European Commission
Research Programme of the Research Fund for Coal and Steel

TGA1: IRON- AND STEELMAKING PROCESSES

Biomass for Cokemaking Decarbonization

Project Deliverable Report

D2.1 - Comprehensive overview of the project

Angelo Sorino (coordinator), Acciaierie d'Italia S.p.A
Viale Certosa 239, Milan (Italy)

Viktor Stiskala, Thyssenkrupp Steel Europe AG
Kaiser Wilhelm Strasse 100, Duisburg (Germany)

Carlo Morelli, Paul Wurth Italia S.p.A.
Via Balleydier 7, Genoa (Italy)

Filippo Cirilli, Rina Consulting – Centro Sviluppo Materiali S.p.A.
Via di Castel Romano 100, Rome (Italy)

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1 Summary

The main source of carbon dioxide in integrated steel plants is fossil coal, mainly used for metallurgical coke production. The scope of the BioCoDe project is the decarbonization of the industrial cokemaking process, replacing a fraction of the fossil coal coking mixture, with carbon-neutral biomass. This project aims to investigate, through experimental tests from the laboratory screening up to industrial scale trials, the influence of biomass introduction on environmental impact of the plant, process, products, and by-products.

The BioCoDe project, beyond the objective of laying the foundations of a more green and sustainable industry, will enhance a local and European synergy between the agri-forestry and steel sectors, by promoting the local agro-forestry residues valorisation following circular and green economy principles in an industrial contest to be exploited in 2 different locations in 2 different Member States.

The general objective of the BioCoDe project is the partial substitution at industrial level of fossil coal with charcoal or biomass in the coke production up to 10%, to reduce CO_2 emissions in hot metal process and to increase the sustainability of cokemaking process. This objective will be achieved via characterization of several types of biomasses and studying the best pre-treatment needed to obtain charcoal at laboratory and pilot scale.

The large range of conditions investigated in BioCoDe is necessary to find the most suitable conditions to substitute the highest amount possible of fossil fuel without reducing the quality of the final product. After this characterization, in BioCoDe the first industrial demonstration of biomass-based cokemaking process is implemented.

The final aim of BioCoDe is to demonstrate for the first time the industrial substitution (TRL 7) of fossil coal up to 10% with biomass-based (charcoal) at industrial scale in Taranto site.

2 Introduction

This deliverable D2.1 offers an overview about the current fossil-based coke-making in integrated steelworks, the potential of biochar for replacing such fossil sources (as reported in the pertinent literature), and the description of the main types of biomasses, both in terms of chemical/physical characteristics and abundancy. This structure highlights the potential of BioCoDe to advance decarbonization efforts within the steel industry by targeting emissions associated with the cokemaking process.

2.1 Exploring biomass integration in steelmaking

Fossil-based carbon dioxide emissions have been identified as the major concern in steel industry and the abatement of these emissions is a fundamental step to reduce the EU emission by 55% by 2030 and achieve carbon neutrality by 2050 (COM n. 80 2020). It is commonly acknowledged that the BF-BOF route emits about 1.9 tCO_2/t crude steel (1.6 tCO_2/t of hot metal)[1] and the biggest share of carbon dioxide emissions come from blast furnace where fossil-based materials (coke and coal injected) are used as a source of energy and reducing agent.

The RFCS dissemination project Low Carbon Future[2] has collected, summarised, and evaluated past research projects and knowledge dealing with CO_2 mitigation in iron and steelmaking. Three main mitigation pathways were identified: CDA (Carbon Direct Avoidance), PI (Process Integration) and CCUS (Carbon Capture, Usage and Storage). The pathway Process Integration is dedicated to the process modifications that are designed to be integrated in conventional steel plants. BioCoDe is fully in line with Clean Steel Partnership (CSP) CO_2 mitigation roadmap.

It has been calculated that 350-400 kg of coke are needed to produce 1 ton of crude steel and 1 ton of coke requires 1.2–1.6 tons of coal. Reduction of fossil coal would be a key step to decarbonising the crude steel preparation process. In this sense, biomass use has been identified as one of the possibilities to mitigate fossil greenhouse gas emissions in iron and steelmaking[3] with a potential decreasing in coke plant of 5% estimated considering the existing literature (Table 2.1).

Table 2.1 – Possible action to mitigate fossil greenhouse gas emissions in iron and steelmaking

	Mitigation potential (% of average BF/BOF plant)
Use of biomass and spent-C streams at the BF	20-25%
Gas injection in the BF (including the energy required for preparing the gas)	15-20%
Use of some biomass and spent-C streams at the coke plant	5%
Actions at the Sinter plant	5%
Operation of heating applications using low-C fuel gas	5%
CCUS on steel plant gases	40%
	90-100%

The steel industry has been increasingly exploring the use of biomass as an alternative to fossil fuels. The ULCOS[4] project has conducted extensive research on the availability and application of biomass in ironmaking. More recently, the RFCS GreenEAF[5] and GreenEAF2[6] have examined the use of agricultural residue biomass in the Electric Arc Furnace (EAF) melting process. Despite this, the direct use of biomass in coke production has not been widely adopted in Europe.

This is due to the need for a sustainable biomass market logistics and optimization of the coke-making process to achieve acceptable coke yield. Additionally, the cost of virgin or pre-treated biomass has been a deterrent. However, in line with the objectives of the Green Deal and the push for decarbonization, there is a growing need to further investigate the introduction of biomass in the coke-making process. This includes examining factors such as calorific value, density, grindability, moisture content, flammability behavior, and dust generation[7].

A recent review on the use of biomass in ironmaking process[8], define that from a perspective of the process application technology, biomass generally has the disadvantages of high moisture and alkali metal content, low fixed carbon content and calorific value, and low energy density. The development of biomass treatment technology can be efficiently applied to the ironmaking production process, which is the key to promote the industrial application of biomass metallurgy.

Some studies have reported a substitution ratio of 2%-10% of charcoal (also named biochar) in the mix for coke-making.

Charcoal is a solid material with chemical and thermo-chemical characteristics including low ash, higher heating values (HHV) and high surface area, suitable for ironmaking and steelmaking processes. In principle charcoal can replace fossil coal or coke in any process where these materials are used.

R.C. Gupta[9] compared the approximate composition of a charcoal (pyrolysis temperature 500°C) and a coke. The results showed a lower fixed carbon content and higher volatile fractions than coke, although the values are much improved compared to those of biomass as it is, but lower content of ash and sulphur. The ashes, although present in a lower quantity in the case of charcoal, are however found to have a higher basicity index, which would lead the charcoal to be more reactive than coke.

Blast furnaces working with charcoal are in operation in several countries (Australia[10], Brazil[11]) and there are even plans for expanding some of these operations. For the large furnaces in Europe the charcoal is not suitable to replace coke. Main constraints are the high reactivity of charcoal the limited strength and size and the ash content and composition.

A more realistic solution is to charge in blast furnace coke made from a blend of fossil coal and charcoal from biomass. Since this is currently the most promising route for introducing biomass in cokemaking process, this is the option chosen in this project.

The introduction of alternative raw materials in coke production, such as biomass, has already been studied in some RFCS projects and it is discussed in international literature. R. Wei et al[12]. carried out a quantitative analysis of the biomass composition of different species. Of particular interest is the low content of sulphur (about 10 times lower than coal) and nitrogen, which characterizes tree species. J. solar et al.[13] conducted quantitative analyses on different residues of olive pruning and eucalyptus wood, also finding reduced quantities of ash and sulphur.

Seo, M et al.[14] used boxwood as a raw material to add to coking coal in different proportions (0, 10, 15, 20, and 30 wt%) and carbonized it at different final temperatures (500–800 ◦C) to generate biochar. The calorific value of biochar is between 7200~7560 Kcal/kg, which is higher than the standard value (7000 Kcal/kg), indicating that biochar can be a suitable substitute for traditional fossil fuels.

E. Mousa et al.[7] reviewed the partial substitution of coal with charcoal in cokemaking. The analysis showed that, although the addition of any different materials in the coal blend can interfere the graphitization process with negative effects on the final quality of the coke, appropriate selection of the biomass and of the pyrolysis conditions to obtain appropriate charcoal characteristics can allow biomass utilization without impairing the product coke quality.

Among the RFCS projects, the main objective of ALTERAMA[15] project was to develop the use of materials not previously considered in cokemaking and to find technological solutions to increase the potential for inclusion in coking mixtures, while maintaining the quality of coke. For this purpose, tests were carried out with compaction and briquetting. The briquetting operation allowed to increase the density. The upper limit of the amount of briquettes present in the mixture has been identified at around 20% in order to avoid segregation phenomena and dangerous pressures on the walls during process. Taking into consideration briquettes containing biomass, the need to remain below 10% was demonstrated to preserve coke quality. In this case the briquettes were composed of 70% PCI coal, 15% pine or chestnut sawdust and tar as a binder for the remaining part. The addition of up to 5% of sawdust to high-grade coals was also tested on a pilot scale, demonstrated that the maximum replacement ratio was around 2% in order to preserve cold mechanical resistance of coke, CRI and CSR. In the test campaign, there were no substantial differences regarding the arboreal origin of the sawdust, but rather the use of roasted sawdust, which led to slightly better results.

In FLEXCOKE[16] alternative carbon sources were tested to produce coke with characteristics comparable to traditional coke. With reference to the selected biomass, their devolatilization behavior at temperatures above 400° C was studied by means of thermogravimetric analysis. The biomass ash content was also determined. The most promising biomass were found to be heat-treated i.e., torrefied or in the form of charcoal. The charcoals were mixed with coking coals, to have 5% of the mixture composed of biomass, 30% of medium-volatile coals (MV), 25% of high-volatile coals (HV) and the remaining 40% of low-volatile coals (LV). During laboratory scale activity, there was an increase in the yield of coke produced from a charcoal whereas a decrease in the yield was recorded with coke produced from the torrefied biomass, both cases with respect to the reference sample. The same biomass was then tested in a pilot coking plant, with lower replacement rates, i.e. 3% in the case of charcoal and 2% in the case of torrefied biomass. The analysis confirmed a similar trend. The coke produced in the laboratory tests were subjected to mechanical tests, which showed that for both types of biomasses the M40 index decreased by 4 points while the M10 index increased. The same trend was obtained for the pilot scale tests, for which, however, the deterioration was higher, in particular for the torrefied biomass rather than for the char. Thus, the introduction of biomass decreases mechanical resistance of coke produced.

2.2 Biomass types and availability for EU- case study

With regards to the overall biomass generation in the EU-27, here we aim to provide an approximate mapping of four main types of biomasses across the EU: Agricultural by-products, Forestry, Industrial residues, and Municipal waste.

Regarding the first type (**Agricultural by-products**), about 1 billion tons of dry vegetal biomass equivalent is currently supplied, with Germany at the top of the list being roughly half of it imported and the other half arising from crop production. Figure 2.1 shows the amount (t) of agricultural residues registered in the EU for each country, referring to 2020[17].

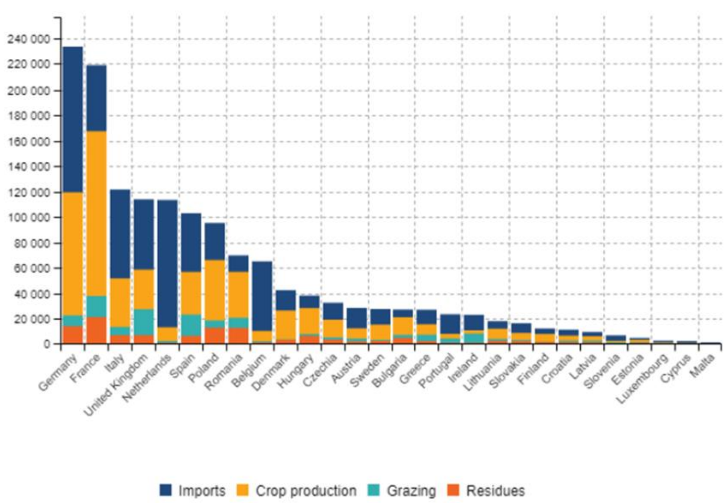

Figure 2.1 – Biomass flow in EU

Most biomass from agricultural by-products arise from crop production, accounting for about 600 Mt of dry biomass every year, and therefore representing about 61% of the total. It is important to notice that imports still account for a significant portion of the whole amount; such value must be monitored to assess the capacity of the EU of self-sustaining, especially considering the recent political events.

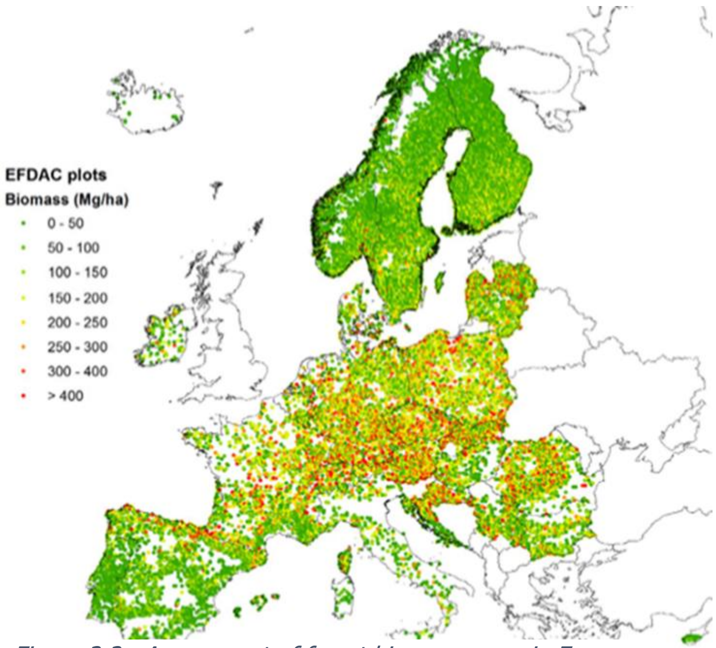

Figure 2.2 - Assessment of forest biomass maps in Europe

National statistics on **forest biomass** are periodically reported for all European countries by the national authorities for regional and global assessment purposes, such as the FAO Forest Resource Assessment (FRA) initiative and the State of Europe's Forest. However, given the large variety of forestry biomass across the EU, JRC launched in 2013 and 2015 two programs to identify and apply a common biomass definition to assess the effective availability across the EU. The European Forest Data Centre (EFDAC) harmonized mapping, including the aboveground biomass compartments of living trees, such as the dead stems and living branches, and foliage. Figure 2.2 shows an approximate mapping of forestry biomass in the EU[18].

The use of the **industrial residues** comparable to conventional biomass generally reflect spent yeast, spent grain, molasse, whey, and beet pulp by-products; the theoretical potential of such industrial residues in the EU-27 is strongly recognized and it is currently undergoing intense investigation. Figure 2.3 shows the theoretical potential (Mt) of industrial residues in biomass (and therefore biochar) making in the EU-27, updated to 2023[19]. The bar plots clearly show the comparably high theoretical biomass potential of whey and beet pulp. The largest producer of whey in the EU is Germany with 14 Mt/y followed by the Netherlands (9 Mt/y), Poland (7 Mt/y), Italy and Ireland (both at approximately 4 Mt/y). Nearly all countries show an increasing trend in whey production, especially Poland and the Netherlands.

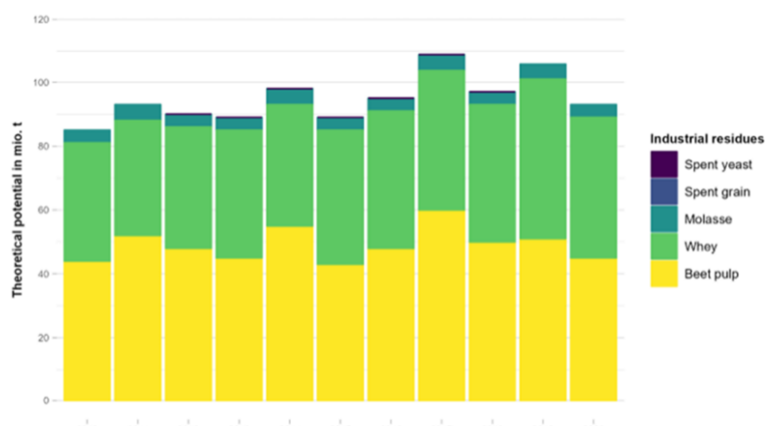

Figure 2.3 - theoretical potential (Mt) of industrial residues in biomass (and therefore biochar) making in the EU-27

Municipal waste is defined as waste collected and treated by or for municipalities. It covers waste from households, including bulky waste, similar waste from commerce, office buildings, institutions and small businesses, as well as yard and garden waste, street sweepings, the contents of litter containers, and market cleansing waste if managed as household waste. The definition excludes waste from municipal sewage networks and treatment, as well as waste from construction and demolition activities. Data on biogenic waste generation from private households, as reported by Eurostat, show a positive trend in total amount generated between 2010 and 2020, as shown in Figure 2.4 [19]. The EU-27 Member States generated a total of 37.2 million tons of biogenic waste in 2020, a 68% increase from 2010. Highly populated countries such as Germany, France, Italy, the Netherlands, and Poland generated the highest amounts. Western European countries collect the largest amounts of biogenic municipal waste due to high collection rates and population size.

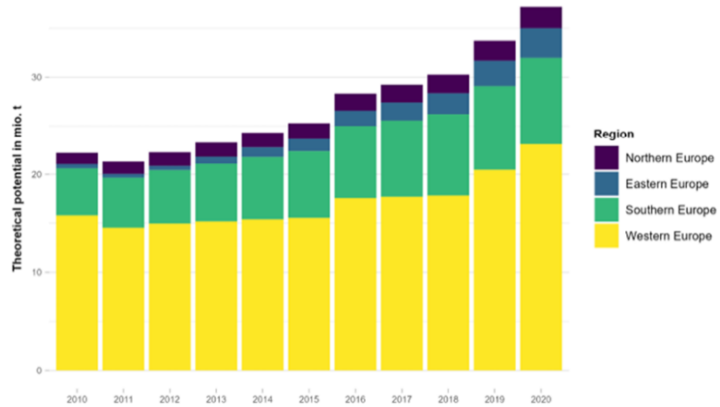

Figure 2.4 - Data on biogenic waste generation from private households

3 Preliminary considerations for selected case studies

The importance of biomass has been constantly and rapidly increasing in the last decade, especially due to the need for decarbonisation of energy-intensive sectors, apart from the obvious energy generation purpose. In the frame of the BioCoDe project, to support the intention of replacing fossil sources in coke-making throughout the EU, it is essential to evaluate the chemical and physical fitting of the biomasses available, whilst approximately assessing their amount and projected generation in the upcoming years.

The following paragraphs will investigate such aspects with focus on the situation in proximity of ADI steelworks (Taranto, Italy), and more in general, in Germany and in the EU-27.

3.1 Biomass types and availability for ADI case study

Embracing the tenets of circularity and sustainability within the green economy, the BioCoDe initiative emerges as a transformative endeavor aimed at valorizing local raw materials and stimulating demand for EU-sourced biomass.

The project's ambition to achieve a 10% substitution rate with charcoal at the Taranto site necessitates an estimated annual requirement of 160,000 tons of charcoal, equivalent to 640,000 tons of biomass based on a biochar production yield of 25%. This will be done by assessing the main types of biomasses in proximity of ADI, aiming to envision a sufficient, continuous, and low-carbon (in terms of transportation) solution for the successful application of the BioCoDe approach within the timeframe of the project and beyond.

In southern Italy, the predominant source of woody biomass is agricultural pruning waste, estimated at 1.16 million tons[20] (Figure 3.1). Figure 3.4 shows the biomass value chain in Taranto area. The straw is present in grater quantity. Conversely, continental Europe predominantly relies on forest residues[21] for biomass (Figure 3.4), a practice that aligns seamlessly with the principles underlying the BioCoDe initiative. Capitalizing on these diverse resources presents ample opportunities for fostering collaborative partnerships between the steel industry and the agricultural-forestry sectors, thereby driving economic prosperity.

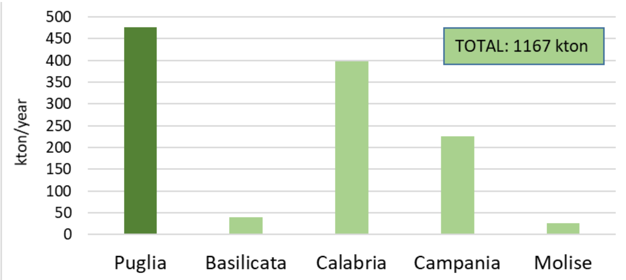

Figure 3.1 – Agricultural pruning waste in south Italy

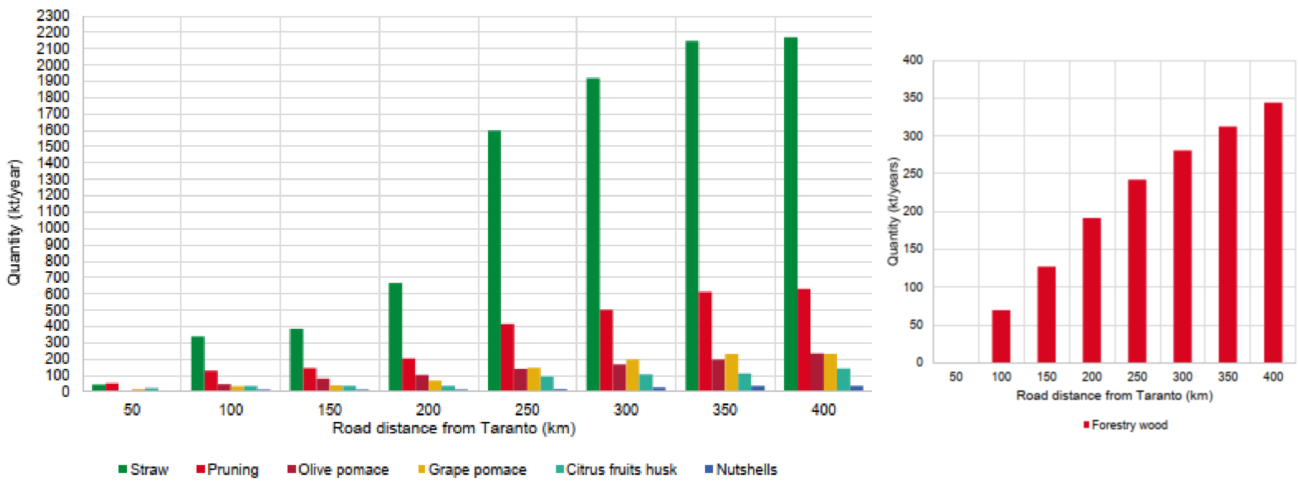

Figure 3.2 – Biomass value chain in Taranto Area

3.2 Biomass types and availability in Germany

Due to its large forest area, Germany is one of the largest wood producers in Europe and therefore has large amounts of forest residues and by-products from wood processing industries. The unutilized potential of biogenic residues from wood industry is currently between 9 and 12 million tons [22-23]. This consists mainly of wood residues that remain in the forest. The German Institute for Economic Research (DIW)[22] has estimated the availability of biomass up to the year 2050 and sees a stable potential with a slightly increasing trend for forestry residues in Germany for the entire period from 2020 to 2050. Since there are large areas of forest, especially in southern regions such as Bavaria, the Black Forest and the Palatinate, there is a greater technical potential for the use of residual wood in southern Germany than in northern Germany.[24]

The second group with a larger unused potential in Germany is agricultural by-products, with a total potential of about 18 million tons.[23] When considering this group, however, it should be noted that not all materials in this group are solid biogenic residues, and therefore materials such as cattle manure have no potential for use in cokemaking. The solid residues with the largest available and unutilized quantities in Germany include various types of cereal straw. As the agricultural areas tend to be located in northern Germany, the potential for straw is distributed in the opposite direction to the wood industry.[24]

Feedstocks	Dry mass (kt/y)			
	2020	**2030**	**2040**	**2050**
Cereal straw	3151	2971	3081	3081
Forestry residues	8913	9534	9902	10300
Open-country biomass residues	1264	1264	1264	1264
Industrial wood waste	3098	3098	3098	3098
Wood in municipal solid waste	1269	1225	1250	1250

Figure 3.3 – Potential of principal solid biomass residues for bioenergy, Germany, 2020-2050

Germany also accounts for 32% of European biochar production with 17,000 tons/year and the number of production units is estimated to increase from 570 today to more than 1000 in 2030. This means that there are already several biochar production facilities in Germany, and at the same time biochar producers are interested in providing biochar for metallurgical applications.[25]

Furthermore, widespread adoption of the BioCoDe approach throughout Europe has the potential to obviate the need for up to 3.3 million tons per year of extra-EU fossil coal procurement, thus strengthening the EU's fuel market autonomy. Against the backdrop of more than half of EU member states exhibiting import dependency rates exceeding 90% for hard coal in 2020, BioCoDe stands as a catalyst for reducing Europe's reliance on coal imports, thereby advancing energy security and sustainability goals.

Steamwood production	Primary forest residues	Secondary forest residues
• Part of tree stem from the felling cut to the tree- top with the branches removed, including bark	• Stem and crown biomass from early pre-commercial thinnings which consists of (thin) stems, branches, bark and needles and leaves • Logging residues from thinnings • Logging residues from final fellings which is mostly branches, bark, needles, and leaves • Stump extraction from final fellings	• Sawmill by-products (excluding saw dust) • Saw dust from sawmills • Other forestry industry by-products.

Figure 3.4 – Geographic distribution of steamwood, primary and secondary forest residue (in million dry tonnes, in 2030)

4 Innovative value of BioCoDe project

BioCoDe project will start from the experience of the previous RFCS project and will overcome the limits encountered solving the problems linked to the biomass quality and their impact on coke quality, thanks to several strategic actions summarized in this section.

Compared to the state of the art, in BioCoDe project more attention will be given to the selection of biomass type that will use for the process and pre-treatment to reach the replacement rate in coal blend up to 10%.

The BioCoDe project starts from the acquired knowledge that pre-treatment of biomass is inevitable, but intents to explore different possible thermal treatment and conditions, to individuate the most appropriate to individuate the most appropriate one to obtain adequate characteristics of the charcoal. On basis of experience of previous RFCS projects (GreenEAF2[6], FLEXCOKE[16]) charcoal will be bought from different producers using thermal pyrolysis and/or torrefaction processes, because the quality of this charcoal proved to be more suitable for the use in coal blend.

The BioCoDe project uses processes, methodologies, and technological knowledge already in use at laboratory and pilot scale to raise them to a first of a kind industrial scale demonstrator (TRL 7). The project is aimed at industrial experimentation, so the technologies and equipment will be adapted to the needs of the latter. The planned industrial experimentation will offer the possibility to directly investigate the effect of the use of charcoal in the coking process, monitoring the real process parameters to adjust also the operating conditions, besides the characteristics of the blend.

Finally, in addition to the experimental campaign at industrial level, the BioCoDe project provides a first concrete feasibility study for the scalability of the industrial coking process when biomass is added to the coal blends. This study will be fundamental step to evaluate the final results of BioCoDe approach in terms of environmental impact and economic feasibility resulting in a step forward toward further scaling up and commercialization.

Based on the state of the art the Technology Readiness Level is currently 5 for the biomass originated products utilization in coking blends tested with coking pilot oven. In BioCoDe the 10% of substitution rate of coal with charcoal in coal blend will be validated and demonstrated with experimentation on a coking pilot oven (TRL6). With the industrial campaign foreseen in BioCoDe project, TRL 7 will be assured, thus widening the field of use of biomass to produce coke on industrial scale. At the end of the project, the results can be used for industrial production by applying the methodologies, industrial practices and technologies experimented.

5 Approach

The project is structured into 6 WPs. The WPs structure is arranged in order to allow the integration of activities of all partners, without duplication and overlapping of works. Below a general scheme with a brief description is reported:

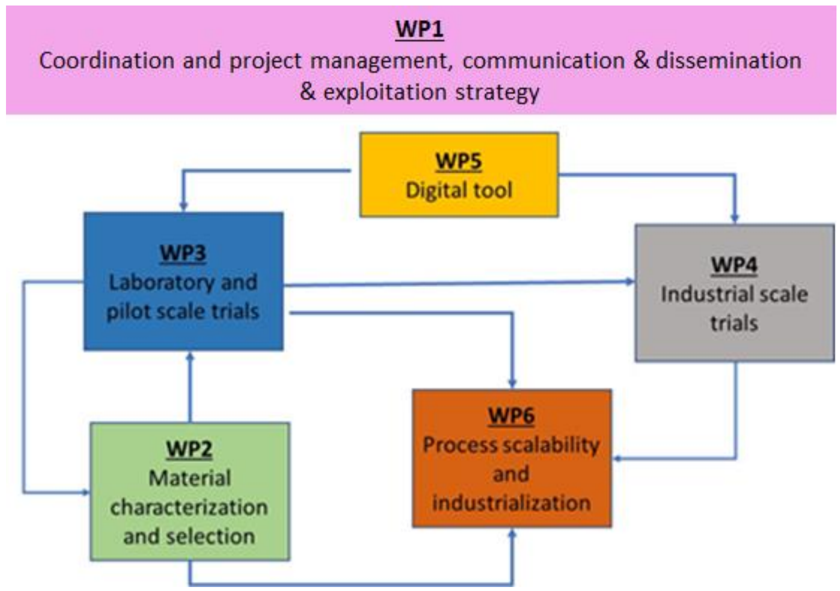

Figure 5.1 – WPs structure

WP1 - Coordination and project management, Communication, Dissemination, Exploitation strategy – In this WP the management of the work and information fluxes between the partners, purpose roles, assign tasks and WP and the related deadlines will be assured. Moreover, Dissemination and Communication and Exploitation (C&D&E) strategy will be defined and implemented.

The main objective of WP1 is the management and coordination of the whole project from the technical, legal, administrative and financial point of view, in order to have smooth and efficient action towards the successful implementation of the project. The specific objectives are defined as follow:

- ✓ Ensuring the achievement of the project targets in line with planned timing, quality and costs.
- ✓ Harmonization and effective coordination of the Consortium, to guarantee the joint action and smooth collaboration among all partners within the consortium, so to achieve the project objectives.
- ✓ Evaluation and management of project-related risks.
- ✓ Carrying out periodic communications to the European Commission and periodic production of high-quality technical and financial reporting of the project's progress.

WP2 – Material characterization and selection - Biomass and the treatment for biochar production will be individuated. A screening and selection of the biomass available in proximity of the involved industrial steel plants will be performed. Then, different biomass pre-treatments will be explored. Coals and coal blend that will be used as references in pilot and industrial tests and then will be mixed with biochar. Biomass addiction will be selected.

Main objectives are:

- ✓ Screening and selection of the biomass available in proximity of the involved industrial steel plants will be performed aimed at the definition of the most promising biomass for coke-making tests. Then, different biomass pre-treatments, both thermal and mechanical, will be explored to assess the optimal solution for biochar production.

- ✓ Selection of each single coals and coal blend suitable to be used in mixtures with biomass-based products in pilot and industrial tests in WP3 and WP4. In addition, both single coals and biomass+coals blends will be fully characterized.

WP3 – Laboratory and pilot scale tests - WP3 deals with the laboratory and pilot scale carbonization tests of the biochar/coal blends selected in the previous WP. The main objective is to select a limited number of candidates blends to be tested at 300 kg pilot scale, and then select the final mixtures to be tested in industrial coke plant.

The mixtures to be tested will be defined and analyzed in T2.4. Both, the biomass/coal blends coking behavior and the coke quality (e.g., hot strength, ash chemistry) will be determined and compared to a reference coal blend performance. Finally, the by-products from gas coke will be collected, sampled, analyzed and characterized, in order to evaluate the influence on biomass addiction.

WP4 – Industrial scale trials - The most promising blends tested in WP3 will be charged in an industrial coke oven cell. The produced bio-coke will be characterized, and the results compared with the current industrial standard. If compliant, the coke will be included in a blast furnace charge. Also, by-products will be sampled and analysed.

The objective of WP4 is to demonstrate, through industrial-scale testing, the use of biochar/biomass in the coking process. The biocoke produced by industrial tests will be characterized and its impact on the blast furnace process will be evaluated. The by-products will also be analysed, with the aim to evaluate the suitability of the actual coke oven gas treatment process and the possible implementation if needed. The mixtures to be industrially tested will be defined in WP3.

WP5 – Digital tool - Advanced digital tools will be developed, adapted, customized and installed, to enable required on-line data acquisition, monitoring and control during the execution of the various pilot and industrial tests, as well as deferred analysis. Future deployment of the same to full scale industrial plants will be also considered during design and implementation.

The 300 kg pilot plant will be equipped with thermocouples along the thickness of the furnace and inside the development tube in such a way as to correlate the different temperatures to the progress of the coking process and understand how the addition of biomass affects these parameters. The gas and its condensable components will be analyzed after being sampled at various time intervals via a custom-made system. The results obtained on the pilot scale tests will then be used to customize PIT's Distillation Process Module, which will be used to monitor the industrial scale tests.

The main objectives of the digital tools will be:

- ✓ Real-Time monitoring of systems to show process trend and detect anomalies and deviations;
- ✓ Definition and calculation of suitable performance indicators (KPIs) based on process data;
- ✓ Monitoring and analysis of the performances based on KPIs, providing charting and reporting.

WP6 – Process scalability and industrialization - In this WP, all the necessary requirements for the industrial scale-up will be fully evaluated. First, the feasibility study of the whole supply chain of the biomass (recovery, transportation, pre-treatment and mixing with the coal blend, charging in the industrial oven cell) is addressed. Moreover, all the necessary permits, both in terms of safety and environmental aspects, are evaluated. Then, an exhaustive LCA and economic evaluation is performed.

6 Outcomes

Different written deliverables will be done throughout the project, and they will include the following topics:

Work Package No	Deliverable Related No	Deliverable Name	Description
WP1	D1.1	Communication, Dissemination, and Exploitation plans [first release]	Publication of the first release of Communication, Dissemination, and Exploitation plans (EN). It outlines how the project intends to communicate its objectives and results to stakeholders, disseminate information to the general public, and exploit the results. This first version will include a detailed strategy for reaching the target audience, a timeline for dissemination activities, and plans for maximizing the impact of the project results.
WP1	D1.2	Policy Brief on enablers and barriers for biomass in the steel sector	The deliverable involves publishing (EN) a Policy Brief on the BioCoDe website, which provides an overview of the key factors that enable or hinder the use of biomass in the steel industry. The document is intended for policymakers and stakeholders involved in developing policies related to carbon-neutral energy sources and decarbonization efforts in the steel sector. The Policy Brief will include a review of existing policies and regulations, an analysis of the enablers and barriers to the use of biomass in the sector, and best practices and case studies from other regions or industries. Its objective is to provide recommendations for facilitating the adoption of biomass in the steel sector while identifying potential challenges and areas for further research and development.
WP1	D1.3	Workshops and final conference	The deliverable involves organizing a series of internal workshops throughout the project's development and a final conference towards the end of the project. These events will provide project team members and stakeholders with opportunities to share information, discuss project progress and results, and collaborate on future plans. The events will be supported by documentation in the form of

			presentations and information brochures, which will be issued to attendees.
WP1	D1.4	Communication, Dissemination, and Exploitation plans [final release]	The deliverable involves publishing the final version of the communication, dissemination, and exploitation plans (EN). The document describes how the project has communicated its objectives and results to stakeholders, disseminated information to the general public, and how it plans to further exploit the results.
WP2	D2.1	Comprehensive overview of the project	Comprehensive overview of the project in the form of a technical report (EN) where the steps to be taken are well detailed and based on the results obtained in the first months of the project.
WP2	D2.2	Biomass and biochar selection and characterization	This deliverable involves selecting appropriate biomass feedstocks for the project and characterizing their properties. The selection of biomass will be based on a variety of factors, including chemical-physical characteristic, availability and sustainability. Also the biochar produced from the biomass will also be characterized to determine its properties. All this information will be collected in a technical report (EN).
WP2	D2.3	Selection and characterization of the mixtures with coal, biomass/biochar	This deliverable provides for the issuance of a technical report (EN) containing the results of laboratory experiments on coal-biomass (biochar) mixtures selected, which will be characterized using the same methods conventionally used for coal-only mixtures. This report will also show the influence of blend pre-treatments on quality indicators.
WP3	D3.1	Influence of biomass type, its pre-treatment, and its percentage in the blend on coking behavior and coke quality	This deliverable involves the publication of a short report (EN) addressing the influence of biomass type, its pre-treatment and its percentage in the blend on coke behaviour and quality. This report will collect information from both laboratory and pilot coking trials and will be preparatory to the identification of mixtures to be tested on an industrial scale.
WP4	D4.1	Influence of the coal-biomass mixture on coking behaviour, coke quality and composition of by-products	This deliverable involves a report (EN) in which the results of the industrial tests carried out on the selected mixtures will be exposed with particular emphasis on the process's yield and the coke's quality.

WP4	D4.2	Influence of biocoke on Blast Furnace process	This deliverable involves a report (EN) in which the influence of the use of biocoke in blast furnace process and hot metal quality will be discussed. The report will analyze a series of technical parameters which will also be evaluated using a mathematical model of the blast furnace process.
WP5	D5.1	Distillation Process Module User Manual	This deliverable provides for the creation of an electronic format manual (EN) of the Distillation Process Module.
WP5	D5.2	Digital tool installation on plant for industrial scale trials	This deliverable involves the creation of the Digital Tool Server and the installation of pre-configured software.
WP6	D6.1	Overall techno-economic feasibility study	This deliverable involves a report (EN) on the overall technical-economic feasibility study concerning the industrial implementation of the BioCoDe concept.
WP6	D6.2	LCA and CO_2 savings report	This deliverable involves a report containing the results of LCA. The report will also include a forecast on the saving of CO_2 emissions deriving from the implementation of the BioCoDe concept.
WP6	D6.3	Public publishable report	This deliverable provides a summary report of the two previous ones intended for public dissemination.

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