Khargone STPS:
Biomass Pellet Firing

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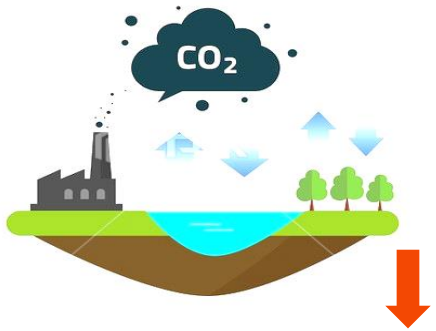
Biomass Co-firing in India

With the advent of mechanized harvesting, agro residue burning has become a practice in many parts of country.

Ministry of Power (MoP) asked NTPC to explore the option of power generation using the agro residue to discourage agro residue burning while generating RE power from carbon neutral biomass.

NTPC carried out detailed study and opted biomass co-firing technology to utilize agro residue based pellets by replacing coal up to 5-10%.

Reduce Net CO2 emission from its coal plants



Reduce stubble burning by farmers in fields

Generate employment and boost green economy

What is Biomass Co-firing ?

Biomass Co-firing is a near term, low-cost option for efficiently and cleanly converting biomass to electricity by adding biomass as a partial substitute fuel in high-efficiency coal boilers.

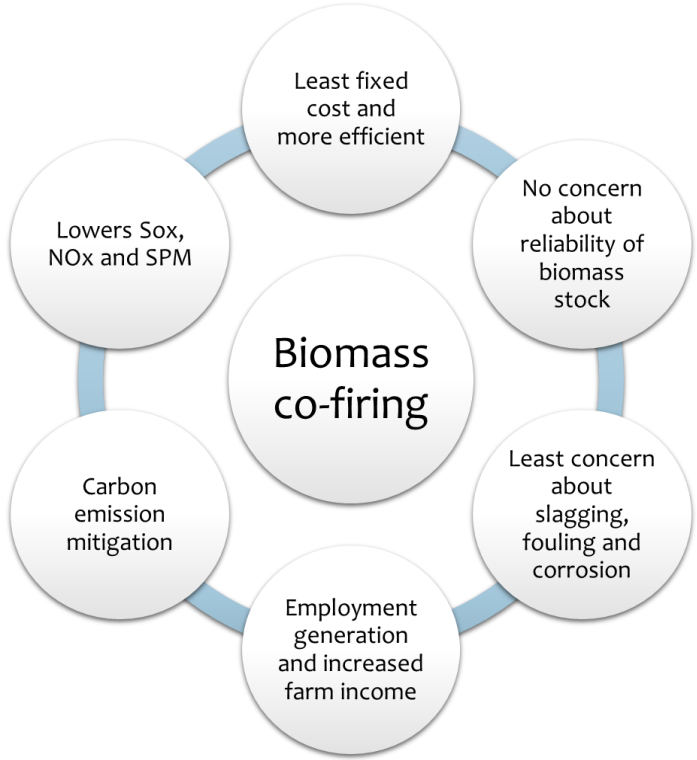
Why Do Farmers Burn Agro Residue?

- Small window between two crops and mechanized harvesting leaves almost 2/3rd of crop portion as residue in field. Clearing it from fields involves certain cost.
- In absence of any market, surplus agro residues are often set on fire by farmers as they find it the easiest, quickest and cheapest solution for clearing the fields.
- Agro residue burning results in severe air pollution as well as loss of valuable RE resource.

Why Biomass

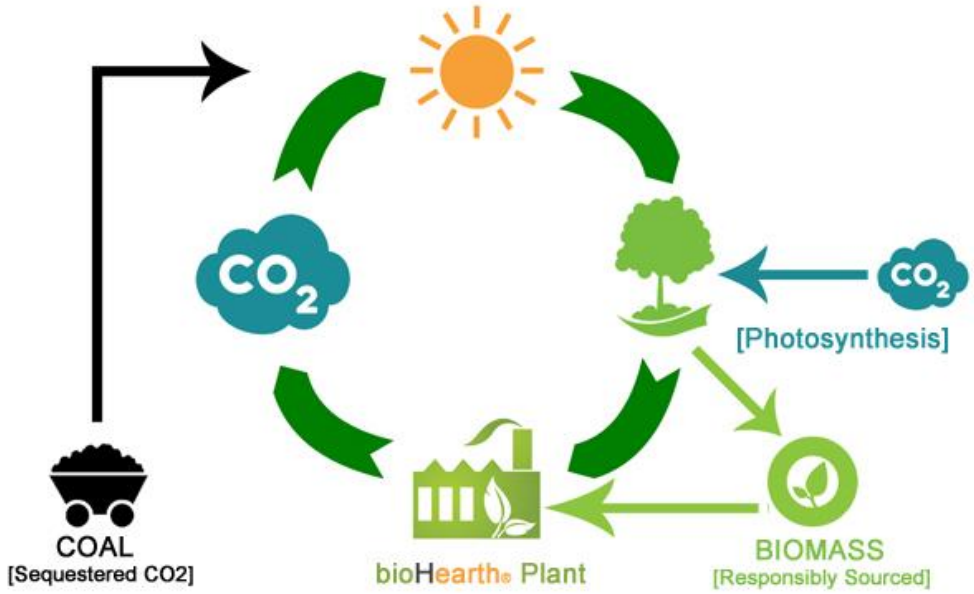
- Primary source of all kind of energy sources (such as coal, oil, gas, hydro, wind, solar and biomass) on earth is sun.
- Fossil sources are the carbon sequestered by nature under earth crust, when used increases carbon di oxide level in atmosphere. So, its not a RE.
- Whereas biomass obtained from sustainable sources such as agro- residue/ sustainable foresting, kept on capturing carbon from atmosphere using photosynthesis and releasing it back making it carbon neutral. So it is RE.
- Wind, hydro and Solar energy also kept on replenishing, so comes under RE.

Hydro limited potential in view of dependence on specific location.
Solar and wind have seasonal variability even if combined with energy storage.
Therefore, biomass remains the only cheapest sustainable source to provide base load RE while meeting pick demand at the same time when used along with coal in power plants. Further, 100% coal to biomass switching is also an option to achieve aim of Net Zero by 2070.



Net saving in CO2 per ton of Biomass cofired is 1320kg (94%).

Why Biomass



Equivalent amount of CO2 emission from combustion of agricultural residue/ biomass from sustainable sources is re-absorbed in next crop cycle which makes it carbon neutral fuel.

Biomass is solar energy in storage form (via photosynthesis) and is dispatchable round the clock renewable power.

Biomass co-firing is recognized by the UNFCCC as a technology to mitigate GHG emissions. It may contribute to NDC goal.

Ash produced from its combustion in furnace is absorbed in Electro Static Precipitator of power plant. So it reduces pollution due to stubble burning.

It is cost competitive with solar and wind if indirect cost of integration of solar and wind/ or energy storage is also taken into account.

Biomass Potential In India

Scale of opportunity

Total Agricultural Residue Generation in India (Million Tons/Year)	Total Agricultural Residue Surplus in India (Million Tons/Year)	Electrical Energy Potential Using Surplus Agro Residue in Biomass Co-firing (Billion Units)	Total Electricity Generation in India (2020-2021) (Billion Units)
754	228	325	1382

Source : "Evaluation Study for Assessment of Biomass Power and Bagasse Co-generation Power Potential in the Country" by Administrative staff collage of India based on District wise data compiled from the Directorate of Economics and Statistics of year 2018

325 MMT

- CO_2 emissions Annual reduction potential

200 GW

- Equivalent Solar PV capacity @ 18% CUF

PATHWAYS

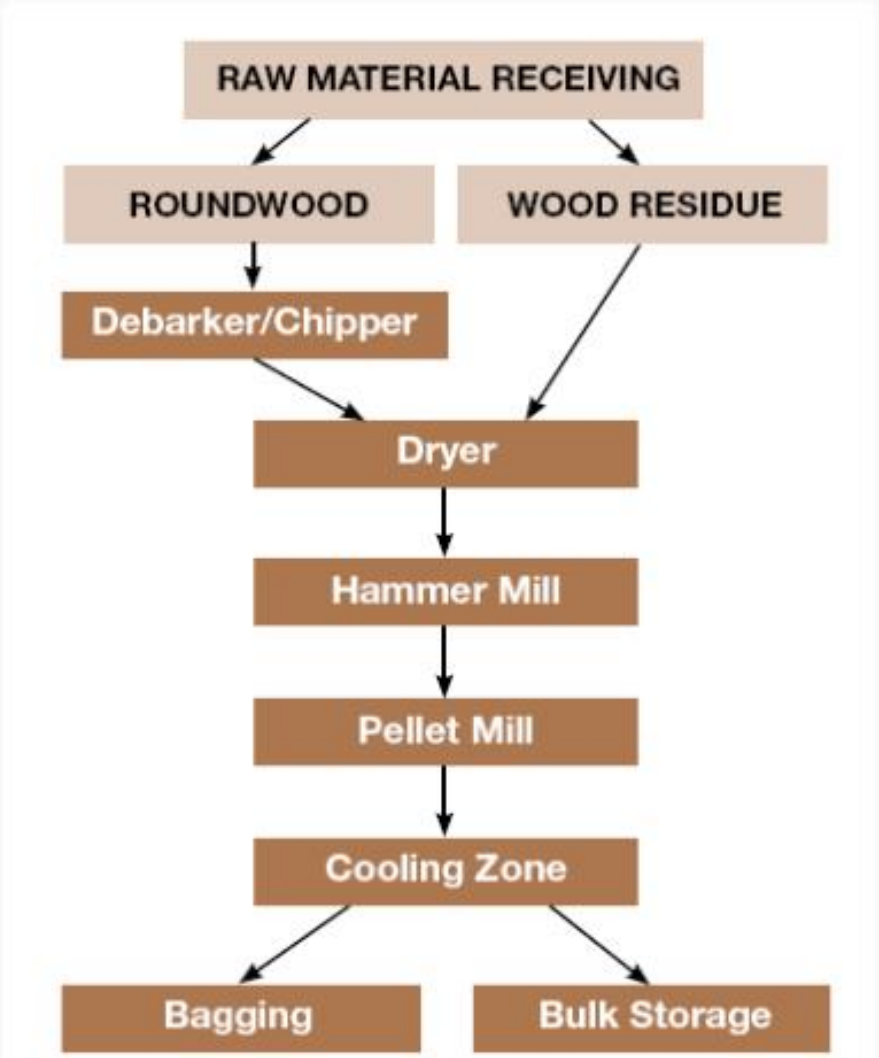
- Biomass fired boilers
- Co-firing in coal based power station

150 MMT Equivalent Imported coal substitution @ 5000 Kcal/kg

Pelletization Process

Pelletization

- Biomass (agro/ crop residue) collected from fields is cleaned and shredded to get adequate size material. If high moisture is there then material is dried and passed through magnet to remove metals.
- Dried biomass is collected in the hopper passed through Hammer mill/ grinder to reduce the biomass to adequate particle size say to less than 2 mm.
- The biomass is pneumatically transferred to a cyclone filter to remove dust particles.
- The dust free biomass is conveyed to the screw feeder to transfer the feed into pellet mill consisting of perforated die of specified diameter holes.
- The densified hot biomass pellets, having temperature in the range 80- 100C, is transferred to cooler and screened to remove dust.
- The screened material is called pellets and is ready for transportation.



Schematic of Pelletization of Woody Biomass

Comparison Between Pellets & Coal

Parameter	Bituminous Coal	Paddy straw Pellet
Carbon content (%)	34-35	10-15
Volatile content (%)	20-21	60-66
Ash content (%)	38	18
Moisture (%)	6	8
GCV (kCal/Kg)	3500	3400
Alkali content (%)	-	6-8
Chlorine content (%)	0.05-0.08	0.8-1.5
Density (Kg/m3)	833	700
Ignition temp, C	454	240
Grind ability index	55-75	Fibrous
Particle type	Brittle	
Ash Fusion Temp, C	1400	850-900
Ash resistivity	moderate	High

A report on Combustion Characteristics of Coal-Biomass Blend in Lab Scale by NETRA dated 16.09.2017:

Combustion Analysis in Simultaneous Thermal analyser (STA):The samples of 100% biomass, 5%/10% biomass blended in coal and 100% coal are analysed in STA for combustion characteristics and following was observed.

- The biomass sample starts evolving Volatile Matter from 200 deg C and completes VM burning at 360 deg C.
- The Coal sample starts evolving the VM at around 300 deg C, completes VM burning at 380 deg C
- The samples of 100 % biomass, 10%/5% biomass in coal burns comparatively faster than coal sample
- The ash evolved in the two samples of 10%/5% biomass in coal is observed to be loose deposits indicating minimal chances of sticky ash deposits.

Agro residue can only be fired up to a limited proportion (5-10%) due to following reasons :

- ✓ Low ignition temperature
- ✓ High volatile content
- ✓ Fibrous nature posing difficulty in milling at higher ratio
- ✓ Low ash fusion temperature/ slagging tendency due to high alkali content at higher ratio
- ✓ Corrosive tendency due to high chlorine content at higher ratio

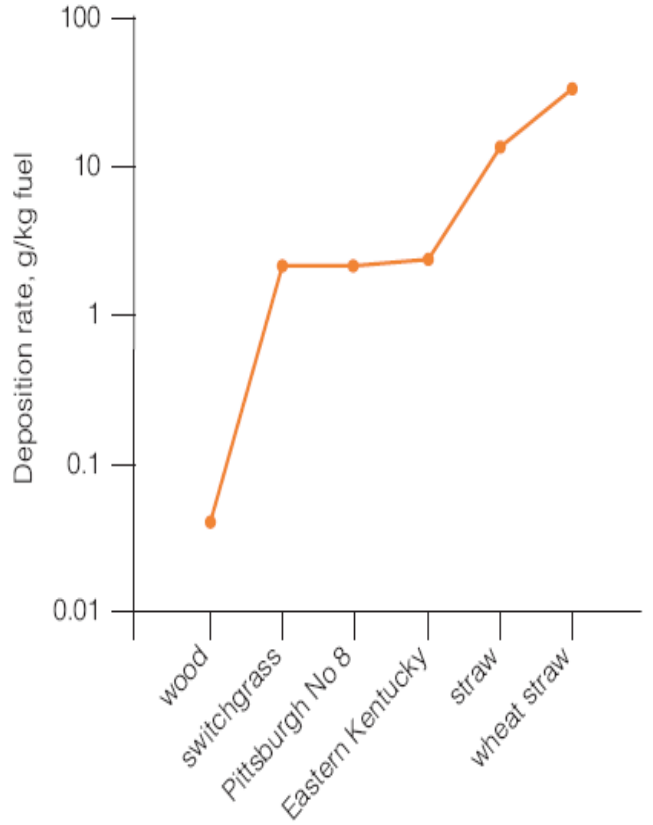
Challenges in Biomass Sector

Technical Challenges	Vendor Based and Logistic Challenges	Commercial Challenges	Networking and Capacity Building
• High Volatile content • High alkali/ chlorine content • Low Ignition Temperature • Fibrous nature • OEM Clearance • Ash Utilisation	• Handful of vendor base, so need of vendor development • Development of logistics and Supply chain was the most challenging part • Financing of biomass collection and processing infrastructure • Biomass storage handling facility at Genco end	Biomass was costlier than that of coal Increased APC and Heat Rate during co-firing No Policy and regulation was in place to make it commercially viable Ramp Rate Reduction	• Pellet manufacturers were not aware of NTPC requirement • Gencos were not aware of biomass co-firing technique • Lack of confidence among financial Institution • Lack of Networking among stakeholders.

- After R&D and Pilot by NTPC , 10% co-firing ratio proven for the first time in India. Further efforts are being made to increase co-firing ratio to 20%.
- Drafted Biomass pellet specification. Did policy advocacy in CEA and CERC to make it commercially viable.
- Multiple rounds of seminars, workshop, advertisement was done for capacity building among GENCO's, pellet manufacturers, attract new enterprisers & investors, financial Institution and finally development of biomass vendor base and supply chain
- Engaging with Bank to develop sector specific scheme. Vendor development program and relaxed certain tender conditions to encourage start-ups. 15% quantity has been reserved for Punjab bidders to discouraging stubble burning. 25% of quantity has been reserved for MSE vendors.
- Organized Open Competitive Challenge “Green Charcoal Hackathon”, 2020, inviting the Innovative Ideas for development of torrefaction technology which will pave the wave for 20% co-firing and encourage utilization of paddy straw

Slagging, Fouling & Corrosion

- Experience in Europe suggests that slagging and fouling are unlikely to be a problem for co-firing ratios up to 10%.
- Wood can be fired 100% due to low alkali content but agro residue should be limited to 10-15% as it has high alkali content.
- Torrefied agro residue based biomass may be fired 20% after trial.
- During co-firing, slagging, fouling behavior may be monitored.
- Biomass ash deposits tend to have relatively high potassium contents and relatively high chloride to sulphate ratios. This can have a impact on corrosion, particularly at high metal temperatures on superheater surfaces, if co-firing ratio is higher.
- However, up to 10% , corrosion is unlikely to be a problem. But same to be kept in monitoring on suitable opportunity such as overhauling etc.



Biomass Pellet Firing – NTPC Khargone Experience

ABOUT BIOMASS PELLETS:
Biomass Pellets Quantity fired at Khargone :4260 Tons upto September 22

Across NTPC, 14 Thermal Plants have started Biomass Coofing and fired approx. 77000Tons of Biomass.

In NTPC Khargone we use NON-Torrefied Biomass Pellets Random Sample Test Results
Moisture : 7.32 %
Ash : 10 %
VM : 63.29%
Fixed Carbon : 19.39%
GCV : 4164 kcal/kg

Biomass Issues :
1. High VM – VM starts evolving at 200 Deg C ,
2. Hygroscopic in nature – Microbial Activity Gas formation

Biomass Pellet Firing – NTPC Khargone Experience

PELLETS Variety received at Khargone:

Type A : (23 mm)

Bagged Supply; Produced from Vendor's dedicated Plant

Constituents :

Groundnut Shell – 85%

Coffee Husk – 10%

Rice Husk – 5 %

Approx GCV : 3900 -4100 kcal / kg

Price : 9200 Rs / Ton

PELLETS Variety received at Khargone:

Type B : (8 mm)

Open unbagged Supply; Outsourced from local spot market

Constituents :

Baggase– 85%

Agro residues– 15%

Approx GCV : 3600-4000 kcal / kg

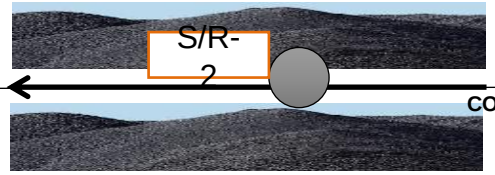
Approx Price : 9000 Rs / Ton

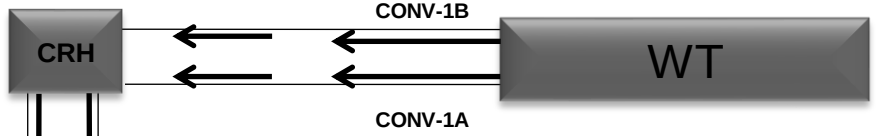
Biomass Pellet Firing – NTPC Khargone Experience

Emergency Reclaim Hoppers

Coal storage yard

Coal from wagon tippler





Coal

Biomass

Coal + Biomass

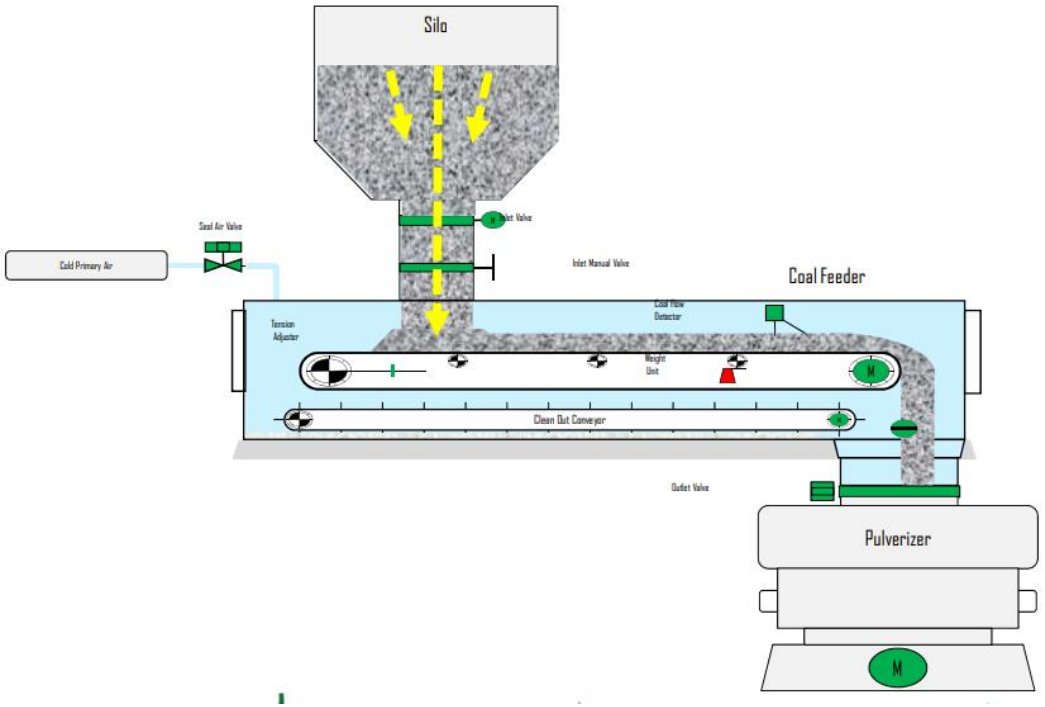
Biomass Pellet Firing – NTPC Khargone Experience

- Documentation of System Process in form of OGN at Corporate Level and LMI at Station level.
- On basis of LMI, modification of logics and finalization of SOPs and checklist. SOPs finalization are as follows
  - 1 . Safe handling, blending and Storage of Biomass Pellets.
  - SOP-2 . Biomass Pellet Firing Procedure for Safe Operation of Milling System.
  - SOP-3 . SOP for chemistry from sample preparation to analysis

Modification in Mill operation procedure

- Steam inerting valve made remote operative.
- Introduction of new Selection mode called "**Pellet Firing Selection**"
- Modulation control for CAD was provided from mill inlet temperature.
- Mill inlet temperature was limited to 175-180 C.
- Mill inlet temperature high alarm was provided at 190 C.
- Temperature sensors were installed in each coal pipe.
- Mill outlet temperature high alarm was given at 70 C.
- Illumination inside feeder was done.

Biomass Pellet Firing – NTPC Khargone Experience



Biomass Pellet Flow pattern in Coal Bunker & Feeder

Biomass Pellet Firing – NTPC Khargone Experience

SOP on Biomass Pellet Firing

- Keep continuous communication with CHP about time of biomass bunkering, percentage of blending, Bunkers in which biomass bunkered and available mills.
- Ensure mill inerting steam header in charged condition, with pulverizer inerting steam pr. of 13.25ksc.
- Maintain Mill outlet temperature- 55 C.
- Mill inlet temperature should not be more than 180°C in any case.
- Observe all 8 coal pipe temperature of Mills with biomass regularly. In case of any deviation from rest of the pipes (any abrupt rise or fall), stop the mill and give PTW for inspection.
- Pre-start and post shutdown purging of mill is to be done compulsorily.
- Monitor continuously mill parameters most importantly - mills inlet air temperature, mill outlet temperature, mill current and mill outlet pressure, mill lower upper house diff. Pr. And furnace differential pressure.

Biomass Pellet Firing – NTPC Khargone Experience

SOP on Biomass Pellet Firing Contd.

- Mill reject system to be kept under observation continuously.
- In case of fire, mill should be tripped and steam inerting should be done immediately by opening steam inerting valve(SOV), keeping watch on furnace pressure. Fire tender may also be used if required.
- View glass of Mill feeders should be periodically cleaned and seal air arrangement shall be provided to prevent dust deposition on view glasses. Illumination inside feeder shall be revived/ provided to keep track on biomass and coal blend.
- Clinkering and slagging tendency to be observed from local as well as from rise in SH zone FG temperatures. Soot blowing and LRSB to be done accordingly

Biomass Pellet Firing – NTPC Khargone Experience

In case of Mill Fire

- Dos
  - Call the CISF fire personnel for immediate assistance.
  - Increase the feeder speed to maximum and dump the coal to mill for few minutes.
  - Stop the feeder after few minutes and close feeder outlet gate.
  - Close HAG, CAG and Mill seal air valve from control room.
  - If the pulverizer temperature continues to rise, admit inert steam by opening the steam inerting valve. (say if fire in mill-A observed, open the mill inerting steam valve 01/02HFX13AA700, at Om meter mill floor.
  - If fire occurs in the feeder then, close the feeder outlet gate, and bunker gate close seal air valve.
- Donts
  - Do not admit cold primary air in order to cool the mill.
  - Do not get exposed to any part of the mill (roller, scrapper chamber and tramp iron gate for any inspection until the mill temp comes down to normal value)

Biomass Pellet Firing – NTPC Khargone Experience

Observations in Biomass Firing

- Issues in Load ramp up
- No noticeable variations observed in Boiler Parameters (Such as Steam temperatures, boiler metal temperatures and SH/RH attempration). Boiler was stable in this low blend ratio used for the trials.
- Impact on ECR. ; Example; IF ECR of Coal is 280 Paisa and Biomass Pellet is 575 Paisa. ECR increases by 15 Paisa for 5% Blend and by 30 Paisa for 10 % Blend.
- It was observed that Mill Rejects had increased 3 times when feeding Biomass Blend Coal through Mill. Airflow bias needs to be optimized to reduce rejection rate of Pellets. Optimizing Hydraulic Pressure Bias of Rollers can also have correlated effects on Mill Rejects.
- Initially envisaged Biomass Mode -1 Mill Inlet Temperature control Philosophy is not viable. Hence, Biomass Mode -2 Mill Outlet Temperature control Philosophy is recommended for Biomass Pellet firing.
- Bunker Pellet Flow pattern and Timing of Biomass Pellets entry into the Coal Feeder cannot be predicted. Hence, the Mill identified for Pellet co firing should be kept in Biomass Protection Mode ON well before anticipated time.

Solutions Proposed

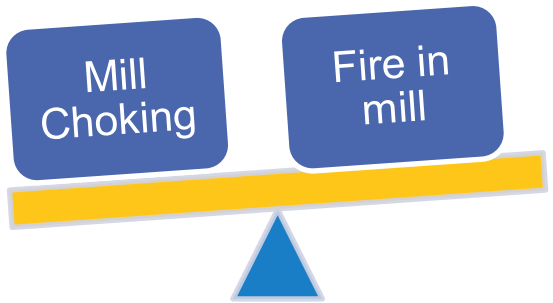
1. **Modified mill loading logic for ramping activity.**

Since sudden loading of mills with biomass is causing temp rise, hence during load ramp up activity following parameters should be included in mill logic:

- Rate of rise of Mill outlet temperature.
- Rate of rise of Boiler metal temperature.
- Coal pipe line temperatures.
- Presently in cases when moisture content is high in pellets and coal, Restricting inlet temp to 180 Degrees may sometimes lead to an outlet temp of 50-60 degree and choking of mill.
  Hence, CAD (Cold Air Damper) of mill **should monitor both** inlet and outlet temperature instead of just inlet temperature.

Low mill Outlet Temperature

High Mill Outlet Temperature



Merit : This will help optimize mill loading without compromising on metal temp rise and mill fire hazard.

It would also allow higher mill loading (when moisture content is higher in fuel) and help us achieve a better ramp rate, which would minimize DSM losses.

2. Algorithm to map boiler metal temperatures

It has been observed that metal temperatures rise only in certain parts of boiler depending upon many factors like soot deposition etc.

Particular mill loading may aggravate the situation whereas other mill loading may not have profound affect on metal temperature of that region.

Hence an algorithm may be developed to monitor rise of metal temperatures vis a vis pattern of mills' loading, Coal pipe line temperatures and other available parameters.

Say it can be observed by a smart algo that boiler right intermediate header metal temperatures are increasing when Mill C is loaded very fast.

3. Protection Mode :

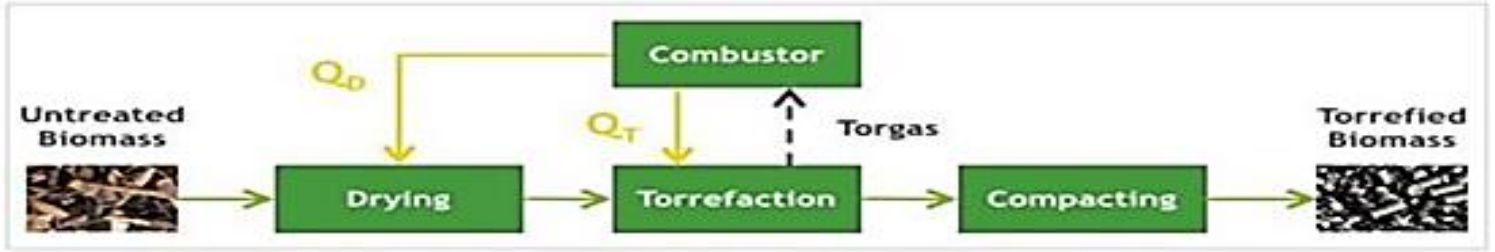
Bunker Pellet Flow pattern and Timing of Biomass Pellets entry into the Coal Feeder cannot be predicted. Hence, the Mill identified for Pellet co firing should be kept in Biomass Protection Mode ON well before anticipated time.

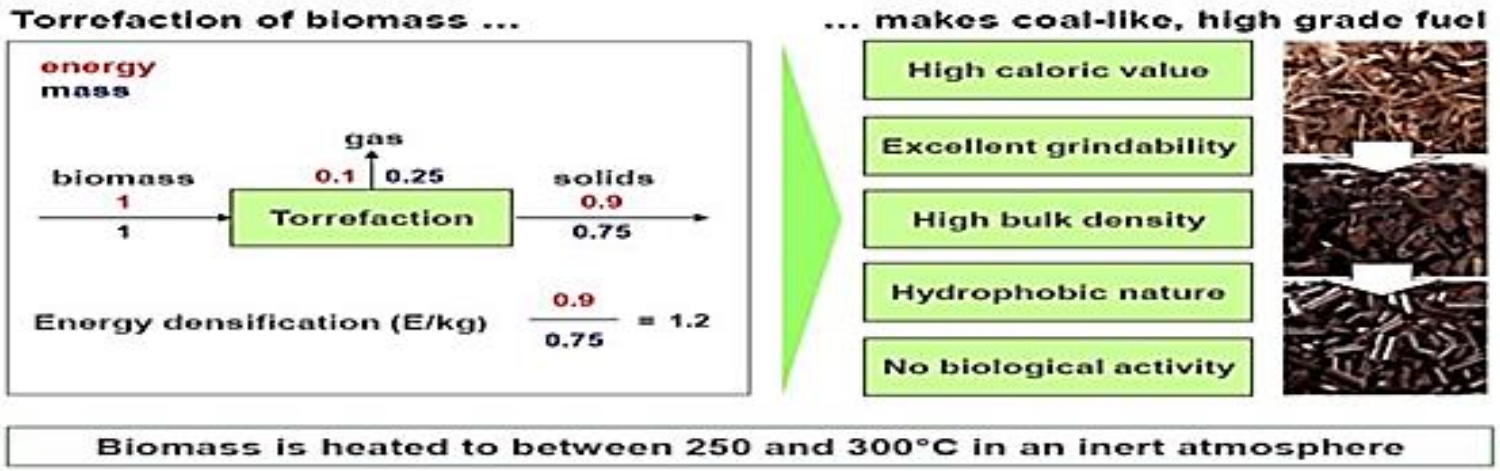
4. Optimum Soot Blower operation : Based on results of smart algorithm envisaged above which will give us regions of boiler to focus upon while operating soot blower.

5. Variable Blending : It will be obligatory for us to maintain 5% blending annually.

We can have variable blending ratios depending on coal quality at different time of the year, more blending with low GCV Coal and less blending with high GCV coal to maintain 5% overall would optimise our mill loading and temperatures.

Biomass Torrefaction : An alternative for high co-firing ratio





Biomass is heated to between 250 and 300°C in an inert atmosphere

What is Torrefaction?

Torrefaction is a process in which biomass is heated between 250 C to 300 C in lack of oxygen to convert it into coal like material. This improves properties of biomass and makes it suitable to be co-fired in higher ratio.

Advantages of Torrefaction

- ✓ Improves GCV by roughly 20%
- ✓ Makes it too brittle to be grinded in mills
- ✓ Makes it hydrophobic
- ✓ Reduces volatile content
- ✓ Increases ignition temperature slightly
- ✓ Reduces chlorine content

Way forward

- ✓ Proven and cost competitive technology of torrefaction is need of hour.
- ✓ Any support in this area is more welcome.

6. Torrefied Biomass :

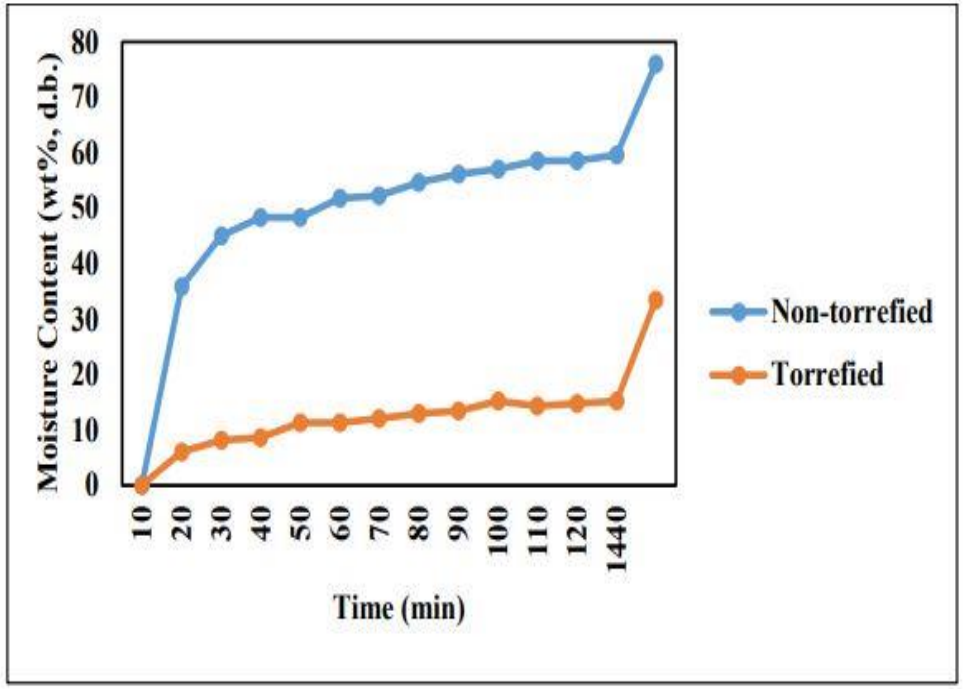


Figure 2.13. Moisture resistance of non-torrefied and torrefied biomass chips in water immersion test.

Type	Before Moisture Testing	At 20% MC Target	After 24 Hour Water Immersion
Non Torrefied			
Torrefied			

Figure 2.19 Water absorption and environmental conditions test visual results on red oak pellets produced at 5% MC and a 0.7-1 mm particle size.

Source : Tianmiao Wang West Virginia University : Compaction behavior & moisture resistance of torrified and non-torrified biomass pellets

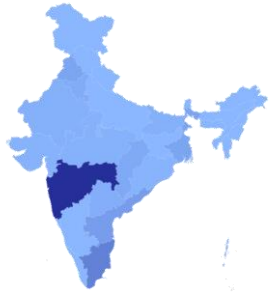
Safety aspects

- In view of fire prone nature of biomass, Fire tender and fire fighting system to be kept ready in advance.
- Continuous monitoring of mills parameters viz. inlet air temperature, mill outlet temperature, mill current and DP is recommended.
- Pre start and post shutdown purging of mill must be done
- Monitoring of Mill and its reject system .
- Clinkering and slagging tendency to be observed from local as well as from rise in SH zone FG temperature.
- Soot blowing and LRSB should be done accordingly.
- During test firing, no such tendency was observed.

SAMARTH : National Mission on Utilisation of Biomass

GOVERNMENT OF INDIA
MINISTRY OF POWER

On dated 25 May 2021, Ministry of Power has announced National Mission on use of Biomass in coal based thermal power plants.



Aim of Mission

To address the issue of air pollution due to farm stubble burning and to reduce carbon footprints of thermal power generation.

Objectives of Mission

- ✓ Increase the level of biomass co-firing from present 5% to higher levels to have a larger share of carbon neutral power generation from the thermal power plants.
- ✓ Take up R&D (Research & Development) activity in boiler design to handle the higher amount of silica, alkalis in the biomass pellets.
- ✓ Facilitate overcoming the constraints in supply chain of biomass pellets and agro-residue and its transport up to the power plants.
- ✓ Consider regulatory issues in biomass co-firing.

Policy on Biomass Co-firing : 8 October 2021

- ➢ Mandatory used of 5% biomass in all plants
- ➢ In case of RSD, effort will be made to co-fire 10% biomass
- ➢ Exemption if applicable on case to case basis
- ➢ Policy will be in force till 25 years or till useful life of power plant whichever is earlier
- ➢ Biomass co-firing limit to be reviewed time to time
- ➢ Provision for long term biomass pellet supply contract with annual price increment as per T &C to enable supply chain
- ➢ Increased cost due to biomass co-firing shall be passed through / can be claimed under change in law
- ➢ No impact on MOD due to biomass co-firing
- ➢ Discom to get RPO for purchase of biomass power

Way Forward

- Biomass co-firing methodology, needed policy support has already been developed to kick start the sector. National Mission has been set up.
- 5-10% co-firing ratio using agro residue has already been achieved at NTPC stations. However, for beyond 10%, study is underway.
- For improving agricultural residue fuel properties, method of reducing alkali and chlorine content is under exploration to enable higher co-firing ratio.
- Creating large scale biomass collection and processing infrastructure is key to success of national mission.
- Building confidence among stake holders of complete business chain (investors, bank, Gencos, Discoms) is needed for rapid proliferation.
- A model pellet plant and collection infrastructure (majorly using paddy straw) funded by state govt. may help in creating that confidence level.
- Incentive per tone of pellet of pellet may be given to kick start the sector while making good business case.






एनटीपीसी
NTPC

Thank You

PRANAM

Challenges

1. High Volatile Content & Low ignition temperature

Biomass has roughly **3 times** VM as compared to bituminous coal due to which:

- **Risk of fire :** High mill outlet temperature increases the risk of fire inside mill.
- **Increased APC :** Restricting Mill inlet temperature would reduce mill loading considerably, more number of mills may be needed for same load thereby increasing APC.
- **Ramp rate reduction :** During load increasing coal is suddenly pushed into mill, high VM content of biomass may increase the risk of fire. Thus load rate increment will be reduced.

2. High Alkali/ Chlorine Content

This makes ash content of biomass corrosive, which may erode boiler tubes and other boiler parts.

Slagging, Fouling & Corrosion

- Experience in Europe suggests that slagging and fouling are unlikely to be a problem for co-firing ratios up to 10%.
- Wood can be fired 100% due to low alkali content but agro residue should be limited to 10-15% as it has high alkali content.
- Biomass ash deposits tend to have relatively high potassium contents and relatively high chloride to sulphate ratios. This can have a impact on corrosion, particularly at high metal temperatures on superheater surfaces, if co-firing ratio is higher.
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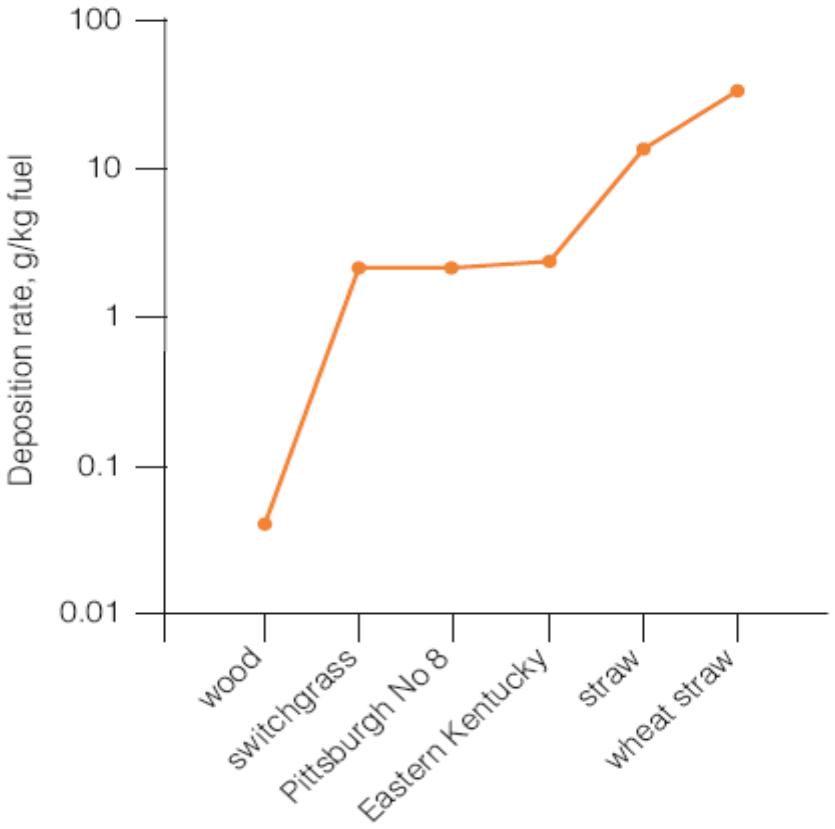


Challenges

- **4. Hygroscopic Nature**

Due to Hygroscopic nature degradation of pellets is fast specially if stored in open areas.

Storage in open areas may cause degradation of biomass pellets at 70 - 80% rate in case of rainfall. Hence proper covered storage is needed raising infrastructure challenge.

This degradation will cause GCV to reduce drastically.

Fibrous Nature

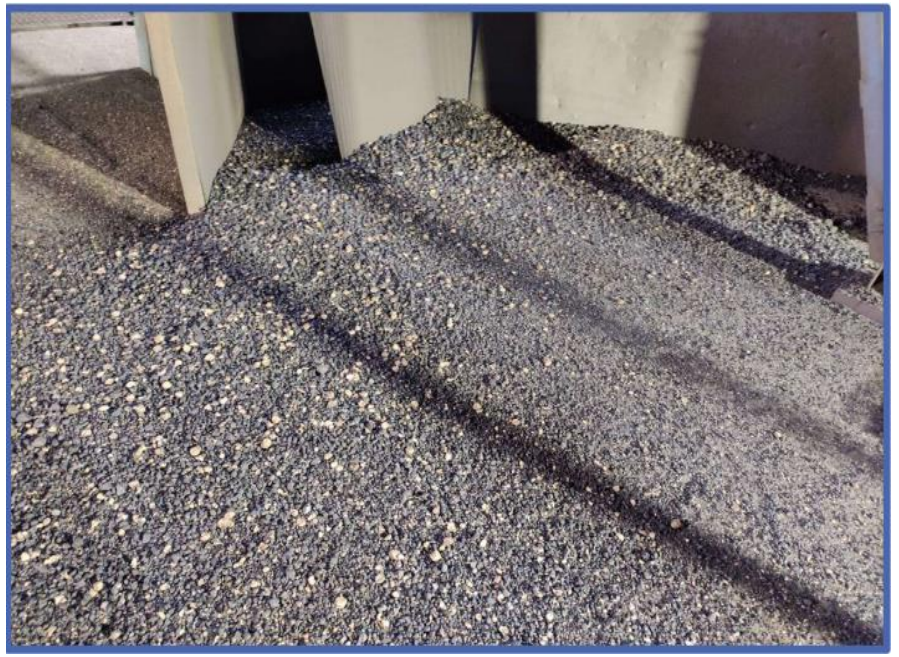
Due to fibrous nature of biomass pellets mill reject have increased upto 3 times as grindability index is poor.

GCV loss due this reject is very high, for example below given is NTPC Khargone's reject data :

AUG,2021					
Collection Date	MILL	UNIT	loisture	ASH %	GCV
28.08.21	A	III	1.81	75.64	1174
28.08.21	B	III	1.11	75.98	1243
28.08.21	C	III	1.21	76.52	1178
28.08.21	D	III	1.48	78.87	918
28.08.21	E	III	1.02	76.82	1177
28.08.21	F	III	1.11	77.32	1117
28.08.21	G	III	2.04	77.75	941

During BIO MASS blend pellet feeding

AUG,2021					
Collection Date	MILL	UNIT	loisture	ASH %	GCV
31.08.21	D	III	2.37	56.03	2938



Solutions Proposed

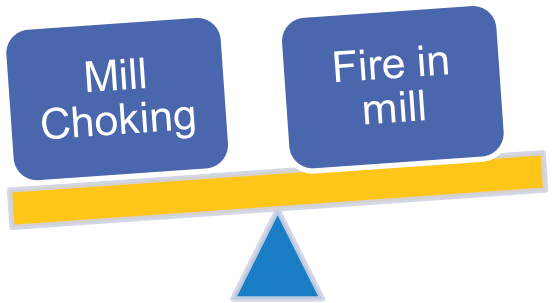
1. **Modified mill loading logic for ramping activity.**

Since sudden loading of mills with biomass is causing temp rise, hence during load ramp up activity following parameters should be included in mill logic:

- Rate of rise of Mill outlet temperature.
- Rate of rise of Boiler metal temperature.
- Coal pipe line temperatures.
- Presently in cases when moisture content is high in pellets and coal, Restricting inlet temp to 180 Degrees may sometimes lead to an outlet temp of 50-60 degree and choking of mill.
  Hence, CAD (Cold Air Damper) of mill **should monitor both** inlet and outlet temperature instead of just inlet temperature.

Low mill Outlet Temperature

High Mill Outlet Temperature



Merit : This will help optimize mill loading without compromising on metal temp rise and mill fire hazard.

It would also allow higher mill loading (when moisture content is higher in fuel) and help us achieve a better ramp rate, which would minimize DSM losses.

2. Algorithm to map boiler metal temperatures

It has been observed that metal temperatures rise only in certain parts of boiler depending upon many factors like soot deposition etc.

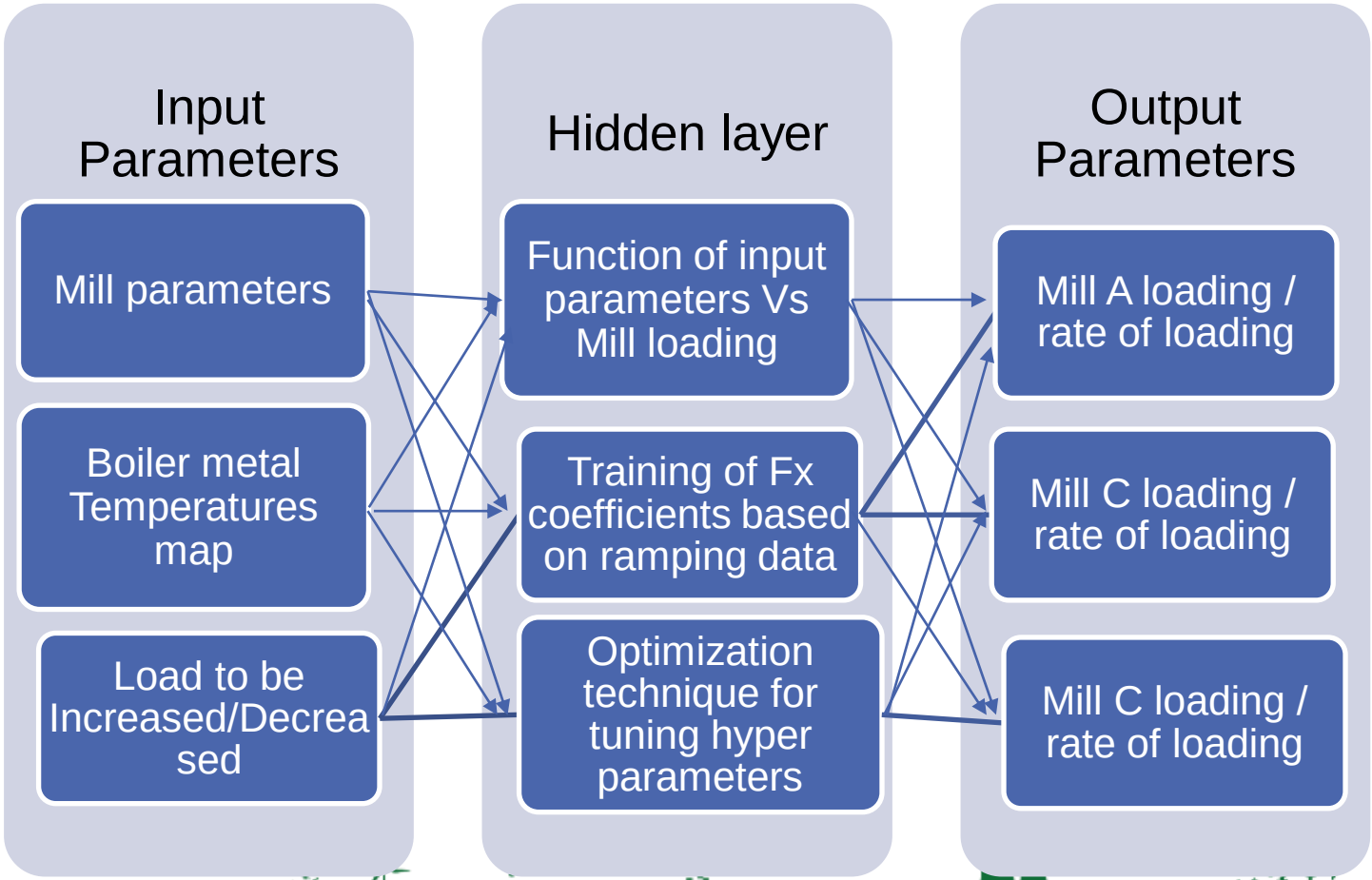
Particular mill loading may aggravate the situation whereas other mill loading may not have profound affect on metal temperature of that region.

Hence an algorithm may be developed to monitor rise of metal temperatures vis a vis pattern of mills' loading, Coal pipe line temperatures and other available parameters.

Say it can be observed by a smart algo that boiler right intermediate header metal temperatures are increasing when Mill C is loaded very fast.

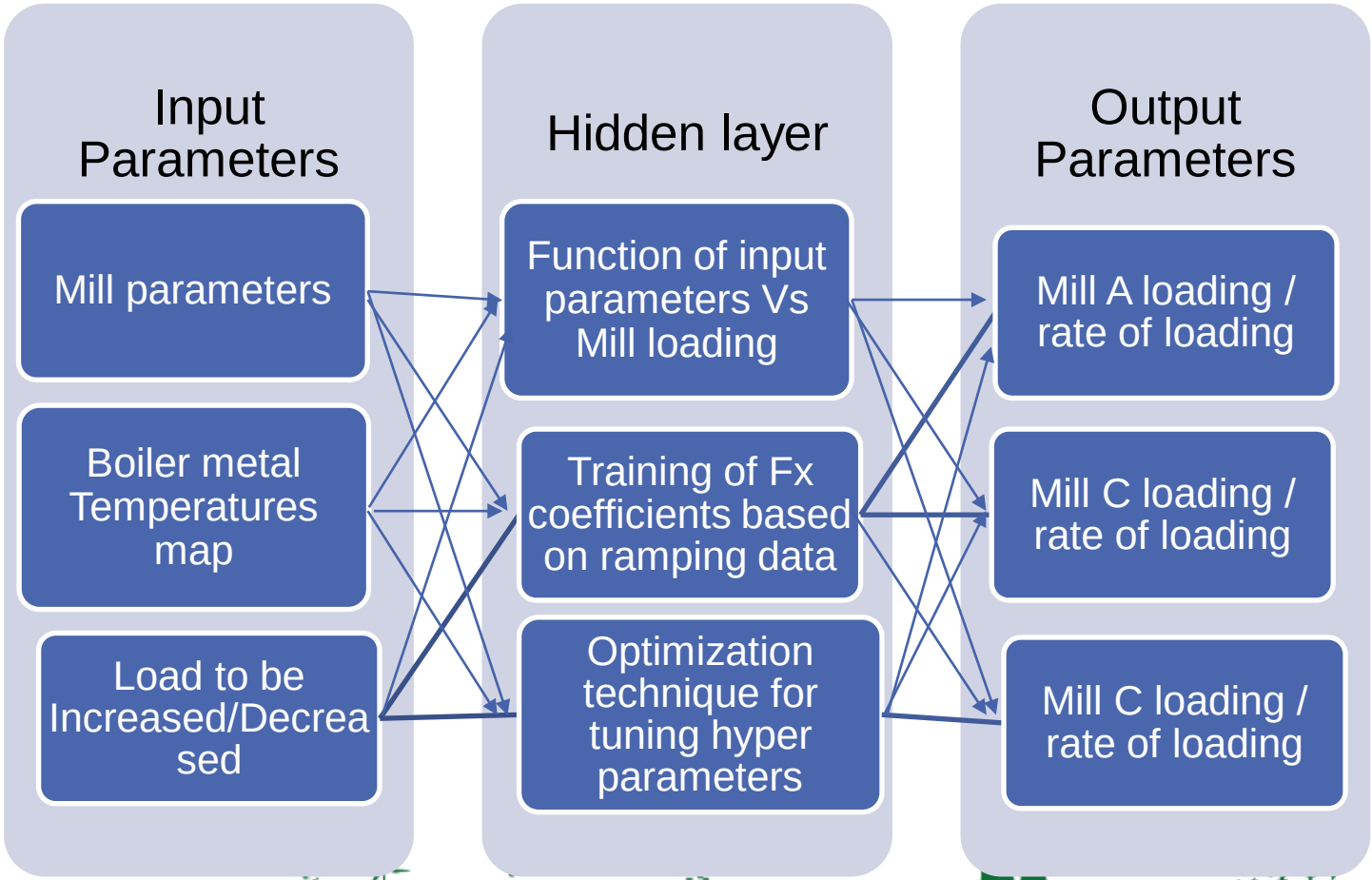
Merit :

Loading and rate of loading of mills during ramping activity will be optimized for better boiler performance and **reducing metal temperature excursions**.



Merit :

Loading and rate of loading of mills during ramping activity will be optimized for better boiler performance and **reducing metal temperature excursions**.



3. Protection Mode :

Bunker Pellet Flow pattern and Timing of Biomass Pellets entry into the Coal Feeder cannot be predicted. Hence, the Mill identified for Pellet co firing should be kept in Biomass Protection Mode ON well before anticipated time.

4. Optimum Soot Blower operation : Based on results of smart algorithm envisaged above which will give us regions of boiler to focus upon while operating soot blower.

5. Variable Blending : It will be obligatory for us to maintain 5% blending annually.

We can have variable blending ratios depending on coal quality at different time of the year, more blending with low GCV Coal and less blending with high GCV coal to maintain 5% overall would optimise our mill loading and temperatures.