Council of Enviro Excellence

5th NATIONAL POWER-GEN ENERGY EFFICIENCY AWARDS-2026

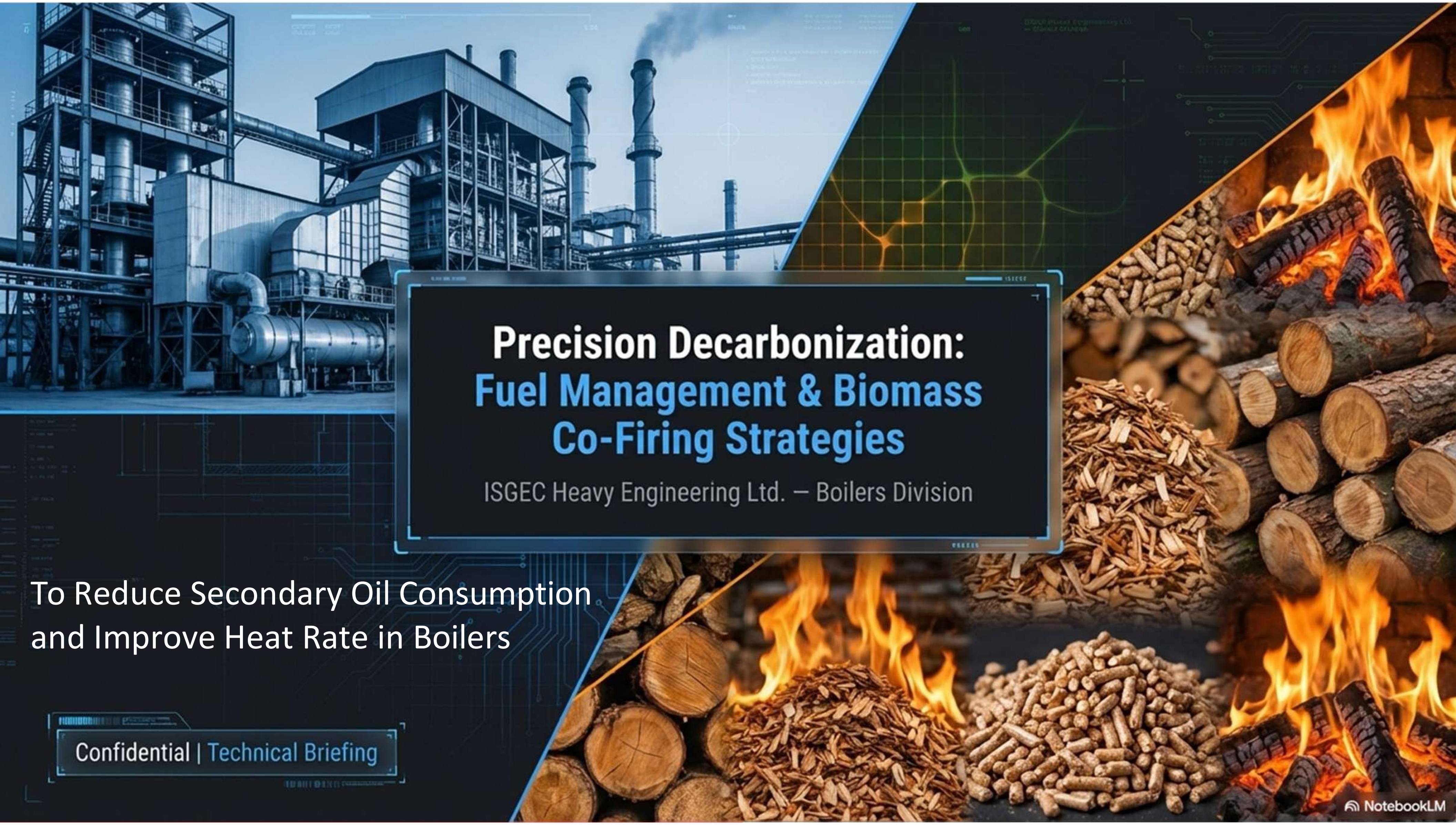
5TH NATIONAL POWER-GEN ENERGY EFFICIENCY

SUMMIT AND AWARDS 2025

Enhancing Efficiency in Indian Thermal Power Plants

FUEL MANAGEMENT & DIVERSITY - STRATEGIES FOR COAL WASHING, BLENDING, AND THE INTEGRATION OF BIOMASS CO-FIRING TO REDUCE SECONDARY OIL CONSUMPTION AND HEAT RATE

MR. AJIT PRAJAPAT



To Reduce Secondary Oil Consumption and Improve Heat Rate in Boilers

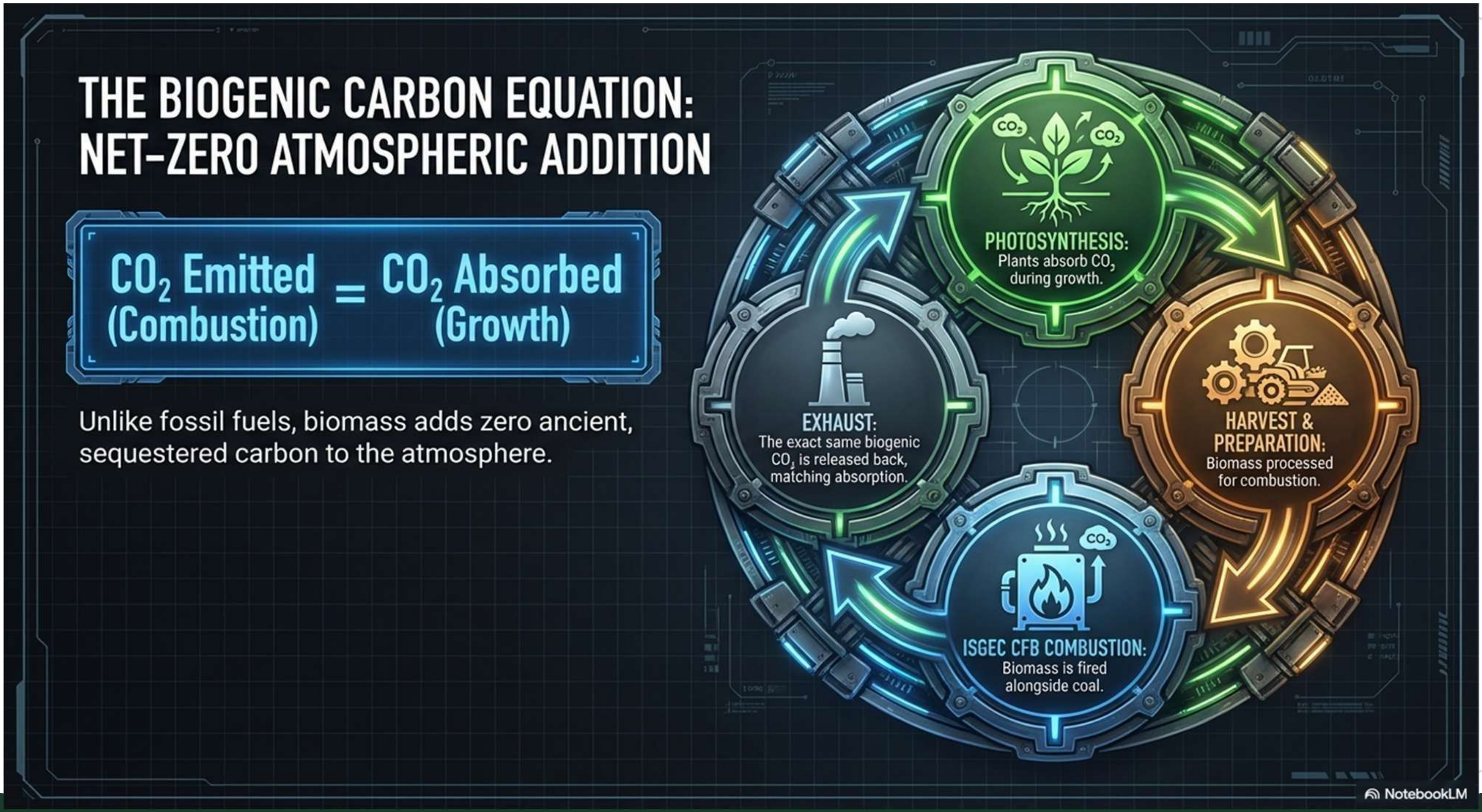
Agenda — Topics Covered

Biomass Overview

Biomass has Sustained Energy Source before fossil fuels came

Biomass has been humanity's primary energy source for millennia. Today, it offers a carbon-neutral pathway back to sustainable energy — harnessing nature's own carbon cycle.

Carbon-Neutral



Biomass Cofiring –Benefits-Ideal Fuel for Boiler

What is Biomass Co-Firing?

- **Process of burning biomass alongside fossil fuels (coal) in boilers**
- Biomass absorbs CO_2 during growth → releases same CO_2 during combustion
- Net atmospheric CO_2 addition = ZERO (Carbon Neutral)
- Mechanizing Boiler Feed Handles widest range of biomass fuels reliably
- **Carbon Neutrality: CO_2 Emitted (combustion) = CO_2 Absorbed (growth)**

Benefits of Co-Firing

- **20–32% CO_2 cut with 20% biomass blend vs coal-only operation**
- Flexibility to use diverse, locally-available biomass fuel sources
- Reduction in coal consumption — supports energy transition goals
- Lower NOx & SOx emissions due to lower combustion temperatures
- **Supports ESG reporting and carbon reduction commitments**

Why Biomass Firing is Ideal?

- **Efficient combustion at 820–870°C — suits high-volatile biomass**
- Handles fuel GCV range of 1,500–6,000 kcal/kg without major modification
- In-furnace desulfurization — natural SO_2 control with biomass fuels
- Proven on 100% biomass (Polaniec, Poland — 205 MWe since 2012)
- ISGEC design accommodates 100+ biomass fuel types

CO_2 Emissions: PC Coal Plant 5.41 MT/yr | Coal CFB+20% Biomass 4.33 MT/yr | OTU CFB+20% Biomass 3.64 MT/yr (600 MWe plant)

Why Biomass Ideal for Co-Firing

Wide Fuel Flexibility

Handles GCV range 1,500–6,000 kcal/kg without major modification. Moisture 5–55% managed effectively. Proven on 100+ biomass fuel types by ISGEC.

Optimal Combustion Temperature

Operating at 820–870°C suits high-volatile biomass. Lower combustion temp vs PC boilers reduces NOx, prevents alkali-induced slagging on furnace walls.

In-Furnace SO_2 Control

Limestone injection directly into furnace provides natural desulfurization. Biomass low-sulfur content further reduces SO_2 — no FGD required for many biomass blends.

Stable Furnance Temperature

Provides thermal mass stability. Sudden fuel quality changes absorbed without tripping.

Proven at Commercial Scale

205 MWe Polaniec (Poland) — world's largest 100% biomass CFB since 2012.

KOSPO (Korea) 4×550 MWe co-fires biomass since 2016.

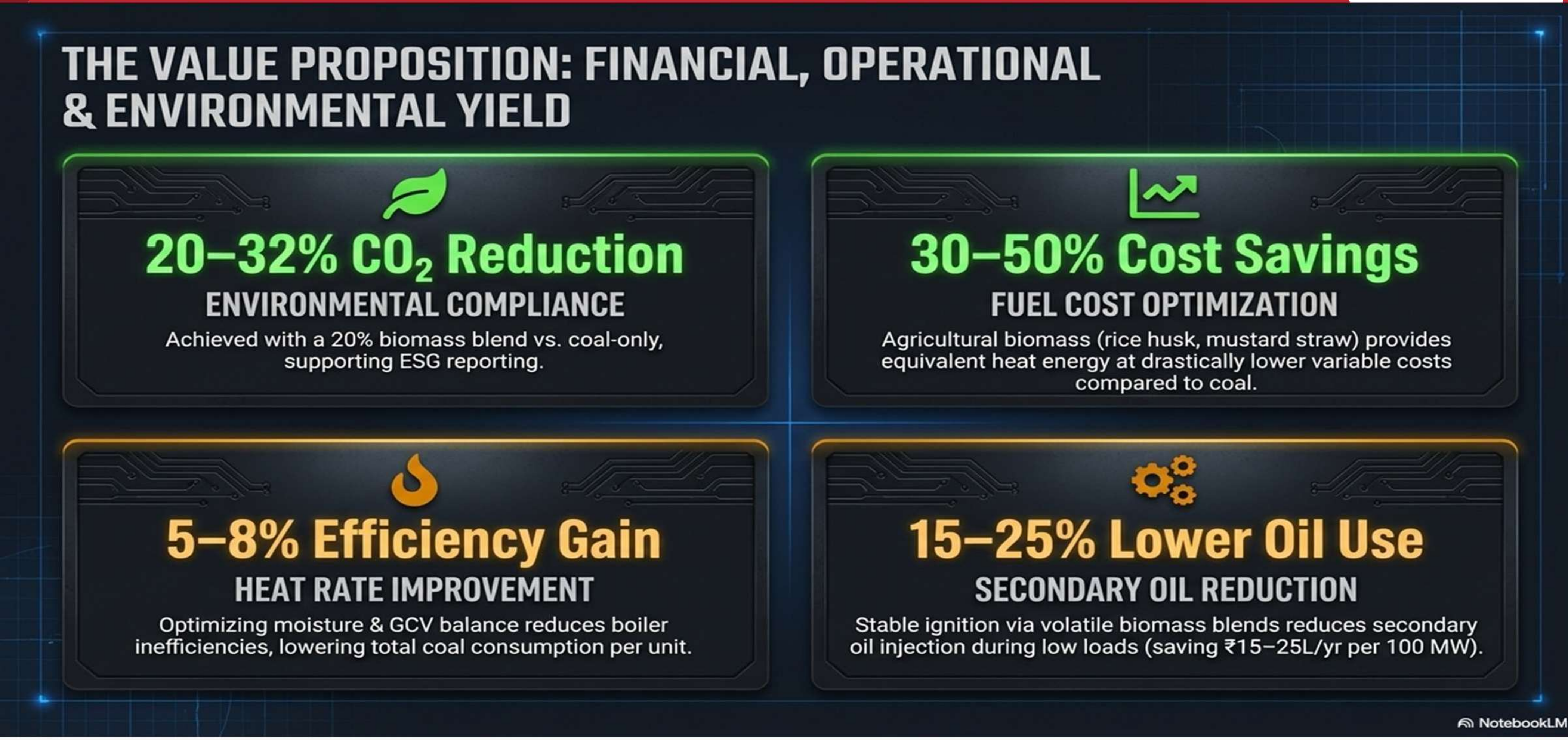
ISGEC India plants commissioned upto 50 % Biomass cofire from 2019 to 2025

Lower Emissions Profile

CO_2 reduced 20–32% with 20% biomass blend. NOx 30–40% lower than PC plants. No FGD or SCR required with biomass co-firing in CFB at 820–870°C.

Why Biomass Fuel Diversity Matters

Executive Overview — Why Biomass Fuel Diversity Matters



Environmental Benefits & Emission Compliance with Biomass Co-Firing

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20–32%
CO_2 Reduction
(20% Biomass Blend)

30–40%
NOx Reduction
vs PC Coal Plant

15–25%
SOx Reduction
with Low-S Biomass

Zero
Net Carbon from
Biomass Combustion

Greenhouse Gas Reductions

- **20% biomass blend → 20–32% CO_2 reduction vs 100% coal (IPCC-validated)**
- **CFB with 20% biomass: 3.64 MT CO_2/yr vs PC coal 5.41 MT/yr (600 MWe)**
- **Biomass-derived CO_2 is biogenic — excluded from fossil carbon accounting**
- **50% biomass blend → up to 50% net CO_2 reduction vs coal baseline**
- **Full 100% biomass (Polaniec) — classified as zero-emission power generation**
- **Annual GHG savings: ~300,000 tCO_2e for 100 MW plant at 20% biomass co-fire**

Air Quality & ESG Compliance

- **NOx**: biomass at 820–870°C produces <300 mg/Nm³ vs >500 for PC plants
- **SOx:** biomass low-S content + in-furnace limestone injection → <200 mg/Nm³
- **PM:** ESP efficiency >99.5% maintained with biomass ash — CPCB norms met
- No mercury concerns — **biomass Hg content negligible vs coal**
- **ESG reporting:** biomass co-fire percentage qualifies as sustainable energy
- **Renewable Energy Certificates (RECs)** available for biomass co-fire output

Executive Overview — Why Biomass Fuel Diversity Matters

15–25%
Reduction in Secondary Oil Use

5–8%
Heat Rate Improvement Potential

20–32%
CO_2 Reduction with 20% Biomass Co-Fire

Environmental Compliance

Biomass co-firing directly reduces net CO_2 emissions.

A 20% biomass blend achieves 20–32% CO_2 reduction vs. coal-only operation, supporting regulatory targets and ESG goals.

Fuel Cost Optimization

Agricultural biomass (rice husk, mustard straw) is often 30–50% cheaper than coal on a heat-equivalent basis, reducing variable fuel cost significantly.

Heat Rate Improvement

Proper fuel blending reduces boiler inefficiencies.

Optimizing moisture & GCV balance improves overall plant heat rate by 5–8%, reducing coal consumption per unit.

Oil Consumption Reduction

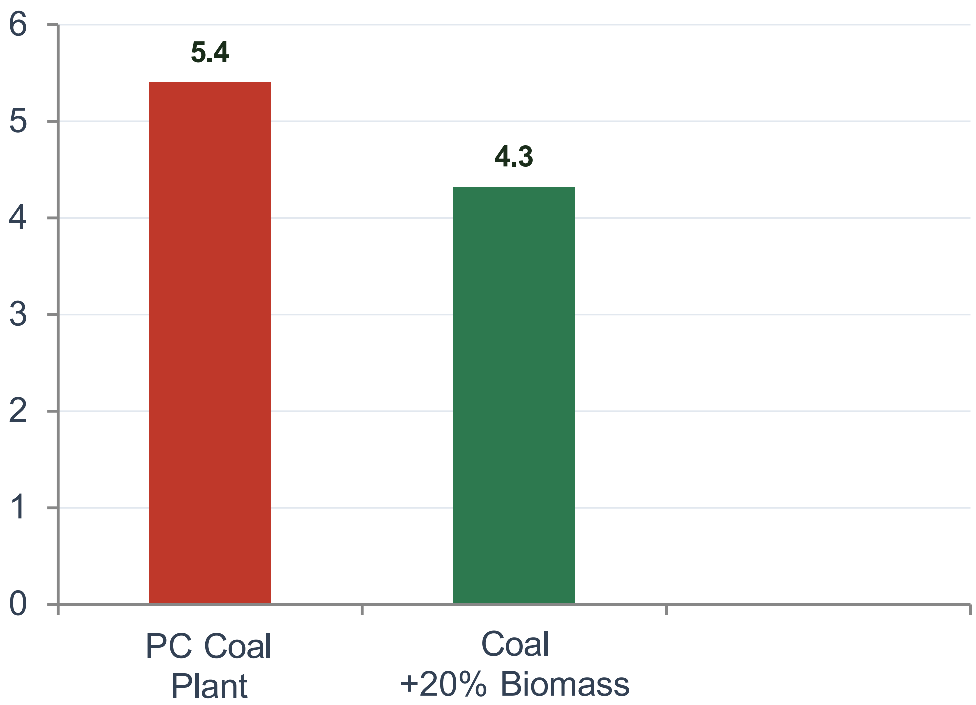
Stable ignition and Furnance temperature via biomass blends reduces secondary oil injection during low-load operation by 15–25%, generating direct cost savings of ₹15–25L/yr per 100 MW unit.

CO2 Emission Comparison with Biomass Co-Firing Fuel

ISGEC

Heavy Engineering Ltd.

CO_2 Emission MT Comparison per (600 MWe Plant)



Key Benefits

Carbon Neutral

CO_2 released = CO_2 absorbed during plant growth. Net atmospheric addition = ZERO.

20–32% CO_2 Cut

With 20% biomass blend vs. coal-only operation. Supports ESG regulatory targets.

Fuel Flexibility

Handles GCV range 1,500–6,000 kcal/kg. Works with 100+ biomass types.

Emission Benefits

Lower NOx & SOx. In-furnace desulphurization. Operates at 820–870°C.

Reducing Secondary Oil Consumption via Fuel Strategies

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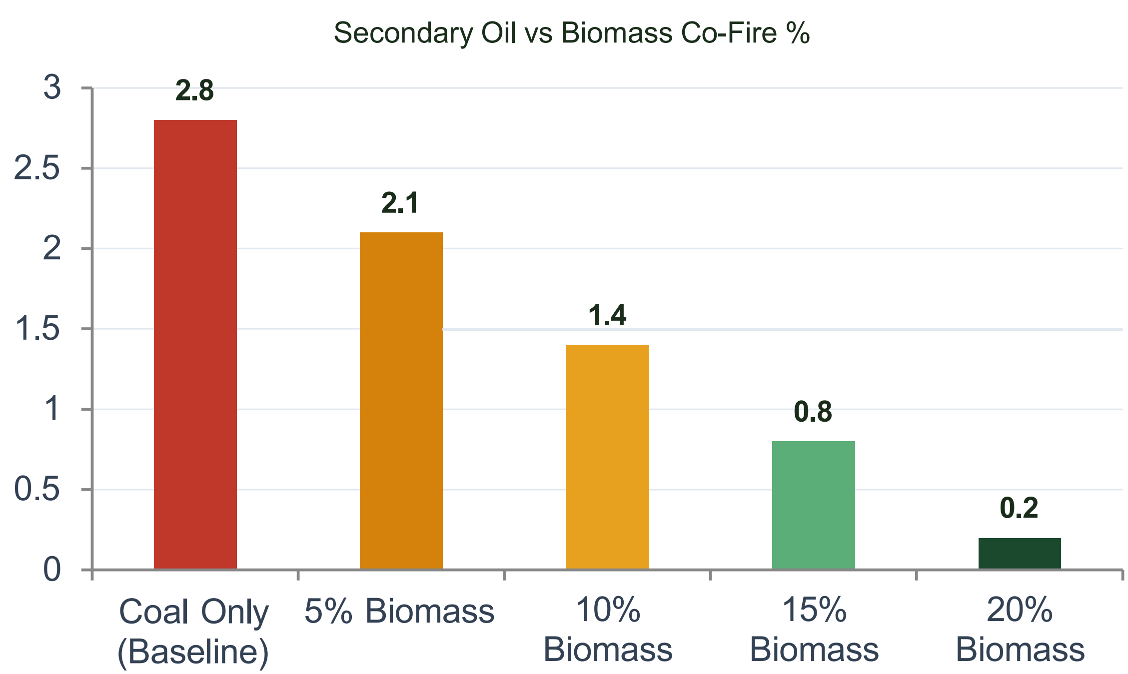

20–40%
Oil reduction on biomass

₹15–25L/yr
Savings per 100 MW unit

<820°C
Furnance temp → oil support

Stable Furnace Temp Control

Maintain 820–870°C without oil. Use high-GCV biomass (groundnut shell, coconut shell) for ignition support at startup.

Biomass as Ignition Support

Highly volatile biomass combusts faster than coal at lower temps. Direct biomass injection reduces oil by 20–40% at startup.

Fuel Management & Scheduling

Strategic fuel management reduces flame holding. Introduce high-GCV biomass during low-load to maintain ignition stability.

Heat Rate Improvement Pathways via Biomass Co-Firing

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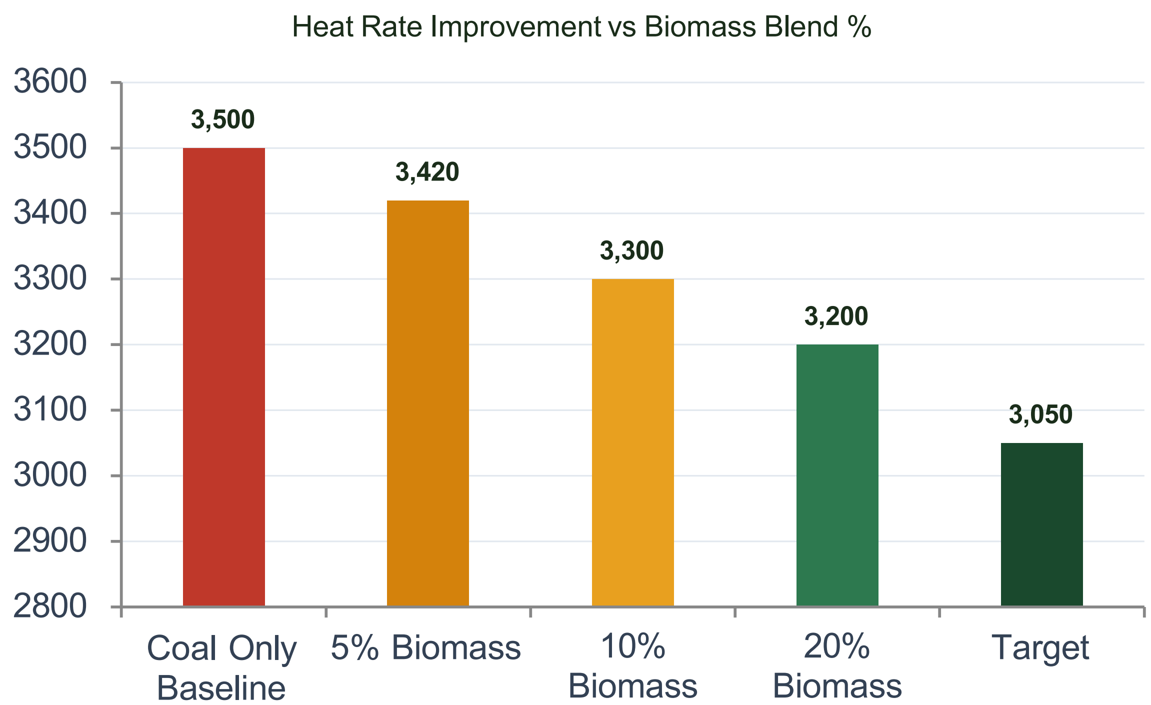


5–8% Total Heat Rate Improvement Potential

Through optimized biomass blend, combustion management & auxiliary power reduction

2–3% — **Combustion Efficiency**

CFB at 820–870°C achieves near-complete combustion of biomass volatiles. Lower unburnt carbon in fly ash.

1–2% — **Auxiliary Power Reduction**

Lower ID/FD fan power due to biomass's lower density. Reduced mill power requirement.

1–2% — **Boiler Efficiency Gain**

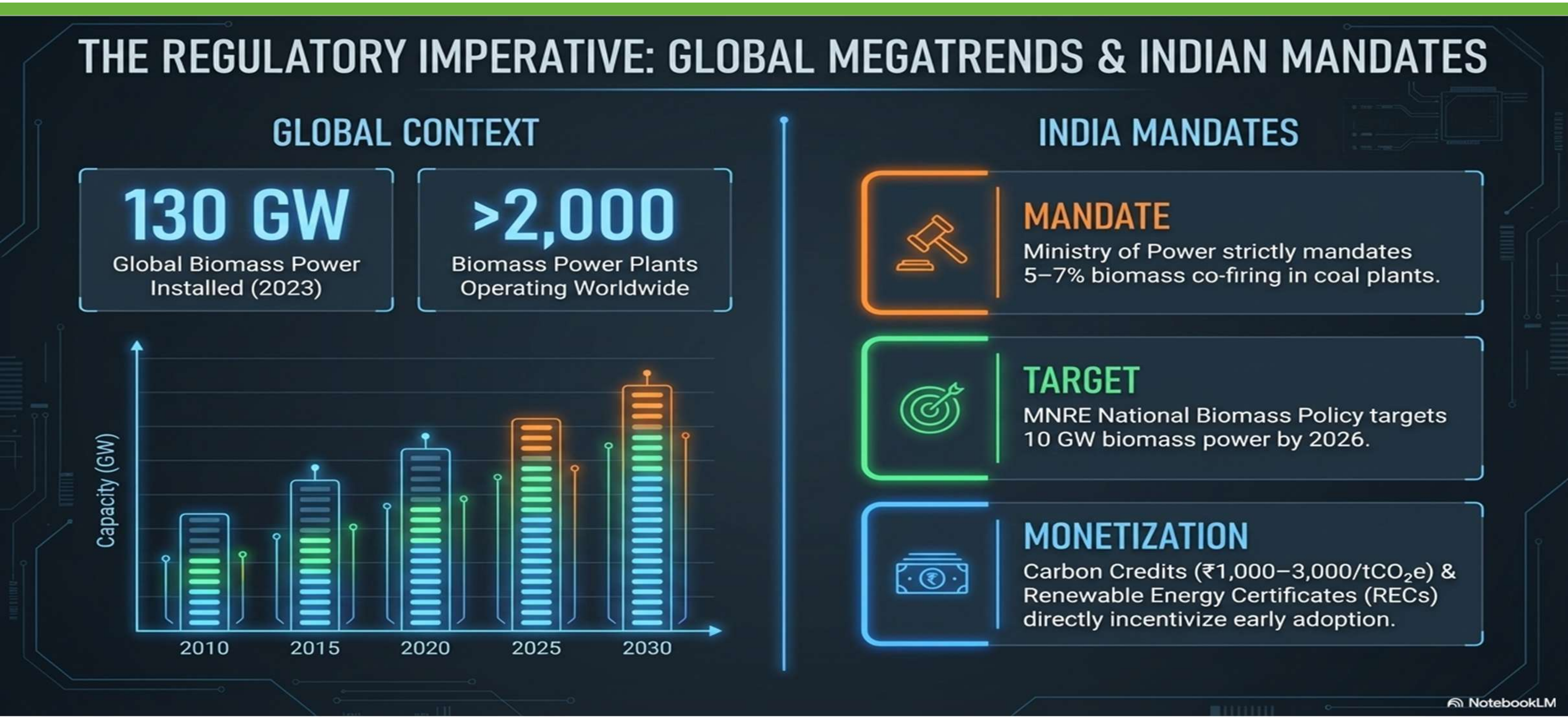
Optimized air:fuel ratio with biomass blend. Better heat transfer from improved flue gas properties.

0.5–1% — **Oil Elimination Gain**

Removing oil burner losses from fuel circuit. Eliminates heat losses from oil preheating circuits.

Biomass Global Trends & India Context & Policy Drivers

Fuel Blending & Diversification -As a Carbon-Neutral Co-Firing Fuel



Biomass as Energy Source — Global Installed Capacity Trends

130 GW
Global Biomass Power Installed (2023)

>2,000
Biomass Power Plants Operating Worldwide

10%
Share in Renewable Energy Generation

Global Trends & Market Overview

- **Europe leads with 45+ GW biomass power (Germany, UK, Finland, Netherlands)**
- **Asia-Pacific growing rapidly — India, Japan, South Korea investing heavily**
- CFB technology dominates utility-scale biomass plants globally (>100 MWe)
- India has 10+ GW biomass potential; agro residues = ~680 MT/year surplus
- Co-firing in existing coal plants is lowest-cost route to decarbonization

India Context & Policy Drivers

- **India's National Biomass Policy mandates 5–7% co-firing in coal plants**
- **IRENA (International Renewable Energy Agency) projects biomass to supply - 20% of global renewable energy by 2030**
- **Carbon credits & REC schemes** in India incentivize biomass co-firing adoption
- **Biomass pellet trade growing at 8% CAGR** — global supply chain maturing
- ISGEC has commissioned biomass co-fire projects across India since 2019

Carbon Credits, Regulatory Framework & Policy Support for Biomass C o

₹1,000–3,000
Per tCO_2e Carbon Credit Value (India)

5–7%
Mandatory Biomass Co-fire (India Policy)

RECs
Renewable Energy Certificates Available

India Policy & Regulatory Drivers

- **Ministry of Power (2021):** 5% biomass co-firing mandatory for all coal plants
- **MNRE National Biomass Policy:** target 10 GW biomass power by 2026
- **CPCB emission norms: biomass co-fire helps meet NOx/SOx/PM limits**
- **Perform Achieve Trade (PAT) Scheme: biomass co-fire earns Energy Saving Certs**
- **State-level biomass purchase policies: UP, Punjab, Haryana offer incentives**
- Carbon Border Adjustment Mechanism (CBAM): **biomass reduces export carbon cost**

Carbon Credit Monetization

- **Gold Standard / VCS CDM projects certifiable for biomass co-firing projects**
- **Calculation basis**: tCO_2e saved = (biomass heat input / total heat input) × plant CO_2
- **Annual carbon credits:** ~300,000 tCO_2e for 100 MW plant at 20% biomass
- **Revenue at ₹2,000/tCO_2e:** ₹60 crore/year additional income stream
- **Renewable Energy Certificates:** 1 REC per 1 MWh of biomass-derived power
- **REC trading price** ₹1,000–3,000/MWh on Indian Energy Exchange

Financial Analysis — Economics of Biomass Co-Firing Implementation

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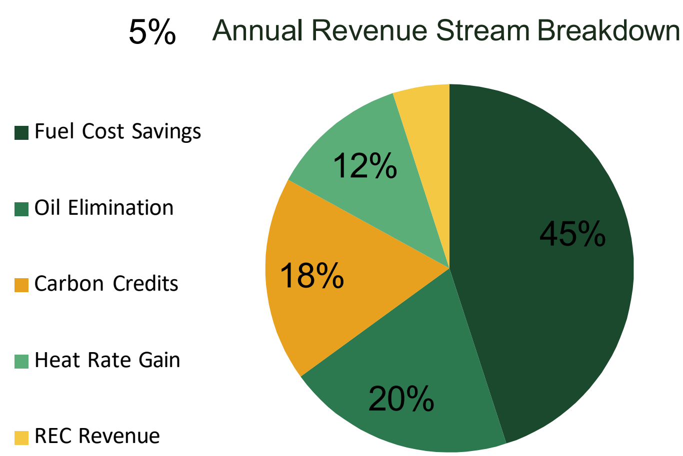
₹5–15 Cr
Capital Investment
Requirement per 100 MW

2–4 Years
Payback Period
on Investment

₹25–60 Cr/yr
Annual Savings &
Revenue Streams



Revenue Stream	Value (100 MW)	Notes
Fuel cost savings	₹10–20 Cr/yr	30–50% cheaper biomass vs coal
Oil elimination	₹5–15 Cr/yr	Full elimination at stable load
Carbon credits	₹4–12 Cr/yr	₹1,000–3,000/tCO_2 at 20% blend
Heat rate improvement	₹3–8 Cr/yr	5–8% improvement on 100 MW plant
REC revenue	₹1–5 Cr/yr	₹2/unit for biomass generation

Global Case Studies — Proven Biomass Co-Firing Results

KR KOSPO Samcheok — Korea | 4 × 550 MWe USC CFB | Since 2016

Co-fires biomass up to 5% by heat input alongside import coals (3,400–6,000 kcal/kg). Heat rate: 8,391 kJ/kWh. Achieves 50 ppm SOx & NOx without FGD or SCR.

GB MGT Teesside — UK | 299 MWe Biomass CFB | From 2021

Fires wood pellets (100%) + wood chips (up to 70%). Boiler efficiency 96% with LTFGHR. Supported by 15-year CfD subsidy. World-class biomass-only operation.

PL Łagisza — Poland | 460 MWe Supercritical CFB | Since 2009

Wide fuel range (4,300–5,500 kcal/kg), **fires biomass & waste coal slurry.** Gross efficiency 45.7%. No FGD or SCR required. Pioneer of large-scale biomass co-firing.

PL Polaniec — Poland | 205 MWe Bio-CFB | Since 2012

World's largest 100% biomass CFB since 2012. Fires up to 20% agro crops. Efficiency 42.6%; 92.7% boiler LHV efficiency. Green Certificates: 9–64 €/MWh.

IN Kuantum Papers — India | 130 TPH ., Punjab | Since 2021

35 % rice husk + Indian coal co-firing. 30 MW captive power + process steam for paper plant. First agro-biomass co-fire at scale in India — ISGEC supply.

IN DCM Shriram — India | 2×150 TPH ., Rajasthan | Since 2019

Indian Coal + 50 % Biomass. 60 MW cogeneration. Both boilers on common structure — ISGEC design innovation.

Biomass Fuels Key Characteristics

Types of Biomass Fuels & Key Characteristics

Agricultural Derived	Rice Husk • Paddy Straw • Mustard Straw/Husk Cotton Stalk • Soya Stalk • Wheat Straw • Bagasse
Wood Derived	Softwoods: Pine, Eucalyptus • Hardwoods: Oak, Olive Saw Dust • Wood Chips • Timber Pellets • Julie Flora
Fruit / Shell	Coconut Shell • Cashew Husk • Groundnut Shell Coffee Husk • King Grass • Elephant Grass
Waste Derived	Municipal Solid Waste (MSW) • Refuse Derived Fuel (RDF) Poultry / Animal Manure • Recycled Wood • Green Waste

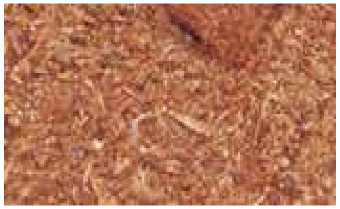
GCV Range: 1,500–6,000 kcal/kg | Moisture: 5–55

ISGEC Experience — 100+ Biomass Fuels Handled

Types of Biomass Fuels & Key Characteristics

Coconut Shell

Mustard Husk



Saw Dust

King Grass

Paddy Straw

Wheat Stalk

Julie Flora

Mustard Stalk

Cotton Stalk

Soya Stalk

Coffee Husk

Wood Chips

Biomass Fuels vs Fossil Fuel — Proximate & Ultimate Analysis

ISGEC experience of handling High Moisture & Low GCV fuels across 100+ biomass types

Parameter	Paddy Straw	Mustard Straw	Cotton Stalk	Groundnut Shell	Bagasse	Coconut Husk	Soya Stalk	King Grass	Coal
Carbon %	26.1	40.2	45.7	47.7	23.5	39.4	43.4	22.7	55.7
Moisture %	25.0	6.5	13.9	10.1	50.0	13.3	6.9	50.6	34.2
Ash %	19.5	5.0	4.5	2.4	1.5	7.4	8.9	2.8	7.3
Sulphur %	0.15	0.80	0.16	0.42	0.00	0.08	0.09	0.02	0.77
Volatile Matter %	55.1	67.2	72.5	73.2	62.0	68.4	70.1	61.3	27.4
GCV kcal/kg	2,387	3,980	3,740	4,130	2,272	3,602	4,134	1,988	3,950

Biomass Parameters for Co-Firing — Raw vs Briquettes vs Pellets

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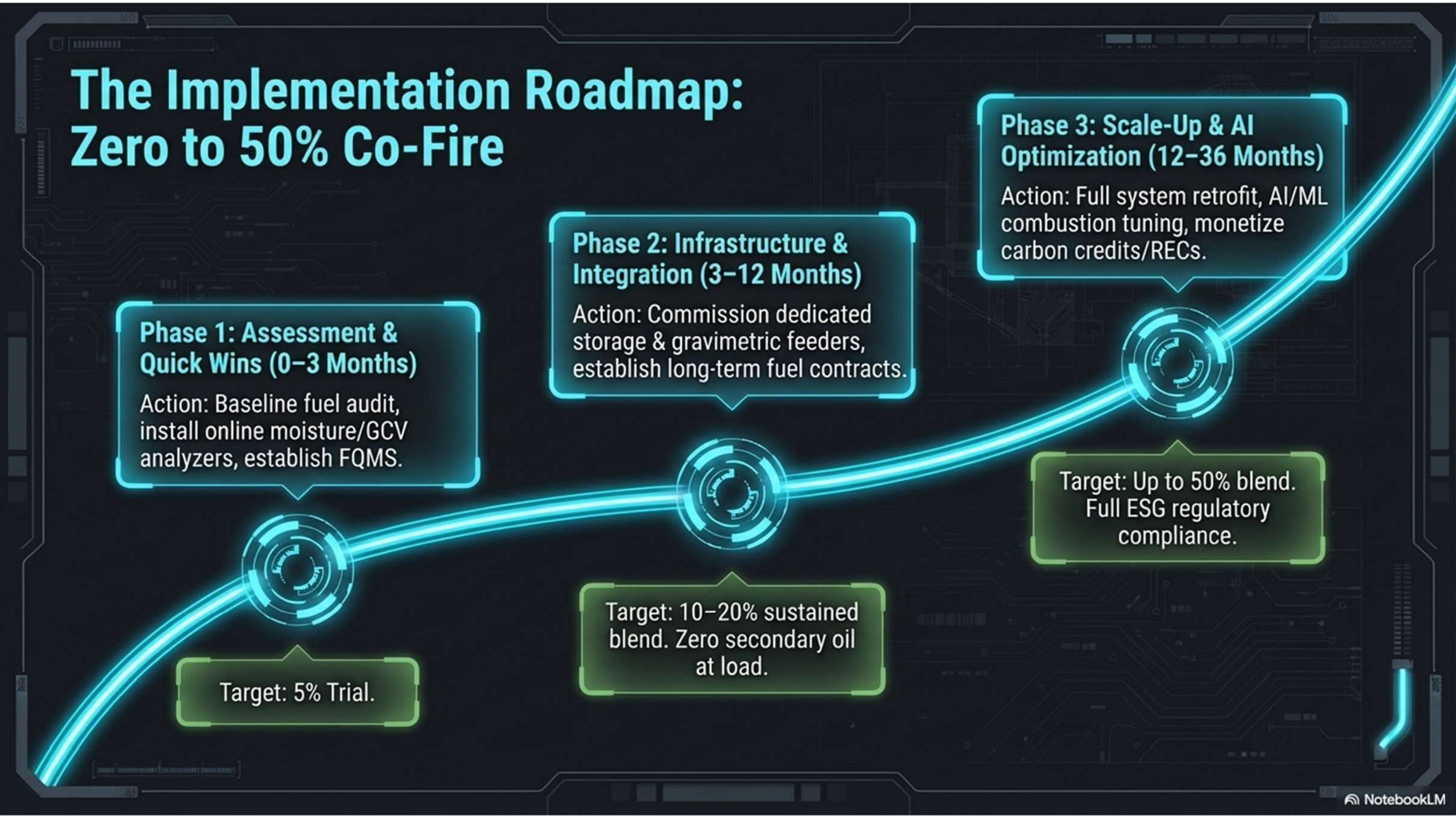
Selecting the right biomass form affects feed system design, combustion stability and overall plant performance.

Parameter	Raw Biomass	Briquettes 50-100 MM	Pellets 6-10 MM	Recommended
GCV (kcal/kg)	1,500–4,500	2,800–4,200	3,900–4,500	Pellets
Moisture %	6–55%	10–15%	5–10%	Pellets
Bulk Density kg/m³	80–250	500–600	600–700	Pellets
Particle Uniformity	Very Poor	Good	Excellent	Pellets
Handling Reliability	Poor–Medium	Good	Excellent	Pellets
Dust Generation	High	Low	Very Low	Pellets/Briquettes
Transport Cost	High	Low	Very Low	Pellets
Procurement Cost/kcal	Lowest	Medium	Highest	Raw (if consistent)
CFB Co-fire Suitability	Low–Medium	Good	Excellent	Pellets

Implementation
KPI Targets & Roadmap

Phased approach to sustainable biomass co-firing deployment


The Implementation Roadmap: Zero to 50% Co-Fire
Phase 1: Assessment & Quick Wins (0–3 Months)
Action: Baseline fuel audit, install online moisture/GCV analyzers, establish FQMS.
Target: 5% Trial.
Phase 2: Infrastructure & Integration (3–12 Months)
Action: Commission dedicated storage & gravimetric feeders, establish long-term fuel contracts.
Target: 10–20% sustained blend. Zero secondary oil at load.
Phase 3: Scale-Up & AI Optimization (12–36 Months)
Action: Full system retrofit, AI/ML combustion tuning, monetize carbon credits/RECs.
Target: Up to 50% blend. Full ESG regulatory compliance.
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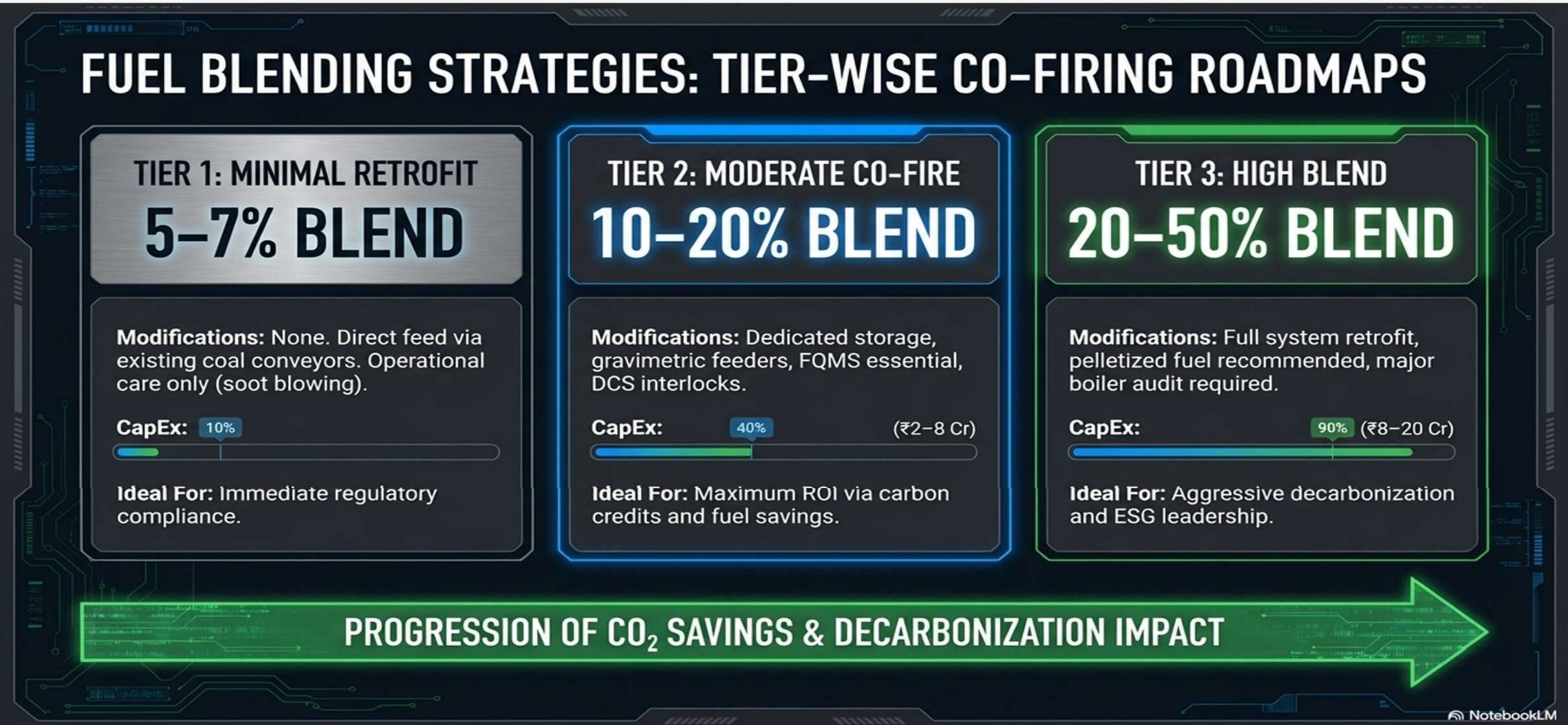
Financial Analysis — Economics of Biomass Co-Firing Implementation



Financial Analysis — Economics of Biomass Co-Firing Implementation

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Isgec Heavy Engineering Ltd.

₹5–15 Cr
Capex for 10% Co-fire (per 100 MW Unit)

2–4 Years
Typical Payback Period

₹25–60 Cr/yr
Annual Savings (Fuel+Oil+Carbon Credits)

Capital Investment Requirements

- **Tier 1 (5–7%): ₹50–200 Lakhs** — minimal retrofit, mostly operational changes
- **Tier 2 (10–20%): ₹2–8 Crore per 100 MW** — biomass storage, feeders, DCS
- **Tier 3 (20–50%):** ₹8–20 Crore per 100 MW — full fuel prep + system retrofit
- Online analyzers (GCV+moisture): ₹50–100 Lakhs per installation
- **Pelletizing plant (1 TPH):** ₹1.5–2.5 Crore installed — optional for consistency
- DCS upgrade for biomass control loop: ₹25–75 Lakhs depending on existing DCS

Annual Savings & Revenue Streams

- **Fuel cost saving at 10% biomass:** ₹5–15 Crore/year per 100 MW (vs coal)
- **Secondary oil elimination:** ₹15–25 Lakhs/year per 100 MW unit
- **Heat rate improvement (2–3%):** ₹3–8 Crore/year saved in coal consumption
- **Carbon credits at** ₹2,000/tCO_2e × 150,000 tCO_2e: ₹30 Crore/year
- **REC revenue** at ₹2,000/MWh × biomass MWh: ₹5–20 Crore/year
- **Total annual benefit range**: ₹25–60 Crore/year for 100 MW at 15% co-fire

Fuel Blending Strategies for Boilers — Tier-wise Co-Firing Approach

5–7%
Tier 1 – Minimal Retrofit

- Direct biomass feed via existing coal conveyors
- No boiler modifications required — operational care only
- Increase soot blowing frequency, monitor deposits closely
- Suitable for rice husk, groundnut shell, mustard straw

10–20%
Tier 2 – Moderate Co-Fire

- Dedicated biomass storage & feed system required
- Fuel quality monitoring system essential — DCS interlocks
- Gravimetric feeders for consistent biomass feed rate
- Target blended GCV within ±300 kcal/kg of design fuel

20–50%
Tier 3 – High Biomass Blend

- **Retrofit of fuel preparation, feeding & combustion systems**
- Feasibility study + boiler audit mandatory before proceeding
- Significant CO_2 impact — 30–40% reduction achievable
- Pelletized or briquetted biomass recommended for consistency

Critical Blending Parameters:

GCV Balance: Target blended GCV within ±300 kcal/kg of design. Compensate low-GCV biomass with higher coal fraction.

Moisture Control: Blended moisture <35% for stable combustion. Pre-dry high-moisture biomass (>50%) before feeding.

Particle Size: Biomass <6mm for CFB feed. Larger pieces cause incomplete combustion and increased unburnt carbon in ash.

Alkali Management: Monitor K_2O content. If >2% in blend ash, use kaolin/lime additives to suppress agglomeration risk.

Reducing Secondary Oil Consumption via Fuel Strategies

Secondary oil is consumed in boilers for ignition support, low-load stabilization, and emergency flame holding. Strategic fuel management can reduce this by 15–25%.

01 — Stable Furnance Temperature Control

- Maintain Furnance temp 820–870°C without oil by optimizing coal/biomass blend ratio
- Use high-GCV biomass (groundnut shell, wood pellets) as thermal buffer during low load
- Pre-warm dense bed material using biomass ignition — eliminate cold-start oil dependency

02 — Biomass as Ignition Supplement

- Highly volatile biomass (>60–70% volatile matter) ignites faster than coal at lower temps
- Direct biomass injection during start-up reduces oil burner firing duration by 20–40%
- Pelletized biomass provides consistent feed and reliable ignition energy input

03 — Load Management & Fuel Scheduling

- Schedule high-biomass blends during stable mid-load operation to avoid oil trips
- Introduce biomass gradually: start at 5%, increase to target in 2–3% steps
- Avoid sudden biomass surges that cause bed temp drops and trigger oil injection

20–40%

Oil burner ON-time reduction via biomass assist

₹15–25L/yr

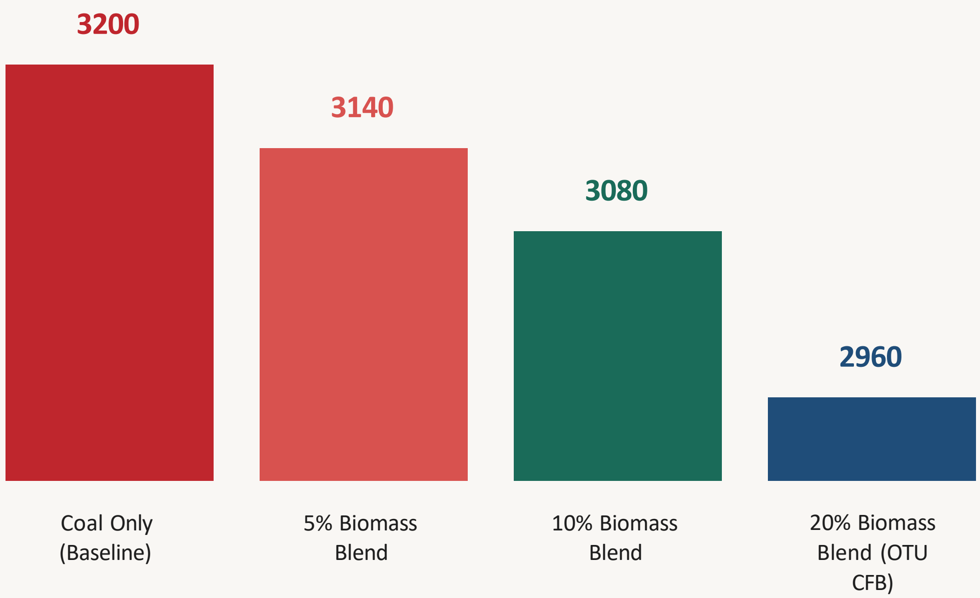
Estimated annual oil cost saving per 100 MW

<820°C

Avoid Furnance temp drop below to skip oil support

Heat Rate Improvement Pathways via Biomass Co-Firing

Plant heat rate (kcal/kWh) is directly impacted by fuel quality, blend consistency, combustion completeness and auxiliary consumption. Proper biomass integration optimizes all four.



★ ISGEC OTU-CFB with 20% biomass achieves 8,391 kJ/kWh net heat rate — Net CO_2 reduction: 32% vs PC coal plant

Key Improvement Levers

2–3% — **Combustion Efficiency**

Volatile-rich biomass → faster burnout, lower unburnt carbon in fly/bottom ash

1–2% — **Auxiliary Power Reduction**

Lower ID fan load due to reduced flue gas volume per kcal with dry biomass

1–2% — **Boiler Efficiency Gain**

Controlled moisture in blend reduces sensible heat loss in flue gas exit

0.5–1% — **Oil Elimination Benefit**

Zero secondary oil at stable load removes oil spray inefficiency from heat balance

Implementation
Key Challenges & Mitigations

NAVIGATING FUEL CHEMISTRY: THE BIOMASS RISK PROFILE

1 THE CHEMICAL CHALLENGE

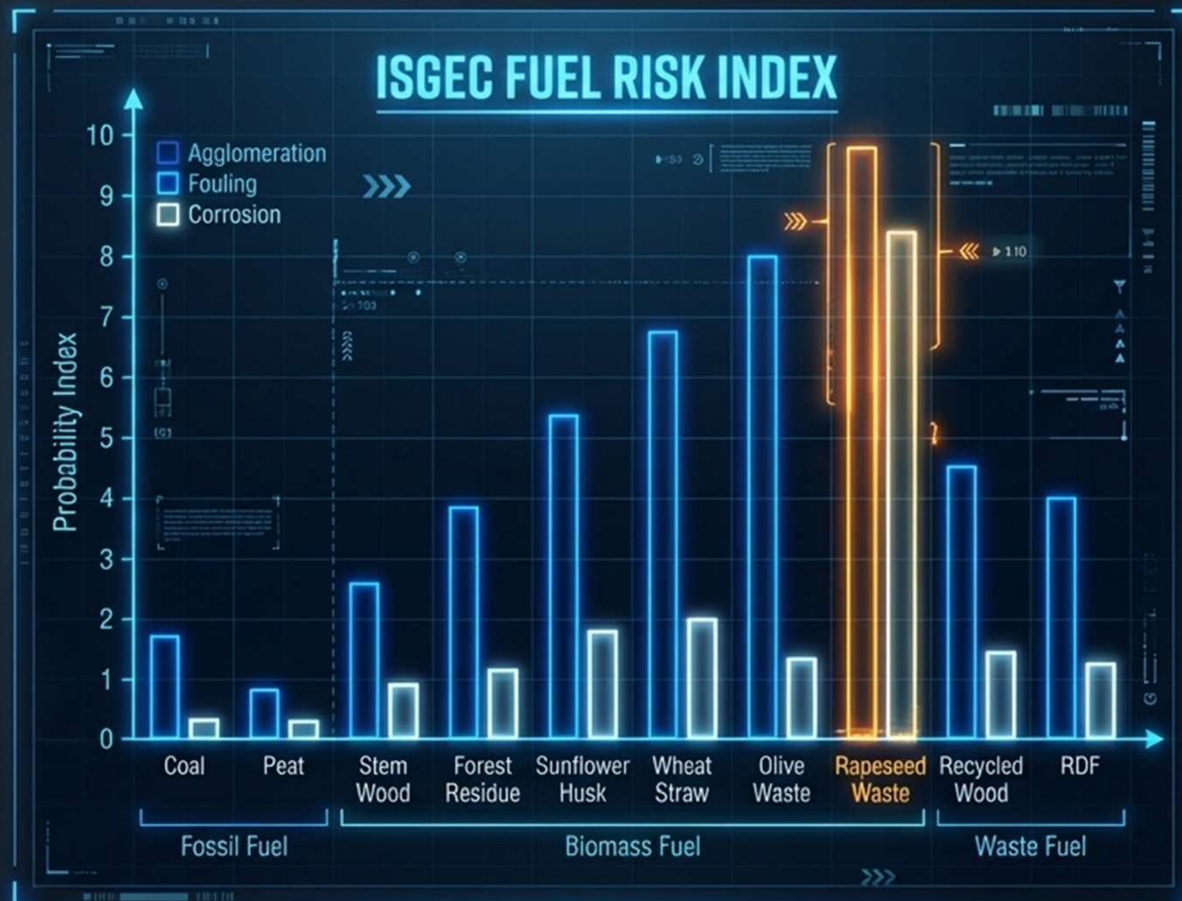
Biomass is fundamentally different from coal. It contains high alkali (K_2O: 15–45%) and chlorine (0.1–2%).

2 THE CONSEQUENCES

- Low ash fusion temperatures lead to severe bed agglomeration at >850°C.
- Chlorine accelerates deposit bonding on superheater (SH) tubes.

3 THE ISGEC SOLUTION

The proprietary Fuel Risk Index scores biomass prior to procurement, quantifying the exact probability of agglomeration, fouling, and corrosion to dictate blending limits.



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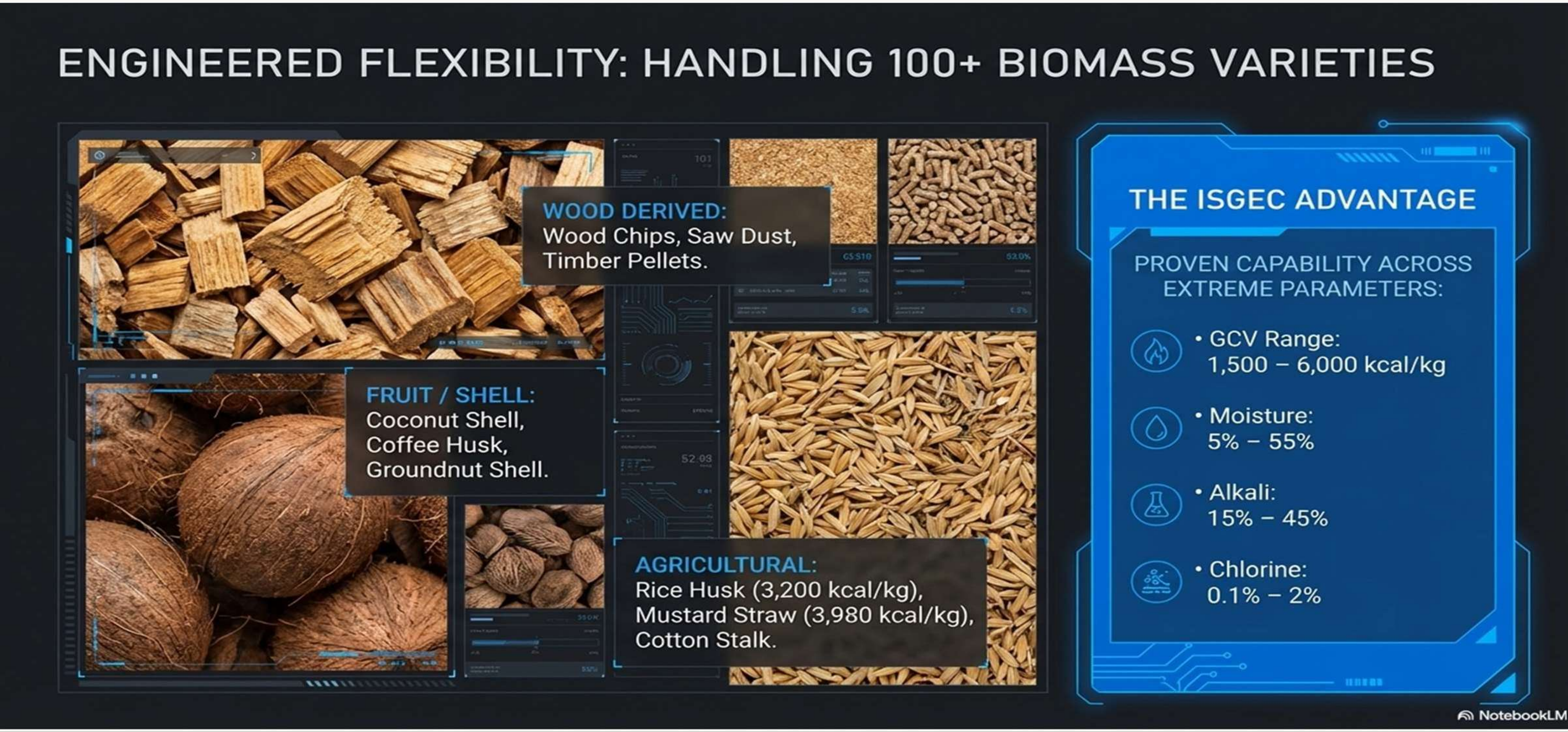
Types of Biomass Fuels & Key Characteristics



Biomass Ash Properties & Ash Management in Boilers

Ash Characteristics — Biomass vs Coal

- **Biomass ash alkali content (K_2O+Na_2O) = 15–45% vs coal <5%**
- **High alkali → low ash fusion temperature → agglomeration risk at >850°C**
- **Chlorine in agro biomass (0.1–2%) accelerates deposit bonding on SH tubes**
- **Silica-rich ash (rice husk: 90% SiO_2) — beneficial as natural bed additive**
- **Bottom ash from biomass co-firing generally suitable for cement use**

Agglomeration Prevention Strategies

- Strict bed temperature control: maintain ≤850°C at all times with biomass
- **Kaolin addition ($Al_2Si_2O_5(OH)_4$) reacts with K_2O → raises fusion temperature**
- **Lime addition (CaO) competes with K for sulfation — reduces alkali activity**
- Regular bottom ash drain: 2–4 times per shift during high biomass operation
- ISGEC Fuel Risk Index scores biomass for agglomeration before procurement

Fouling & Slagging Mitigation

- Soot blowing frequency doubled during >10% biomass co-firing operation
- SH tube spacing (wide pitching): prevents ash bridging in convective pass
- Flue gas temperature monitoring: >10°C rise in exit temp triggers soot blow
- Annual chemical cleaning of economizer and air preheater recommended
- Deposit analysis post-shutdown guides next season fuel procurement strategy

Ash Utilization & Disposal

- Fly ash from biomass co-firing: evaluate for brick/cement/board use
- Bottom ash: suitable as road construction fill if heavy metals within limits
- Rice husk ash (>90% SiO_2): valuable pozzolanic material for concrete
- Ash testing: TCLP (toxicity) + XRF (composition) before reuse/disposal
- Carbon-neutral biomass ash has lower regulatory burden than coal ash

Key Challenges in Biomass Co-Firing & ISGEC Mitigation Strategies

High Moisture Content ▸ HIGH

Impact**: Moisture 6–50% degrades GCV**, reduces flame stability, raises flue gas volume & ID fan load

✓ Pre-drying sheds | Blend with dry coal | Use pelletized/briquetted forms | Limit high-moisture input to <35% in blend

Alkali-Induced Agglomeration ▸ HIGH

Impact: **K_2O (10–30% in agro ash) causes bed agglomeration at >850°C** — risk of unplanned shutdowns

✓ Bed temp ≤850°C | Kaolin/lime additives | Fuel rotation to dilute K content | Active bed material management

Chlorine-Driven Corrosion ▸ MEDIUM

Impact: Cl content (0.01–4%) **forms KCl/NaCl deposits on superheater tubes** — accelerated corrosion at high temp

✓ **Blend Cl <0.3% |** Sulfur-bearing additives | Large transverse SH pitching | Parallel flow SH design

Fouling of Heat Transfer Surfaces ▸ MEDIUM

Impact: **Alkali sulfates & chlorides form sticky deposits on convective surfaces,** degrading heat transfer rate

✓ Increase soot blower frequency | Monitor flue gas temps | Schedule boiler washdowns during maintenance

Inconsistent Fuel Quality ▸ MEDIUM

Impact: Seasonal variability in biomass GCV, moisture and ash destabilizes combustion control systems

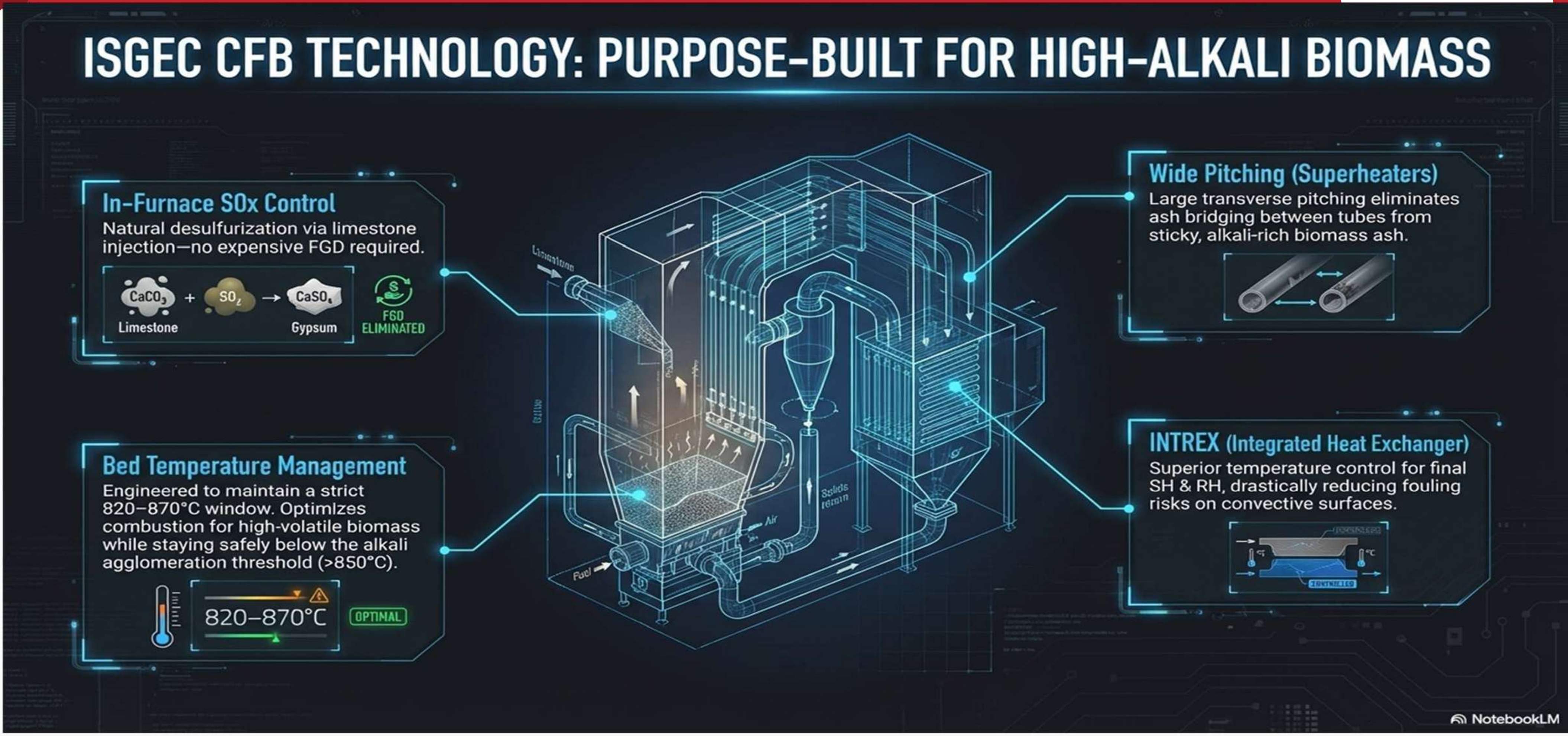
✓ Establish FQMS with lab testing before procurement | Maintain minimum 7-day inventory quality buffer

Feed System Reliability ▸ LOW

Impact: Fibrous biomass can bridge in hoppers, causing feed interruptions and load swings

✓ Install vibrating feeders, rotary airlock valves | Use gravimetric control for accurate biomass dosing

ISGEC Boiler Design Philosophy for Biomass Co-Firing



Proven at Scale: DCM Shriram Ltd., Rajasthan

Stat Card

Configuration:

2 × 150 TPH CFB Boilers (60 MW Cogeneration)

The Multi-Fuel Challenge:

Simultaneously firing Indian Coal + Indonesian Coal + US Coal + Petcoke + 10% Biomass.

ISGEC Engineering Innovation:

Both massive boilers successfully placed on a common structure to bypass severe site space constraints.

Status:

Successfully commissioned (2019/2020) and operating continuously, proving baseline stability with complex fuel chemistry.

Milestone Achievement: Kuantum Papers Ltd., Punjab

Configuration:
1 × 130 TPH CFB Boiler
(30 MW Captive Power + Process Steam)

The Fuel Benchmark:
25% Rice Husk co-firing by heat input alongside Indian Coal.

The Sourcing Advantage:
Utilizing locally sourced agricultural biomass directly from Punjab farmers.

Historical Significance:
Commissioned in 2021, this stands as the first utility-scale agro-biomass co-fire CFB plant commissioned in India, delivering massive coal cost and CO_2 reductions.

Biomass Feed, Handling & Preparation Systems

Biomass Receipt & Storage

- Covered storage with concrete floor to prevent moisture pickup
- FIFO rotation policy — maximum 7-day inventory buffer maintained
- Separate storage for each biomass type to manage GCV variation
- Moisture sensors in storage zones for real-time quality monitoring

Sizing & Preparation

- Primary crusher/shredder: reduces biomass to <25mm
- Secondary hammer mill: final sizing to <6mm for CFB feed
- Vibrating screen: rejects oversize and removes fines
- Clay/stone trap on conveyor — prevents abrasive material entry to boiler

Gravimetric Feed System

- Loss-in-weight gravimetric feeders for accurate dosing
- DCS interlocked auto-adjust on bed temperature feedback
- Rotary airlock valves prevent air in-leakage and bridging
- Biomass injection points designed to prevent feed interruptions

Blend Ratio Control

- Online GCV analyzer at coal+biomass blend point
- DCS blend ratio setpoint linked to live bed temperature
- Auto-ramp biomass in 2–3% steps to avoid bed temp drops
- Surge protection: maximum feed rate change <2%/minute

Combustion Optimization with Biomass Co-Firing

Air Distribution & Staging

- Primary air: 55–60% of total combustion air through grid nozzles
- Secondary air: 40–45% injected at multiple levels via OFA ports
- High secondary air pressure ensures deep penetration across cross-section
- **Biomass high volatile content — reduces primary air requirement by 5–8%**

Bed Temperature Management

- Optimal furnace temp range: 820–870°C for biomass co-firing stability
- Below 820°C: risk of oil support activation; above 870°C: alkali agglomeration
- Real-time DCS feedback loop adjusts biomass feed rate on bed temp deviation
- Sand bed thermal mass absorbs GCV variation in incoming biomass batches

Unburnt Carbon Minimization

- Target unburnt carbon in fly ash <2% and bottom ash <1%
- Biomass particle size <6mm ensures complete burnout in residence time
- Volatile biomass (>65% VM) promotes faster ignition and burnout
- LOI monitoring linked to combustion control optimization algorithm

Emission Control with Biomass

- NOx reduction 30–40% vs PC plants due to lower combustion temperature
- SOx naturally controlled by in-furnace limestone injection + biomass low-S
- CO emissions minimized by OFA system and adequate residence time >10s
- Particulate control: ESP efficiency maintained above 99.5% with biomass ash

Fuel Quality Management System (FQMS) — Framework

01 Fuel Source Qualification

Lab analysis for GCV, moisture, ash, Cl, K_2O before procurement. ISGEC Fuel Risk Index scoring for agglomeration/fouling/corrosion risk. Approved supplier register maintained.

02 Preparatory System

Crushing/sizing to <6mm. Clay/stone separation via conveyor traps. Magnetic separator for metal removal. Density separator for heavy impurities.

03 Fuel Storage Protocol

Covered storage only. FIFO rotation policy strictly enforced. Maximum 7-day biomass inventory maintained. Moisture measurement at intake and before each shift start.

04 Blend Ratio Control

Gravimetric feeders with DCS interlocks. Auto-adjust blend ratio on bed temperature feedback. Maximum blend change rate: 2%/minute to prevent thermal swings.

05 Online Monitoring

Continuous monitoring: bed temperature, O_2%, flue gas temp, steam temperature, biomass feed rate. All parameters logged in DCS historian for trend analysis.

06 Deposit Inspection

Weekly visual inspection of convective section surfaces. Soot blowing frequency log review. Tube metal temperature trend monitoring. Annual borescope inspection of SH zone.

Operational Best Practices — Daily Checklist for Biomass Co-Firing

PRE-SHIFT CHECKS

- Verify biomass moisture before shift start — target <35%
- Confirm blend ratio set point in DCS matches daily fuel plan
- Check biomass feed hopper level — maintain >50% at all times
- Inspect conveyor belt condition & gravimetric feeder calibration

COMBUSTION MONITORING

- Check bed temperature — maintain 820–870°C; no oil if stable
- Monitor steam temperature deviation; trigger soot blow if >5°C drop
- Verify O_2% at furnace exit: target 3.5–4.5% for biomass co-fire
- Review unburnt carbon in fly ash / bottom ash — should be <2%

DEPOSIT & FOULING

- Inspect deposit pattern on convective surfaces — log findings
- Check soot blower operation log — all blowers exercised each shift
- Measure ID/FD fan current — rising trend indicates fouling buildup
- Visual check of biomass feeding chutes for blockages or bridging

END-OF-SHIFT REPORTING

- Log secondary oil consumption per shift — target = ZERO at stable load
- Record biomass co-fire percentage achieved vs. daily target
- Report any biomass quality deviation to fuel management team
- Document any bed temperature exceedances with root cause notes

Biomass Procurement, Supply Chain & Logistics

Supplier Qualification Process

- Initial lab analysis: GCV, moisture, ash, Cl, K_2O, S, particle size distribution
- ISGEC Fuel Risk Index evaluation before first procurement
- Trial co-fire at 3–5% before scaling — monitor bed and deposit behavior
- Approved supplier register maintained with seasonal quality data
- Annual requalification if GCV or ash chemistry shows >10% variation

Supply Chain Considerations

- **Seasonal availability: harvest-linked biomass (rice/wheat straw) available Oct–Mar**
- Diversify biomass portfolio — 3+ biomass types to manage supply risk
- **Pelletization / briquetting: standardizes fuel quality, reduces handling issues**
- **Maximum transport radius for agro biomass: 100 km for cost viability**
- **Buffer inventory: minimum 7 days; plan for 15-day buffer during monsoon**

Biomass Quality Control at Intake

- Moisture measurement: NIR/capacitance probe at unloading point
- Visual inspection: no visible mold, excessive fines, or contamination
- Lot-wise sampling: one composite sample per 50-tonne delivery truck
- GCV tested in plant lab within 24 hours of receipt
- Rejected lots: material returned to supplier with written non-conformance

Cost Economics of Biomass Procurement

- Rice husk: ₹1,500–2,500/MT vs coal ₹4,500–6,500/MT (30–50% heat-value saving)
- Mustard/cotton straw: ₹1,800–3,000/MT — competitive at 20%+ co-fire ratio
- Timber pellets: ₹6,000–9,000/MT — premium but very consistent quality
- Break-even co-fire ratio: typically 8–12% for agro biomass vs. coal pricing
- Carbon credit value (₹1,000–3,000/tCO_2e) can offset premium biomass cost

Biomass Pelletization & Briquetting — Benefits for Co-Firing

Why Pellets/Briquettes Outperform Raw Biomass

- Standardized GCV: pellets 3,900–4,500 kcal/kg regardless of feed source
- Moisture controlled to 5–10% — eliminates handling and combustion variation
- Consistent particle size (6–8mm dia) — ideal for CFB feed systems
- Higher bulk density: 600–700 kg/m³ vs loose biomass 80–200 kg/m³
- Reduced transport cost: 3–4x less volume for same energy content
- Eliminates bridging in hoppers — more reliable automated feeding
- Longer storage life: 6–12 months vs 4–8 weeks for raw biomass
- Reduces dust generation at handling points — improved plant hygiene

Pelletization Process & Economics

- Feed: any lignocellulosic biomass after drying to <15% moisture
- Process: drying → grinding (3–5mm) → conditioning → pellet press → cooling → screening
- Pellet mill capacity: 2–10 TPH per unit — modular, scalable
- Capex: ₹1.5–3 crore per TPH installed pelletizing capacity
- Opex: ₹300–500/MT for power, maintenance, labor (excl. raw material)
- Local briquetting: lower capex vs pellets, suitable for agro residues
- Briquette specs: 60–90mm dia, density >600 kg/m³, moisture <12%
- ROI typically 2–4 years for captive pelletizing at 100+ MW plants

ISGEC Boiler Design Philosophy for Biomass Co-Firing

Conservative Bed Area Loading

Ensures efficient combustion and prevents overheating. Bed temp maintained at 820–870°C for all biomass types. Lower bed loading = better fuel flexibility.

Conservative Volumetric Furnace Loading

Residence time >10 seconds for complete fuel burnout. Minimizes unburnt carbon loss & ensures low furnace exit flue gas temperature. Key for high-volatile biomass.

Superheater Design — Wide Pitching

Large transverse pitching + high steam-side pressure drop ensures proper tube cooling. Wide pitching eliminates ash bridging between tubes — critical for alkali-rich biomass ash.

INTREX — Integrated Heat Exchanger

Water/steam cooled solid separator and return leg. Final SH & RH as INTREX for superior temperature control with biomass ash. Reduces fouling risk on SH surfaces.

Step Grid / Arrowhead / Kickout Air System

Over Fire Air system with high secondary air pressure — better air penetration across furnace cross section. Minimizes unburnt carbon loss. Reduces CO formation at part-load.

Operational Troubleshooting Guide — Biomass Co-Firing in .

Bed Temperature Drop

Sudden increase in high-moisture biomass feed

Incorrect blend ratio — too much low-GCV biomass

Steps: Reduce biomass feed 50% immediately; increase PA air; check coal feed rate; if <820°C add secondary oil for 10 min; resume biomass after temp recovery

Bed Agglomeration Signs

Rising differential pressure across bed; hot spots in furnace; poor fluidization

Steps: Reduce bed temp to 820°C; increase bottom ash drain frequency; add kaolin at 1% of ash rate; if persistent, initiate controlled shutdown for bed inspection

SH Steam Temperature Drop

Fouling of convective surfaces by biomass ash deposits

Steps: Initiate manual soot blowing of all convective section blowers; increase soot blow frequency to every 2 hrs; check ID fan current for fouling trend; plan next maintenance washdown

Biomass Feed Interruption

Hopper bridging, feeder jam, or conveyor blockage

Steps: Activate vibrator on affected hopper; reduce biomass set point to allow recovery; clear blockage in safe isolation; maintain coal feed at 100% until biomass feed restored

High Unburnt Carbon in Ash

Particle size too large; poor air distribution; low volatile biomass

Steps: Check biomass particle size — reject if >6mm; verify PA distribution across all nozzles; increase excess air by 0.5%; check OFA port blockage on affected side

CO Alarm at Furnace Exit

Incomplete combustion — insufficient air or poor mixing

Steps: Increase secondary air pressure; verify OFA ports clear; check biomass moisture — reduce feed if >40%; ensure bed temp >840°C; reduce load if CO persists

Maintenance & Inspection Schedule for Biomass Co-Firing Systems

DAILY

- **Gravimetric feeder zero-check and span calibration**
- Conveyor belt visual inspection — look for tears, biomass buildup
- Hopper/silo level check and top-up if <50%
- **Soot blower operation verification — all blowers activated**
- Bottom ash drain: 3–4 times per shift during high biomass operation

WEEKLY

- **Gravimetric feeder full calibration with test weights**
- Online GCV/moisture analyzer calibration check with lab samples
- Convective section deposit inspection — visual or endoscope
- Biomass crushing/sizing system inspection — screen and hammer inspection
- Feed chute inspection for blockage or wear patterns

MONTHLY

- Full bed material sample analysis: sieve test + XRF for alkali content
- **Tube metal temperature review — trend vs commissioning baseline**
- SH/RH tube ultrasonic thickness measurement at high-fouling zones
- Biomass feed system complete overhaul: bearings, seals, wear parts
- Fire suppression system test in biomass storage area

ANNUAL OUTAGE

- Full borescope inspection of SH/RH tube banks — document deposit map
- **Chemical washing of economizer and tubular air preheater**
- Bed nozzle inspection and replacement of worn/choked nozzles (>10%)
- Complete bed drain and bed material renewal or topping if needed
- Pressure part thickness survey — all SH, RH, evaporator panels

Instrumentation, Control & Automation for Biomass Co-Firing

ISGEC
Isgec Heavy Engineering Ltd.

Key Instruments Required

- Biomass gravimetric feeder: accuracy ±0.5% — essential for blend ratio control
- **Conveyor belt moisture sensor: NIR or microwave type at feed point**
- **Online GCV analyzer: NIR spectrometer at coal+biomass blend discharge**
- Bed temperature thermocouples: 6 points minimum across furnace cross-section
- Furnace O_2 analyzer: zirconia type at economizer outlet — continuous reading
- Steam temperature: thermocouple at SH outlet with high-deviation alarm

DCS Control Loops for Biomass

- Biomass blend ratio control: setpoint from operator; PID on gravimetric feeder
- **Bed temperature stabilization: cascaded loop — fuel ratio → PA air → bed temp**
- O_2 trim control: secondary air adjusted on O_2 deviation from setpoint ±0.3%
- Steam temperature control: modified spray water control for biomass ash fouling
- Biomass surge protection: rate-of-change limiter on feed setpoint (max 2%/min)
- Interlocks: auto-reduce biomass if bed temp <820°C or O_2 <2%

Alarms & Protective Actions

- Bed temp <810°C: alarm + auto-reduce biomass to 50% of current setpoint
- Bed temp >880°C: alarm + increase PA airflow + reduce biomass feed by 30%
- Biomass feed loss: alarm + compensation increase in coal feed within 30 sec
- High CO at furnace exit (>500 ppm): alarm + increase secondary air flow
- GCV deviation >500 kcal/kg from setpoint: alarm + operator notification
- Hopper low-level: warning at 30%, alarm at 15% — ensure continuity of feed

Data Historian & Reporting

- **All biomass parameters logged at 1-second intervals in DCS historian**
- Daily report: actual vs target biomass %, oil consumption, bed temp profile
- **Weekly heat rate report with biomass co-fire correlation**
- **Monthly CO_2 reduction calculation for ESG reporting and carbon credit claim**
- **Fuel quality database: all incoming biomass test results archived 5 years**
- Performance dashboard: real-time KPI display in control room and management

Safety Considerations in Biomass Co-Firing Operations

Fire & Explosion Hazards

- Biomass dust clouds: explosive when concentration > 50–100 g/m³
- Spontaneous combustion risk in stockpiles — monitor pile temperature daily
- Install CO detectors and sprinkler systems in biomass storage buildings
- Dust suppression at conveyor transfer points — wet dust suppression preferred
- Inerting of biomass silos with N_2 for fine-powder biomass types (sawdust)

Personnel Safety Protocols

- Respiratory protection mandatory in biomass handling areas (FFP2 minimum)
- ATEX-rated electrical equipment in biomass storage and processing zones
- Confined space entry permit for silo inspection and cleaning operations
- Emergency evacuation plan specific to biomass fire scenario — annual drill
- First responder training for biomass dust fire suppression (not water on live fires)

Structural & Equipment Safety

- Conveyors: emergency stop at all transfer points; regular belt inspection
- Hopper/silo: structural load rating for wet biomass (up to 3x dry density)
- Feed chutes: inspection access every 72 hours; no manual clearing during operation
- Rotating equipment: guarding on all drives; bearing temperature monitoring
- Static electricity discharge points at biomass conveyor earthing every 20m

Regulatory Compliance

- PESO approval required for large biomass storage above 100 MT capacity
- DGFASLI/Factory Inspector clearance for biomass processing installations
- Fire NOC from State Fire Service for covered storage buildings
- Environmental clearance: biomass handling dust emission to CPCB norms
- MSIHC Rules compliance if biomass includes RDF/MSW content

Advanced Combustion Optimization — AI/ML Tools for Biomass Co-Firi

Online GCV & Moisture Prediction

- NIR (Near-Infrared) spectroscopy at coal+biomass conveyor for real-time GCV
- Predicted GCV accuracy: ±150 kcal/kg vs lab analysis — suitable for DCS feed
- Moisture prediction from conveyor belt microwave sensors (<1% error)
- Data fed directly to DCS blend ratio controller for automatic compensation
- Eliminates 4–8 hour lag of manual lab sampling — improves combustion control

AI-Based Bed Temperature Optimization

- Machine learning model trained on 12+ months of plant data
- Inputs: biomass GCV, moisture, blend ratio, PA/SA flows, bed height
- Output: optimal biomass feed rate set point to maintain 840°C ± 5°C
- Reduces bed temp exceedances by 60–70% vs manual operator control
- Enables higher biomass blend without agglomeration risk — up to 25% safely

Predictive Fouling & Maintenance

- Flue gas temperature trend analysis predicts convective fouling 24–48 hours ahead
- Soot blower scheduling automated based on predicted fouling index
- SH tube metal temperature monitoring with ML anomaly detection
- Reduces forced outages due to fouling by 40–50% vs manual inspection
- Integration with CMMS for automatic work order generation on fouling alerts

Digital Twin for Biomass Co-Firing

- Process simulation model calibrated to actual plant performance data
- Tests new biomass blends virtually before physical trial — reduces risk
- Optimizes air distribution, feed rate, bed level for each biomass type
- Supports operator training: scenario simulation for upset conditions
- ROI: 2–3% heat rate improvement worth ₹20–40 crore/year for 200 MW plant

Implementation Roadmap — Three-Phase Biomass Co-Firing Deployme

Phase 1
0–3 Months
Assessment & Quick Wins

- Baseline fuel audit — current GCV, moisture, ash profiles
- Identify 5–7% biomass co-fire potential without retrofit
- Install online moisture & GCV analyzers at fuel feed points
- Establish FQMS protocols and operator training program
- Begin biomass supplier qualification and trial contracts
- Conduct trial co-fire at 3–5% — monitor bed and deposits

Phase 2
3–12 Months
Infrastructure & Integration

- Commission dedicated biomass storage & crushing system
- Install gravimetric feeders with DCS biomass control loop
- Biomass supplier qualification & long-term contracting
- Target 10–20% biomass blend — full oil elimination at load
- Achieve zero secondary oil at stable load operation
- Commence ESG/carbon credit documentation process

Phase 3
12–36 Months
Scale-Up & Optimization

- Evaluate 20–50% co-fire via detailed feasibility study
- Implement AI/ML advanced combustion optimization tools
- Monitor and report CO_2 reduction for ESG/regulatory compliance
- Explore captive briquetting/pelletizing of local agro biomass
- Establish digital twin for continuous performance improvement
- Target full carbon credit certification and REC monetization

Summary, Conclusions & Way Forward

Proven Technology

Boilers are the most flexible and reliable platform for biomass co-firing. ISGEC has demonstrated 10–25% biomass co-firing at DCM Shriram (2019) and Kuantum Papers (2021) in India.

Immediate Value

5–7% biomass co-fire can be implemented TODAY with minimal or zero capex. Delivers 5–15% fuel cost reduction and initiates CO_2 emission reduction without modifying the boiler.

Scale-Up Path

A structured 3-phase roadmap takes a plant from 5% to 20%+ co-fire in 18–36 months. Each phase delivers measurable KPI improvements in heat rate, oil consumption and CO_2 emissions.

Financial Returns

Combined fuel savings, oil elimination, heat rate improvement and carbon credits deliver ₹25–60 Cr/year benefit for a 100 MW plant — with 2–4 year payback on investment.

ISGEC Heavy Engineering Ltd. — Boilers Division Contact us for Biomass Co-Firing Assessment for your. Plant

Thanks

A big round of Applause to all Attendees For Listening to me

ISGEC Reference Plant — DCM Shriram Ltd., Rajasthan (India)

ISGEC . Boiler — Operating Successfully on Multi-Fuel including Biomass since 2019

Plant Owner	Shriram Fertilizers (DCM Shriram Ltd. Group)
Location	Kota, Rajasthan, India
Configuration	2 × 150 TPH . Boilers on common structure (space constraint solution)
Power Output	60 MW from 2 boilers — Cogeneration Plant (Power + Process Steam)
Fuels Fired	Indian Coal + Indonesian Coal + US Coal + Petcoke
Biomass Co-Fire	10% Biomass co-firing — multiple biomass types simultaneously
Commissioning	1st Unit — 2019 | 2nd Unit — 2020
Key Feature	Both boilers on common structure — unique ISGEC engineering for site constraints
Status	BOILERS RUNNING ON MULTI-FUEL ALONG WITH BIOMASS — Operational continuously
Significance	Largest cogeneration plant in Rajasthan operating on multi-fuel+biomass blend

ISGEC Reference Plant — Kuantum Papers Ltd., Punjab (India)

ISGEC . Boiler Firing 25% Rice Husk + Indian Coal — Commissioned 2021 | First Agro-Biomass Co-Fire at Scale in India

Plant Owner	Kuantum Papers Limited
Location	Hoshiarpur, Punjab, India
Configuration	1 × 130 TPH . Boiler
Power Output	30 MW Captive Power + Process Steam for Paper Manufacturing Plant
Fuels Fired	Indian Coal + Rice Husk (25% co-fire by heat input)
Biomass Used	Rice Husk — agricultural biomass, locally sourced from Punjab farmers
Commissioning	2021 — Successfully commissioned and operating
Key Benefit	25% Rice Husk co-firing — significant coal cost reduction + CO_2 savings
Application	Steam used for both power generation & paper manufacturing process
Achievement	First utility-scale agro-biomass co-fire . plant commissioned in India

Co-Firing in Existing . vs. Dedicated Biomass Plant — Decision Framewo

When should a plant invest in co-firing upgrade vs. building a dedicated biomass plant?

Parameter	Co-Firing in Existing .	Dedicated Biomass CFB Plant
Capital Cost	Low–Medium (₹5–20 Cr / 100 MW)	High (₹8–15 Cr/MW installed)
Implementation Time	3–18 months	3–5 years
Biomass Supply Risk	Low — coal backup always available	High — 100% dependent on biomass
CO_2 Reduction	15–50% (proportional to blend %)	Up to 100% (if 100% biomass fired)
Operating Flexibility	High — can revert to coal any time	Low — designed for biomass only
Efficiency	Slightly lower (moisture penalty)	Optimized for biomass (best efficiency)
Policy Incentives	Moderate — REC + carbon credits	High — full renewable classification
Best For	Existing plants targeting quick decarbonization	New projects, 100% renewable target
ISGEC Recommendation	Preferred for retrofit projects	For greenfield or full decarbonization