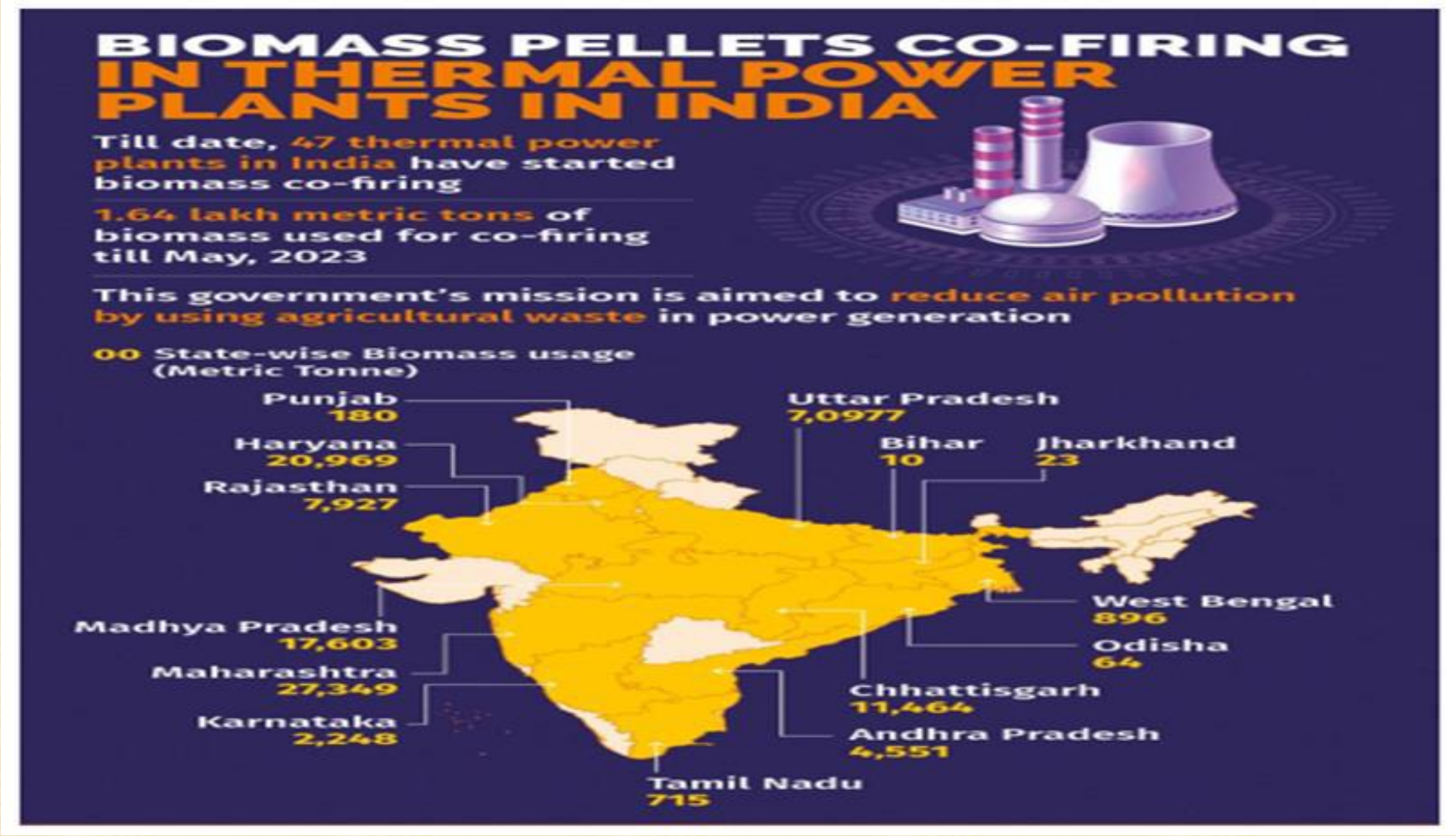
Technical Challenges of Thermal Units to Adopt Biomass Utilization through Co-firing in Coal based Thermal Power Plants.



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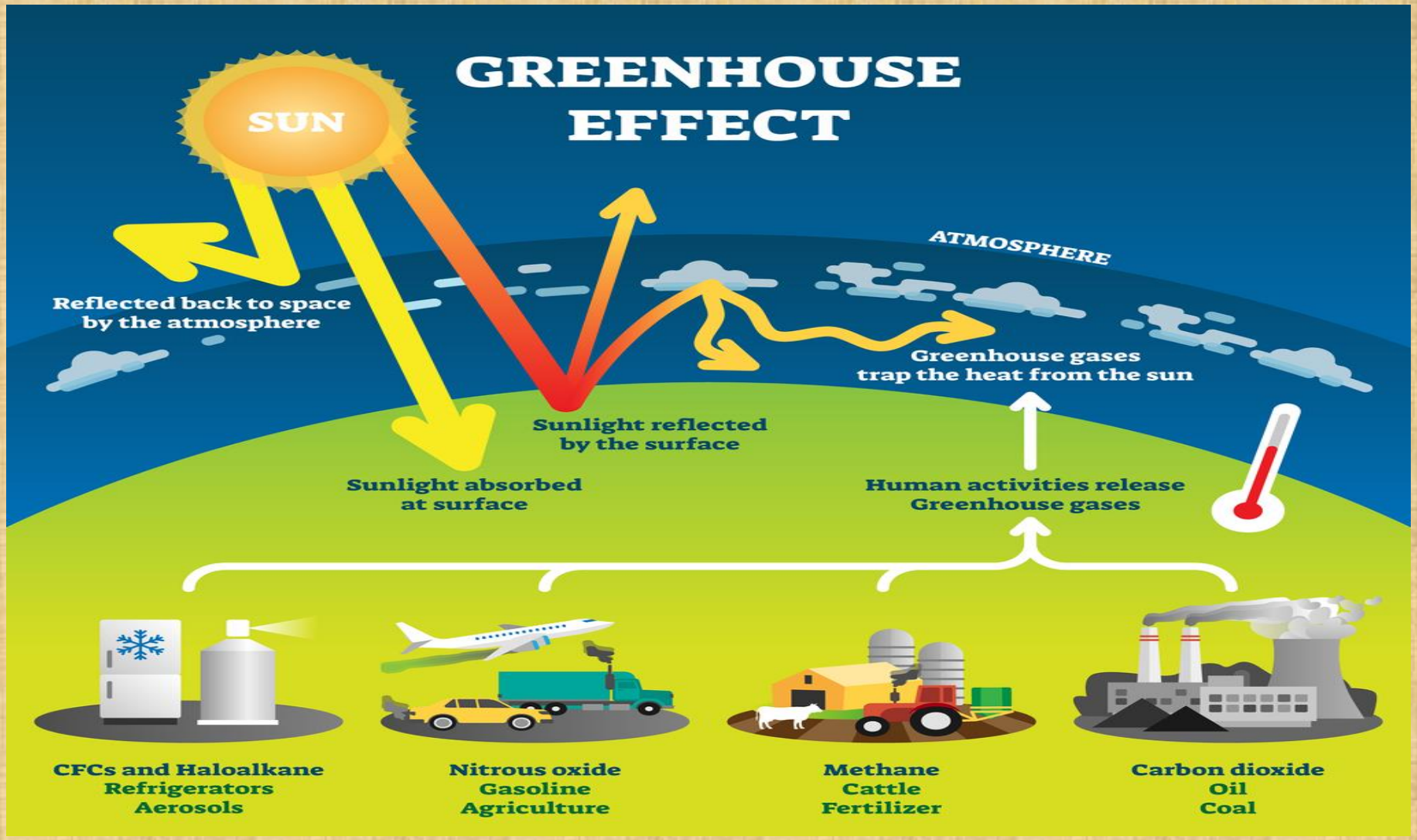
Green House Gas Emission

Generating electricity by burning of fossil fuels (like coal, oil, and gas), produces large chunk of green house gases, blanket the earth, traps sun's heat which causes global warming and climate change.



Climate Change and global warming

Warmer temperatures over time are changing weather patterns and disrupting the usual balance of nature. This poses many risks to human beings and all other forms of life on Earth.

Causes and Effects of Climate Change

Causes

- Rapid industrialization
- Energy use
- Agricultural practices
- Deforestation
- Consumer practices
- Livestock
- Transport
- Resource extraction
- Pollution

Effects

- Rising temperatures
- Rising sea levels
- Unpredictable weather patterns
- Increase in extreme weather events
- Land degradation
- Loss of wildlife and biodiversity

What are the social impacts of climate change?

Displaced people. Poverty. Loss of livelihood. Hunger. Malnutrition. Increased risk of diseases. Global food and water shortages.

GlobalGiving

Urgent need to curb emission of GHG

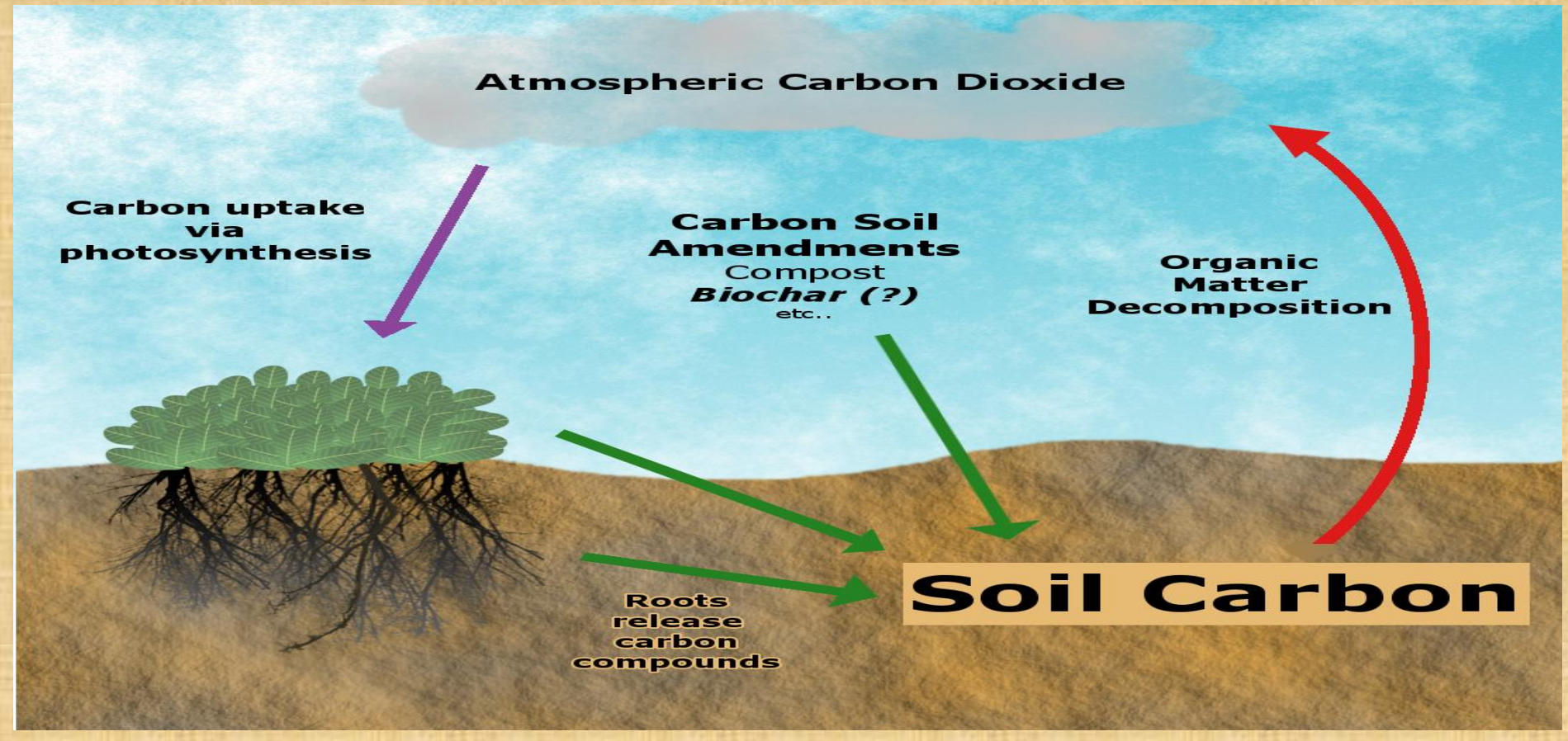
There are four common scenarios to prevent the global warming effect of CO_2 in the atmosphere gradually

- Increasing the efficiency so that the fossil fuel consumption decreases
- Mix of renewable fuels with fossil fuels so that fossil fuel consumption has also decreased
- Substitution of fossil fuels with renewable fuels
- The absorption of CO_2 in the atmosphere so that the concentration of greenhouse gases can be reduced.

Types of fuel

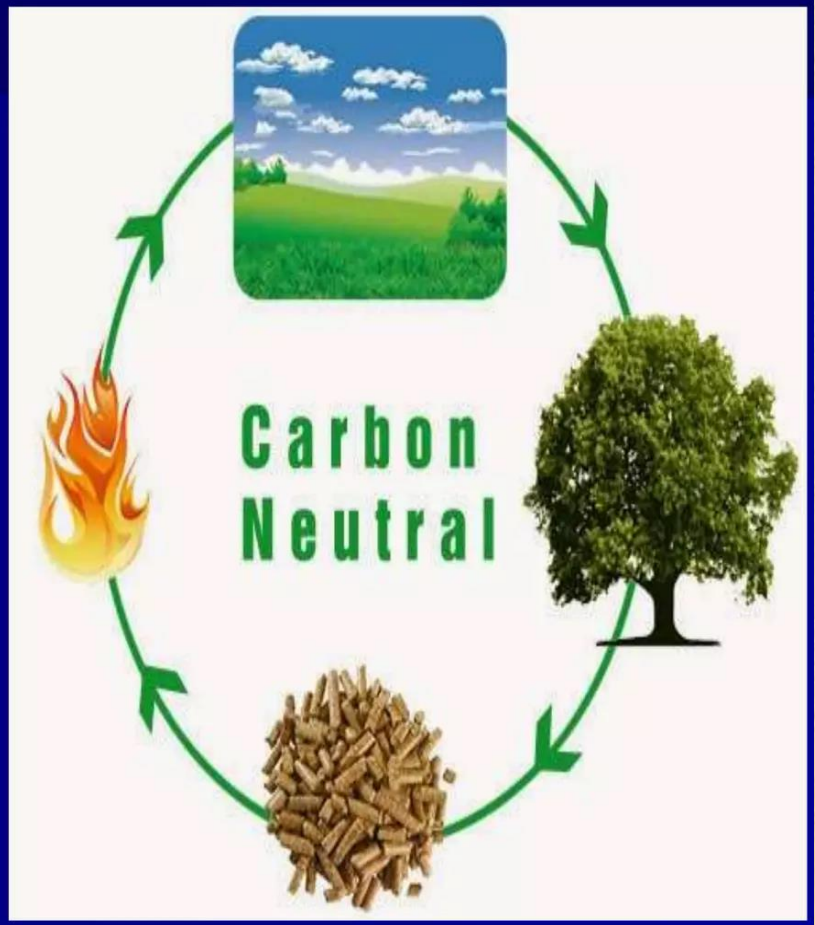
Carbon positive:- Fossil fuel are carbon positive, its burning increases carbon dioxide concentration in atmosphere.

Carbon Negative:-Biochar is a charcoal-like substance that's made by burning organic material from agricultural and forestry wastes. It can absorb carbon dioxide and increase soil fertility.



CARBON NEUTRAL

- CO_2 gas in the atmosphere does not increase due to the generation of energy from an energy source it is said that energy sources Carbon Neutral
- Renewable energy sources such as biomass, wind, water and sun are Carbon Neutral
- Material substitution of fossil fuels with renewable fuels included in the Carbon Neutral scenario

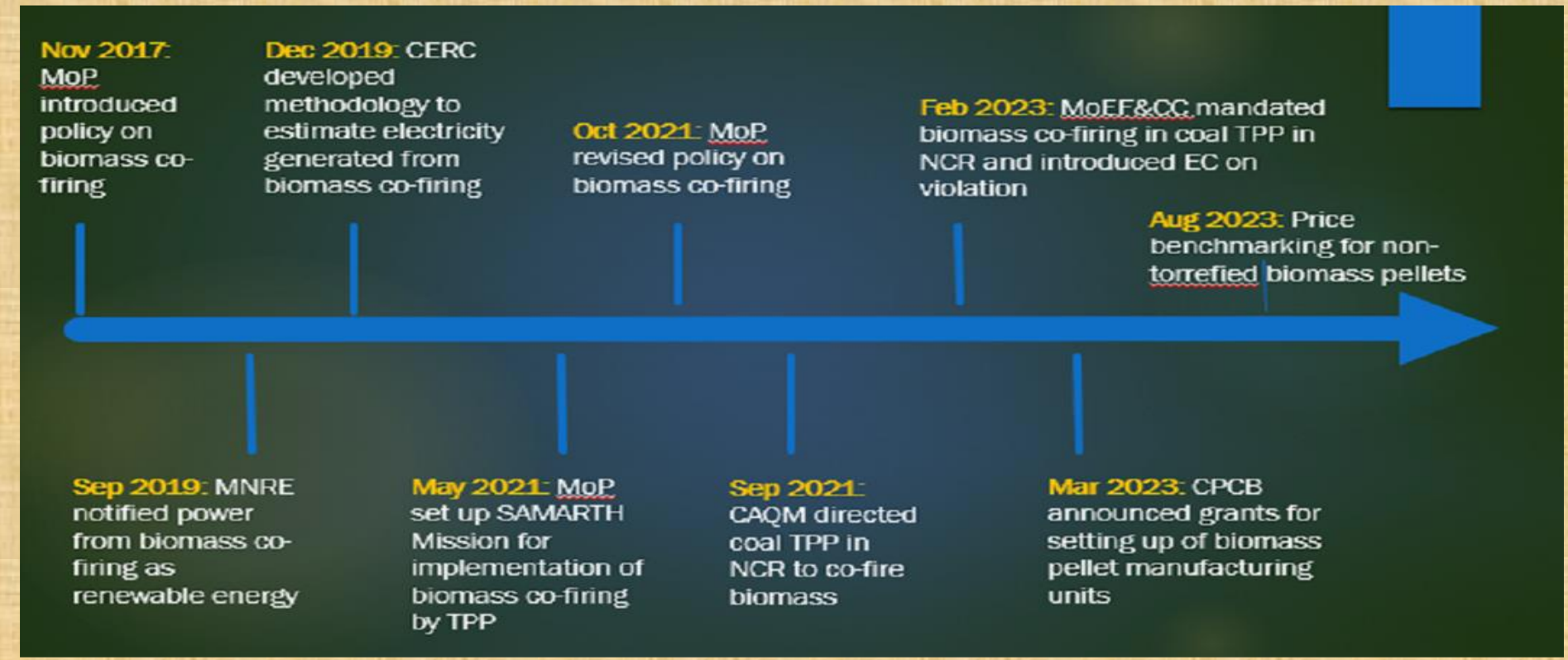


Biomass cofiring

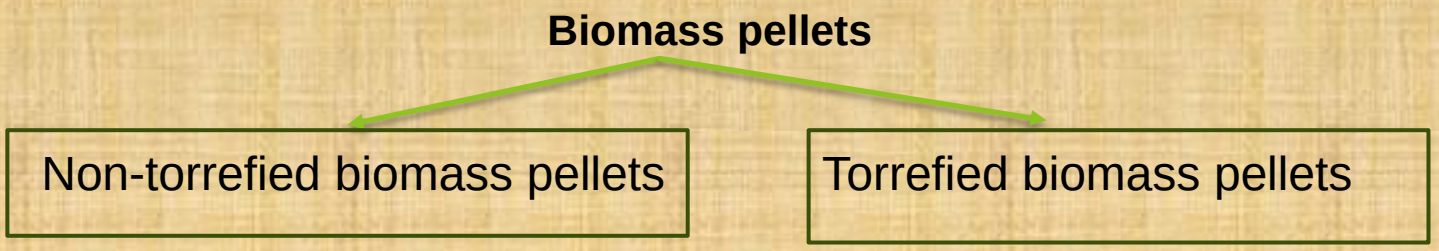
To reduce greenhouse gas emissions from its coal-based power plants, the Power plant intends to utilize agro residue-based pellets/torrefied pellets along with coal for power generation through biomass co-firing which is a technology recognized by UNFCCC to mitigate carbon emission. It is worth mentioning that the equivalent amount of CO2 (carbon-di-oxide) emitted from the combustion of agro residue-based pellets/ torrefied pellets in a power plant gets absorbed in the next crop cycle by photosynthesis. CO2 emission from agro residue-based pellets combustion does not increase CO2 concentration in the atmosphere and thus it is also termed as carbon neutral fuel which is a renewable source of energy. Further, CO2 emission from diesel and electricity consumption for agro residue collection, processing and transportation is quite negligible as compared to saving in CO2 emissions from its utilization in large coal-fired power plants having higher efficiency which makes biomass co-firing a greener alternative. In addition to reducing carbon emission from the coal-based power plant, the utilization of agro residue-based pellets/ torrefied pellets in the power plant will also reduce air pollution due to the burning of stubble (i.e. paddy straw and other agro residues) in the fields by farmers.

Biomass cofiring

Ministry of Power has brought out the policy for "Biomass utilization for power generation through co-firing in coal based power plants". The policy has been uploaded on the CEA website. As per the policy all fluidised bed and pulverised coal units (coal based thermal power plants), of power generation utilities, public or private, located in India, shall endeavour to use 5-10% blend of biomass pellets made, primarily, of agro residue along with coal after assessing the technical feasibility, viz. safety aspects etc. Keeping the above in mind, the National Mission on use of Biomass in TPPs has been constituted by the Ministry of Power in July 2021.



Types of biomass pellets:



Non-Torrefied biomass pellets:- Made from agro based residue (Crop Residues: Paddy, Soya, Arhar, Cotton, Gram, Jawar, Bajra, Moong, Mustard, Maize, Sunflower, Jute, Coffee, etc. Shell Waste:Groundnut Shell, Coconut Shell etc. Additional Biomass Sources: Bamboo and its by-products, horticulture waste etc.The main disadvantage with these pellets is that they are hygroscopic in nature and absorbs moisture readily.

Torrefied biomass pellets: Torrefaction involves the heating of biomass in the absence of oxygen to a temperature of typically 200 to 400°C. The structure of the biomass changes in such a way, that the material becomes brittle , making grinding easier and more hydrophobic (ability to repel water).

Specification and Properties of biomass pellets:

The main constraints with these pellets are:-
a. Ignition temperature: 240 degree Celsius.
b. Moisture affinity: Very high.

Sl No.	Description	Range
1	Carbon Content	10-20 %
2	Volatile Matter	60-66%
3	Moisture	9-14%
4	Density	700 kg/m3
5	Ash content	approx. 20%
6	GCV	3400-4000 Kcal/kg

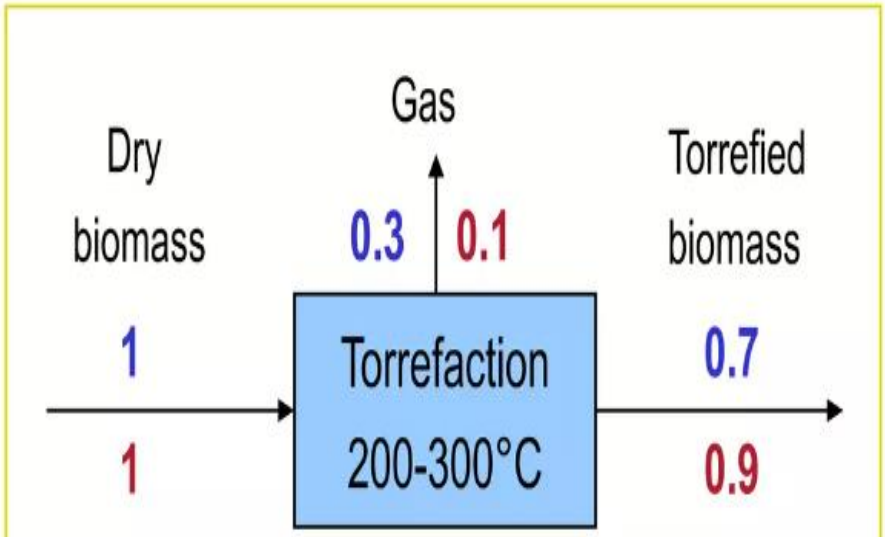
Specification and Properties of biomass pellets:

- Logistics (feeding, as well as handling and transport)

- Difficult properties are:
  - Low energy density (LHV_{ar} = 10-17 MJ/kg) (*LHV_{coal} > 30 MJ/kg*)
  - Hydrophilic
  - Vulnerable to biodegradation
  - Tenacious and fibrous (grinding difficult)
  - Poor "flowability"
  - Heterogeneous

Specification and Properties of biomass pellets:

In short: the roasting of biomass



Energy densification (MJ/kg) $1 \frac{0.9}{0.7} = 1.3$

mass energy

Process parameters

- Temperature: 200-300°C
- Residence time: 10-30 minutes
- Particle size: < 4 cm
- Absence of oxygen
- Pressure: near atmospheric

Specification and Properties of biomass pellets:

Woody biomass

Agricultural residues

Friable and less fibrous
19 - 22 MJ/kg (LHV, ar)
Hydrophobic
Preserved
Homogeneous

Improved fuel properties:

- Transport, handling, storage
- Milling, **feeding**
- Gasification, combustion
- Broad feedstock range
- Commodity fuel

Mixed waste

Torrefaction and pulverisation

Fuel powder

Increasing density

Pelletisation

Fuel pellets

Tenacious and fibrous
10 - 17 MJ/kg (LHV, ar)
Hydrophilic
Vulnerable to biodegradation
Heterogeneous

Bulk density 650-750 kg/m^3
Bulk energy density 13-17 GJ/m^3

Specification and Properties of biomass pellets:

Sl No.	Technical data	Unit	Guaranteed value range
1	Base material	-	Agro residue/ crop residue
2	Diameter	mm	Not more than 25 mm
3	Length	mm	Not more than 50 mm
4	Bulk density	kg/m3	Not less than 600 kg/m3
5	Fines% (length <3 mm) (ARB*)	Weight %	fines ≤ 5%**
6	Gross calorific value (ARB*)	kcal/kg	Non- torrefied pellets: 3500 ± 100 and Torrefied pellets:4500 ± 100
7	Moisture (ARB*)	Weight %	Not more than 9%
8	Ash (ARB*)	Weight %	Not more than 20%
9	Hardgrove Grindability Index (HGI)	-	50 or more
10	Particle size distribution (After crushing and pulverizing)	Weight %	Passing proportion from 2 mm mesh size sieve:≥ 75% Passing proportion from 3. mm mesh size sieve:=100%

HANDLING, STORAGE AND BLENDING OF PELLETS:

Receipt and unloading:

1. On receipt of truck, vendor test report to be checked.
2. Sample to be collected and acceptance of lot will be based on result at station end by chemistry group.
3. After acceptance, the truck shall be weighed and unloaded at designated point.
4. The empty truck shall be weighed and to be released from plant premises.

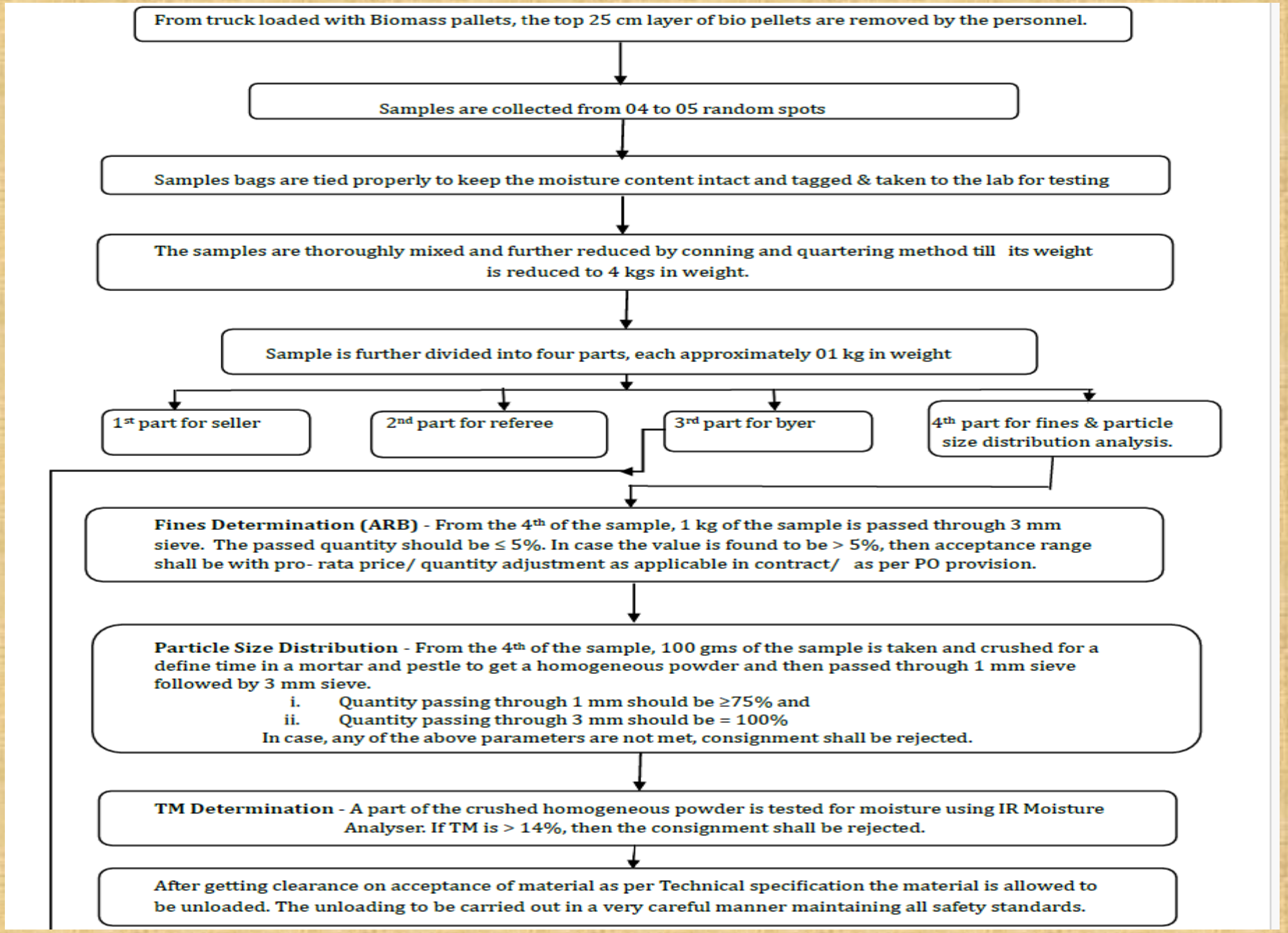
Storage:

1. Biomass pellets having low ignition temp and high VM, so needs continuous monitoring and storage area should have firefighting facilities.
2. Facilities to transport pellets from the storage area to the blending area.

Bunkering and blending:

1. Pellets do not require crushing, so blending is to be done after crusher.
2. The maximum percentage of blending allowed is only 5% to 7%.
3. Don’t spray water / dry Fog / plain water fogging system on the pellets and its bunker feeding path. The biomass pellets are hygroscopic in nature. After absorbing water or moisture, the pellets lose their shape and converts to powdery.
4. Conveyor interlock is to be modified so that pellets go only when coal is in the conveyor, and not otherwise. Conveyor streams and chutes used for pellet firing must be thoroughly emptied after feed operations.

Flowchart for sample Collection & Preparation of Biomass pellets



Method to be used for quality determination:

Sl. No.	Technical Data	Testing Method/Standard
1.	Dimension (Diameter & Length)	ISO 17829 or Equivalent method may be referred
2.	Fines (%)	ISO 18846 or Equivalent Method may be referred
3	GCV(ARB)	IS 1350 or equivalent method may be referred
4.	Moisture content (ARB)	Method based upon IS 1350 or equivalent method may be referred (Hand-Held Moisture Meter may also be used)
5.	HGI	ISO 5074 or equivalent method may be referred

For Determination of Total Moisture (TM) content: a. Samples shall be collected from each truck/dumper for TM determination. b. TM will be determined by Power Plant lab validated method based on IS 1350, (10g of 2.90mm passing sample will be heated for 2 hours at 108 +/- 2 Deg C. Total Moisture will be computed as per the formula below: TM% = (W1-W2) X100/ W1 Where: W1= Initial Weight of Sample (10 grams) W2= Final Weight of Sample.

Note: Before unloading, samples shall be tested for moisture at Station end. If this value is in the rejection level range, the consignment shall be rejected and it shall be the suppliers' responsibility to carry it back at his own cost.

IMPACT OF BIOMASS CO-FIRING ON COMBUSTION: -

Biomass fuels have high VM combustion can be a positive factor in the improvement of ignition and flame stability. However, it also enhances the fire explosion risk in the pre-processing combustion. Biomass pellets may have a very low content of Sulphur and nitrogen compared to coal which makes them environmentally friendly by reduced SOx levels.

Biomass fuels are high in alkali and alkaline earth elements which tend to act as fluxing agents and reduce the melting temperature of the coal ash and promote slagging and fouling/**deposition in the boiler.**

Potassium and sodium are two most abundant alkali metals found in biomass fuel, **may react with SO_2 or SO_3 in the gas to form the alkali sulphates, K_2SO_4 and Na_2SO_4, which can condense and deposit. Some of the sodium and potassium are readily volatile even at relatively low temperatures. The vaporization and subsequent chemical reactions are responsible for much of the fouling, corrosion, and silicate formation found in boilers.**

Biomass pellets ultimate analysis to be done before the start of co-firing and understand the impact on the combustion. Ash elemental analysis , furnace temperature measurement , **ash build-up and slagging during the biomass co-firing has to be monitored closely .**

Unit Operational issues while handling pellets

- The mill inerting (steam pressure 02-04 ksc) system should be available.
- Mill Air Inlet and Outlet Temperature probes are to be re-checked and validated.
- Biomass ON/OFF buttons must be provided on individual Mill screen.
- Whenever Biomass firing is ON, the following changes should happen in the Mill logics: Mill temperature control by CAD (cold air damper) of the mill to be shifted to Mill inlet temperature control as per the Mill Inlet temperature set point. Mill inlet temperature set point increase/ decrease button may be provided in the control interface.
- Observe all coal pipe temperature of Mills with biomass every shift. In case of any deviation from the rest of the pipes (any abrupt rise or fall), stop the mill and give PTW for inspection of coal pipes.
- Initially, periodic internal inspections of mills should be done during biomass co-firing to observe any possible accumulation of biomass inside mills, inspection may be carried out in shorter frequency say every 1 hour and gradually it may be increased based on experience.
- Pre-start and post-shutdown purging of the mill is mandatory. In case of Mill Trip, the Mill must be emptied at the earliest to avoid fire in the mill.
- Continuous monitoring of mill parameters most importantly mill inlet air temperature (Mix Air Temperature), Mill outlet temperature, mill current, and mill DPs.

Unit Operational issues while handling pellets

- Mill reject system to be kept under observation.
- Deployed Mill Operator must monitor for any kind of Fire in the rejects and intimate control Room immediately in wake of fire hazard.
- In case of fire, the mill should be tripped and steam inerting should be done immediately by opening steam inerting motorized valve, keeping watch on furnace pressure. Fire tender may also be used if required.
- Step by step procedure for going to Biomass mode shall be provided to all desk engineers and proper training to these people essential before going for pellet firing.
- Changes in the logbook and log sheets are to be done before going for pellet firing and the operator should monitor the parameters and record them in the log sheets.
- In case of fire, Call the fire personnel in the plant for immediate assistance.
- Do not expose any part of the mill (roller, scrapper chamber and tramp iron gate for any inspection until the mill temperature comes down to normal value).

Combustion issues in pellet firing:

- Clinkering and slagging tendency to be observed by any rise in SH zone FG temperatures. Frequency of Soot blowing and LRSB to be determined accordingly.
- Flue gas temperature profile increased unburnt, changes in Spray and metal temperature to be monitored, and any abnormality to be discussed and appropriate action is to be taken.
- Elemental analysis of biomass for each sample/lot to be done to keep a check on the chlorine content and alkali content like Sodium, potassium, etc. which have high slagging and fouling tendencies

Safety aspects of pellet-firing: :

- Pellets have got very high amount of volatile matter.
- The storage area must be pre defined and proper barricading is to be ensured. No cutting and welding works should be carried out near that area. The area should be clearly demarcated a “No Smoking Area”.
- Conveyor firefighting system should always be healthy as the fuel is highly inflammable; hence all protection needs to be healthy.
- The storage areas should have proper firefighting provisions like hydrants and water monitors.
- MSDS for these pellets are to be displayed near the storage area.

Infrastructural requirements of biomass pellet handling

- Closed shed (from sides also) covering feeding Area as well as Storage space as the fuel is highly susceptible to atmospheric moisture if left in open for a reasonable amount of time. The Shed should cover the feeding point and the storage yard and should allow the movement of dozing equipment like pay-loader or bob-cat. The shed should be provided with flameproof lighting.

- Weighbridges calibrated for weighing of the trucks.

- Belt weighing scales for proper blending.

- Pay-loader or bob-cat for feeding and for achieving finer control over the feed rate.

- Safe Working Platform for collecting a sample from the truck.

- Methane, CO, Multi-gas detectors at the storage location.

- CCTVs for monitoring at different points like unloading Points, Blend points, Feed points, and conveying path.

Further actions required:

- Ultimate analysis of biomass pellets to be done.
- Effect of pellet-ash on the performance of wet/dry ash handling system to be checked periodically by stations. (like scaling inside pipes, hoppers, sumps, silos, etc. and evacuation & flowability of dry ash from hoppers).
- All parameters impacting heat rate shall be recorded and Heat rate before the start of biomass co-firing and during biomass co-firing should be recorded to analyze its commercial impact.

Role of C&I - Pointwise Summary for Biomass Co-Firing

- Modulation Control for Hot Air Damper and Cold Air Damper to be provided from Mill Inlet Temperature rather than Mill Outlet Temperature. Provision for variable Mill Inlet Temperature Set point is to be done so that set point can be varied as per requirement.
- Mill Air Inlet (Hot, Cold and common) and Outlet Temp probe to be re-checked and validated.

Role of C&I - Pointwise Summary for Biomass Co-Firing

- Mill Outlet Temperature Low alarm to be given at 55 Deg Cent.
- Mill Outlet Temperature High alarm to be given at 90 Deg Cent.
- Alarm to be provided for rate of rise of Mill Outlet Temperature.
- Installation of temperature sensor in each of the coal pipe of corresponding Mill to keep a track on any volatile combustion due to biomass co-firing in coal pipe.
- Mill HAG (Hot Air Gate) shall close on protection if Mill inlet temperature reaches 190 deg Cent. Alarm for Mill inlet temperature to be provided at 180 deg C.
- Mill protection at mill outlet temperature will also remain in service irrespective of Biomass ON/OFF mode.

BIOMASS MARKET

- The adoption of biomass in power generation is also faced with various hurdles including in logistics and supply chain. It said that biomass is available in small and dispersed land holdings. Thus, the collection, transport, and storage push feedstock costs.

Efforts to overcome supply challenges:

- Several plants have initiated measures to address the supply challenge by issuing tenders for raw materials to set up in-house pellet manufacturing units also explored partnerships and in-house manufacturing for biomass pellets. Timely planning and a coordinated approach, from tendering by coal TPPs to crop residue procurement by pellet manufacturers, are essential to effectively address the supply chain.

Government Assistance

- The MNRE and Central Pollution Control Board (CPCB) have introduced Finance Assistance Schemes to support biomass pellet manufacturing units. The Reserve Bank of India (RBI) has approved 'Biomass pellet manufacturing' as an eligible activity under Priority Sector Lending (PSL), fostering financial viability for such endeavours. A dedicated Procurement Provision of Biomass Category has been established on the Government e-Marketplace (GeM) portal.

Summary

- Biomass co-firing is an effective way to decarbonises the process of electricity generation in coal based thermal power plant and to curb emissions from open burning of crop residue. India has large biomass availability and Co-firing of 5-7% biomass with coal is an efficient and clean way to address the climate change burgeoning issue (Paris agreement UNCC Conference of parties) with reduction in greenhouse gases emission and global warming.

Technical Challenges: -

- **Hygroscopic:** - Disadvantage is that biomass is having high moisture affinity. Can't use spray water /plain water fogging system during pellets feeding.
- **Restriction in coal mill temperature**:- Low Ignition temperature, high Volatile matter around 60-66% increases risk of fire hazard.
- **Deposition & corrosion in Boiler**:- Promote deposition in the boiler , each sample/lot needs to be checked for alkali content like Sodium and potassium compound which have high slagging, fouling tendencies also chlorine content is to be kept under control which tends to increase corrosion.
- **Combustion issues** :- Soot blowing frequency to be increased to control fouling.
- **Availability and storage:-** Availability and quality of biomass vary across regions in India Biomass pellets are difficult to store at plant locations for extended periods of time because they quickly collect moisture from the air, making them unusable for co-firing.
- **Infrastructure and Logistics**:- Biomass co-firing requires specialized equipment, such as biomass grinders, conveyors, and storage systems.

What Should be the Way Forward?

- **Ensuring a Steady Supply of Biomass to Power Plants:-** Steady supply of biomass to power plants can be ensured by developing a reliable supply chain that can transport biomass from source to plant. This could involve partnering with farmers, forestry companies, or other biomass suppliers to secure a steady supply of biomass.
- **Building Infrastructure and Logistics:-** Developing the necessary infrastructure and logistics to transport, store, and process biomass is critical to the success of biomass co-firing.This could involve building new storage facilities, upgrading transportation networks, or investing in new processing technologies.
- **Robust Regulatory Framework:-**The Biomass Co-firing Policy needs to be backed by a strong policy and regulatory framework that provides incentives and support for biomass co-firing. Also, there needs to be a clear, competitive market for biomass to make sure that prices and distribution are fair.
- **Developing and Deploying the Necessary Technology and Equipment:-** Developing and deploying technology and equipment is crucial for the success of biomass co-firing. This includes developing specialized boilers, burners, and control systems that can handle the unique characteristics of biomass, as well as retrofitting existing equipment to accommodate biomass co-firing.


THANK YOU