generator due to high temperature.
- Scale formation or salt deposition in the tubes in the boiler



**Pic 4.5: Scale formation**

### Effects:

- The process within the closed boiler creates high temperature and pressure. Improper maintenance will lead to vapour explosion.
- High temperature in the furnace will melt the ash, forming clinkers. This will stick to the furnace walls. Clinkers deposition in the furnace result in pressure build up and possible explosion.



**Pic 4.6: Furnace accident**

- The boiler is connected to hot water and steam pipelines. Improper maintenance may lead to leakage in the pipelines causing burn injuries.
- Moisture in the steam corrodes the turbine blades (Refer Chapter 7 for Power Generation)

### **Remedies:**

- Pressure and temperature valves should be maintained properly and periodically
- Clinkers should be removed regularly for proper maintenance of the furnace
- Ash and flue gas should be treated, remove, and disposed efficiently without affecting the environment (refer Chapter 5 & 8)
- Water should be pre-treated for reducing hardness and other minerals to prevent scale formation or salt deposition
- Steam should be super-heated above its saturation point, till the point where it has no moisture, to ensure turbines run without problems.
- Updated boiler technology should be adapted for efficient use of coal and water.

### **DID YOU KNOW**

Additional Studies of EIA report should address

- inventory storage capacity,
- applicability of “Public Liability & Insurance coverage” and
- layout plan with risk assessment

### **REFERENCE TO EIA DOCUMENTS**

Information on the boiler technology can be found in the ‘Name of the project’ under all documents.

# CHAPTER 5

## FLUE GAS

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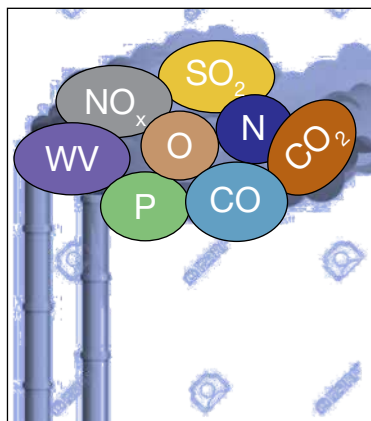
**B**urning of coal in the furnace produces gas and ash. Gas is let out into the atmosphere through a pipe or flue. It is commonly called flue gas. Most of the ash produced is also carried via the flue gas while the rest gets collected at the bottom of the boiler (refer Chapter 8 for Ash).









The flue gas before being let out into the atmosphere through stacks, undergoes certain screening processes to remove toxins. Stacks are big chimney like structures, which let out the flue gas from a thermal power plant.



**Pic 5.1: Flue gas from stack**

## Flue gas pollutants:



 NO <sub>x</sub>	- Nitrous oxide	 CO <sub>2</sub>	- Carbon dioxide
 SO <sub>2</sub>	- Sulphur dioxide	 CO	- Carbon monoxide
 WV	- Water vapor	 N	- Nitrogen
 O <sub>2</sub>	- Oxygen	 P	- Particulate matter

Once the flue gas exits into the atmosphere, it is called as plume. The plume behavior changes depending on the atmospheric stability such as wind, temperature, heat, rain etc. This affects the dispersion of the flue gas components and therefore it is important to understand plume behaviour.

### Plume behavior:


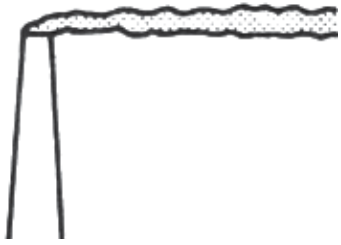
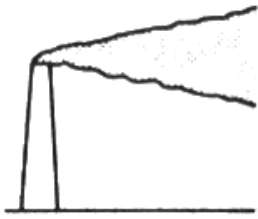
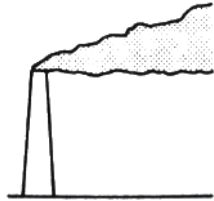
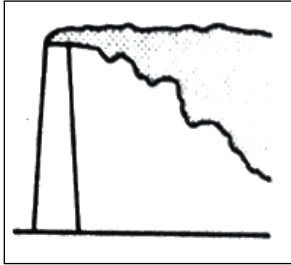
The dispersion of the plume into the atmosphere depends on a) height of the stack, b) velocity of the plume, and c) atmospheric conditions.

There are two reasons for the plume to exit the stack: a) temperature differences between the plume and atmospheric air with the former being hot and therefore making it light, b) velocity at which the plume is released by a fan placed at the bottom of the stack.

The particulate matters in the plume, depending on the wind flow, move away from the source and get deposited on the ground, trees, etc., either in the vicinity of

the power plant or elsewhere. While the gases present in the plume react with the atmospheric air to form ozone etc.

Range of wind speed is kept constant in below explanation, highlighting the plume behaviour:




<p><b>Looping behavior</b> occurs during periods of light to moderate wind speeds on a hot summer afternoon. It affects areas in the immediate vicinity of the power plants with high concentrations of pollutants.</p> 	<p><b>Fanning behavior</b> occurs when the plume is dispersed in the presence of very light winds. Due to the wind speed and steady elevation, it is possible that the pollutants are carried long distances without touching the ground. They contribute to less ground pollution.</p> 
<p><b>Coning behavior</b> occurs under cloudy skies both during day and night. It takes the pollutants to fairly long distances before reaching the ground.</p> 	<p><b>Lofting behavior</b> occurs during evening to night time. It takes the pollutants up into the atmosphere. It is seen as a favorable condition as the pollutants have less chances of reaching the ground.</p> 
<p><b>Fumigation behavior</b> occurs on clear skies and light winds, and it is more common during summer, when hot air pushes the pollutants down. This behaviour is the most dangerous as high concentration of pollutants travel towards the ground, increasing contamination.</p> 	

## Problems:

- Ash gets deposited on land, water and households
- Ash particles suspended in the air are Respirable Suspended Particulate Matters (RSPM)
- Oxides of Nitrogen are acidic in nature and cause acidity in air and land surface. SO<sub>2</sub> emission causes acid rain

## Plume colour:

- One can observe the plume colour and understand whether thermal power plants have installed air pollution control equipments, as per regulations. This can help one understand whether they are being operated regularly and maintained properly.
- Plume colour vs. effectiveness of air pollution control equipments is shown in the table below.

Plume Color	Pollutants	Inference	Image
White	Water vapor	Air pollution control equipments are working properly and are in good condition	
Grey	Particulate matter (fly ash) at slightly higher concentration.	Air pollution control equipments are not maintained properly	
Dark Brown to Black	High levels of pollutants including PM, SO <sub>2</sub> and NO <sub>x</sub>	Air pollution control equipments are neither maintained properly, nor working regularly.	



## DID YOU KNOW

Indian coal has low sulphur but high ash content as compared to imported coal, which generally has high sulphur with low ash content. In India, both domestic and imported coals are used depending on which is easily available.

### Effects:

#### Particulate matter:

- Particulate matter in the plume mainly consists of fly ash
- Particulate matter depositing on the ground contaminates the soil reducing its fertility. This seeps into the ground water while PM contaminates surface water and makes it unusable.
- Ash exiting the stack affects health causing lung damage and respiratory issues
- Tropospheric ozone which is a greenhouse gas responsible for global warming is formed

#### SO<sub>2</sub> and NO<sub>x</sub>:

- Acid rain is caused when SO<sub>2</sub> combines with atmospheric oxygen. It leaches more aluminum from soil and drains it into the nearby water body, affecting the aquatic ecosystem. Dead or dying trees are one of the visible impacts on plants.



**Pic 5.2: Dead tree**

- Higher concentrations of NO<sub>x</sub> affect the metabolic activity and photosynthesis in plants. In humans, high levels of NO<sub>x</sub> will cause respiratory and lung related diseases.



**Pic 5.3: Ozone damage on plant leaves**

- SO<sub>2</sub> and NO<sub>x</sub> corrode stone structures and monuments

### **Remedies:**

Electrostatic Precipitator (ESP):



**Pic 5.4: ESP**

An ESP collects fly ash from the flue gas before it enters the stack. An electric field is induced inside the ESP attracting the particulates (fly ash) towards the oppositely charged electrodes. When sizeable amounts of fly ash stick onto the electrodes, it will vibrate, loosening the particles and making them fall into the hopper at the bottom. It will then be routed to the fly ash silos.

### **Flue Gas Desulphurization (FGD):**

FGD is a technology used to remove sulphur content from the flue gas in order to reduce the SO<sub>2</sub> levels.



**Pic 5.5: FGD system**

Flue gas will be sent into the FGD reactor from the bottom. A scrubbing solution (alkaline in nature) will be sprayed from the top of the reactor. The acidic nature of  $\text{SO}_2$  will get neutralized and particulate matter, if present, will also settle at the bottom. The resultant residues of this process are gypsum and ash in slurry form. Ash slurry should be taken to the ash pond for drying. The operation of this system consumes more auxiliary power (refers to the electricity consumed by the plant for its own purpose).

FGD system is recommended for power plants, a) using coal with sulphur content more than 0.5%, b) located in environmentally sensitive areas, and c) if many projects are located in the same area.

#### DID YOU KNOW

Dry Lime injection along with Coal Feed is “Environmentally desirable”, by which fly ash composition for Cement Industry is advantageous.

<b>REFERENCE TO EIA DOCUMENTS</b>	
<b>Form 1</b>	<p>Sections:</p> <p>“6. Release of pollutants or any hazardous, toxic or noxious substances to air”</p> <p>“9. Risk of accident during construction or operation which could affect human health or environment”</p>
<b>ToR</b>	<p>Sections:</p> <p>“38 &amp; 39. AAQ data as per MOEF &amp; CC”</p> <p>“41. Monitoring stations, air quality contours, wind rose data collection and submission”</p>
<b>Executive Summary</b>	<p>Sections:</p> <ul style="list-style-type: none"> <li>• “Project at a glance”- No. of stacks, stack height and stack diameter details;</li> <li>• “Baseline Environmental studies” - CPCB pollutant limits;</li> <li>• “Impact assessment (operational phase)” - predicted pollutants and their concentrations at Ambient Air Quality Monitoring locations</li> </ul>
<b>EIA</b>	<ul style="list-style-type: none"> <li>• “Impact during construction phase” - Impact on air quality</li> <li>• “Identification potential impacts during operation” - Impact on air quality (such as air pollution modelling, stack emission, SO<sub>2</sub> concentration at AAQ monitoring location etc.)</li> </ul>
<b>EC</b>	<p>EC Conditions:</p> <ul style="list-style-type: none"> <li>• “Details on ESP efficiency, stack height, no. of stacks provided, velocity of stack exit, dust collection equipment will be provided along with SPCB emission standards for air pollutants like CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>, etc.,”</li> <li>• “Periodical monitoring of AAQS by TNEB details”</li> </ul>
<b>CTE</b>	<p>General conditions:</p> <ul style="list-style-type: none"> <li>• “Details of point source emission with stacks”</li> </ul>
<b>CTO</b>	<p>Special conditions:</p> <ul style="list-style-type: none"> <li>• “Stack Height, Emission Standards, Ambient Air Quality in plant area, Air Pollution control equipment (such as Electrostatic precipitator, flue gas desulphurization, bag filter) used”</li> </ul>

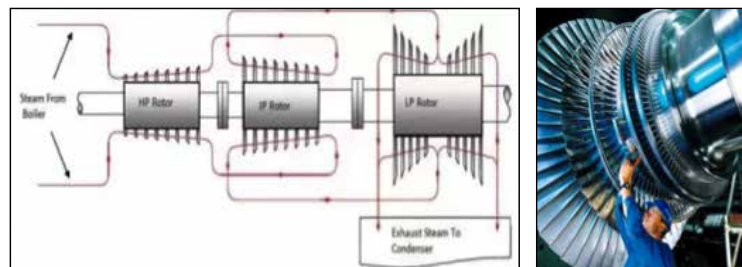
# CHAPTER 6

## POWER GENERATION

During power generation, steam produced from the boiler rotates the turbine blades. The turbine is connected to generators that produce electricity. The turbine generators are made up of a number of steam turbines, which are interconnected to each other along with a generator for conversion of mechanical energy into electrical energy.

The turbine generator consists of a High Pressure Steam Turbine (HPT) at one end, an Intermediate Pressure steam Turbine (IPT) in the middle, and two or more Low Pressure Turbines (LPT) at the other end.

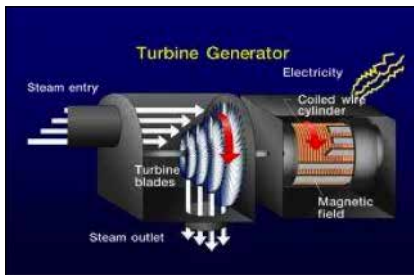
Superheated steam from the steam generator is supplied into the HPT to rotate the turbine. From the HPT, the residual steam is taken to the re-heater to increase its temperature before sending it to IPT. In the next stage, steam from the IPT goes to the LPT.



Pic 6.1: Turbine

This sequential set up of HPT, IPT, and LPT allows for maximum utilisation of steam energy. The materials used for each turbine is different, depending on the pressure at which it operates.

The HPT rotates when very high steam pressure is applied and remains idle at lower steam pressure. On the other hand, the LPT works under low pressure and can also rotate when higher pressure steam is supplied. To avoid damage of LPT blades, high pressure steam is passed over the HPT and then gradually over the LPT.



**Pic 6.2: Turbine working**



**Pic 6.3: Turbine with casing**

Turbines are coupled with the generator, which will convert mechanical energy to electric power at specific voltage and current. The turbine must rotate at a constant speed to produce electricity in the thermal power plant.

### **Problems:**

- Machine noise is unavoidable.
- Turbine blades may corrode due to improper treatment of water entering the boiler; and
- Heating up of turbines due to excessive speed of turbine blades

### **Effects:**

- Failure of the cooling system may lead to an explosion in the turbine. Cooling system is necessary to cool the heat produced by the frictional force of the turbine generators. Cooling can be done either by air or hydrogen. The latter is more efficient than air. Gaseous Hydrogen is circulated around the generators to absorb heat.



**Pic 6.4: Turbine accident**

- Hydrogen can be dangerous as it may explode when mixed with air



**Pic 6.5: Hydrogen storage accident**

### **Remedies:**

- Turbine accidents can be prevented through regular inspection and maintenance
- Turbines should be connected to cooling systems for cooling the steam. Compressed hydrogen gas must be used to cool the turbine
- Hydrogen is very effective in cooling the generator and helps in producing more electricity (megawatts). Hydrogen gas is a critical resource for the power plant, thus its supply and use should be precisely handled.
- Mufflers can be applied to motors or compressed air piping to reduce equipment noise, which can be typically applied to blowers and generators
- Plant should maintain recommended purity and pressure of hydrogen in the generator casing for efficiency, safety, and equipment reliability
- High speed turbines and generators tend to generate high levels of noise pollution. Workers should be provided with noise control devices, such as ear plugs and earmuffs.



**Pic 6.6: Earmuffs and Helmet**

<b>REFERENCE TO EIA DOCUMENTS</b>	
<b>Form 1</b>	Section: “7. Generation of Noise and Vibration and Emission of light and heat” “9. Risk of accidents during construction or operation which could affect human health or environment”
<b>ToR</b>	Section: “37. Health and safety of workers” “49. Disaster management plan and risk assessment study”
<b>Executive Summary</b>	Under Section: <ul style="list-style-type: none"> <li>• “Impact Assessment” - Impact on Noise level</li> <li>• “Environmental management plan” - Noise level Management</li> </ul>
<b>EIA</b>	Section: <ul style="list-style-type: none"> <li>• “Parameters and value of turbine and auxiliary equipment”</li> <li>• “Details of steam generator (STG) and auxiliaries describes the power generator its use and capacity of the equipment”</li> <li>• “Analysis of alternative technologies” - Steam generation technologies and unit size</li> <li>• “Risk assessment” - Identification of hazard due to steam generator</li> </ul>
<b>EC</b>	Under EC conditions: <ul style="list-style-type: none"> <li>• “Well-designed acoustic enclosure for the DC sets”</li> <li>• “Noise emitting equipments to achieve the desirable insertion loss”</li> </ul>
<b>CTE</b>	Specific conditions; <ul style="list-style-type: none"> <li>• “Noise pollution control” - information on noise control measures</li> <li>• “Health and safety” - employee safety equipment details</li> </ul>
<b>CTO</b>	General conditions; <ul style="list-style-type: none"> <li>• “Noise pollution control” - noise control measures</li> </ul>



# CHAPTER 7

## COOLING SYSTEM

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**C**ooling system is the process where the hot steam from the turbine is cooled using a cooling tower. The steam from the turbine is first condensed and is high in temperature. The condensed water needs to be cooled down before letting out to the nearby water body. For cooling the water, a cooling system comprising of a cooling tower is used. The cooling tower does two things a) collects cooled water at the bottom of the tower; and b) sends excess heat into the atmosphere.



**Pic 7.1: Cooling tower**

Considerations for a cooling system;

- Water withdrawal and its effect on local and regional water supply;
- Intake design and hydraulics and its impact on aquatic life;
- Temperature difference across the condenser; and



- Maximum temperature at the effluent mixing zone compared to the natural temperature



### Types of cooling systems:

**Once through cooling system:** Under this system, water is not recirculated or recycled. It is discharged at higher temperatures into the water bodies nearby. Hence, this system requires large quantities of water. This system is operational only in thermal power plants along the coastal areas.

**Closed Cycle cooling system:** This system re-circulates the water, thus minimising intake of freshwater from nearby water sources. Recirculation of water increases the Total Dissolved Solids (TDS) i.e. concentration of any minerals, salts, metals, cations or anions dissolved in water. Thus, blowdown is performed where a bulk amount of highly concentrated water will be removed from the circulation system and replaced with equal quantity of fresh treated water.

#### DID YOU KNOW

- The wastewater reject, ash pond overflow and once through cooling water is sent to “Marine Outfall” for disposal in mid sea and its temperature must not be more than 5°C of Marine water.
- In case of Turtle Migratory region, International treaty for Sea Turtle Migratory route says the temperature should not be more than 2.5° to 3°C above the marine water temperature

### Problems:

- Water with high temperature exits the cooling system
- For once through cooling, large quantities of water are needed for cooling the steam.
- For Closed System, high Total Dissolved Solids (TDS) content in the blow down water.



**Pic 7.2: Temperature difference**

### Effects:

- Fishes get trapped in the inlet system while drawing water for cooling. It will get caught in the intake screen (mesh) provided to remove debris entering the system.



**Pic 7.3: Trapped fish**

- When high temperature outflowing water comes into contact with the water body, it destroys the aquatic ecosystem in that area



**Pic 7.4: Dead fish**

- The blow down water, if not treated to reduce TDS concentration, becomes a threat to the water bodies and their eco systems.

### Remedies:

- Modified intake screens and returns systems should be installed to reduce aquatic impingement stresses and help fish return safely to the water body
- An acoustic deterrent system, which uses sound to frighten fishes, can be installed to keep them from entering the cooling water intake area
- Blow down water from the cooling tower should be taken to Effluent Treatment Plant (ETP) (Refer Chapter 9 for ETP)
- Proper recirculation of the condensed and cooled water should be followed

### DID YOU KNOW

Dry Cooling Tower can be used for Terrestrial TPP to save water resource. In such case, the specific coal consumption for the TPP will go up by 10 to 15% extra than wet cooling system. EIA report must be reviewed whether such impact has been considered or not (usually no change in coal consumption is addressed, which is impossible)

### REFERENCE TO EIA DOCUMENTS

<b>Form 1</b>	<p>Section:</p> <p>“7. Generation of Noise and Vibration and Emission of light and heat”, “8. Risk of contamination of Land or Water”</p>
<b>ToR</b>	<p>Section:</p> <p>“19. Water utilization in cooling system”</p> <p>“22. Impact of discharged water to water bodies”</p> <p>“23. Impact on fisheries”</p> <p>“26. Adoption of zero discharge concept”</p>
<b>Executive Summary</b>	<p>Section:</p> <p>“The project at a glance” - Source of water for cooling system</p> <p>“Baseline Environmental status –</p> <ul style="list-style-type: none"> <li>• Water quality as per limit prescribed by CPCB</li> <li>• Ecology : Sampling of aquatic ecology near water discharge</li> </ul> <p>“Impact Assessment”</p> <ul style="list-style-type: none"> <li>• Operation Phase Impact on water quality due to discharge, its discharge temperature.</li> <li>• Impact on ecology due to hot water discharge</li> <li>• Water Pollution Management - Temperature gradient of discharge cooling water,</li> <li>• Design of proper outfall system for heat dissipation</li> <li>• Water Pollution Management - measure for improvement of aquatic ecology</li> <li>• Temperature limit as per EPA, using of buffer zone for heat toleration</li> </ul>

<b>EIA</b>	<p>Section:</p> <p>“Identification of Potential Impacts during Operation”</p> <ul style="list-style-type: none"> <li>• Impact on surface water quality due to waste water generation includes quantity and quality of cooling water used in cooling tower blow down system</li> <li>• Calculation of expected noise pollution due to cooling tower using models</li> </ul>
<b>EC</b>	<p>EC conditions:</p> <ul style="list-style-type: none"> <li>• Cooling water disposal should be sufficiently cool and treated properly before disposal into any water body, as prescribed by Tamil Nadu Pollution Control Board, prior to disposal</li> <li>• Before discharge of any effluent from the plant into the sea, consultation with Director of fisheries is needed to avoid marine environment pollution</li> </ul>
<b>CTE</b>	<p>Specific Condition:</p> <ul style="list-style-type: none"> <li>• “Water consumption (WC) in KLD”</li> <li>• “Details of sewage/Trade effluent generation and disposal”</li> </ul>
<b>CTO</b>	<p>Special Conditions:</p> <ul style="list-style-type: none"> <li>• Discharge of effluent permitted from cooling water outlet</li> <li>• Details of effluent discharge standards</li> </ul> <p>General Conditions:</p> <ul style="list-style-type: none"> <li>• Ensuring the limits set by Tamil Nadu Pollution Control Board for cooling water temperature</li> <li>• Transportation of cooling water should be through open channel or closed pipe line and before disposing cooling water in sea</li> <li>• Consultation with director of fisheries is needed to maintain marine environment</li> <li>• Temperature of cooling water should not exceed 5°C.</li> </ul>

# CHAPTER 8

## ASH

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**C**oal ash is the residue from coal combustion and is composed of fly ash and bottom ash. This forms the major portion of solid waste produced in the thermal power plant.

Fly ash is a very fine, powdery material composed mostly of silica, made from the burning of finely ground coal in a boiler. Its major chemical components are Silicon dioxide, Aluminium dioxide, Calcium oxide, Mercury and Arsenic. They get carried by the exhaust flue gas to the stack, and before entering the stack they are collected by electrostatic precipitators/bag houses. Fly ash contributes about 80% to the total ash content.

Its chemical components makes it harmful but they are not dangerous, thus can be used as raw material for cement, brick production, etc. Fly ash from the electrostatic precipitator outlet is taken to the ash handling system, where it is stored and prepared to be sent to cement and brick manufacturing industries.



**Pic 8.1: Fly ash**

Bottom Ash is coarse ash particle that are too large to be carried up into the smoke stacks so it gets collected in the bottom of the coal furnace. This contributes to 20% in the total ash content.



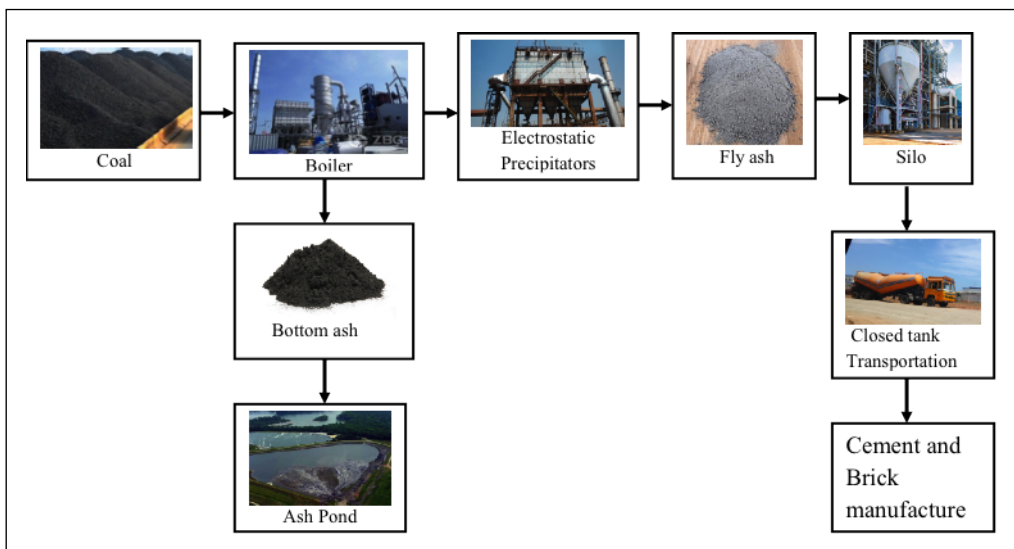
**Pic 8.2: Bottom ash**

Boiler slag or clinkers are molten ash deposited on the walls of the furnace. They turn into pellets and have a smooth glassy appearance after being cooled with water. They form huge lumps which need to be broken, using a clinker grinder.



**Pic 8.3: Boiler slag/Clinker**

**Ash cycle:**



## Ash handling:

- Fly ash will be collected at the bottom of the ESP hoppers using vacuum pressure and then sent to silos



**Pic 8.4: Fly ash collection**



**Pic 8.5: Fly ash silos**

- Hot bottom ash will be collected at the bottom of the furnace in water stored hoppers and then taken to the ash dyke



**Pic 8.6: Bottom ash collection**



**Pic 8.7: Bottom ash pond**

Apart from these,

- Pulveriser rejects from the coal handling plant will be sent to the bottom ash collection hoppers.
- Economiser (refer to Chapter 4) ash (ash from flue gas gets deposited on the economiser during heat exchange) will be collected in hoppers beneath the economizer.

## Problems:

- Among the above mentioned types of ash, fly ash and bottom ash are more harmful form of ash
- Ash, being very light by nature, can be carried easily by wind over long distances
- Toxins, such as mercury, arsenic etc., may leach into the soil from ash pondClogging soil pores and increasing its acidity



## Effects:

### Air Pollution

- Fly ash is not just particulate matter. Heavy metals present in the fly ash, even in small concentrations, can cause health problems. The table below gives details on the same:

Heavy metal	Concentration (ppm)	Health Impact
Nickel (Ni)	77.6	Respiratory problem, lung cancer
Cadmium (Cd)	3.4	Anemia, hepatic disorder
Arsenic (As)	43.4	Skin cancer, dermatitis
Chromium (Cr)	136	Cancer
Lead (Pb)	56	Anemia

**Table 1: Heavy metals and their health impacts**

- Small particles of ash, when inhaled, can cause inflammation of lungs, lung cancer, asthma etc. It can cause damage to the nervous system and skin cancer.

### Soil Pollution

- It reduces fertility of soil making it acidic in nature.
- Blocks the pores of leaves affecting the photosynthesis process.
- Cattle in the area will produce less milk. They graze on ash deposited vegetation which affects the quality of the milk. This will indirectly affect the health of the population consuming it.

### Water pollution

- Leaching may have an adverse effect on the quality of ground water.
- When Ash dispersed by wind, comes in contact with water bodies, it will change its pH level thus affecting the aquatic ecosystem. This is more so in the case of coastal thermal power plants.

## Remedies:

- During dry ash collection, the conveyors taking the ash to the silos have to be covered properly to reduce the effects of the wind

- In ash ponds, the bottom of the pond is to be lined with plastic liners in case of non-clayey soils, to prevent the seepage of the ash water into the soil and the groundwater. In the case of clayey soil, plastic liners are not required as the former acts as a liner when compacted.



**Pic 8.8: Ash pond liner**

### **Fly ash utilization:**

Fly ash can be made use of or utilised by other industries as raw material. Hence, its utilisation mitigates environmental impacts while addressing the problem of disposal of this solid waste.

Fly ash bricks: The toxicity present in the fly ash gets trapped inside the block/brick making it a successful product.



**Pic 8.9: Fly ash bricks**

#### **DID YOU KNOW**

- Coal fed to Boiler must conform to an ash content  $< 34\%$ .
- 100% Ash Utilization of Fly-Ash and Bottom Ash should be followed.

Fly ash in cement manufacture: Pozzolona is used as supplementary cement material in the production of Portland cement. Fly ash can be substituted for pozzolona cement because it also exhibits pozzolonic activity.



**Pic 8.9: Cement and fly ash comparison**

Fly ash distemper: Fly ash distemper can be used as a substitute for white cement as this will reduce the cost by 50%.

Apart from the above, fly ash can also be used as road construction component.

Bottom Ash: Due to continuous dumping of bottom ash into the ash pond, water overflows. This overflowing water should be treated and recirculated for reuse in the power plant. Once the ash pond is filled, the pond should be closed and covered by a green belt.

**TO CHECK**

Let us say,  
 TPP capacity = 600 MW.  
 Specific coal consumption = 0.8 Kg/KW.hr  
 Daily Coal requirement = 1152 Tonnes/day (0.8 X 24 X 600 = 1152 TPD).

Total ash generation = 391 TPD (1152 X 0.34 = 391 TPD),  
 Fly-Ash = 313 TPD  
 (391 x 0.8 = 313 TPD)  
 Bottom Ash = 78 TPD  
 (391 x 0.2 = 78 TPD)

A Cement plant can take only 25% Fly-Ash  
 For 100% Fly-Ash Utilization, the Cement Plant capacity should be (within 100 Kms radius),  
 1252 TPD (313/.25 = 1252 TPD)

<b>REFERENCE TO EIA DOCUMENTS</b>	
<b>Form 1</b>	<p>Section:</p> <p>5. Production of Solid Waste During Construction/ Operation/ Decommissioning which will include details on ash production</p>
<b>ToR</b>	<p>Section:</p> <p>“18. Details on fly ash utilization plan”</p> <p>“19. Water requirement optimization for ash management”</p> <p>“28. Plan for recirculation of ash pond water”</p> <p>“40. List of industries around the study area”</p>
<b>Executive Summary</b>	<p>Section:</p> <ul style="list-style-type: none"> <li>• “Land requirement” - ash quantity</li> <li>• “Process description” – information on ESP</li> <li>• “Liquid effluents” - information on bottom ash water handling</li> <li>• “Solid waste and hazardous waste” - utilization of fly ash and bottom ash</li> </ul>
<b>EIA</b>	<p>Section:</p> <ul style="list-style-type: none"> <li>• “Environmental setting of proposed plant site” - information on ash pond coordinates</li> <li>• “Details of project”- ash content, fly ash and bottom ash generation</li> <li>• “Land requirement” - ash dyke land details</li> <li>• “Water requirement” - ash pond water recirculation and ash disposal water requirement</li> <li>• “Process description and technology” - details on ash generation, storage and disposal</li> <li>• “EMP” - Impact mitigation measures for ash handling</li> </ul>
<b>EC</b>	<p>Section:</p> <p>“Water pollution control”</p> <ul style="list-style-type: none"> <li>• Details on storm water drain from the ash handling unit, overflow from ash pond treatment</li> <li>• Ground water monitoring areas near the ash disposal area will also be included</li> </ul> <p>“Solid waste management” - Details on ash disposal and utilization</p>

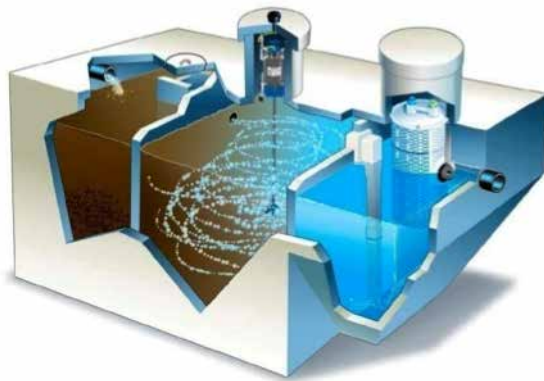
<b>CTE</b>	<p>General Condition:</p> <ul style="list-style-type: none"> <li>• Air pollution control dry ash utilization information</li> </ul> <p>Specific conditions:</p> <ul style="list-style-type: none"> <li>• Ash pond water usage</li> </ul>
<b>CTO</b>	<p>Specific Conditions</p> <ul style="list-style-type: none"> <li>• Ash wetting at ash handling area</li> </ul> <p>“Solid waste (Hazardous waste) disposal” - information on ash disposal</p> <p>“Fly ash and Solid waste disposal” - information on fly ash and bottom ash storage, transport and disposal.:</p>

# CHAPTER 9

## WATER & WASTE WATER

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**W**ater is needed in a power plant at various stages such as coal storage, steam production, cooling, ash pond etc. The water consumed also includes water used for domestic purposes around the plant. For efficient performance of boiler and cooling tower, the water has to be treated for impurities. Waste water from various stages is also collected and treated through an integrated waste water treatment system. This makes water and waste water treatment mandatory components in a thermal power plant.



**Pic 9.1: Treatment plant**

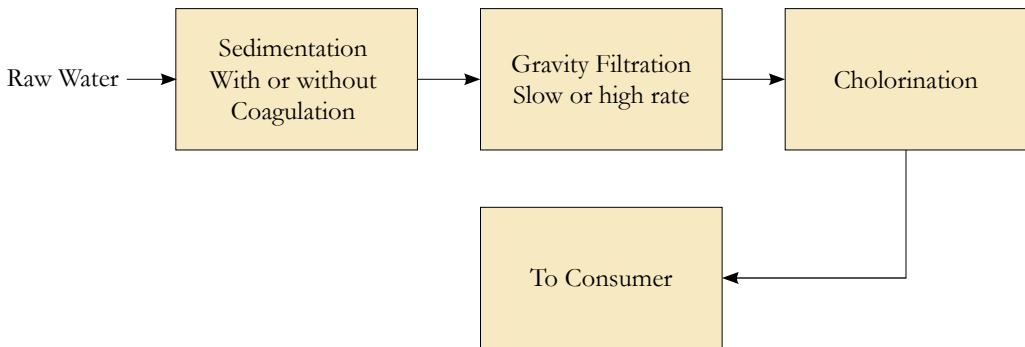
Functions of water and waste water treatment in a thermal power station:

- Raw water treatment for domestic purposes;

- Boiler water treatment for the boiler;
- Cooling water treatment for the cooling system; and
- Waste water treatment.

### Raw water treatment - domestic purposes:

Raw water treatment usually consists of physical treatment like sedimentation, filtration and simple chemical disinfection process. It removes impurities and dissolved salts from water while reducing colour, turbidity, and odour of water, thus making it potable.



**Pic 9.2: Raw water treatment process**

### Boiler Water Treatment:

The water sent to the boiler has to be treated for the following:

- Continuous heat exchange (refer Chapter 4) – non-treatment of the boiler water results in salt deposits (scale deposition) on the walls of the boiler tube, thus reducing the heat exchange capacity and efficiency of boiler.
- Protection from corrosion of boilers
- Production of high quality steam

#### DID YOU KNOW

TPP installed in a location far away from sea should not consume more than a specific water consumption norm of 2.5 m<sup>3</sup>/MWh. Groundwater use should not be permitted

There are two types of boiler water treatment,

**External treatment** is necessary for all boiler technologies. It is done outside the boiler and includes softening, evaporation, deaeration etc.

- Softening is done for reduction of dissolved salts, otherwise known as hardness, in the feed water.
- Water is evaporated to produce pure vapour which is then condensed and fed into boilers.
- Deaeration is to remove oxygen from the water as presence of oxygen will lead to corrosion in the boiler tube.

**Internal treatment** is used only in low or moderate pressure boilers (sub-critical technology) where the condensed steam is reused as feed water in large portions. The process takes place within the boiler, where chemicals like phosphates/poly-phosphate dispersants are sent in with the feed water into the boiler for reducing hardness in the feed water (refer Chapter 4 for Feed Water). These chemicals react with the depositing salts inside the boiler, thus making it non-sticky on the boiler wall.

### **Cooling water treatment – cooling system**

The need for this treatment is to remove dissolved salts from the cooling water as in boiler water treatment. Here, it consists of softening the water while maintaining neutrality of pH value to make the water less corrosive.

Also, to reduce the total dissolved salts, blowdown is practiced. Blowdown is a process wherein a bulk amount of water, concentrated with dissolved salts, is removed from the closed cycle cooling system, and equal quantity of clean water is substituted.

### **Waste Water Treatment:**

Waste water treatment ensures transforming polluted water into an environment-friendly product that can be disposed with negligible impacts.

In thermal power plants two types of waste water treatment happens: effluent treatment for waste waters from coal handling plant, coal storage area, blown down water, etc. and sewage treatment for the domestic waste water.

#### **DID YOU KNOW**

Visually one can check TSS carry over in bottom ash over flow

Waste water treatment plant treats the waste water in three ways; a) physical, b) chemical and c) biological to remove the pollutants.



<b>Physical</b>	Screening	Removes grits and other coarse and fine particles
	Sedimentation	Sedimentation of finer particles suspended in the waste water by the action of gravity
	Filtration	Filters solids from liquid using mesh made of paper/sand/metal
	Absorption/ Aeration	Waste water is aerated and this process is accompanied with chemical/biological process to remove dissolved solids/salts
	Adsorption	Adsorbents like activated carbon is used to adsorb impurities
<b>Chemical</b>	Coagulation	Coagulant, a substance e.g. a metallic salt, is added to facilitate settling of particles (fine particles stick together to settle)
	Flocculation	Floc (loosely clumped up mass of particles) floats on water which will later be removed using scrapers.
	Disinfection	Disinfectants like chlorine/ozone/UV are used to make the water potable
<b>Biological</b>	Aerobic-Activated Sludge Process	In the presence of air(oxygen), aerobic microbes cleanse the waste water
	Anaerobic	In the absence of air(oxygen), anaerobic microbes cleanse the waste water

### Problems:

- Waste sludge at the end of all treatment processes.

### Effects:

- Chemicals like disinfectants, alum etc. used during water and wastewater treatment, to remove impurities from the water can, cause pollution by contaminating ground and surface water sources, if not properly disposed.
- The blow down water that is let into the nearby water body, if not treated properly for dissolved salts before disposing or reusing, will cause rashes, skin diseases and other health issues to people coming in contact with it.

### Remedies:

- The sludge from the water treatment facility should be dewatered (separating the water from the sludge). The sludge should either be dried in sludge beds or disposed in landfills.
- The water from the dewatered sludge should be redirected to the wastewater treatment plant for further treatment.

<b>REFERENCE TO EIA DOCUMENTS</b>	
<b>Form 1</b>	<p>Sections:</p> <p>“3. Use of Natural Resources Including Source Information &amp; Data”</p> <p>“5. Production of Solid Waste During Construction/ Operation/ Decommissioning”</p> <p>“8. Risk of contamination of Land or Water”</p> <p>“11. Environmental Sensitivity”</p>
<b>ToR</b>	<p>Sections 19 to 29:</p> <ul style="list-style-type: none"> <li>• Water utilization in thermal power plant</li> <li>• quality and quantity</li> <li>• impact of discharged water to water bodies</li> <li>• fisheries</li> <li>• adoption of zero discharge concept</li> <li>• waste water treatment</li> <li>• Cycle of Concentration</li> </ul>
<b>Additional TOR for Costal Based Thermal Power Plants Projects</b>	<p>Sections:</p> <p>e. no discharge of effluent in to sea without appropriate treatment</p> <p>f. assessment of impact on fisheries at various socio-economic level</p> <p>i. flood water capture facility</p> <p>l. no contamination of surface water with sea water in and around the proposed project site</p>
<b>Executive Summary</b>	<p>Sections:</p> <p>“The project at a glance”: Source of water, raw water treatment</p> <p>“Baseline Environmental status”:</p> <ul style="list-style-type: none"> <li>• Water quality and effluent quality as per limit prescribed by CPCB</li> <li>• Ecology : Sampling of aquatic ecology near water discharge</li> </ul> <p>“Impact Assessment”: Operation Phase Impact on water quality due to discharge, water resources</p> <p>“Water Pollution Management”:</p> <ul style="list-style-type: none"> <li>• Expenditure on environmental measures</li> <li>• Measure for improvement of aquatic ecology: Temperature limit as per EPA</li> <li>• Using of buffer zone for heat toleration”</li> </ul>

<p><b>EIA</b></p>	<p>Sections:</p> <p>“Impact during construction phase”:</p> <ul style="list-style-type: none"> <li>• Impact on water Quality includes source of water utilization and generation of sewage during construction and its impact</li> </ul> <p>“Identification of Potential Impacts during Operation”:</p> <ul style="list-style-type: none"> <li>• Impact on surface water quality due to waste water generation includes quantity and quality of water used in operation</li> <li>• Waste water generated from the project</li> <li>• Quality of waste water and different effluent treatment facilities</li> <li>• Resultant water quality at discharge point</li> <li>• Impact on ground water</li> </ul>
<p><b>EC</b></p>	<p>EC conditions:</p> <ul style="list-style-type: none"> <li>• Waste water generated should be treated as prescribed by Tamil Nadu Pollution Control Board, prior to disposal</li> <li>• Before discharge of any effluent from the plant into the sea, consultation with Director of fisheries is needed to avoid marine environment pollution</li> </ul>
<p><b>CTE</b></p>	<p>General conditions:</p> <ul style="list-style-type: none"> <li>• Manufacturing process</li> <li>• Source of Water and Water Consumption</li> <li>• Water consumption (WC) in KLD</li> <li>• Details of sewage/Trade effluent generation and disposal and Source of Trade Effluent</li> <li>• Details of Sewage/Effluent Treatment</li> <li>• Cost of Water Pollution measures</li> <li>• Details of Water bodies like lakes/rivers/canals within a radius of 1KM and river within a radius of 5Km</li> <li>• Is the unit is located within 1Km from marine costal area (sea, estuaries, back waters</li> </ul>

<b>CTO</b>	<p>Special Conditions:</p> <ul style="list-style-type: none"><li>• Discharge of effluent permitted from sewage</li><li>• Details of effluent discharge standards should be mentioned</li><li>• Quality of effluent Discharged</li></ul> <p>General Conditions:</p> <ul style="list-style-type: none"><li>• Ensuring not mixing of discharge from other premises into his/her/their premises</li><li>• Not mixing of storm water into discharge effluent</li><li>• Limits set by Tamil Nadu Pollution Control Board for cooling water temperature should be followed</li><li>• Non-compliance with effluent limitation</li><li>• Cost of effluent sample tasting before and after treatment</li><li>• Use of mechanical dozers and proper equipment for chemicals</li><li>• Utilization of treated effluents in plant</li><li>• Periodical monitoring of effluent by Tamil Nadu Electricity Board</li></ul>
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