Realizing Potential of Biofuel as raw material for iron and steelmaking

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Why

Steel industry is in search of alternate raw material?

Dimensions of Direction

Triple environmental crises :

- Climate change
- Biodiversity loss

Pollution

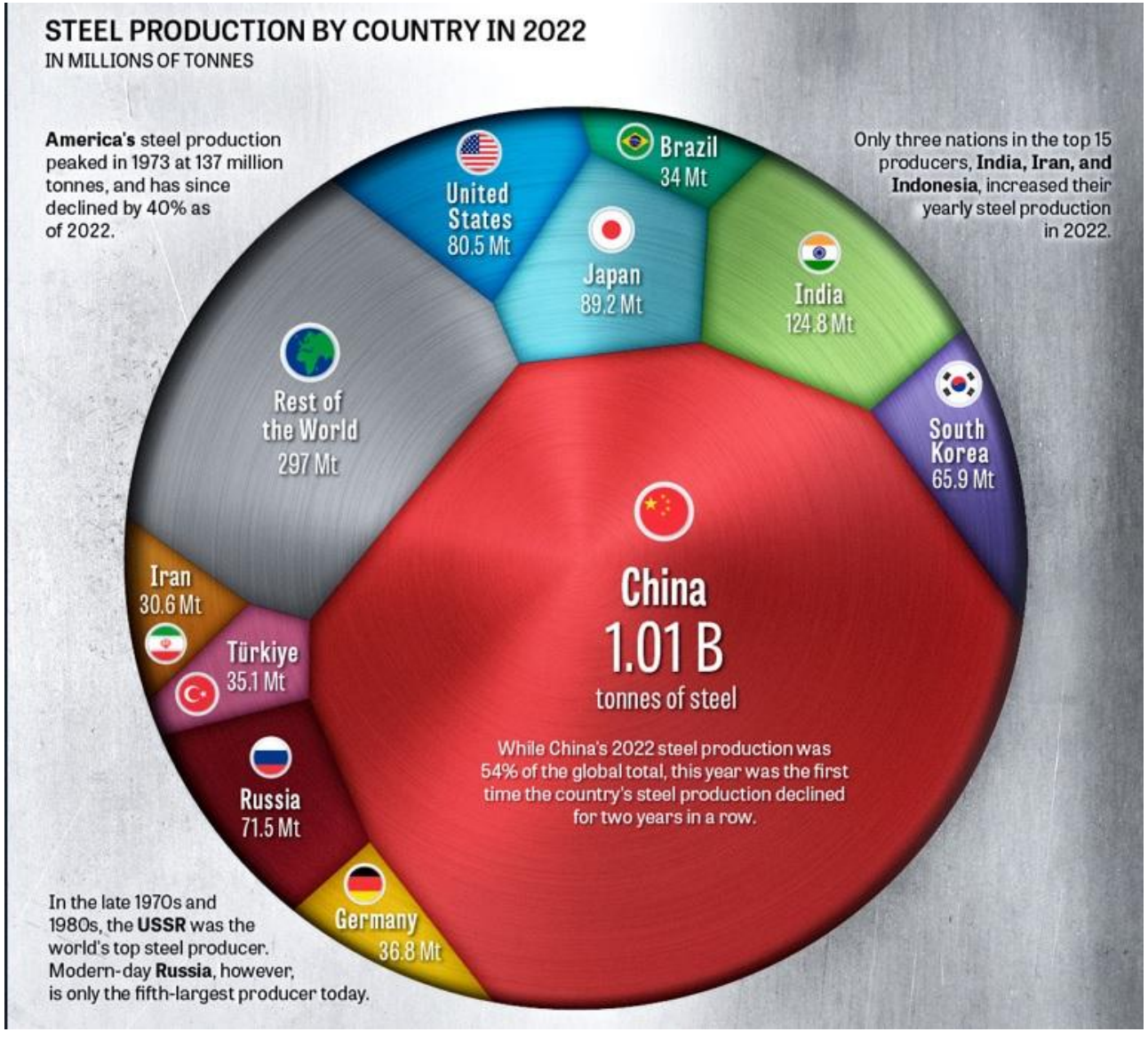
Al Gore effect

Unlike previous extinction events caused by natural phenomena, the sixth mass extinction is predicted to be driven by human activity, primarily (though not limited to) the unsustainable use of land, water and energy use, and climate change.

Do we need nature ? **Wrong question**

Does nature need humans ?

Global Steel Production and decarbonization need



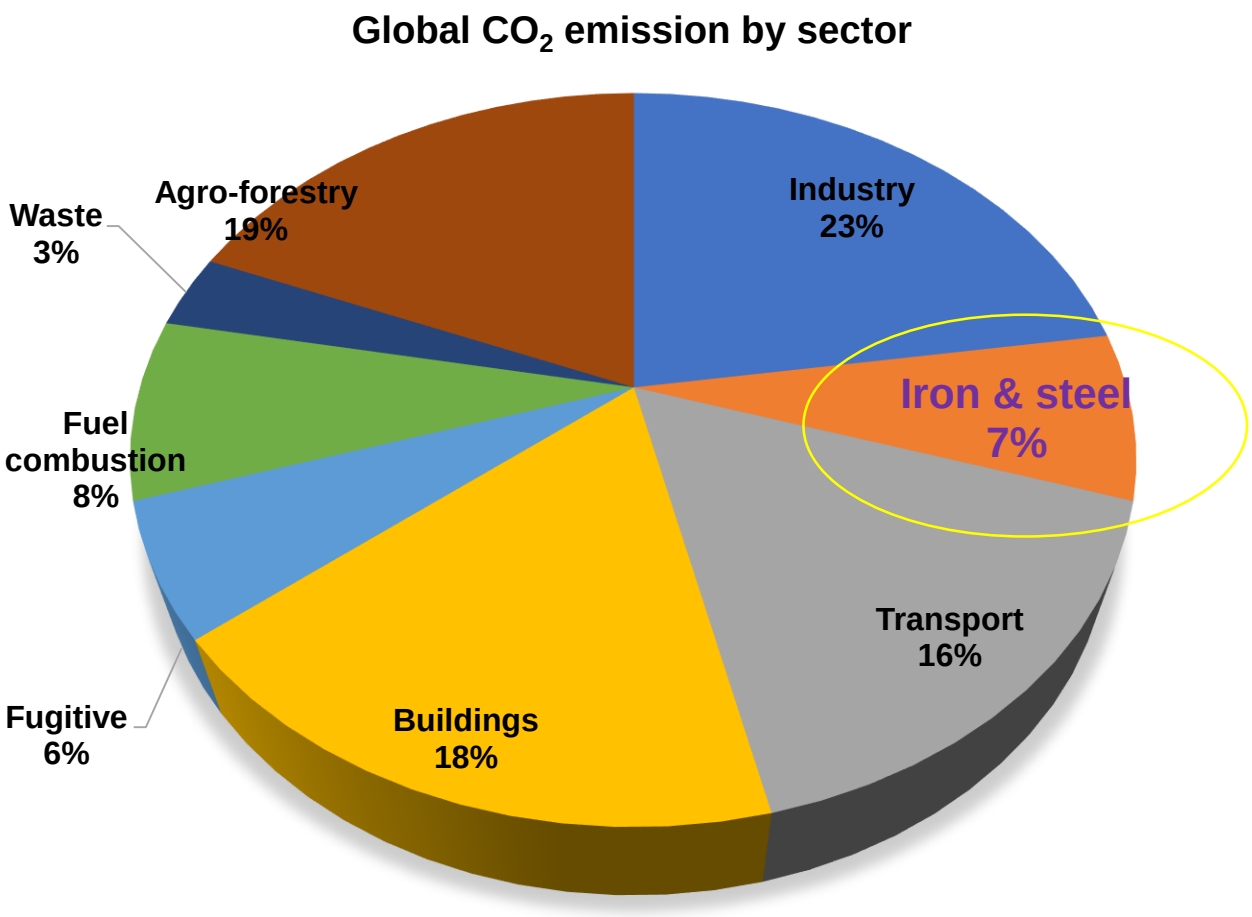
Ferrous metallurgy based industries emits around 23% of the total global industrial emission (IEA, 2022).

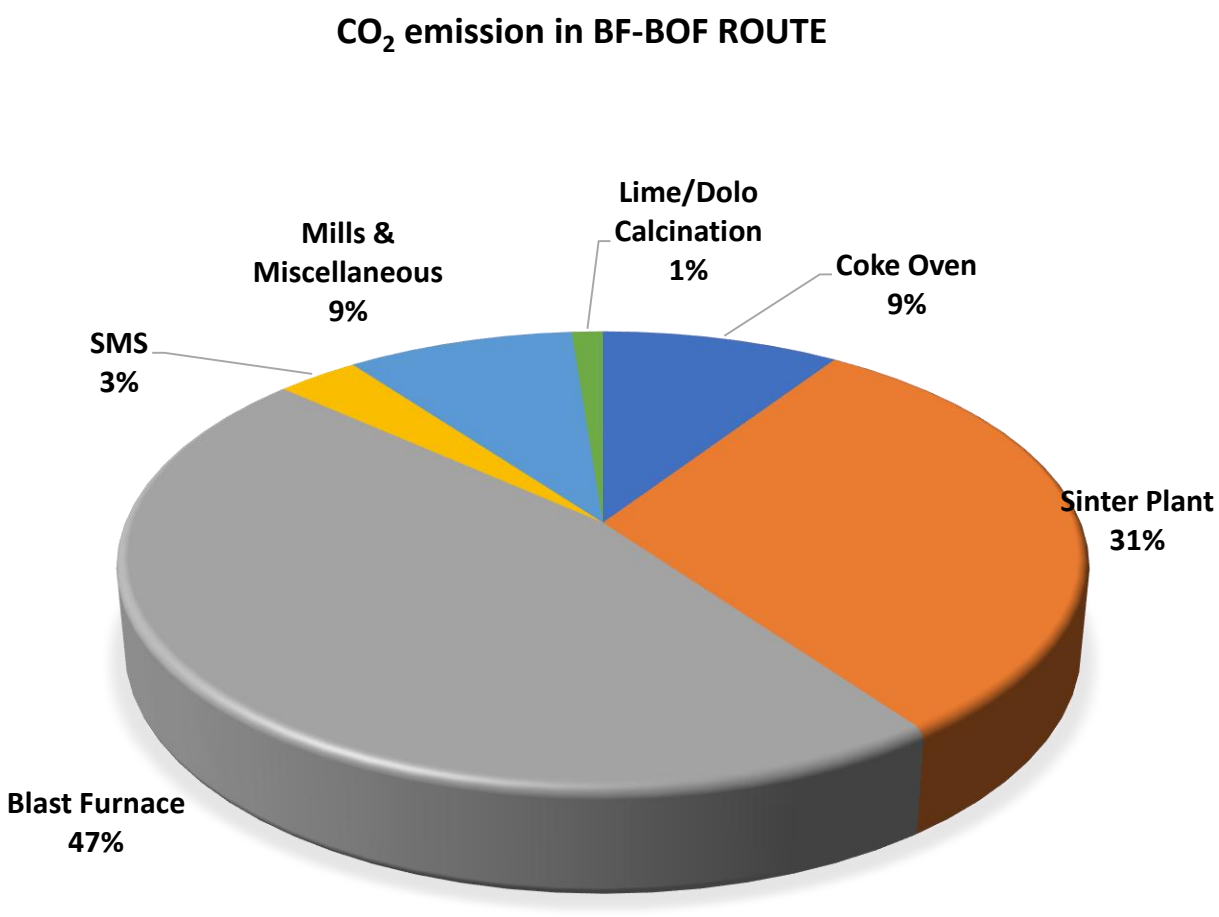
Approximately 9-11% of Global Industrial CO2 emission is from Iron & Steel Sector

By 2050 almost one-fifth of the steel produced globally is expected to come from India, compared to around 5% today.

Sector Accounts for 19% of final energy use and quarter of direct CO_2 emissions from industry

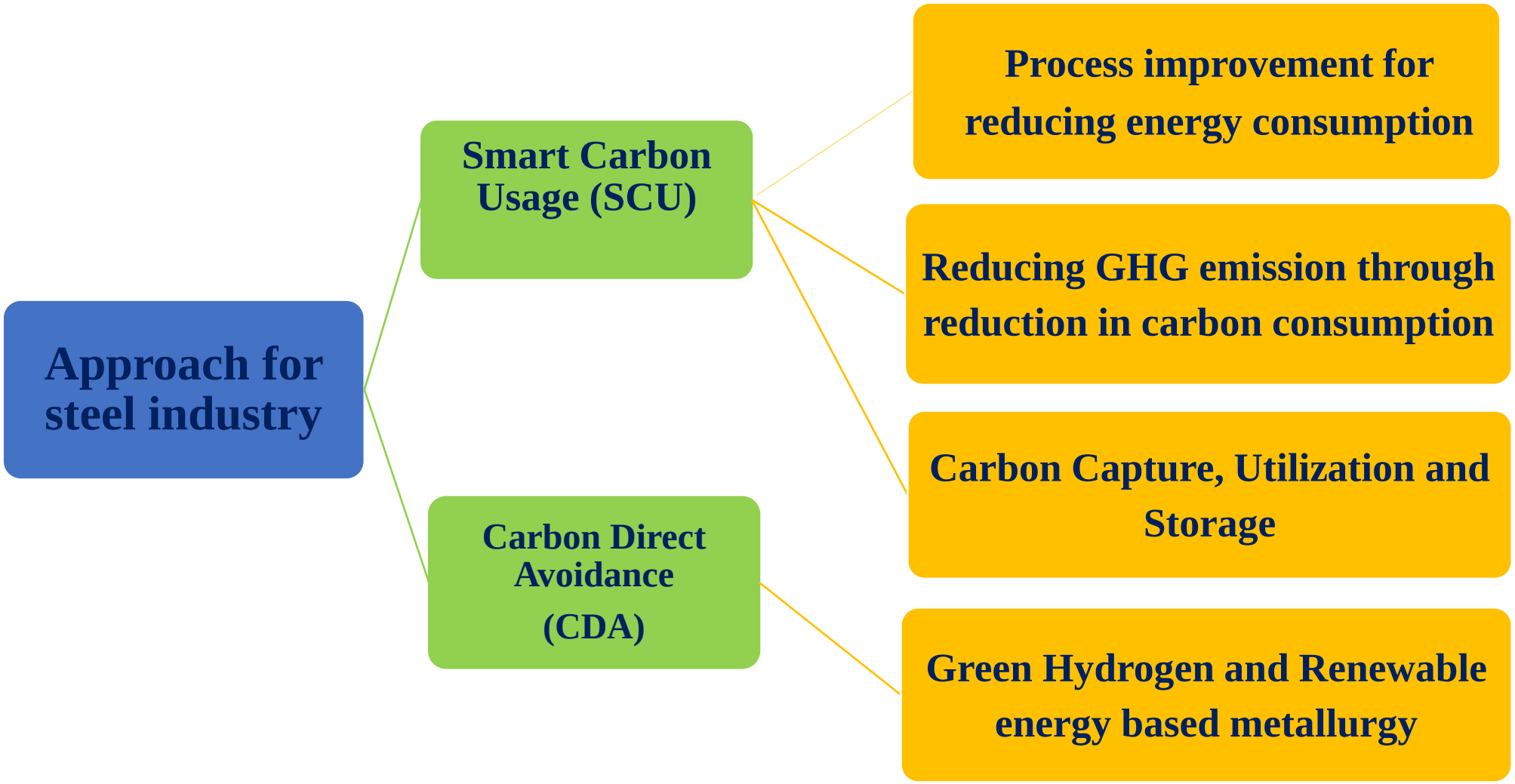
Steel Industry and CO_2 emission



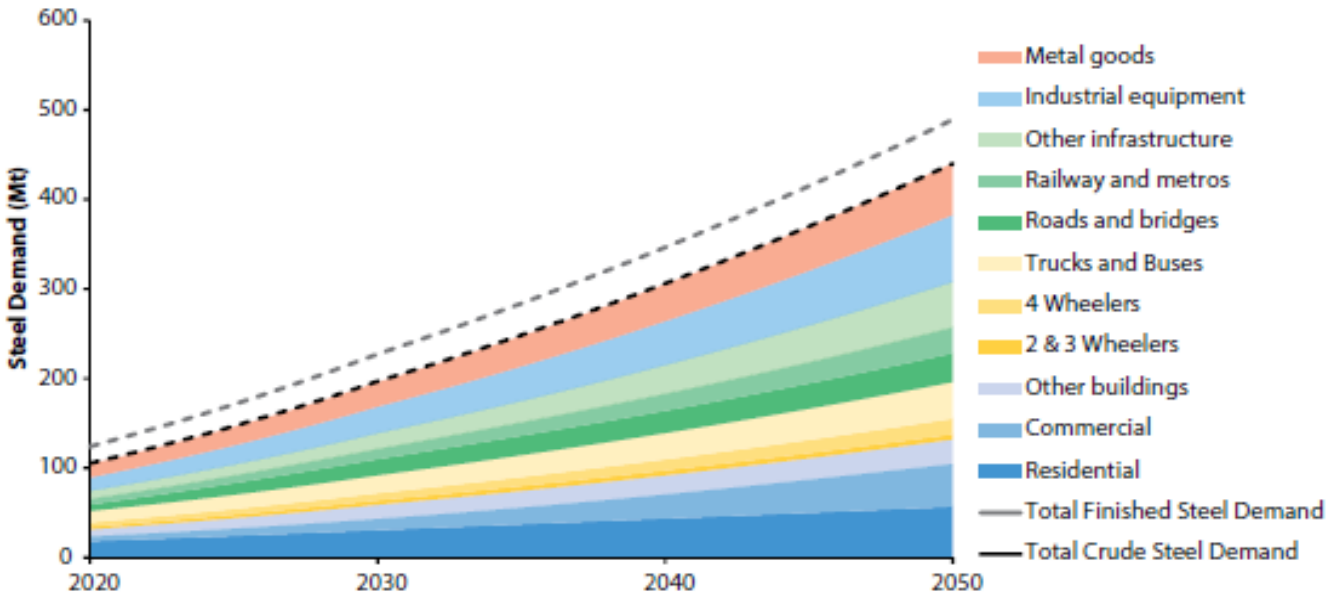


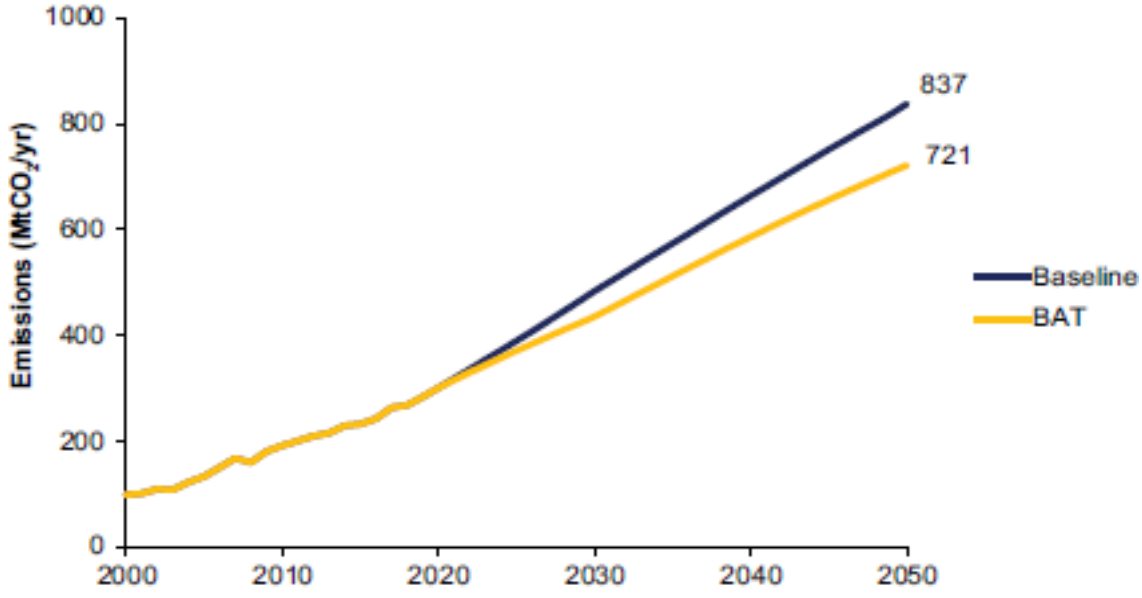
Source: IEA

Mitigation and Adaptation as Low Carbon Pathways



Projections - Steel Demand and increase in GHG Emissions





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Carbon emissions by India's steel sector to triple by 2050

Biofuel/ Biochar – A promising raw material for Steel Industry

Bamboo species

OFMSW

Agro-waste

Non-woody/grass species

Biomass Feedstock Diversity

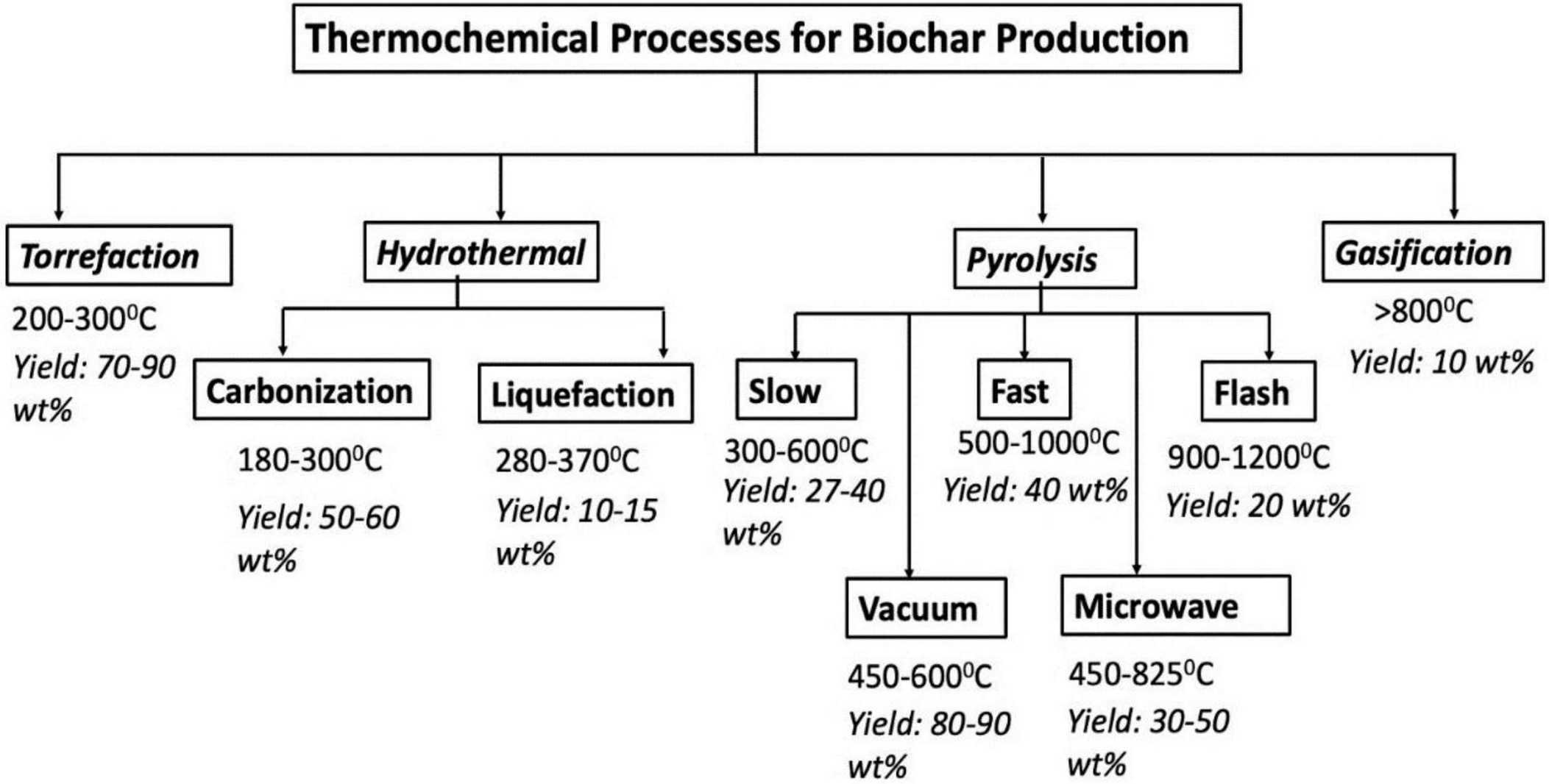
Forestry residues

Algae

Aquatic weed species

Shrub species

Biochar Production Techniques



Types

Non-Torrefied Biomass Pellets

Torrefied Biomass Pellets

Rationale for Biochar/ Biofuel Integration

Carbon Source Replacement

Reduction of Carbon Emission

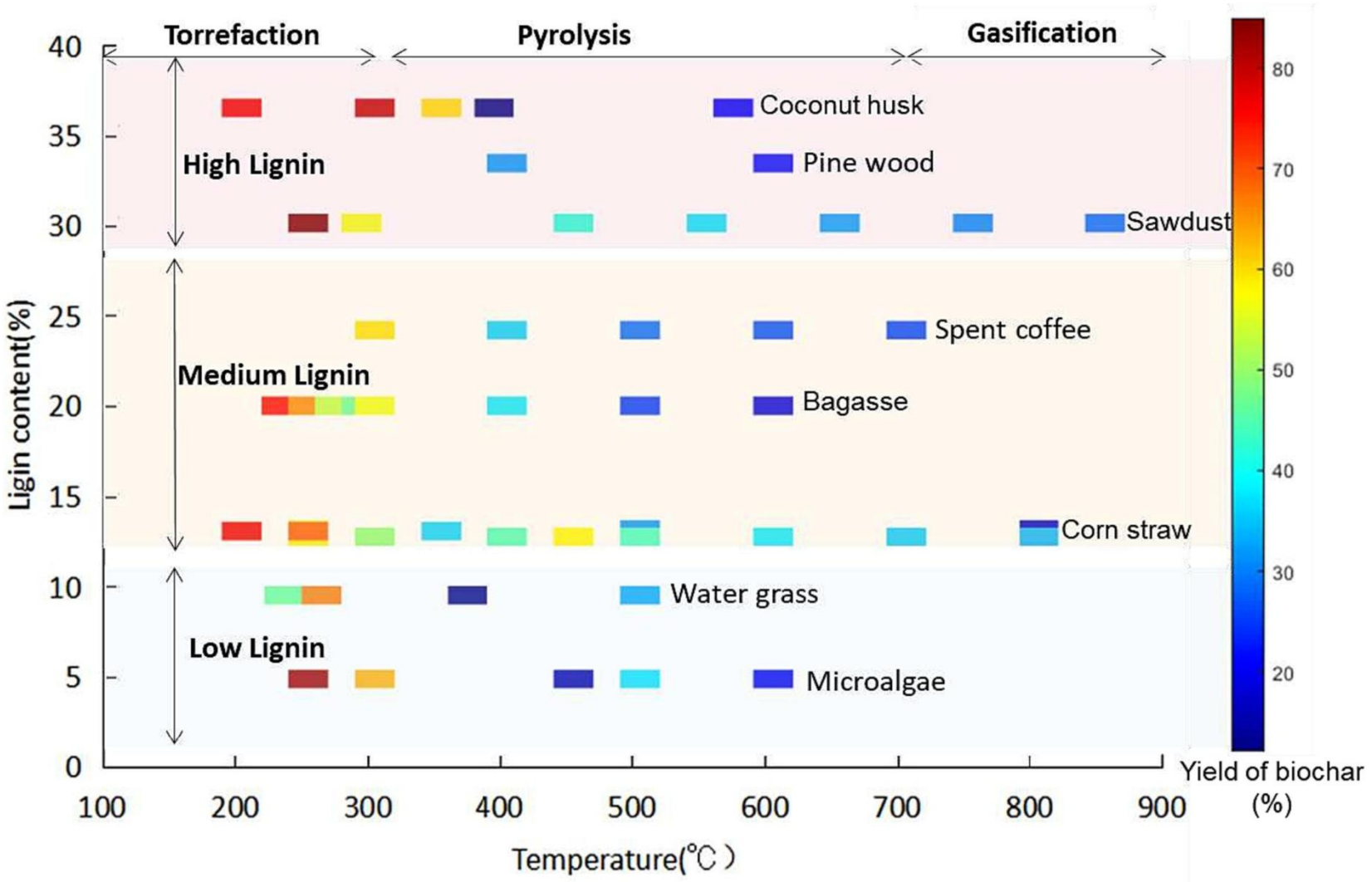
Renewable carbon neutral material

Reduction in environmental nuisance

Waste Utilization

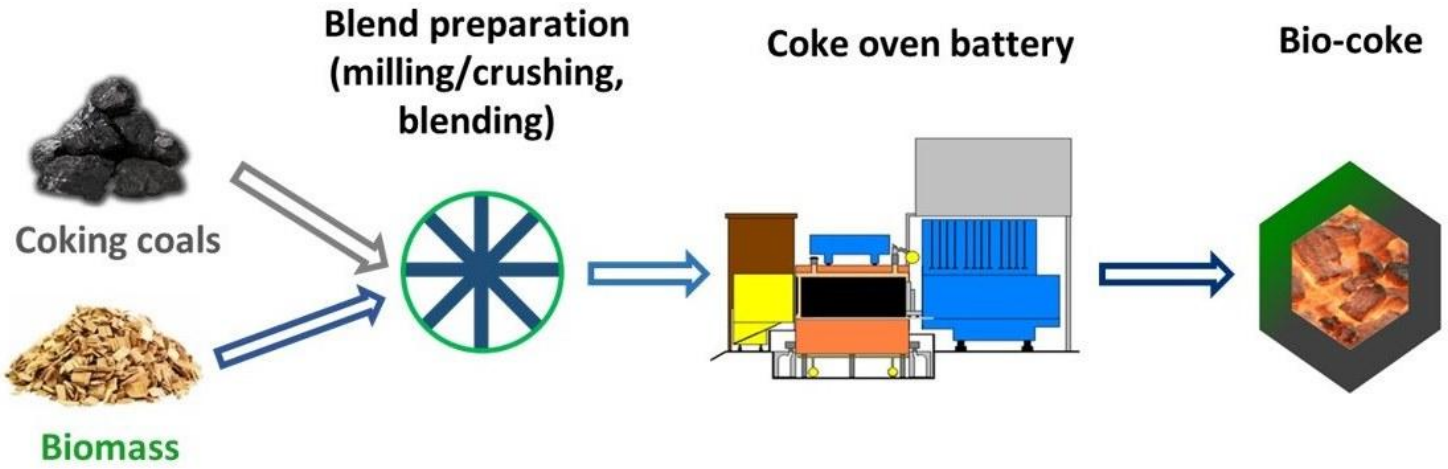
Compatible with Hydrogen economy

Lignin Content – An essential ingredient of Biofuel / Biochar



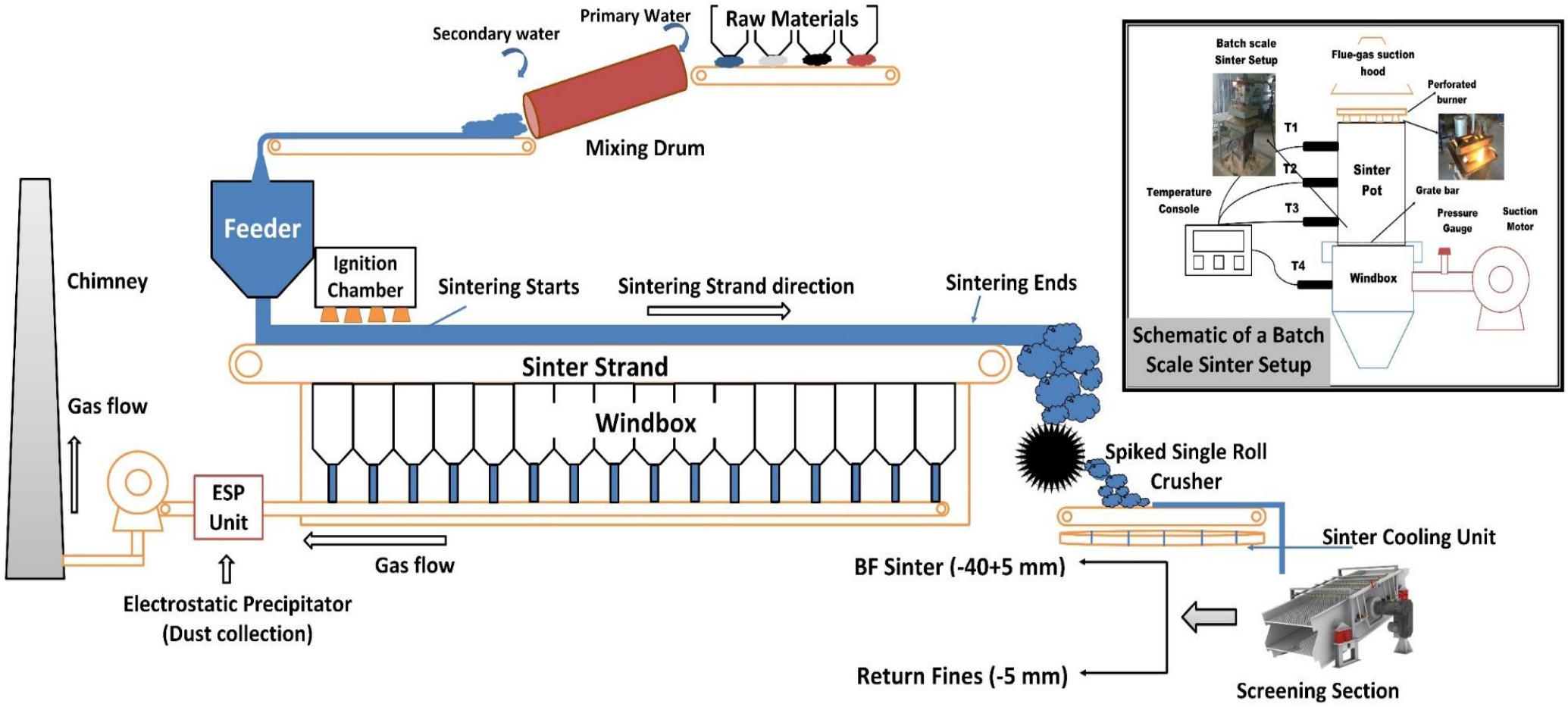
Effect of Lignin Content on Biochar Yields

Possibility of Biochar application in coke making



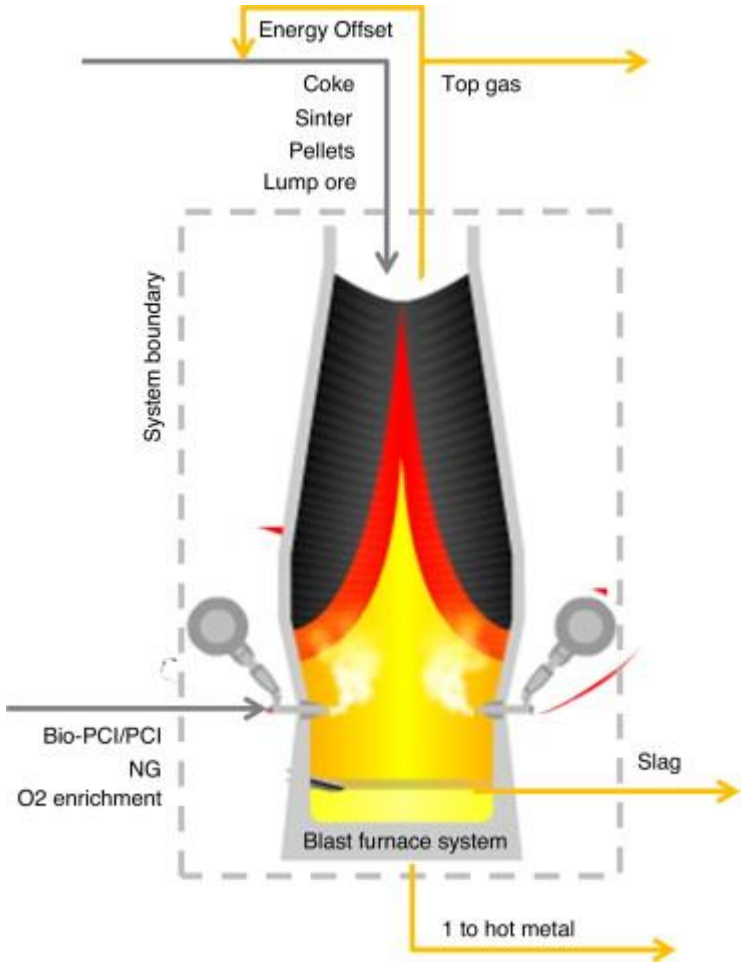
- Bio-coke can be produced on the basis of coal with the addition of substances of biomass origin.
- There is a decrease in fluidity, dilatation etc with more favorable results obtained for the addition of carbonized biomass and for additives with a higher apparent density.

Possibility of Bio-Char application in Sintering



It has been reported that bio-char can replace coke breeze upto 10% in iron ore sintering

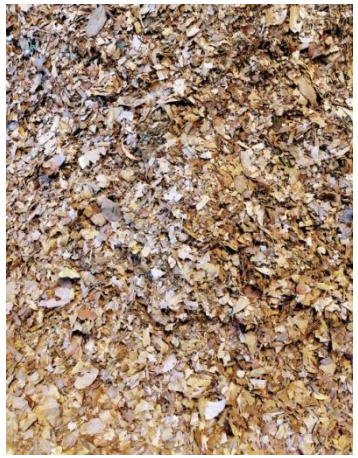
Possible Biochar application in Blast Furnace



- CO_2 reduction in BF accounts from 0.28 to 0.59 to CO_2/t HM (18.0–40.2%), when Bio-PCI is used instead of fossil coal and natural gas

- Findings lead to conclude that Bio-PCI may significantly reduce the CO_2 emissions in ironmaking.

Products from Biomass that may find use



Shredded Leaves

Bamboo Flakes

Dry Biomass

Gasification

Blending

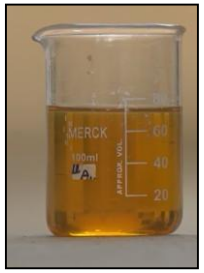
Pyrolysis

Char

Sintering, Injectant in Blast Furnace

Raw Biomass

Coke making



Oil

Coke making

Char

Sintering, Pulverised Coal Injection

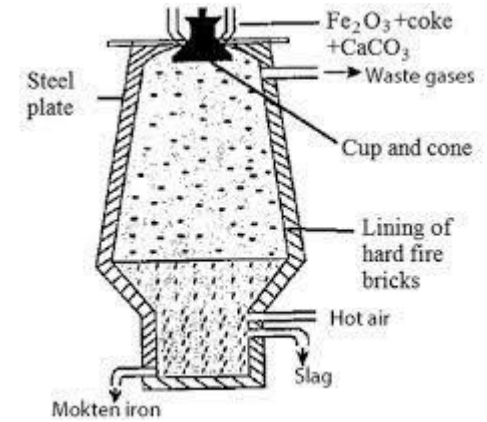
Synthesis gas

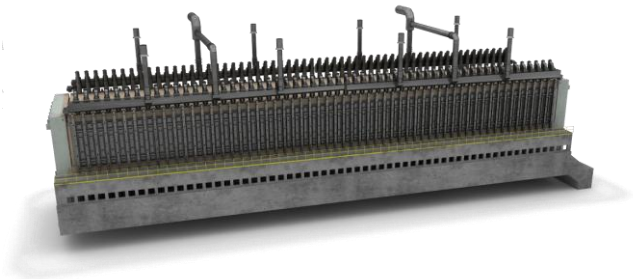
$CO + H_2$

(syngas)

Syn-gas

Reheating purpose in Mills / Laddle





Comparative properties of coal & coke with biochar

Properties	Coal	Coke	Biochar from				
			Rubber wood	Wood pellets	Corn straw	Lignin	Walnut shell
Moisture content, %	6	1.34	0.83	1.94	4.7	0.5	5.7
Volatile matter, %	41.5	10.3	9.08	11.06	13	41	35.7
Fixed carbon, %	39.6	88	87.49	83.04	72.9	58	56.6
Ash, %	12.9	0.4	2.6	3.96	14.1	0.5	1.8
Carbon, %	80.7	87	87.17	87.32	91.53	75.3	56.57
H, %	5.8	3.5	1.23	1.43	1.54	5.14	5.2
N, %	1.2	1.1	0.4	0.33	0.7	0.97	1.5
O, %	8.7	0.5	11.2	10.9	6.16	18	36.6
S, %	3.6	7.9					
Calorific value, (MJ/kg)	20.6	27.2	30.38	31.07	27.6	30.18	25.54
Surface area, (m^2/g)	4.13	4.4	112.6	247.03	25		5.89
Bulk density, (g/cm^3)	1.72	2.01	4.95	5.3	1.4	1.36	1.32

Work carried out to replace coke and coal with biomass: Global status

Sl. No.	Use in Blast Furnace	Organization	General conclusion	Recommendation	CO2 reduction potential
1	Replace coke in large blast furnace	BlueScope, CSIRO and OneSteel CSIRO	❑ Reduced coke rate	❖ Replace 50-100 wt% nut coke ❖ Max 20% replacement of lump coke	❖ 0.08-0.16 tCO_2/tHM (50-100 % replacement of 45 kg nut coke/tHM)
2	Biofuel blending in coke making	Canmet Energy	❑ Decreased strength ❑ Increased reactivity	❖ 5-10 wt% blend with charcoal Blend coarse charcoal (>10mm)	❖ 0.02-0.11 tCO2/tHM (2-10% coal blend, with coke used at 300-350 kg/tHM)
3	Replace PCI in large blast furnace	RWTH and CENIM LASID and RWTH	❑ Higher combustion efficiency or burn out ❑ Combusts readily with better flame stability	❖ 100 % replacement possible in large blast furnaces ❖ Coal-charcoal blend is also possible, ❖ lower coke reactivity due to interaction	❖ 0.41-0.51 tCO2/tHM (100% replacement of PCI at 150-200kg coal/tHM)
4	Use in coke-making process	Oulu, Finland	❑ Decreased strength ❑ Increased reactivity	❖ 2–10 % blend biochar with coal to make bio-coke	❖ 0.02–0.11 ton CO2/ ton crude steel
5	Use in Iron Ore Sintering	Nippon Steel & Sumitomo Metal Corp	❑ product yield more than 80 %	❖ 40 % and 60 % to have the good quality sinter product	❖ 5 to 15 % net CO_2 emission
6	Use in Ferroalloys	CSIR-NML	❑ Reduced coke rate	❖ 20- 25% replacement of nut coke	❖ Reduced CO_2 emission
7	Use in DRI - Tunnel Kiln	CSIR-NML	❑ Quality product	❖ 100% replacement of coke or coal by bio-char	❖ Significant reduction in CO_2 emission

Other possible application of biochar in the steel industry

Biochar

Waste Remediation

- Stabilizing contaminants and reducing their environmental impact.
- Absorbs heavy metals and other pollutants.

Slag Valorization

- Enhances water retention, drainage, and fertility.
- Making it valuable soil amendment for agricultural or landscaping purposes.

Soil Improvement

- For land reclamation around steel plants, the overall soil quality can be enhanced.
- Improves water retention, nutrient retention, and microbial activity.

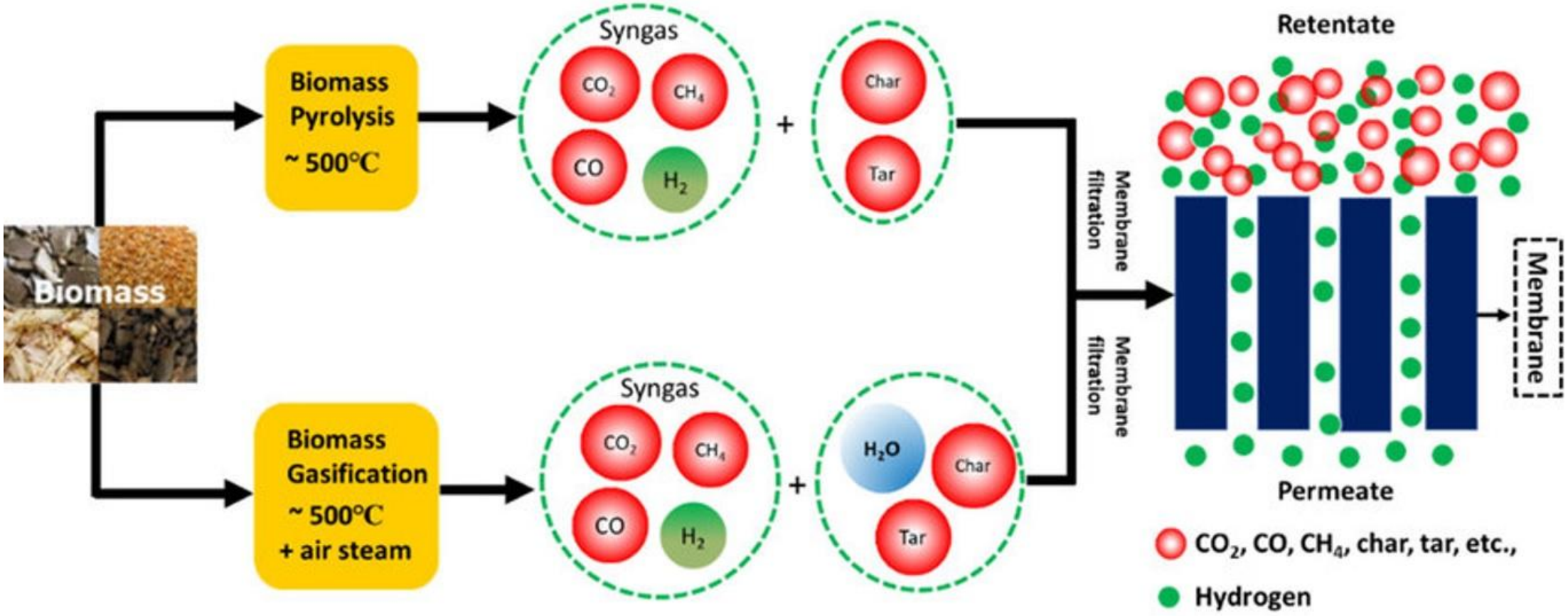
Carbon Sequestration

- High carbon content in soil, making it a potential tool for carbon sequestration.
- Adding biochar to land rehabilitation projects can enhance soil carbon storage.

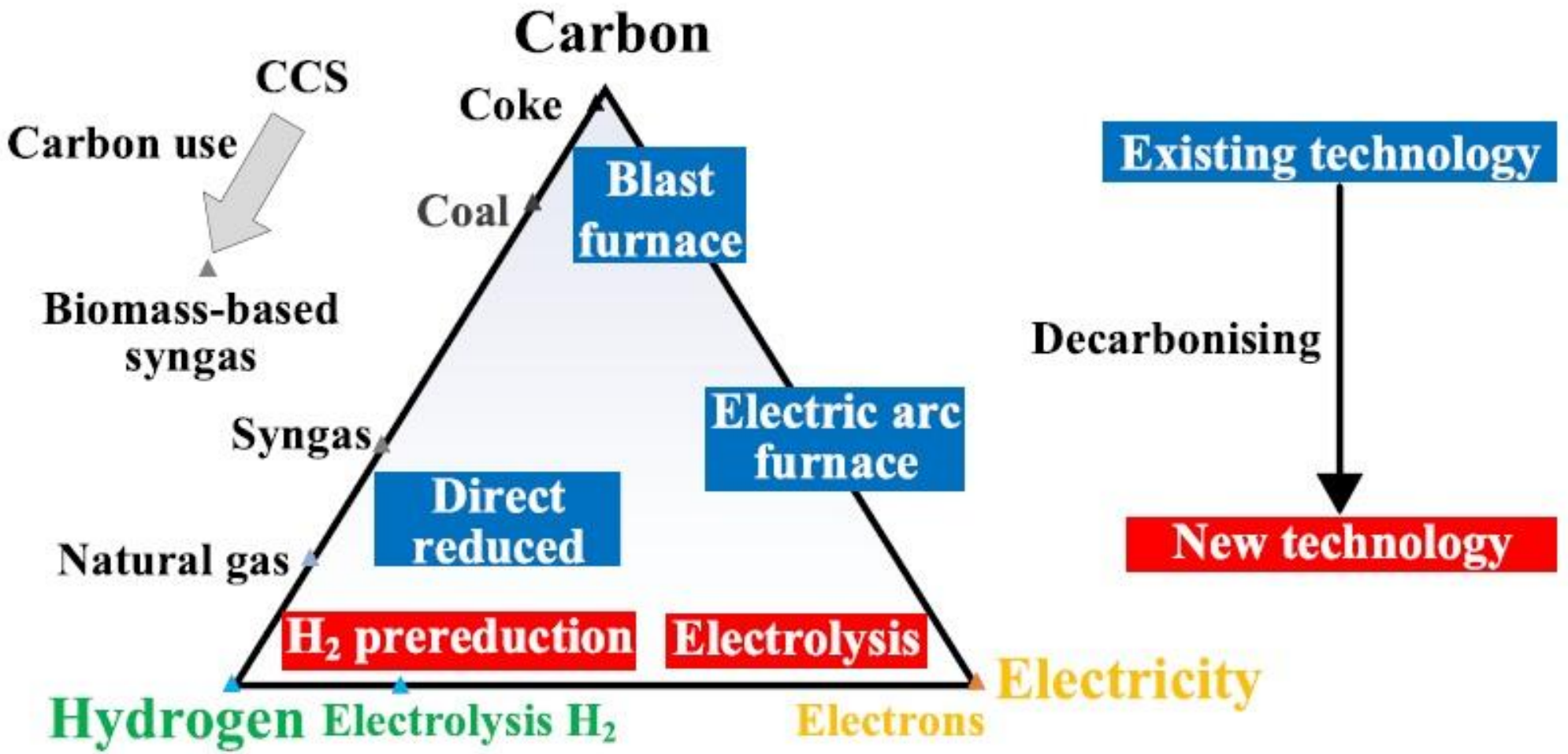
Economic Benefits

- Biochar production is integrated into the steel plant's waste management strategy.
- Production and selling of biochar can be an additional source of revenue.

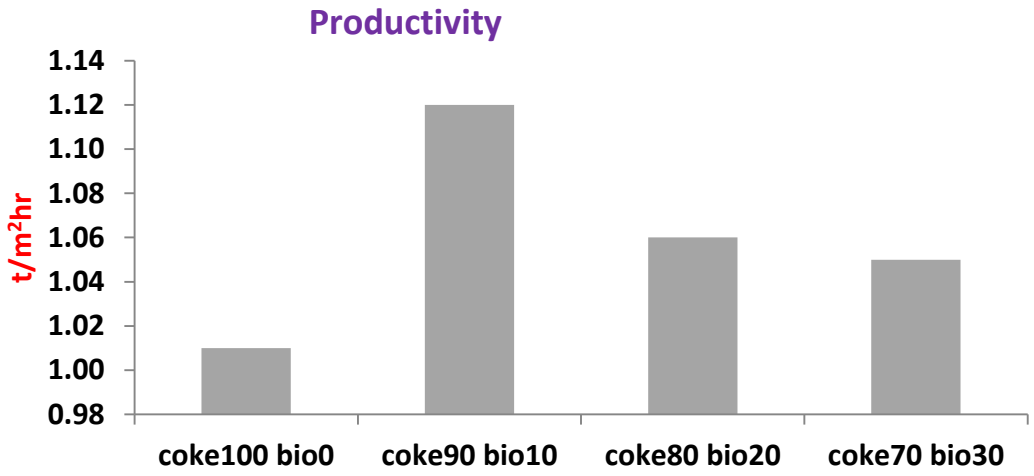
Biomass will have a role even in future CDA route….

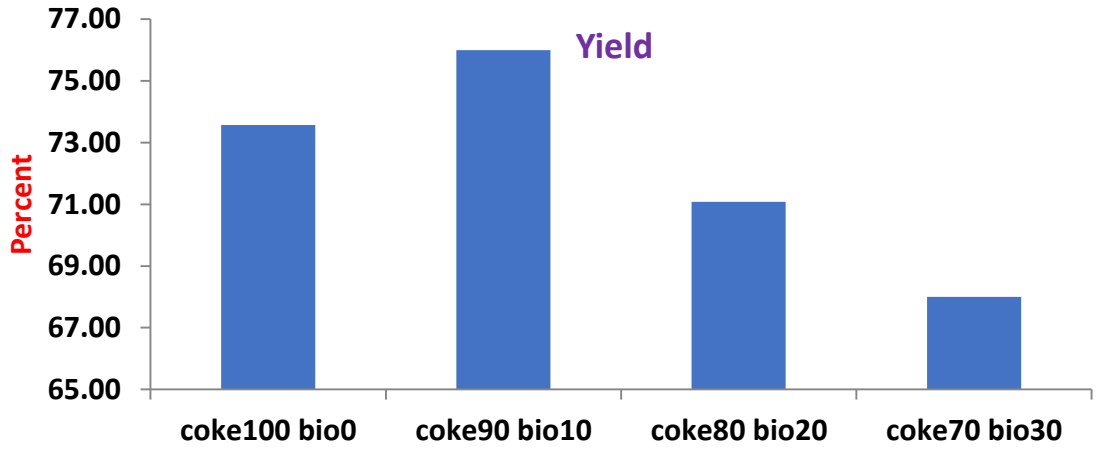


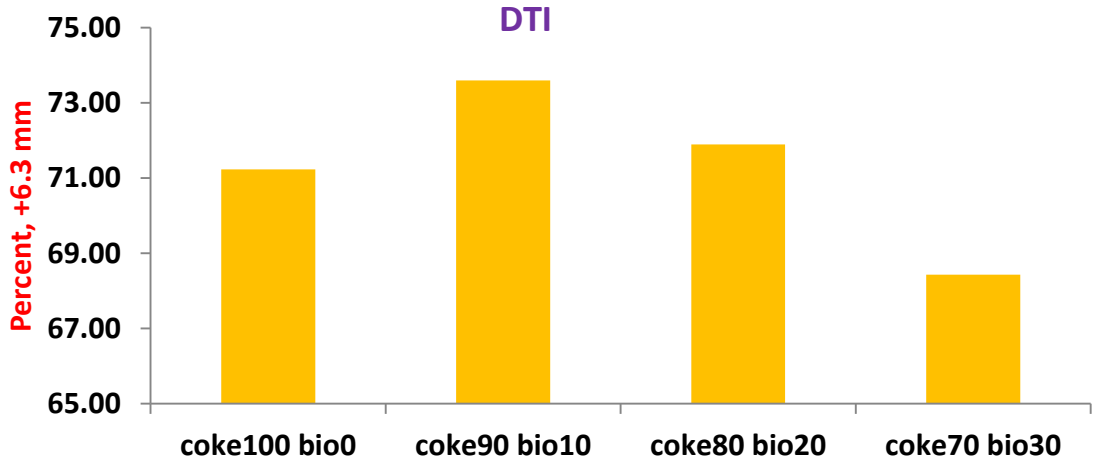
Biomass will have a role even in future CDA route…

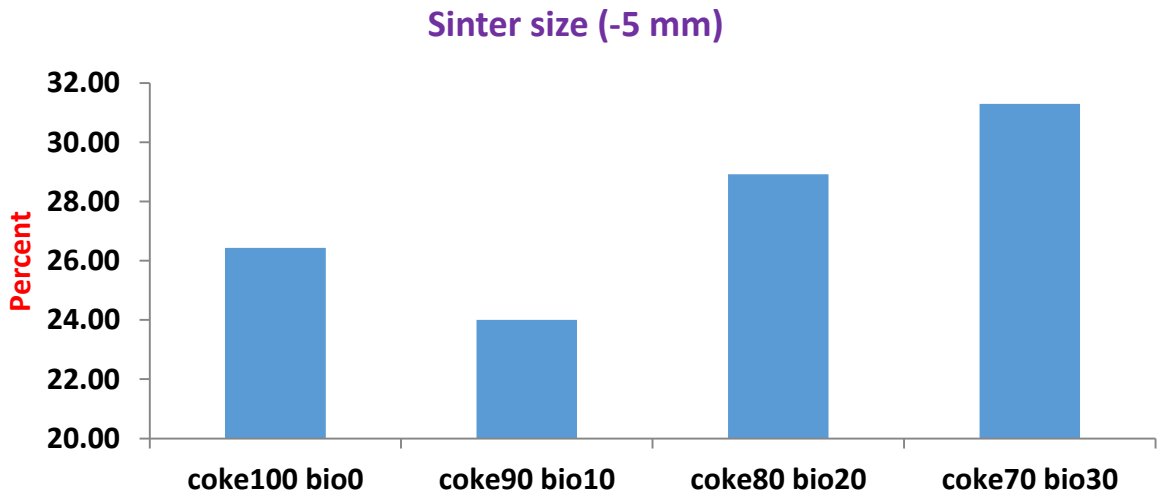


Sintering with Agro-waste biomass ….



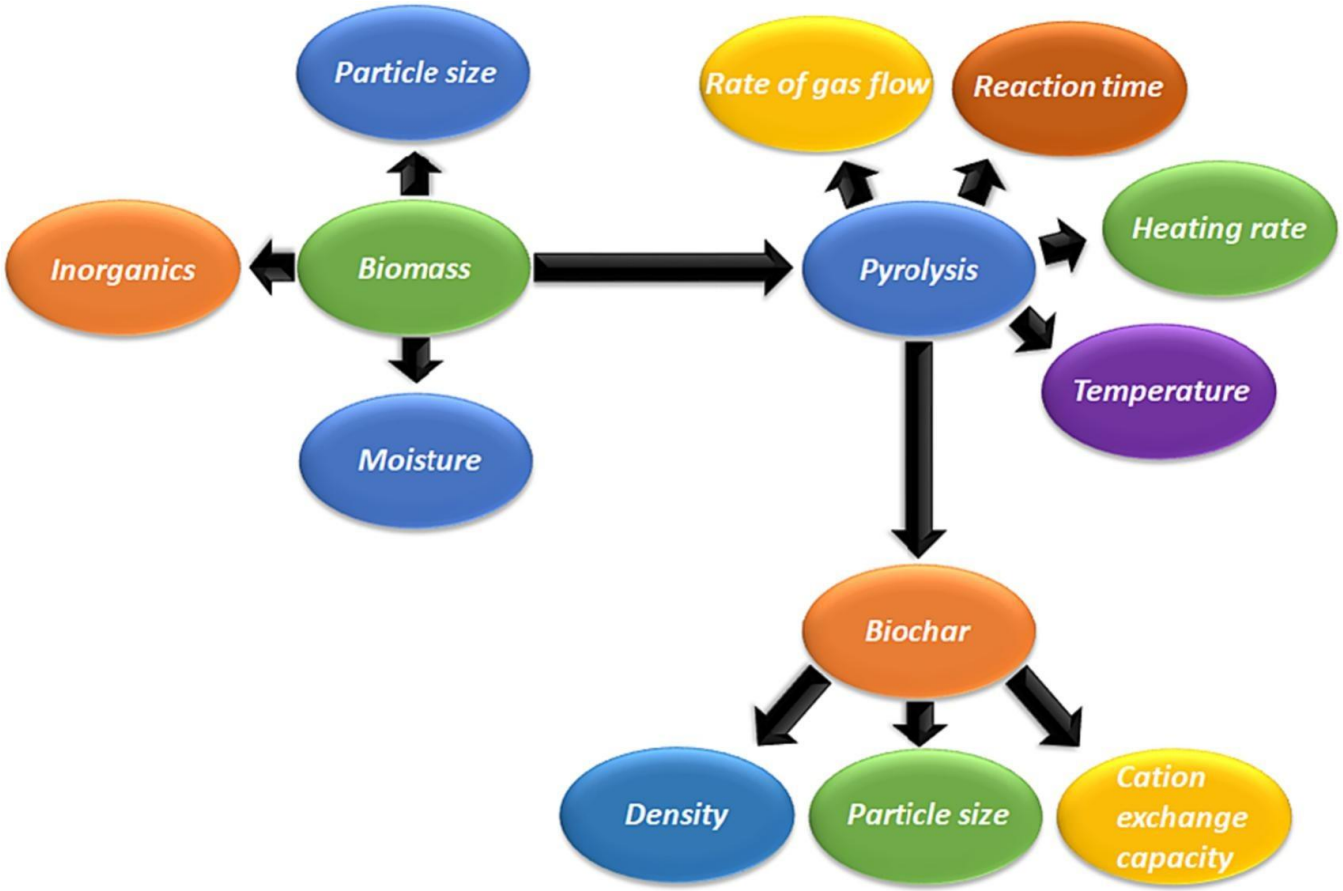






Road Ahead

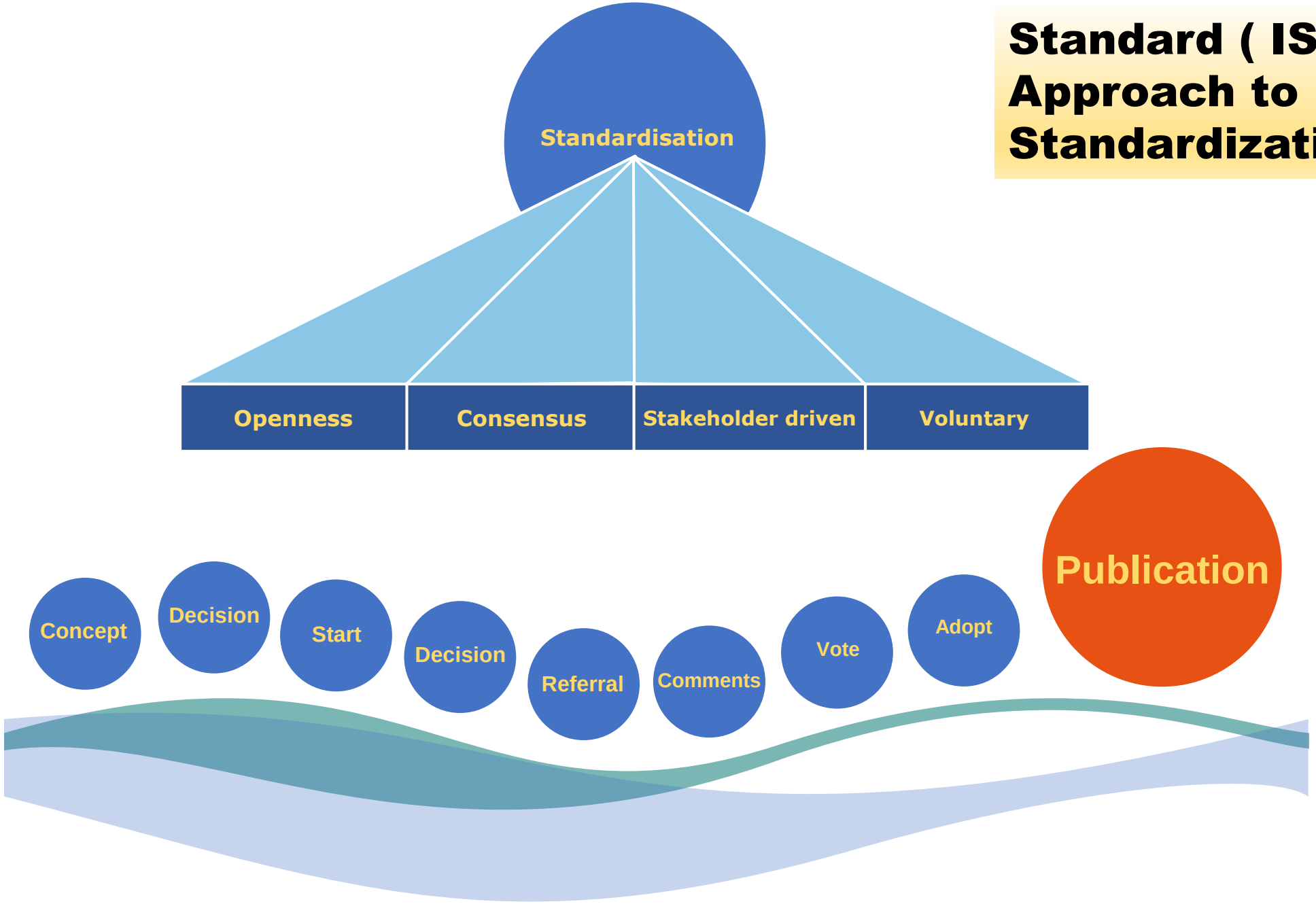
Study of effect ofVarious Parameters on Biochar Production and optimization is required to be carried out



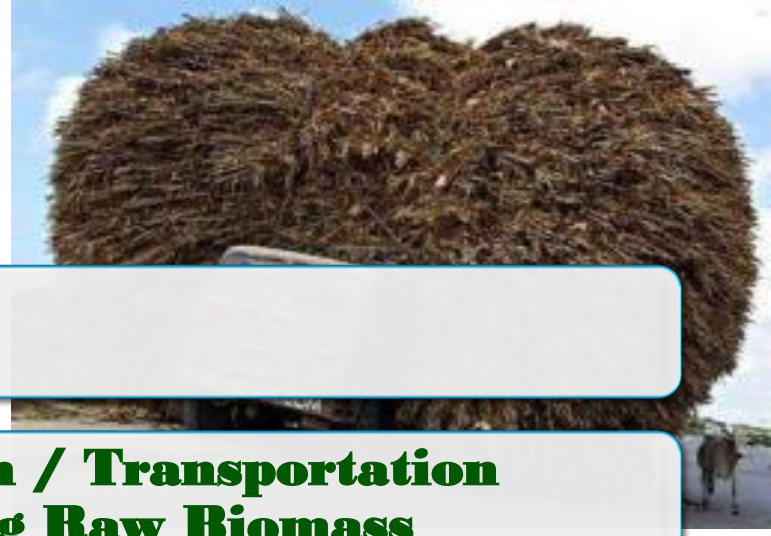
Research Gap exists, uniform design of experiments required for …

- Testing for strength and reducibility.
- Assessment of material chemistry.
- Simulation of actual process conditions
- Assessment of process chemistry
- Comparative Assessment for emissions.

Standard (ISO) Approach to Standardization

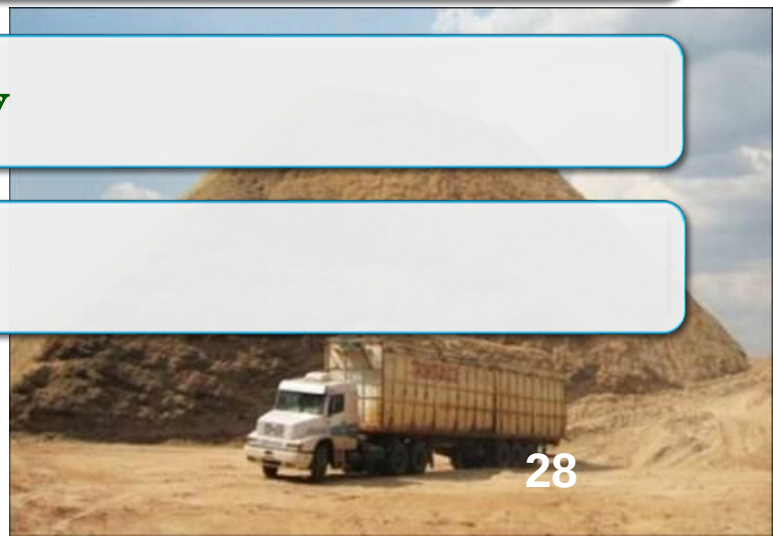


Issues to Address

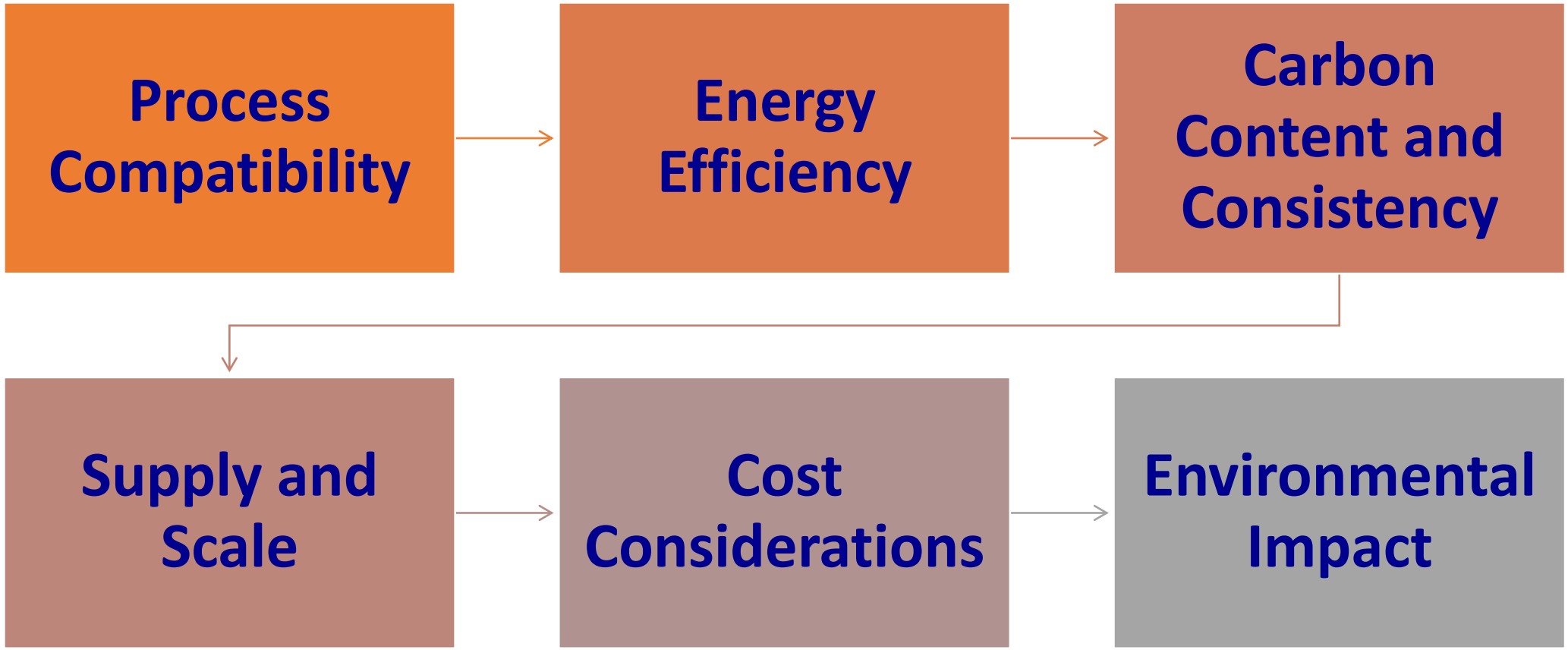


Challenges

- Cost
- Collection/ Aggregation / Transportation mechanism for handling Raw Biomass
- Storage of raw biomass to ensure availability round the year.
- Low Bulk Density and energy Density
- Sustainable Availability
- Change adoption



Issues to address before wide-scale implementation



+ Standardization

Multi-dimensional action required

Addressing issues related to sourcing of biomass, required for producing biochar, in association with agriculture & forestry sector

Collaborative studies to develop optimal process flowsheet for biochar production

Tailored biochar design for Steel Industry

Optimization of Biochar utilization as partial substitute of coke in sinter plant

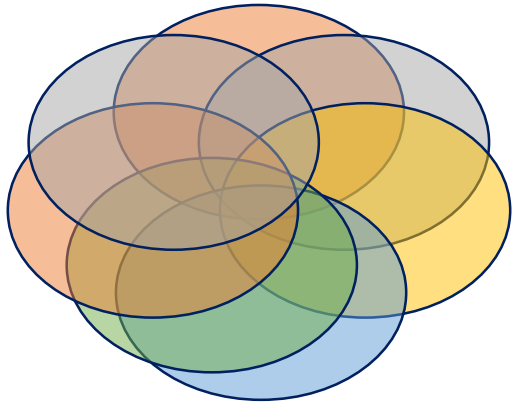
Development of technical understanding and application study in other areas of Steel Plant

Exploration of other applications in the context of steel industry beyond conventional raw material replacement

Accelerators

Database development

Monitoring



Testing labs and certification bodies

Stakeholder Integration platofrm for mission mode action

Financing and clearances

Thank You All

सेल SAIL

स्टील अथॉरिटी ऑफ इण्डिया लिमिटेड

STEEL AUTHORITY OF INDIA LIMITED

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