International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

The Potential of Biochar in the EU Integrated Iron and Steel Making Industry

Jim Allansson[1,2], Shubham Tiwari[1], Joakim Lundgren[1,2], Florian Kraxner[1]

[1]International Institute of Applied System Analysis, Biodiversity and Natural Resources Program, Austria

[2]Luleå University of Technology, Division of Energy Sciences, Sweden

Parts of this work was completed and supported by:

Open Geospatial Carbon Registry (OGCR)

FINAST VID LULEÅ TEKNISKA UNIVERSITET Forskning och Innovation i Norrbotten för Avancerad grön Stålframställning och Tillverkning

9th Austrian Biochar Day

2026-10-01

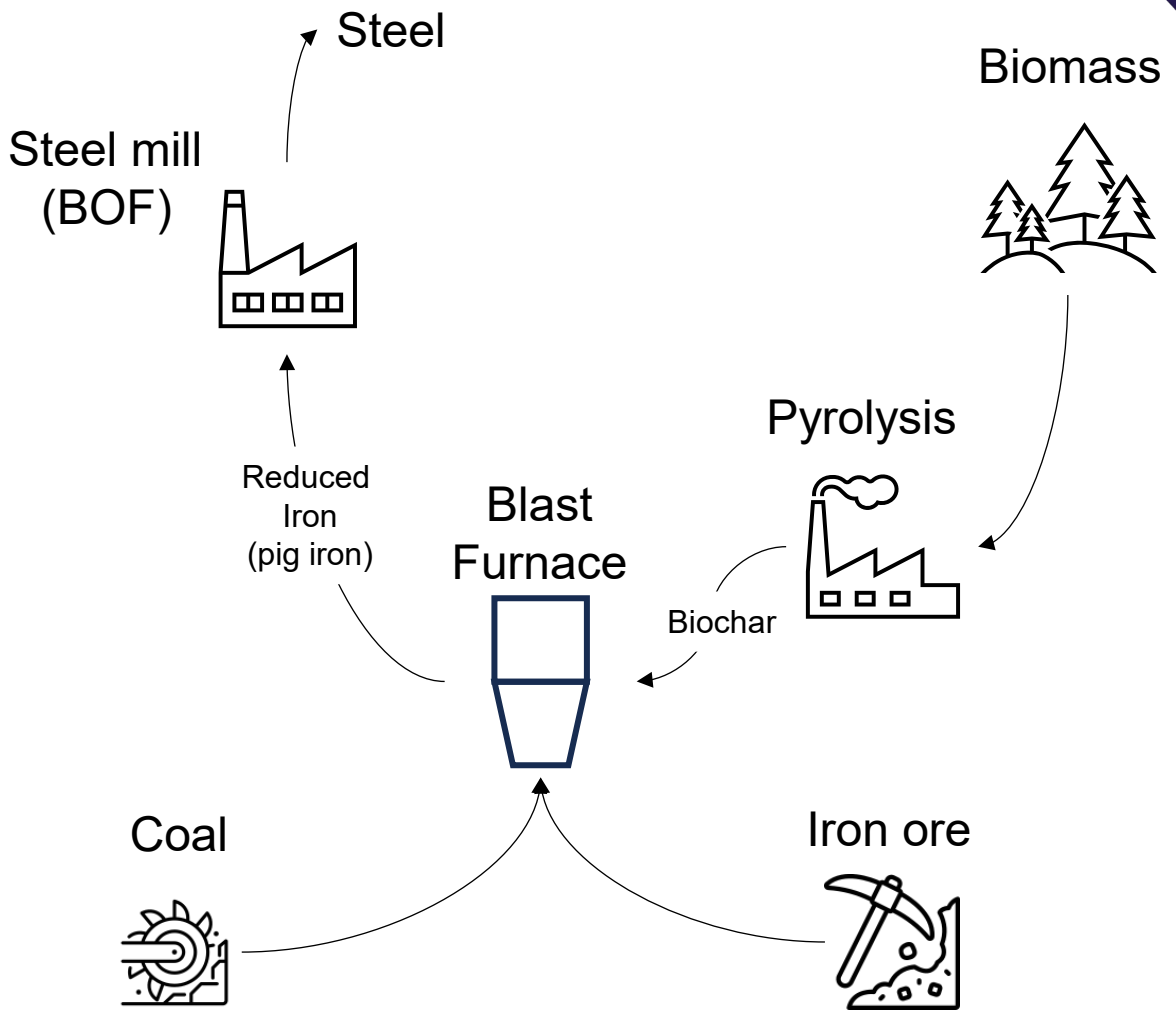
The EU Iron and Steel Industry

- EU27 represent ~7% of global steel production [1]
- ~7.5% of global steel use [1]
- Iron and steel responsible for ~6% of EU27s GHG
- Aims to cut carbon emissions by 55% 2030 (Compared to the levels of 1990) [2]
- **~55% Primary steel produced**, ~45% recycled [1]
- Two main iron prodcuing technologies: Blast Furnace and Basic Oxygen Furnace (BF-BOF) and Direct Reduction and Electric Arc Furnace (DRI-EAF).

1. European Steel in Figures 2026 (2026). Report available: https://www.eurofer.eu/publications/brochures-booklets-and-factsheets/european-steel-in-figures-2026
2. Low-CO2 emissions projects in the EU steel industry. (2022). https://www.eurofer.eu/issues/climate-and-energy/maps-of-key-low-carbon-steel-projects

Blast Furnace and Basic Oxygen Furnace (BF-BOF)

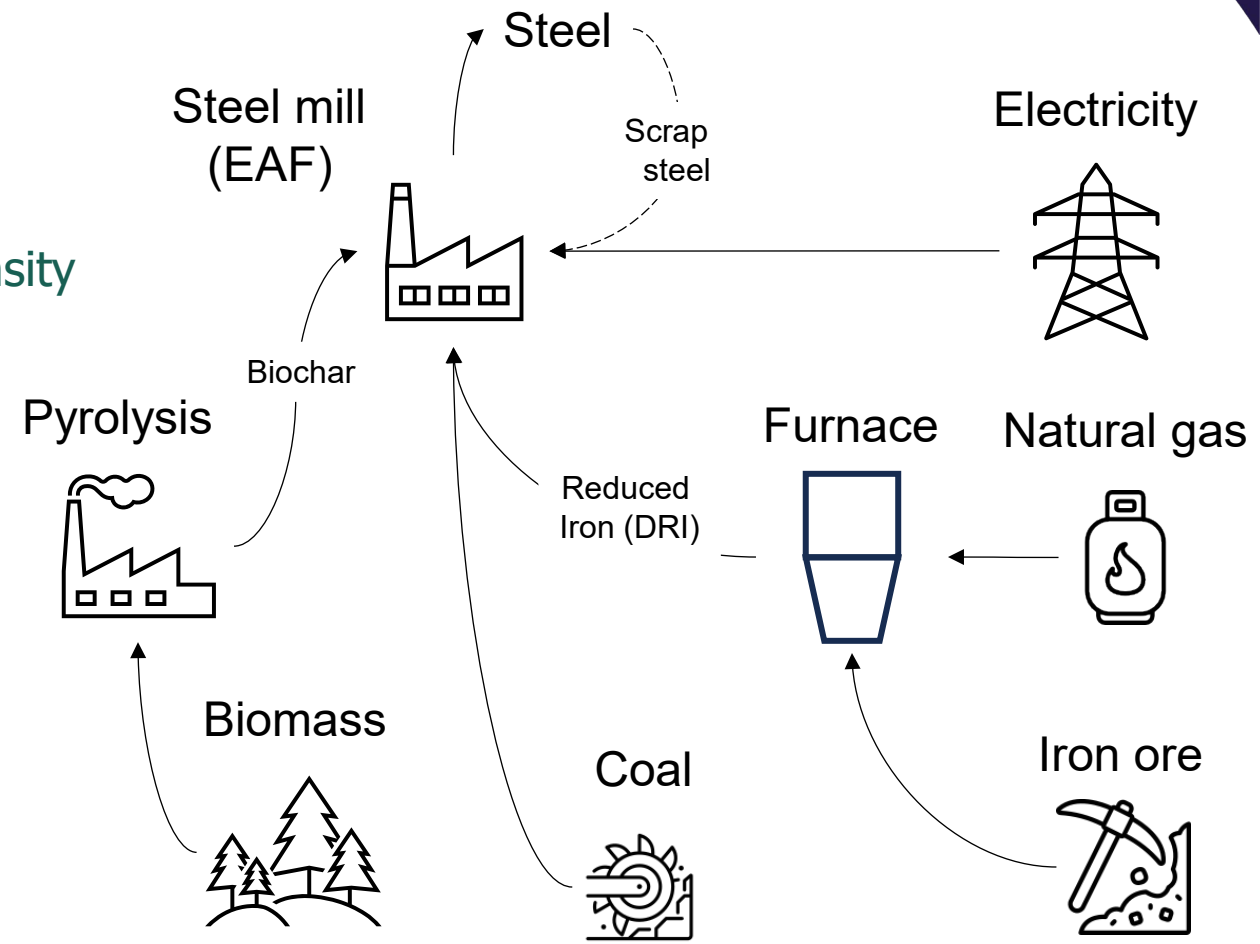
- ~100% of EU27s primary steel produced
- Emission intensive ~2 tCO_2/t steel
- Coal is the primary fuel
- **Biochar** has the potential to **substitute coal**
- Maximum coal substitution 42% [1]



1. Mathieson, J. G., Rogers, H., Somerville, M., Ridgeway, P., & Jahanshahi, S. (2011). Use of biomass in the iron and steel industry–an Australian perspective. EECR-METEC InSteelCon, 1(1).

Direct Reduction and Electric Arc Furnace (DRI-EAF)

- Potential for **high share** of **scrap steel**
  - Large impact on energy and material needs
- ~1 tCO_2/t steel but highly depends on grid carbon intensity
- **Natural gas** acts as the primary fuel
- **Coal** demand is only ~5% of BF-BOF
- **Biochar** has the potential to **substitute coal**
- **Maximum** coal substitution possibility is **100%** [1]



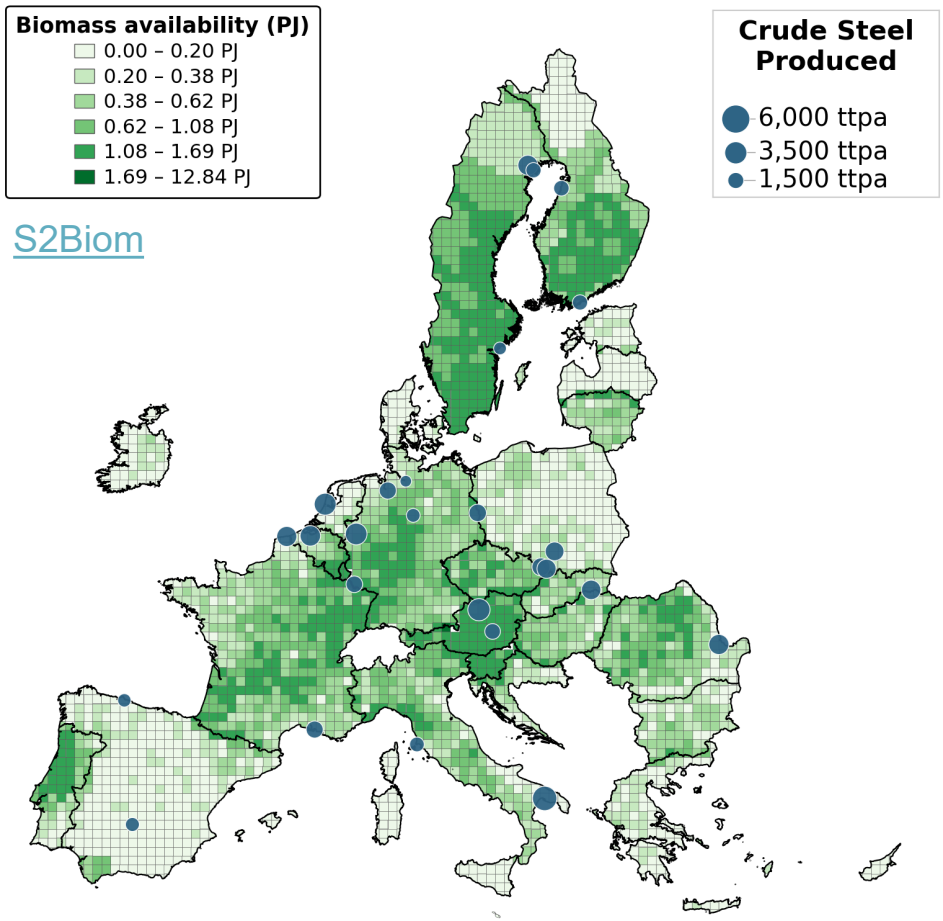
1. Mathieson, J. G., Rogers, H., Somerville, M., Ridgeway, P., & Jahanshahi, S. (2011). Use of biomass in the iron and steel industry–an Australian perspective. EECR-METEC InSteelCon, 1(1).

Biochar Quality

- **High quality standards** for steel applications
  - Low ash content (especially phosphor)
  - High fixed-C content
  - High mechanical strength
  - Low reactivity
- **Stemwood**, primary candidate to achieve right quality metallurgical charcoal/biochar
- Slow pyrolysis ~500-600°C
- **Rotary kiln**
  - Mature technology
  - Potential for large scale

BeWhere model: for spatial techno economic analysis

- **The BeWhere model**:
  - Inter-temporal, MILP optimization model
  - Spatial scope: EU27, 40x40km grid
  - Temporal scope: 2025-2050
- 26 Integrated (BF-BOF) steel mills
- Forestry biomass availability
  - 10 Categories of forestry biomass
  - 4 Stemwood (for biochar), 6 Residue categories
- Techno economic data
  - BF-BOF and DRI-EAF iron and steel making
  - Pyrolysis for biochar production

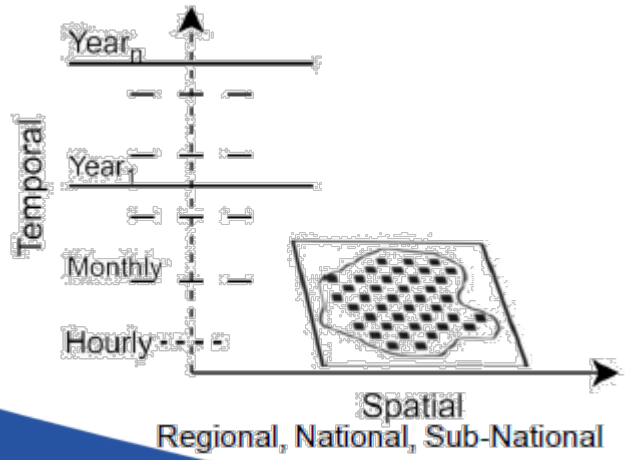


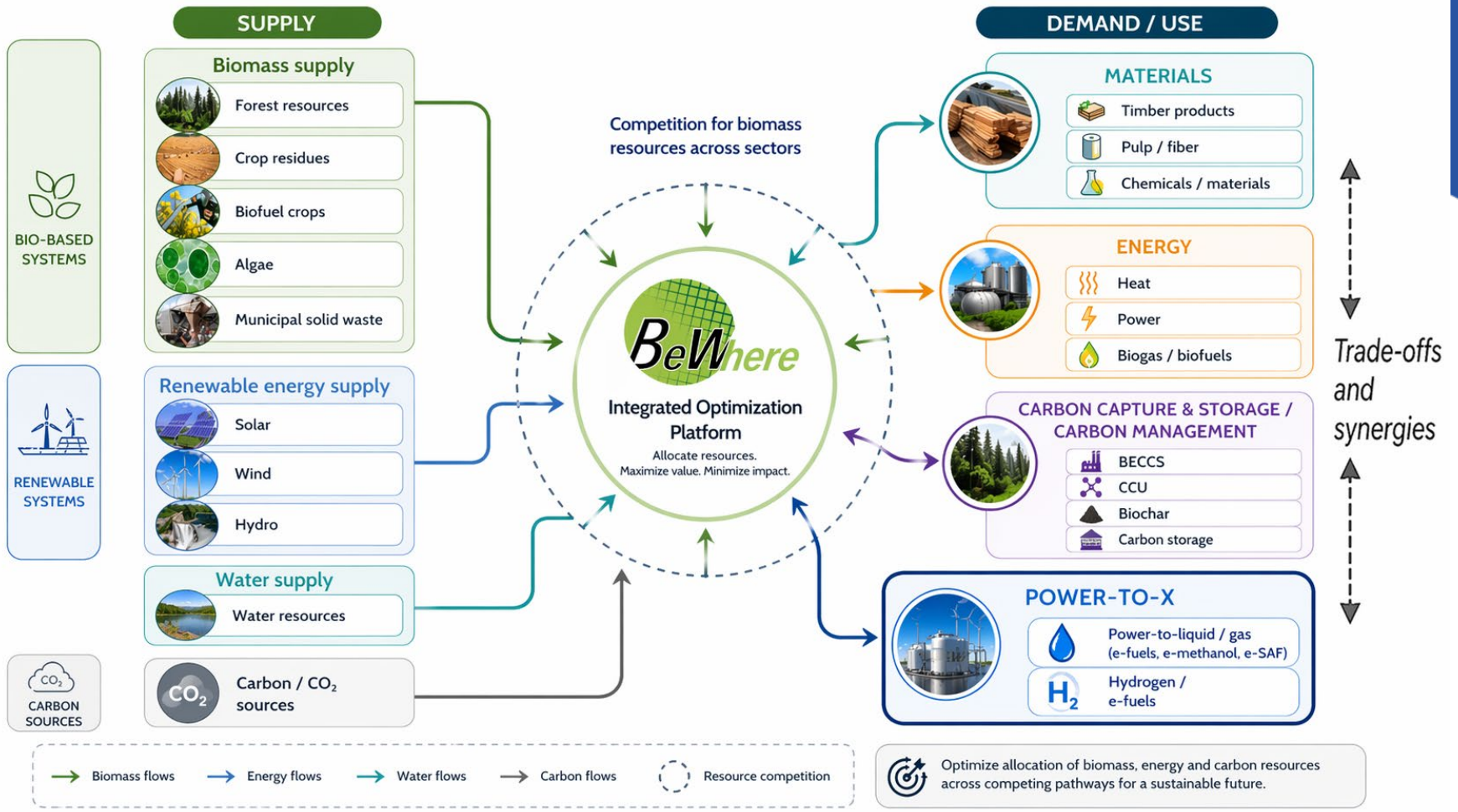
Available biomass after fulfilling current biomass demand

BeWhere Model

A **decision-support tool** for assessing supply (and value) chains across **energy, industry,** and **bio-based systems.**

Explicitly Answers: What to build?, Where?, Why? and When?

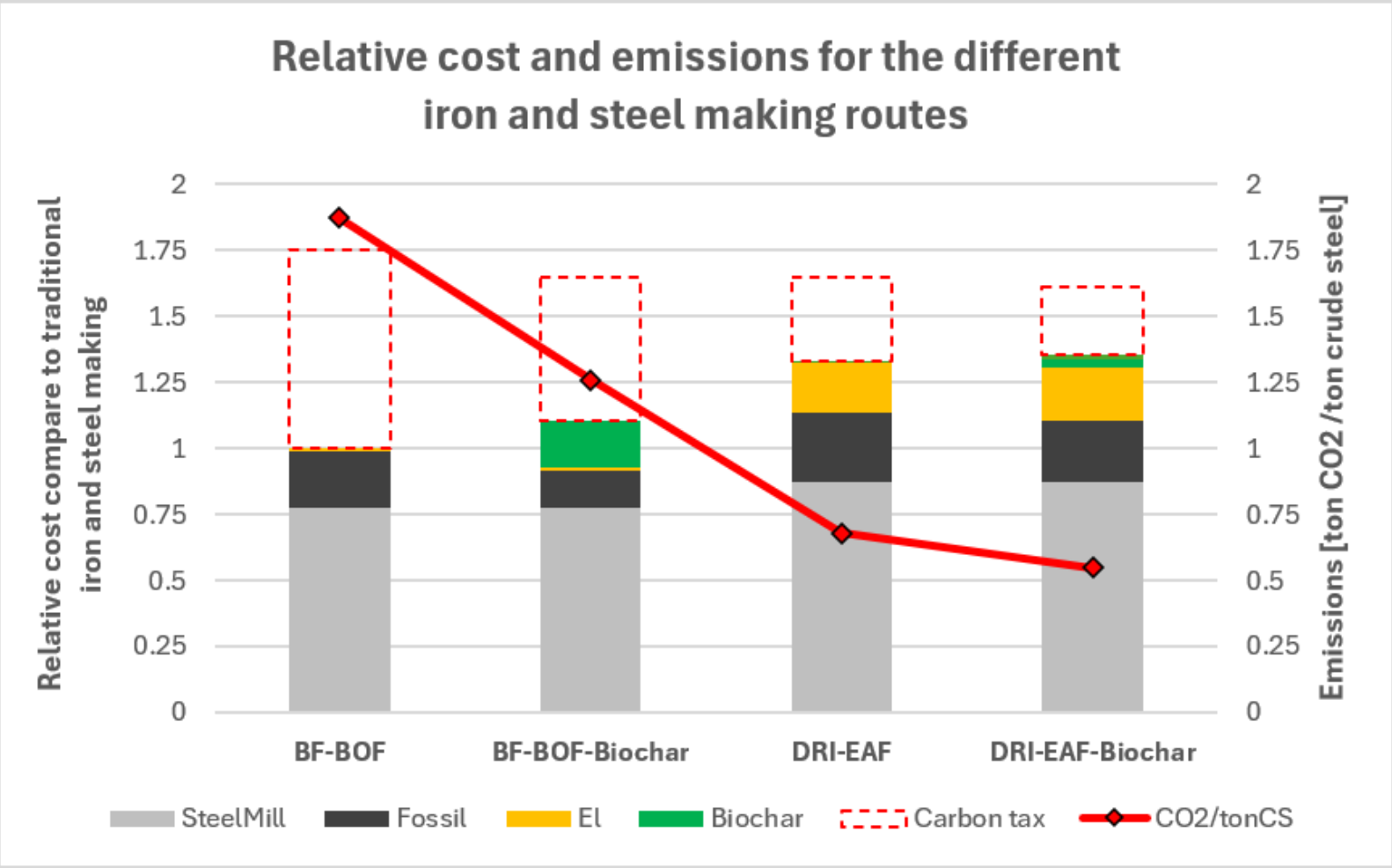




How should biomass and renewable energy be allocated across competing sectors?

How future biomass or renewable energy-based supply chain look like?

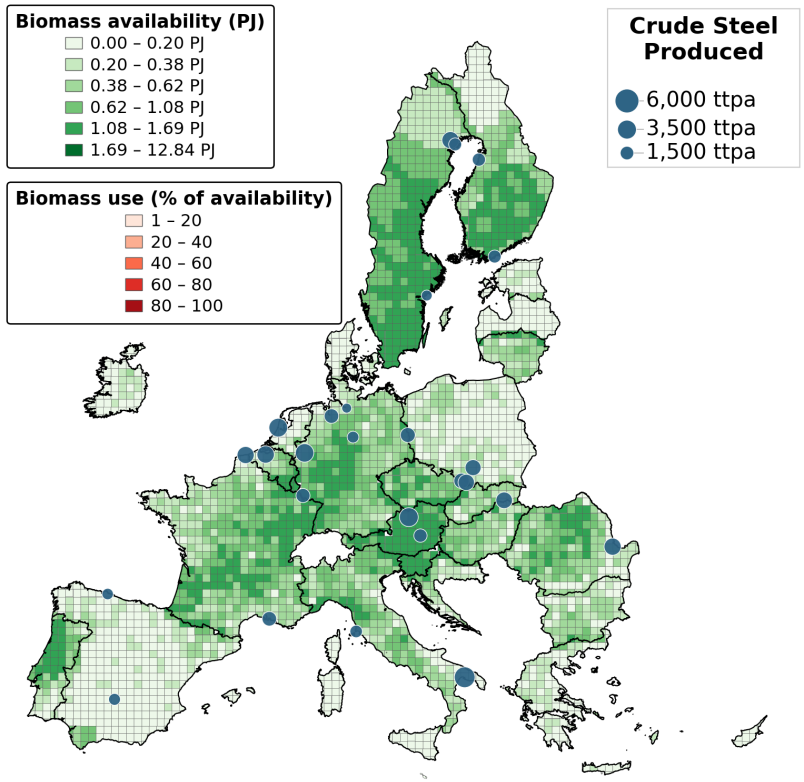
Results: Performance comparison



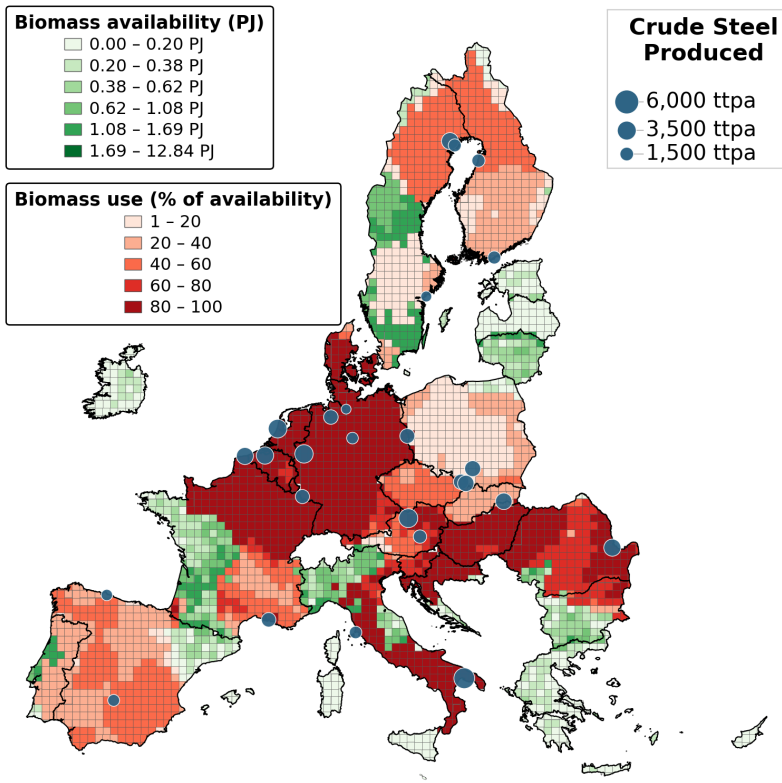
Assuming 20% scrap charge in both BF-BOF and DRI-EAF. The carbon tax equals an estimated average of the EU-ETS from 2025-2050, resulting in ~120€/tCO2

- BF-BOF stable cost and emissions across years and countries
- DRI-EAF range
  - 2025: 0.66-1.03 tCO_2/tCS
  - 2050: 0.64-0.72 tCO_2/tCS
  - Cost 2025-2050: ~±10%
- DRI-EAF-Biochar range
  - 2025: 0.56-0.92 tCO_2/tCS
  - 2050: 0.54-0.62 tCO_2/tCS
  - Cost 2025-2050: ~±10%

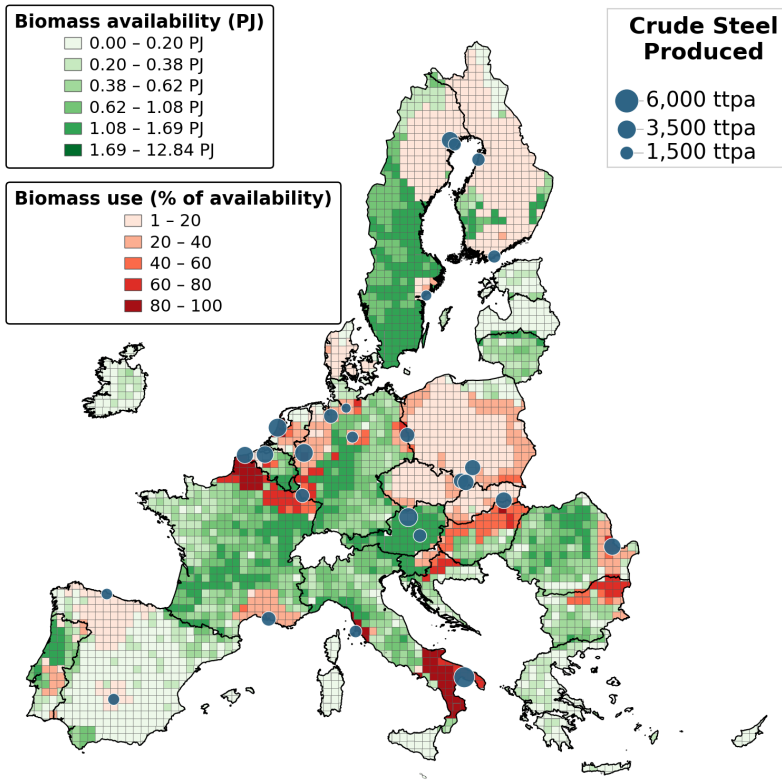
Biomass availability comparison



Available biomass after fulfilling current biomass demand



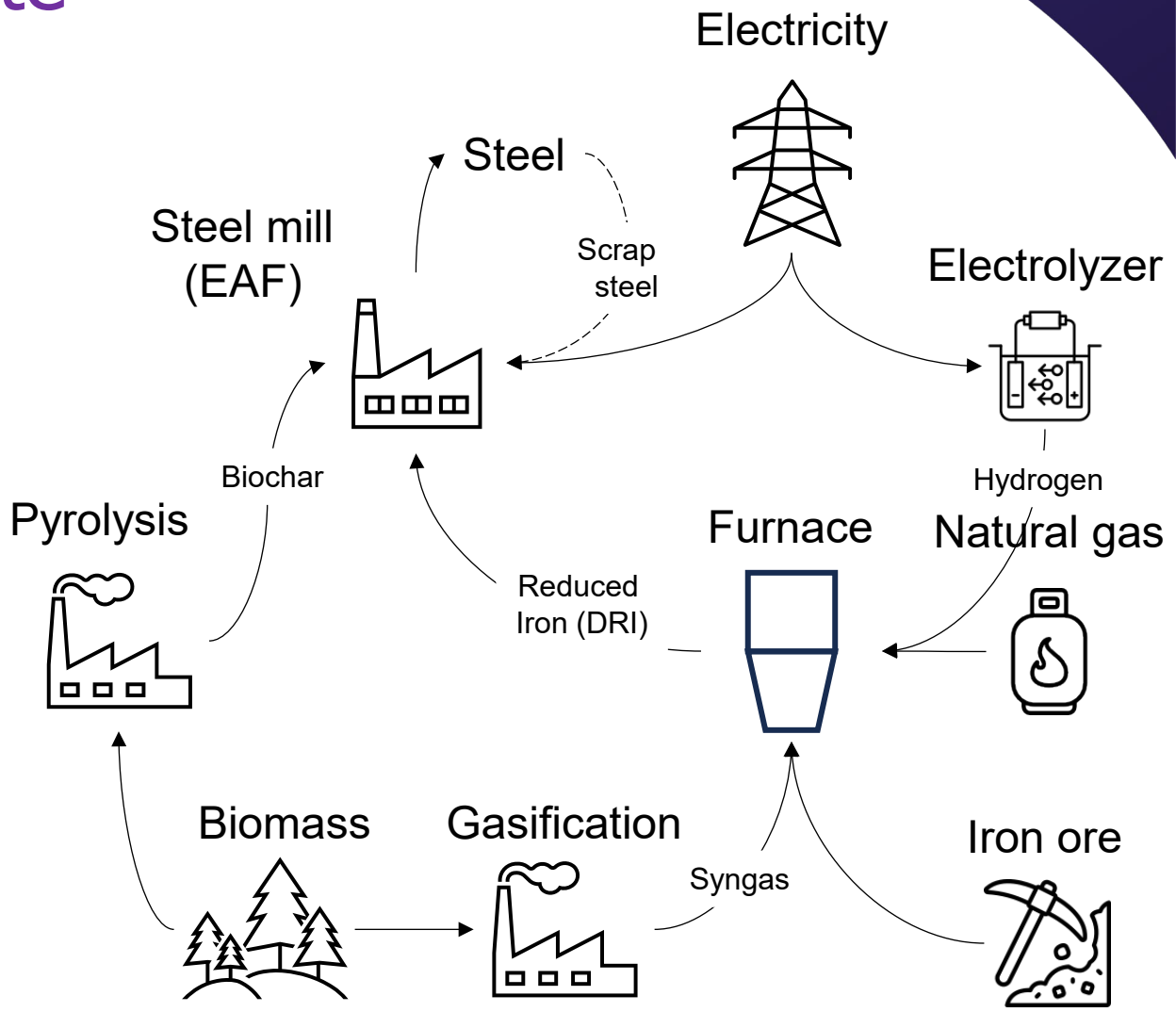
Biomass utilized to fulfill biochar demand of BF-BOF route



Biomass utilized to fulfill biochar demand of DRI-EAF route

Alternatives for the DRI-EAF route

- Syngas based DRI
  - + Benefits:
    - + Carburization of DRI
    - + Similar composition to natural gas
  - − Downsides:
    - − High biomass demand
- H2-DRI
  - + Benefits:
    - + No direct CO2 emissions
    - + Low biomass demand
  - − Downsides:
    - − No carburization of DRI
    - − Expensive



Final Reflections

- Biochar is key to make the Iron and Steel industry fossil free
    - No other fossil free alternative for material purposes
- Biochar will cost more than fossil coal. However, low impact on final steel cost in DRI-EAF
- Fossil tax and incentives could be a driver for biochar and other renewable substitutes
    - Other financial incentives must be in place to keep EU steel competitive
- EU steel is a small player globally, but have large potential for self-sufficiency
    - Both in terms of fuel and material when producing, and as a final product to meet market demand

International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

Thank you for your time

Open floor for questions

E-mail: Jim.Allansson@ltu.se

International Institute for Applied Systems Analysis (IIASA)
Schlossplatz 1, A-2361 Laxenburg, Austria

iiasa.ac.at
iiasa.ac.at/contact
IIASA
iiasa-vienna
@IIASAVienna
@IIASALive
@iiasavienna

Parts of this work was completed and supported by:

FINAST VID LULEÅ TEKNISKA UNIVERSITET
Forskning och Innovation i Norrbotten för Avancerad grön Stålframställning och Tillverkning

Open Geospatial Carbon Registry (OGCR)