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How decarbonisation, digitisation  
and circular solutions forge the  
sustainable European steel future?

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# TGA/MS ANALYSIS AS A TOOL FOR ASSESSING BIOMASS UTILISATION IN IRON ORE SINTERING PROCESS



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# The Challenge: Decarbonising Steel Production

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The steel industry faces pressure to reduce CO<sub>2</sub> emissions, a critical step towards global climate goals. **Traditional metallurgical processes**, while essential for modern economy and infrastructure, are **highly carbon-intensive**.



Palm Kernel Shells (PKS) offer a promising biomass-derived substitute of coke breeze in iron ore sintering, aligning with efforts to decarbonize steel production and reduce reliance on fossil fuels. PKS possesses key advantages including:

- **widespread availability,**
  - **high lower heating value (LHV),**
  - **and low ash content,**
- making it an attractive sustainable option.



## Research Methodology

### Semi-technical Sintering Trials

- **Sintering tests** were conducted with **PKS replacement at 5, 15, 25, and 35%**.
- The mixture contained **40% Rudomite** and **60% KR65 concentrate**, with **limestone and dolomite** as fluxes to achieve a **basicity of 1.2**.
- **45% return sinter (<5 mm)** was added to maintain a **return sinter equilibrium index of 95–105%**.
- The **reference sinter** (with coke breeze) was used to compare substitute fuels, maintaining constant carbon content.
- Additionally, **1.5% burnt lime** was added in all tests.
- Sintering was performed in a **490 mm diameter pan**, with a **layer height of 550 mm**.

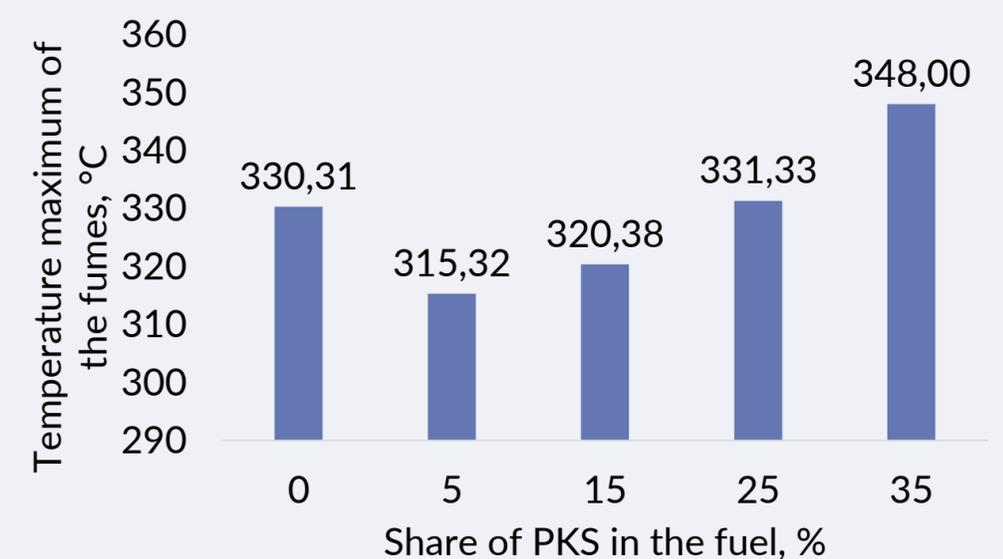
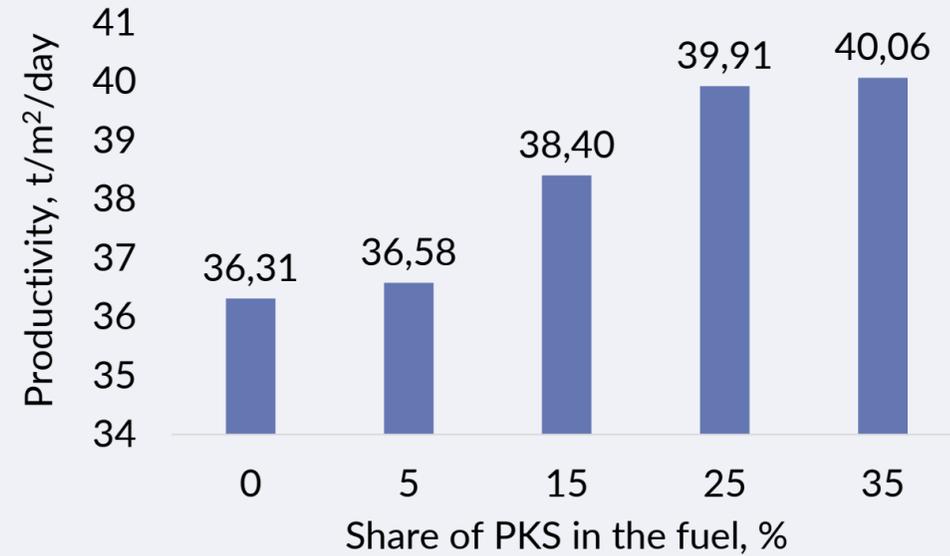
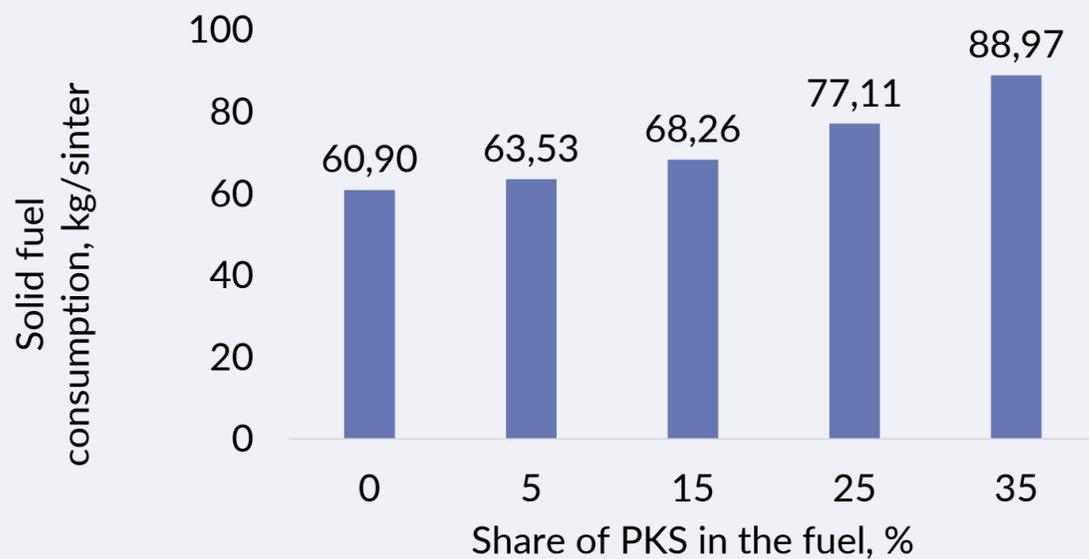
### TGA/MS Thermal Analysis

- Utilized to better understand the decomposition behaviour of PKS under sintering conditions.
- Performed under inert conditions (Ar atmosphere).
- Three different heating rates were used of 5, 10 and 15 K/min

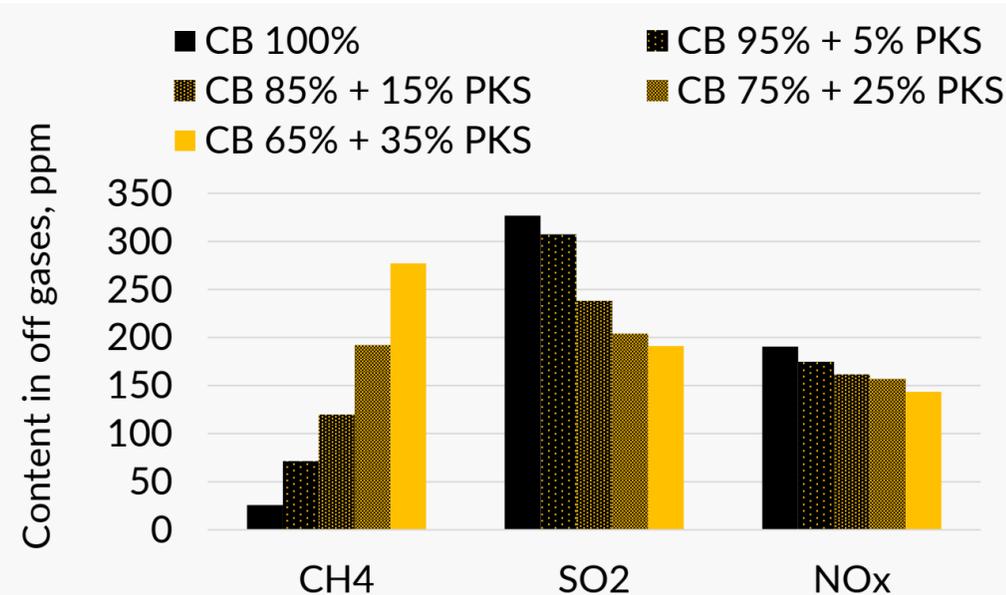
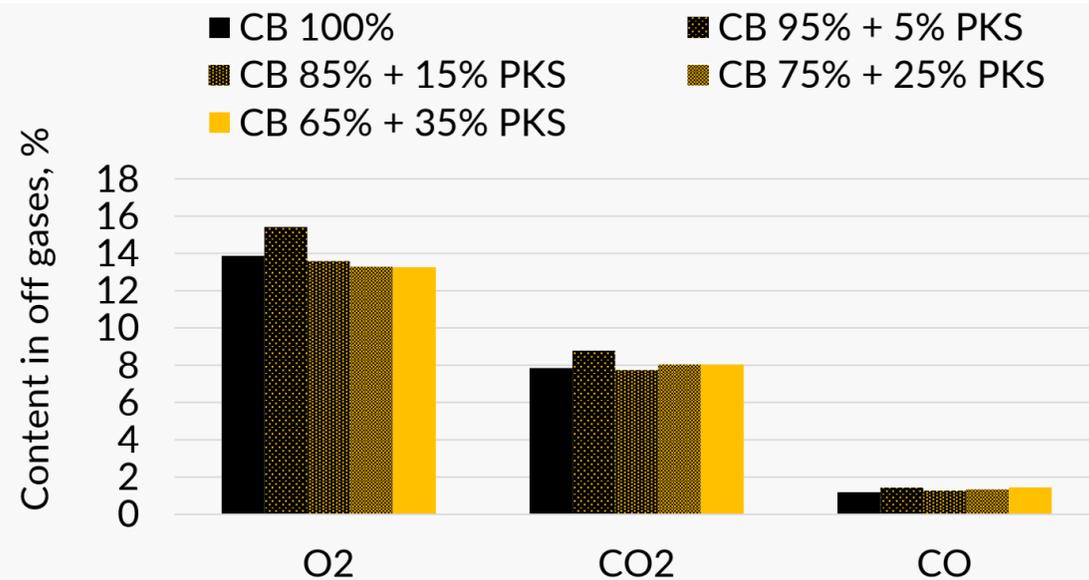
# Key Results & Environmental Impact of Sintering Process

Analysis of Palm Kernel Shells (PKS) in iron ore sintering revealed several key operational outcomes and significant environmental implications.

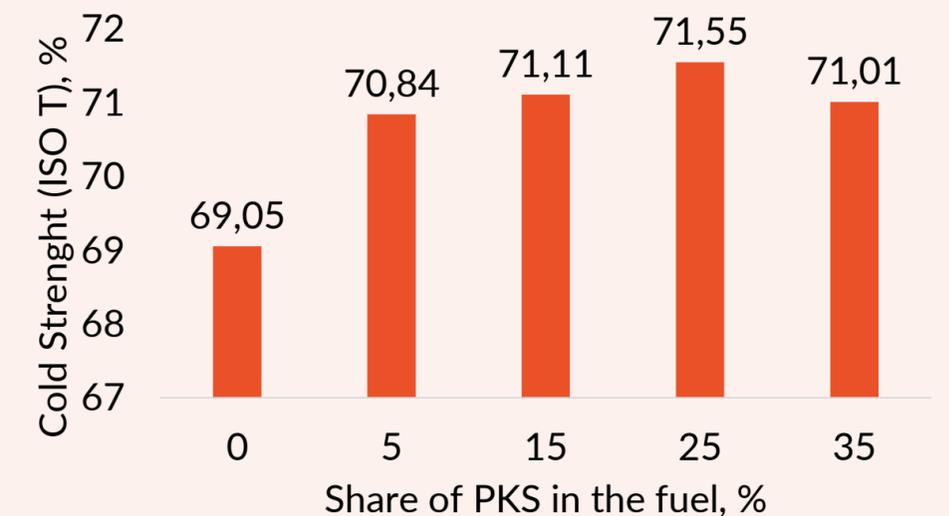
## OPERATIONAL RESULTS:



## ENVIRONMENTAL FINDINGS:



## SINTER PROPERTIES RESULTS:



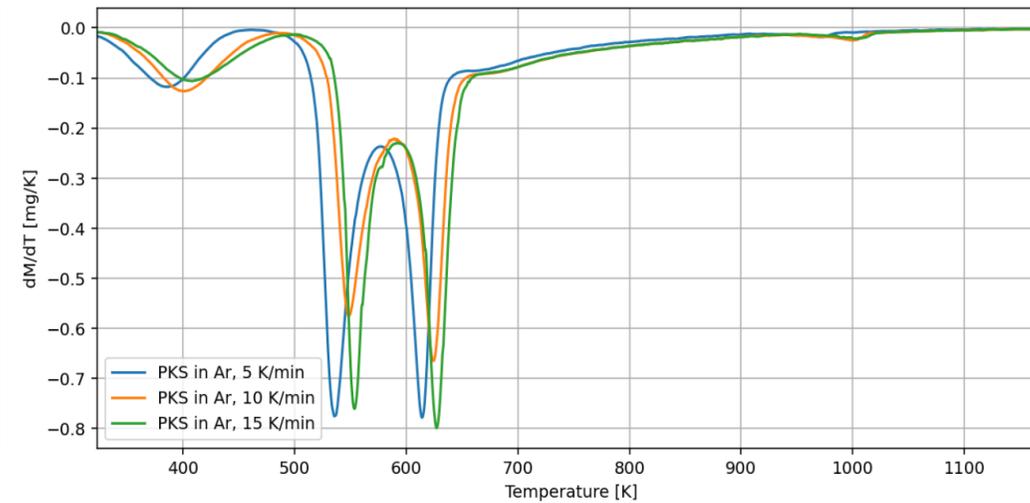
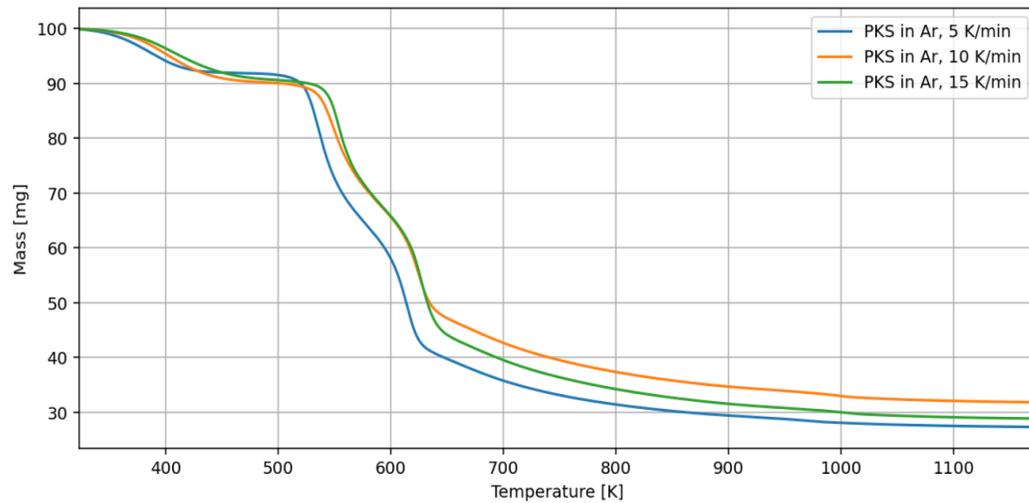
Productivity, maximum fumes temperature and solid fuel consumption increase

Increased cold strenght (ISO T)

Increased gas concentration (CH<sub>4</sub>, CO, CO<sub>2</sub>)

Reduced emissions (NO<sub>x</sub>, SO<sub>2</sub>)

# Key Results of TGA/MS analysis



## Results:

- Solid residue (fixed carbon + ash) at 1000°C is 31.6 %
- Three distinct stages of mass loss were identified:
  - (i) initial water evaporation occurring between 320 and 450 K, which produces water vapour;
  - (ii) the first main stage of pyrolytic decomposition associated with hemicellulose degradation, observed between 460 and 580 K, which produces primarily carbon dioxide and carbon monoxide, with smaller amounts of methane and hydrogen;
  - (iii) the second main stage, corresponding to cellulose decomposition, in the range of 580–650 K, which produces primarily carbon dioxide and carbon monoxide, with smaller amounts of methane and hydrogen,

The next stage of fuel degradation primarily produces hydrogen and methane, resulting from secondary pyrolysis reactions and lignin decomposition.

Such analysis enables kinetic calculations that allow the determination of the fuel reactivity.

## Conclusions & Future Directions

### Novel Sustainable Approach

This study shows a novel approach, demonstrating that biomass residues like PKS can effectively reduce fossil fuel reliance in energy-intensive processes like iron ore sintering. Key operational and environmental outputs are determined.



### Importance of Thermal Analysis

The findings highlights the importance of considering biomass thermal decomposition characteristics for optimal process design and emission control when integrating alternative fuels.



### Future Work

Future research should focus on managing biomass properties variability, process scale-up, and exploring the potential of PKS-derived biochar as a coke replacement.