GreenHeatEAF

Gradual integration of REnewable non-fossil ENergy sources and modular HEATing technologies in EAF for progressive CO2 decrease

D4.4 First Draft of the exploitation plan

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1. Exploitation Strategy

GreenHeatEAF applies a proven methodology to achieve successful sustainability of results and maximize their impact.

The exploitation strategy has two phases:

1. Analytical phase in the first 2 years of the project
2. Strategic and business orientated phase in the middle and end of the project

The first phase of the exploitation strategy focusses mainly on the definition of the impact plan, analysis of the deployment opportunities, identification of strategic stakeholders to be involved as well as potential adopters, the definition of the value proposition, and on the compilation of detailed description of exploitable results. This phase also includes a preliminary definition of the business and sustainability models. All partners describe here their first individual exploitation plans at this stage. The second phase addresses the definition and implementation of the sustainability strategy, considering the analysis and initial versions of previously mentioned elements. That includes deciding on the sustainability model and a deployment/commercialization strategy that fit better on partners' exploitation interests and market around, defining the value chain and the specific partner role for the sustainability of the GreenHeatEAF results especially in the post-project period.

The exploitation actions of GreenHeatEAF are in strong interaction with the dissemination and communication actions in this project to increase the future use of the developments in the steel industry.

Expected outcome: A business model will be developed in WP4 to guide the further exploitation of the project results by ensuring their viability and maximizing the derived economic benefits.

2. Methodology

In order to define the exploitation strategy, the starting points were the Key Exploitable Results (KERs) as defined in the GreenHeatEAF project. Table 1 reports the identified KERs.

Table 1: GreenHeatEAF KERs

No	Key Exploitable Result
KER1	CFD EAF process model to study alternative C-lean production and optimise process parameters for new boundary conditions
KER2	Industrial experience when using biomass/biochar in substitution of anthracite and/or foaming coal during the melting process in an EAF
KER3	Holistic and modular off-line simulation model of the EAF-based process including exploitation of non-fossil fuels and renewable C-materials and auxiliary units
KER4	Distributed advanced control system for flexible management of heat capacities in EAF-based steelmaking
KER5	Demonstration result from hydrogen use in CoJet burners for different charge mix praxis
KER6	Gas monitoring system based on AGAM and process data to support EAF off-gas heat recovery
KER7	Demonstrated HEC with existing technology and validated CFD model to predict combustion with hydrogen enriched fuel and enriched off-gases
KER 8	Test-bed for heat recovery from off-gas
KER 9	Demonstration of recovery of heat from EAF slag as energy source for slag reduction

The methodology applied was composed by the following steps:

1. definition of a set of questions about Gap analysis and exploitation plan for each KER;
2. collection of information from GreenHeatEAF partners involved in KERs;
3. analysis of collected answers;
4. collection of preliminary inputs about possible business plan.

2.1 Questionnaire definition

The questions reported in **Table 2** were designed for collecting information about **gap analysis**.

The gap analysis was performed in the first project year and it will updated during the entire project.

An individual exploitation plan is set up for each KER to define their expected results which can be exploited, to describe the value proposition, deployment opportunities and name possible stakeholders. The questions about individual **exploitation plan** are reported in **Table 3**.

Table 2: Questions for gap analysis

	Individual gap-analysis for KER # -	
#	**Question**	**Specific answers**
1	Company or institute, abbreviation.	
2	Tasks, in which you are involved/ for which you are responsible.	
3	What comparable developments or products are available on the market which have a comparable use case as the GreenHeatEAF – technologies (KER) are planned to have?	
4	Which gaps do these products have on the market or what specific properties / features are missing, when they are applied for the use cases?	
5	What do GreenHeatEAF – technologies (KER) achieve in addition? What is different or better when they will be applied for the use cases?	
6	What is the unique selling point of the GreenHeatEAF – technologies (KER) compared to existing technology/products?	

Table 3: Questions for individual exploitation plan

	Individual exploitation plan for KER #	
#	Question	Specific answers
1	Company or institute, abbreviation.	
2	Tasks, in which you are involved/ for which you are responsible.	
3	What is your expected result and/or development?	
4	What is your value proposition concerning exploitation?	
5	Description of exploitable results: Please describe in a few words your expected exploitable results.	
6	When do you expect your results? Date or time frame?	
7	What is/are your potential target group(s)?	
8	Which deployment opportunities do your results and /or developments have for industrial use?	
9	At what TRL are your results and/or developments?	
10	Which further development steps are necessary for the industrial use in plants, processes and/or production (if suitable)?	
11	Which stakeholders and decision makers will be involved in exploiting your developments? When will they be involved (month in project)?	
12	Sustainability plan: With which platforms do you expect to cooperate? (please select or add!)	
13	Which barriers (operational, market barriers and/or regulatory barriers) do you see for exploitation?	
14	Which strategy is foreseen to react on this/these barrier(s)?	
15	Preliminary definition of business and sustainable model (if applicable)? *)	
16	What is the target group for your development/results?	
17	Other…?	

All partners involved in a KER included the relevant planning for exploitation at the current stage of the project, achieved findings and results.

Here the planned and achieved results and developed technologies in GreenHeatEAF are compared with available, existing and comparable products or technologies on the market. This gap analysis is performed and updated during the project for each KER in the deliverables D4.5 and D4.6.

Finally, a strategic and business-oriented phase has been performed, in which the partners of a KER set up a **business plan** for the exploitation of developments and project outcomes by answering to the questions reported in **Table 4**.

Table 4: Questions for business-oriented phase

#	Question	Specific answers
1	Company or institute, abbreviation.	
2	Tasks, in which you are involved/ for which you are responsible.	
3	Topic, development, new technology or outcome. Which benefits result for possible users, when applying the developed technology of the project compared to applying existing technology or products: e.g., better production performance compared to…, higher quality of products, efficiency, economical or ecological benefits?	
4	Who are users in industry, who is potential customer?	
5	Who can manufacture, produce a product from the development: who are possible suppliers?	
6	How big is the market? How many customers are expected. Expected number of possible users, customers per year.	
7	Expected cost for implementation/invest of new technology?	
8	If relevant: savings per year achieved in industry with new technology?	
9	Other..?	

In the following chapters the individual gap analysis as well as the exploitation plans for each GreenHeatEAF- KER are listed as tables.

3. Analytical phase for exploitation

In the Analytical phase an individual exploitation plan is set up for each KER to define their expected results which can be exploited, to describe the value proposition, deployment opportunities and name possible stakeholders.

In the frame of the exploitation plan for each KER a gap analysis is performed in the first project year and updated during the entire project. Here the planned and achieved results and developed technologies in GreenHeatEAF are compared with available, existing and comparable products or technologies on the market. This gap analysis is performed and updated during the project for each KER in the deliverables D4.5 and D4.6.

2.1 Exploitation plan KER 1

2.1.1 Gap-Analysis

First gap analysis for KER 1 in which the planned and achieved results and developed technologies in GreenHeatEAF are compared with available, existing and comparable products or technologies on the market.

Table 5: Gap analysis for KER 1

Partners	Comparable developments or products are available on the market	Gaps or missing features of existing products	Added Value of GreenHeatEAF solution	Unique selling point/ features of GreenHeatEAF solution
BFI	Usage of C-lean gases without pre simulation, with higher risk of furnace misbehaviour/damage and total failure	No knowledge or impression how the furnace will behave with c-lean process gases	Early knowledge of process change, lower risk for furnace operator and stuff, better understanding of process and energy efficiency potential, responsible use of resources	See point 4-5, lower risk of furnace failure, better usage of resources and process optimisation and knowledge to react to critical furnace states, early adaptation options during the planning phase

2.1.2 Exploitation plan

Table 6: Exploitation plan for KER 1

BFI	
Expected result and/or development	Better understanding of influence caused by process gas changes (c-lean gases)
Value proposition	CO2 reduction, energy efficiency improvement
Description of exploitable results	Knowledge about furnace process states with C-lean process gases, potential of usage of gases in terms of CO_2 reduction, energy efficiency
Expected date	End of 2024
Potential target group(s)	Steel producer with EAF furnaces
Deployment opportunities for industrial use	Better estimation of reachable CO2 saving potential, process optimisation with usage of C-lean gases
TRL	TRL 4-7
Further development steps	Change of furnace equipment, change of furnace geometry, or plant aggregates (furnace, duct …)
Stakeholders and decision makers	EAF Furnace operator, Steelmaking Industry
Platforms to cooperate	ESTEP, SusChem, EUROFER, Federacciai, VDEh, Jernkontoret, Platea
Barriers	High cost for implementation/ acquisition costs of strategies, e.g. installation of new furnace equipment
Strategy to react on barrier(s)	Stepp wise implementation, implementation at new furnace purchase in the planning phase
Preliminary definition of business and sustainable model	Steelmaking Industry, furnace operator
Target group	Steelmaking Industry, furnace operator

2.2 Exploitation plan KER 2

2.2.1 Gap-Analysis

First gap analysis for KER 2 in which the planned and achieved results and developed technologies in GreenHeatEAF are compared to available, existing and comparable products or technologies on the market.

Table 7: Gap analysis for KER 2

Partners	Comparable developments or products are available on the market	Gaps or missing features of existing products	Added Value of GreenHeatEAF solution	Unique selling point/ features of GreenHeatEAF solution
HOG	The current product widely used is anthracite. There are several manufacturer/suppliers for biocarbon which few of them have been selected to be used during this project according to D2.1.	Höganäs has not been using biocarbon so far. This is planned as part of plant trials at Höganäs in 2024. Lower density of biocarbon could be a limiting factor which requires higher cost of post processing such as extrusion and crushing to increase the density	Deeper understanding of injection parameters when replacing anthracite by biocarbon.	Providing a platform combining both plant and pilot trials using Hydrogen burners and new source of foaming carbon for EAF production.
SID	The carbon source currently used in the melting process is anthracite, but in the market, there are other renewable C-sources than could be used as substitute. Market research involving more than 20 biomass experts (producers, research institutes and consultants) was carried out and 3 of them were selected for the trials	The properties that the biomass should accomplish to be used as substitute of anthracite were the Carbon content, ashes, volatile, moisture and HHV. It was possible to find materials with these properties, but the problem is the availability and costs.	The project allows to generate knowledge about the feasibility of using C renewable sources during the melting process. Once the biomass will be available, the transition will be much easier.	Industrial experiences using biomass, plastics and tires as substitute of the anthracite and foaming coal... what will provide new information about their impact on the facility, on the process and on the product.

CEL	The prevalent product in use currently is anthracite. There are multiple manufacturers /suppliers of biocarbon, and a specific subset has been chosen for utilization in this project as per Deliverable D2.1	Up until now, CELSA has refrained from utilizing biocarbon. However, in 2024, biocarbon incorporation is scheduled for experimentation during plant trials at CELSA. The potential constraint lies in the lower density of biocarbon, necessitating increased expenses for post-processing techniques like extrusion and crushing to enhance its density.	Enhanced comprehension of injection parameters during the substitution of anthracite with biocarbon.	Enhanced comprehension of injection parameters during the substitution of anthracite with biocarbon.

2.2.2 Exploitation plan

Table 8: Exploitation plan for KER 2

Question	HOG	SID	CEL
Expected result and/or development	To obtain a better understanding of the effect of biocarbon on the foaming process compared to anthracite.	To obtain a better understanding of the effect of biochar on the foaming process compared to anthracite.	To obtain a better understanding of the effect of biocarbon on the foaming process compared to anthracite.
Value proposition		It is a real industrial demonstration of the use of biochar, plastics, and tyres in the EAF.	Reduce in CO_2 emission in the steelmaking process, increase of circularity ratio.
Description of exploitable results	1) Potential supplier of biocarbon for long term delivery. 2) Understanding the cost involved for 100% replacement of anthracite with biocarbon including required extra storage. 3) Optimised process parameters for sufficient/efficient foaming practices by biocarbon.	1) Information about different biochar suppliers and about the availability of material. 2) Technical requirements for using these renewable C-sources in the EAF. 3) Optimised process parameters for the new operation with biochar, plastics and tyres.	1) Potential supplier of biocarbon for long term delivery. 2) Understanding the cost involved for 100% replacement of anthracite with biocarbon including required extra storage 3) Optimised process parameters for sufficient/efficient foaming practices by biocarbon.
Expected date	End of 2024	End of 2024	End of 2024
Potential target group(s)		EAF route industrial partners	Customers, politicians, suppliers, etc.
Deployment opportunities for industrial use	Full scale industrial trials with biocarbon replacing anthracite. This includes finding new/optimum injection parameters for biocarbon.	Full scale industrial trials with biocarbon replacing anthracite. This includes finding new/optimum injection parameters for biocarbon.	Full scale industrial trials with biocarbon replacing anthracite. This includes finding new/optimum injection parameters for biocarbon.
TRL	TRL 7	TRL 7	TRL 7
Further development steps	Tuning of biocarbon characteristics/composition to provide	Availability of sufficient amount of biochar at a competitive price.	Tuning of biocarbon characteristics/composition to provide acceptable foaming

	acceptable foaming practices based on Höganäs EAF furnace.		practices based on Höganäs EAF furnace.
Stakeholders and decision makers	Steel plant managers. During acquiring of biocarbon and after final trials and assessment of the obtained results.	Steel plant managers. During acquiring of biocarbon and after final trials and assessment of the obtained results.	Plant Managers, Innovation Managers, Sustainability Managers Managing Directors. Innovation & Sustainability Managers will be involved since the beginning of the project. Plant Managers & Managing Directors will be involved in the end of the project.
Platforms to cooperate	ESTEP, SusChem, EUROFER, Federacciai, VDEh, Jernkontoret, Platea	ESTEP, EUROFER, Platea, UNESID	ESTEP, A.SPIRE, EUROFER, Platea, INDPULS.
Barriers	Complexity involved in long term availability/supplying of biocarbon with a reasonable price suitable for EAF process.	Complexity involved in long term availability/supplying of biocarbon with a reasonable price suitable for EAF process.	Complexity involved in long term availability/supplying of biocarbon with a reasonable price suitable for EAF process.
Strategy to react on barrier(s)	Conduct market assessment considering Nordic and non-Nordic supplier of biocarbon.	Increase the consumption by steelmakers and other carbon consumers.	Conduct market assessment considering Nordic and non-Nordic supplier of biocarbon.
Preliminary definition of business and sustainable model			
Target group	Steel industry and production	Steel industry and biochar producers	Costumers & general public.

2.3 Exploitation plan KER 3

2.3.1 Gap-Analysis

First gap analysis for KER 3 in which the planned and achieved results and developed technologies in GreenHeatEAF are compared to available, existing, and comparable products or technologies on the market.

Table 9: Gap analysis for KER 3

Partners	Comparable developments or products are available on the market	Gaps or missing features of existing products	Added Value of GreenHeatEAF solution	Unique selling point/ features of GreenHeatEAF solution
SSSA	Few models allowing considering singularly the solutions studied in GreenHeatEAF and for investigating only limited aspects on the EAF-based process.	Jointly investigation on exploitation of non-fossil fuels and renewable C-materials is not possible. Limited aspects of the EAF-based process can be monitored. Models are generally theory-based without validation on industrial trials data Auxiliary units (e.g. for hydrogen production, biomass upgrading) are generally not included in the whole process route simulations.	Models validated and improved on industrial trials. Models including the possibility of simulating jointly the solutions proposed in GreenHeatEAF for analysing several aspects related to the EAF-based route (e.g. process behaviour, effects on product and by-product, emissions) and including the possibility of integrating auxiliary units for the internal production of hydrogen and for internal upgrading of biomass	The possibility of: 1. providing the steelworks of holistic knowledge on the effects of the usage of one single or multiple GreenHeatEAF solution on the process and related impact as well as on the product; 2. allowing investigating the advantages related to internal production and/or upgrading of alternative non-fossil fuel and C-sources.

2.3.2 Exploitation plan

Table 10: Exploitation plan for KER 3

Question	SSSA
Expected result and/or development	Providing a model suitable for multiple scenario simulations on the effect of the usage of non-fossil fuel and C-sources on the EAF-based route. Improving the related knowledge through the simulations, and providing indications on the best solutions for CO2 emission reduction.
Value proposition	Assisting and guiding the steelworks on managing in a feasible, efficient and suitable way more sustainable operating practices and materials.
Description of exploitable results	Model for multiple scenario analysis and feasibility studies of process transformation to lower Carbon footprint including the possibility of investigating on the impact of the integration of auxiliary units (e.g. of hydrogen production and biomass upgrading) inside the steelworks. Knowledge on the effect of the use of alternative and non-fossil fuel and C-sources on EAF-based process, product and impact. Suitability range of alternative C-sources and natural gas/hydrogen blend. Roadmap towards C-lean steel production including the use of alternative and non-fossil fuels and C-sources and the integration of related auxiliary units.
Expected date	End 2023 (first versions of the models) – end of March 2026 (last results of simulations)
Potential target group(s)	Steelmaking Industry, Workers, Researchers
Deployment opportunities for industrial use	Better understanding of EAF-process behaviour by using hydrogen as fuel and alternative C-sources. Services for helping steelworks on the deployment of these solutions.
TRL	TRL 6
Further development steps	The models can achieve higher TRL if they are validated with significant datasets concerning the continuous usage of proposed solutions (currently not available). In addition to be applied in plants, e.g. for supporting real-time decision, it needs to be converted in more complex dynamic model.
Stakeholders and decision makers	Steelmaking industry and related workers. Already involved in the project.
Platforms to cooperate	ESTEP, SusChem, EUROFER, Federacciai, VDEh, Jernkontoret, Platea

Barriers	Lack of models transferability and robustness because of low availability of a good set of data to tune the model. Limited capability to represent dynamic phenomena. License costs for the simulation environment Workers don't trust in simulation results. Lack of suitable skills to use the models.
Strategy to react on barrier(s)	GreenHeatEAF models are developed based on analytical equations according to a parametric approach and can be provided equipped with well-defined guidelines and procedures for their adaptation to other industrial plants. Developing surrogate/simplified models using data generated by the model. Improving the model by including also dynamic aspects. Training and upskilling of workers for allowing models usage and for trusting in simulation results
Preliminary definition of business and sustainable model	Services for scenario analyses and studies concerning the feasibility of process transformation to lower Carbon footprint.
Target group	Steelmaking Industry, Workers, Researchers, General public and society

2.4 Exploitation plan KER 4

2.4.1 Gap-Analysis

First gap analysis for KER 4 in which the planned and achieved results and developed technologies in GreenHeatEAF are compared to available, existing, and comparable products or technologies on the market.

Table 11: Gap analysis for KER 4

Partners	Comparable developments or products are available on the market	Gaps or missing features of existing products	Added Value of GreenHeatEAF solution	Unique selling point/ features of GreenHeatEAF solution
SSSA	Existing complex supervision and control systems trying to balance product quality and use of energy and material resources. Model Predictive Control solutions proved to be effective in managing energy streams in the context of traditional steelmaking routes.	A joint management of all the heat capacities in electric steelmaking, optimization of alternative C-sources and non-fossil fuel usage and heat recovery is not possible with existing systems	Distributed MPC-based solutions for optimal management of all the heat capacities and heat flows in EAF including alternative C-sources and non-fossil fuel and possibilities of heat recovery, by maximizing performance while reducing resource and energy consumptions.	Flexible and joint management of heat capacities and heat flows in EAF steelmaking by harmonising and synchronising the control of each subsystem.

2.4.2 Exploitation plan

Table 12: Exploitation plan for KER 4

Question	SSSA
Expected result and/or development	Distributed control system upgrading existing strategies. Reduction of fossil CO2 emissions. Improvement of energy efficiency of the process and of heat recovery
Value proposition	Maximizing the use of alternative C-sources and non-fossil fuel in EAF steelmaking, improving the related energy efficiency and the heat recovery
Description of exploitable results	Strategies for optimal usage of heat capacities and flows in EAF steelmaking.
Expected date	April 2026
Potential target group(s)	Steelmaking Industry
Deployment opportunities for industrial use	Better management of energy in EAF steelmaking reducing losses and improving heat sources exploitation efficiencies including alternative ones
TRL	TRL7
Further development steps	Improvement in monitoring and measurement systems (expected to be done in GreenHeatEAF) Establishment of infrastructure to collect the data and to allow the right connection and usage of developed control system
Stakeholders and decision makers	Steelmaking industry and related operators
Platforms to cooperate	ESTEP, SusChem, EUROFER, Federacciai, VDEh, Jernkontoret, Platea
Barriers	Models used in MPC do not fit to a different steelworks Computational cost, time and complexity Cost of control strategy design and implementation Cost of infrastructure establishment, system development, test and maintenance
Strategy to react on barrier(s)	Using simple model to be easily customized to different steelworks Starting with simple optimization formulations and gradually improving the complexity

	Using open-source libraries Establishing local data repository and a virtual machine to setup, tune and test the system
Preliminary definition of business and sustainable model	Services for improved control of energy capacities in EAF steelmaking extended to include waste heat recovering and usage of non-fossil fuels
Target group	Steelmaking industry

2.5 Exploitation plan KER 5

2.1.1 Gap-Analysis

First gap analysis for KER 5 in which the planned and achieved results and developed technologies in GreenHeatEAF are compared to available, existing, and comparable products or technologies on the market.

Table 13. Gap analysis for KER 5.

Partners	Comparable developments or products are available on the market	Gaps or missing features of existing products	Added Value of GreenHeatEAF solution	Unique selling point/ features of GreenHeatEAF solution
LINDE	CoJet-like burners are used in EAFs	These burners are not tested with hydrogen	Proven feasible, hydrogen fired CoJet burners will help the decarbonization effort of the steel industry	Proven feasible, hydrogen fired CoJet burners will help the decarbonization effort of the steel industry.

2.5.2 Exploitation plan

Table 14: Exploitation plan for KER 5

Question	LINDE
Description of exploitable results	Feasibility of hydrogen use in -EAF CoJet burners
Expected date	Promote emission free fuel, hydrogen, sales by demonstrating its use and effect on EAF product quality
Potential target group(s)	Knowledge on hydrogen fired CoJet burner operation, quantitative results on decarbonization level and product quality
Deployment opportunities for industrial use	Q4 2024
TRL	EAF operating steel mills, starting with the CoJet using 150 EAFs
Further development steps	There are around150 CoJet using steel mills that can utilize hydrogen if proven feasible
Stakeholders and decision makers	TRL 5 -> TRL 7
Platforms to cooperate	If found necessary, burner retrofitting effort will be required to optimize the CoJet operation
Barriers	Steel plant managers, when hydrogen is readily available in Europe
Strategy to react on barrier(s)	ESTEP, SusChem, EUROFER, Federacciai, VDEh, Jernkontoret, Platea
Preliminary definition of business and sustainable model	Lack of available hydrogen, high green hydrogen prices
Target group	Linde is investing on electrolysers to produce green hydrogen
Expected result and/or development	
Value proposition	EAF operating steel mills

2.6 Exploitation plan KER 6

2.6.1 Gap-Analysis

First gap analysis for KER 6 in which the planned and achieved results and developed technologies in GreenHeatEAF are compared to available, existing and comparable products or technologies on the market.

Table 15: Gap analysis for KER 6

Partners	Comparable developments or products are available on the market	Gaps or missing features of existing products	Added Value of GreenHeatEAF solution	Unique selling point/ features of GreenHeatEAF solution
BFI	Thermocouples, Thermal mass flow and the AGAM, which are used in other processes, e.g. Blast Furnace.	The new AGAM at KER6, will measure the temperature and gas flow in real time, so the operator can handle the process saving more energy.	Early knowledge of process change, lower risk for furnace operator and stuff, better understanding of process and energy efficiency potential, responsible use of resources.	See point 4-5, lower risk of losing energy, better usage of resources and process optimisation and knowledge to react to critical furnace states, early adaptation options during the planning phase.

2.6.2 Exploitation plan

Table 16: Exploitation plan for KER 6

Question	BFI
Expected result and/or development	Optimization of the energy usage
Value proposition	Energy efficiency improvement
Description of exploitable results	This system will filter and analyze the available information and give feedback to the operator how to optimize heat recovery. One aim is to optimize the suction flow rate of the primary dedusting system to increase energy efficiency of the EAF.
Expected date	30.05.2025
Potential target group(s)	Energy intensive producer, as Steel plants with EAF furnaces
Deployment opportunities for industrial use	Saving energy, more heat recovery systems are possible, optimise the geometry of exhaust gas tubes
TRL	TRL8
Further development steps	Change of furnace equipment, change of furnace geometry, or plant aggregates (furnace, duct, tubes …)
Stakeholders and decision makers	EAF Furnace operator, Steelmaking Industry, M34
Platforms to cooperate	ESTEP, SusChem, EUROFER, Federacciai, VDEh, Jernkontoret, Platea
Barriers	High cost for implementation/ acquisition costs of strategies, e.g. installation of new furnace equipment
Strategy to react on barrier(s)	Cost savings through lower energy consumption, Stepwise implementation, implementation at new furnace purchase in the planning phase, Funding
Preliminary definition of business and sustainable model	
Target group	Steelmaking Industry, furnace operator

2.7 Exploitation plan KER 7

2.7.1 Gap-Analysis

First gap analysis for KER 7 in which the planned and achieved results and developed technologies in GreenHeatEAF are compared to available, existing, and comparable products or technologies on the market.

Table 17: Gap analysis for KER 7

Partners	Comparable developments or products are available on the market	Gaps or missing features of existing products	Added Value of GreenHeatEAF solution	Unique selling point/ features of GreenHeatEAF solution
BFI	Developments of supplier i.e., SMS: New burners are developed. But not existing burners for hydrogen enhanced combustion (HEC) like in the project	Missing availability of Hydrogen as a fuel. No tests in Advance performed. Therefore, security issues and risk of damage in EAF, when test of existing burners with HEC are performed in the plant.	The developments and studies are relevant information for assessing the feasibility and risk of implementation and planning the implementation accordingly.	If technology is feasible: simplicity of applying hydrogen as fuel for decarbonisation.

2.7.2 Exploitation plan

Table 18: Exploitation plan for KER 7

Question	BFI
Expected result and/or development	Validated simulation results of applying HEC for EAF heating and the heating of the melt itself with this fuel of transition to carbon free heating -> Relevant information for the decision-making process of applying this technology in EAF.
Value proposition	Process specific validated simulation results for EAF heating by combustion.
Description of exploitable results	Feasibility of HEC application in pilot scale for existing burners.
Expected date	Burner tests first half of 2024. Simulation results from 2025 to summer 2026.
Potential target group(s)	Steel producers with the EAF route and combustion heating in their EAF.
Deployment opportunities for industrial use	Relevant data for decision-making processes if other producers are planning to apply hydrogen for EAF heating.
TRL	Project start TRL 5, project end TRL 6
Further development steps	Not clear at this state, if simulation of other burners are necessary and purposeful or if experiments for other use cases are essential.
Stakeholders and decision makers	DEW, Höganäs - during the project. Other EAF operators approximately in last project year and after the project ended.
Platforms to cooperate	ESTEP, SusChem, EUROFER, Federacciai, VDEh, Jernkontoret, Platea
Barriers	Regulations for NOx emission norming.
Strategy to react on barrier(s)	Keep in contact and inform experts in technical committees for these norming processes.
Preliminary definition of business and sustainable model	
Target group	EAF burner suppliers and operators with combustion heating in their EAF.

2.8 Exploitation plan KER 8

2.8.1 Gap-Analysis

First gap analysis for KER 8 in which the planned and achieved results and developed technologies in GreenHeatEAF are compared to available, existing, and comparable products or technologies on the market.

Table 19: Gap analysis for KER 8

Partners	Comparable developments or products are available on the market	Gaps or missing features of existing products	Added Value of GreenHeatEAF solution	Unique selling point/ features of GreenHeatEAF solution
BFI SWERIM	Not for heat recovery from EAF off gas for gas preheating.	Heat recovery from off gas is used for: a) steam generation used for electric power generation b) scrap preheating before charging the EAF. These are other technological approaches.	Process internal heat recovery and increase of process efficiency for preheating the future input materials: DRI/HBI	Heat recovery for EAF-process internal use and for future operation with future input materials.

2.8.2 Exploitation plan

Table 20: Exploitation plan for KER 8

Question	BFI, SWE
Expected result and/or development	Heat recovery from aggressive and dust loaded off gas from the EAF. Knowledge of recuperator regarding heat resistance, thermal stress, deposits on recuperator surface and efficiency
Value proposition	Increased energy efficiency of the EAF by in-process heat recovery from its off-gases by using the ceramic recuperator

Description of exploitable results	Concept for heat recovery from EAF off gas with ceramic recuperator to preheat gases. Proof of feasibility to operate recuperator with high dust load. Results of heat exchanger efficiency. - A pilot testbed for heat-recovery - Recuperator that manage the high dust load and fluctuation of gas temperature
Expected date	2025
Potential target group(s)	Suppliers for EAF plants and EAF operators
Deployment opportunities for industrial use	Heat recovery from aggressive and dust loaded off gas at 1.300 °C especially EAF off gas. Results will show a recuperator suitable for heat recovery of EAF. An important input for further projects on higher TRL.
TRL	TRL 5
Further development steps	Long term tests under industrial conditions need to be carried out.
Stakeholders and decision makers	EAF plant suppliers and operators 2025/2026
Platforms to cooperate	ESTEP, SusChem, EUROFER, Federacciai, VDEh, Jernkontoret, Platea
Barriers	Safety regulation due to toxic off gas. Dust load and fluctuations of gas temperature, Low TRL, Investment cost
Strategy to react on barrier(s)	Further technical development of this technology i.e., pilot trials conducted in the project. Long term trials in industrial scale.
Preliminary definition of business and sustainable model	Not yet.
Target group	EAF operators.

2.9 Exploitation plan KER 9

2.9.1 Gap-Analysis

First gap analysis for KER 9 in which the planned and achieved results and developed technologies in GreenHeatEAF are compared to available, existing, and comparable products or technologies on the market.

Table 21: Gap analysis for KER 9

Partners	Comparable developments or products are available on the market	Gaps or missing features of existing products	Added Value of GreenHeatEAF solution	Unique selling point/ features of GreenHeatEAF solution
SSAB	GGBS-Ground Granulated Blast Furnace Slag has the properties as a SCM-Seconcary Cementitious Material ie an alternative cement clinker material.	The hydraulic properties of the slag from EAF needs to be improved by postprocessing with heat and or additives.	Reduce the carbon footprint of cement raw material since the EAF slag has a lower emission rate compared to the BF-slag.	Modified EAF slag through Green Heat modification will enable the use of EAF slag as SCM and thereby decrease waste from steel process and support circularity of slag.

2.9.2 Exploitation plan

Table 22: Exploitation plan for KER 9

Question	SSAB
Expected result and/or development	Knowledge of the feasibility of modifying EAF slag for the use as a cement raw material.
Value proposition	Reduce carbon emissions for cement production. Save energy in cement production. Utilize heat in liquid slag and avoid slag deposit, improving circularity.
Description of exploitable results	Given positive outcome of the trials, the results will display feasibility for a method for slag modification in slag pot. For industrial verification.
Expected date	Main results will be generated during 2024.
Potential target group(s)	Cement and concrete producers.
Deployment opportunities for industrial use	Results will show the suitability of producing cement from modified EAF-slag. This will be important input for further industrialization projects.
TRL	TRL 5-7
Further development steps	Development of industrial process including dedicated process equipment.
Stakeholders and decision makers	If feasible method is identified, steel making plant managers will be involved in next step trials (not a part of this project). This will be towards the end of the project.
Platforms to cooperate	ESTEP, SusChem, EUROFER, Federacciai, VDEh, Jernkontoret, Platea
Barriers	Cost efficiency, process kinetics and robustness of the process.
Strategy to react on barrier(s)	Results will generate more detailed data for building business cases depending on the circumstances.
Preliminary definition of business and sustainable model	Modified slag will be a product of the steelmaker, to be sold as raw material for the cement industry.
Target group	Steelmakers and cement industry.

4. Business orientated phase for exploitation

In the strategic and business-oriented phase the partners of a KER set up a business plan for the exploitation of developments and project outcomes.

These development plans are then used by all partners to inform stakeholders and decision makers they contact during and after the project. The different business plans are then assembled by the project partners with regard to the specific interests of the stakeholders.

3.1 Business plan – structure (phase 1) for KER 1

Content of the business plan named by each partner in KER 1 guided by **Table 23**.

Table 23: Business plan for KER 1

Partners	Topic, development, new technology or outcome	Potential customer	Possible suppliers	Expected cost for implementation/invest of new technology	Savings per year achieved in industry with new technology
BFI	Contribution to reach the Green Deal, lower CO_2 emissions towards 2050, contribution to improve the leadership for clean products and technologies usage of renewable raw materials (usage of bio-based C and green H_2), process optimisation, enhanced efficiency	Steel-making Industry, operator of EAF furnaces	Plant manufacturer, supplier of furnace equipment	40k –60k € for model-based tools Installation/modification of hardware (furnace)	165 €/heat 5-10% from off gas saving

In the **strategic and business-oriented phase** from July 2025 on, further points will be added to the business-plan according to the project progresses.

3.2 Business plan – structure (phase 1) for KER 2

Content of the business plan named by each partner in KER 2 guided by **Table 24**.

Table 24: Business plan for KER 2

Partner	Topic, development, new technology or outcome	Potential customer	Possible suppliers	Expected cost for implementation/invest of new technology	Savings per year achieved in industry with new technology
HOG	Usage of bio-based C, process optimisation and enhanced efficiency for full industrial trials.	Steel producers	Biocarbon suppliers where steel producers are the customers	Will be resulted at the end of the trials	Will be resulted at the end of the trials.
SID	Usage of bio-based C, process optimisation and enhanced efficiency for full industrial trials	Steel producers	Biocarbon suppliers, plastics and tyres waste suppliers.	Depends on the material	Savings are expected only in CO_2 emissions
CEL	NA	NA	NA	NA	NA

In the **strategic and business-oriented phase** from July 2025 on, further points will be added to the business-plan according to the project progresses.

3.3 Business plan – structure (phase 1) for KER 3

Content of the business plan named by each partner in KER 3 guided by this table.

Table 25: Business plan for KER 3

Partner	Topic, development, new technology or outcome	Potential customer	Possible suppliers	Expected cost for implementation/invest of new technology	Savings per year achieved in industry with new technology
SSSA	Better knowledge of the effect of the use of alternative C-sources and non-fossil fuel on EAF steelmaking will allow a more efficient management of the process by obtaining advantages in terms of energy efficiency, emissions and product/by-product compositions. Furthermore, economic benefits can be obtained knowing in advance the best way to use these new materials and how to integrate related auxiliary units in existing plants.	Steelworks manager and internal researchers	Model developers, researcher	50k-70k€ for the customization of models	Full replacement of fossil carbon with alternative C-bearing materials and full usage of hydrogen as fuel

In the **strategic and business-oriented phase** from July 2025 on, further points will be added to the business-plan according to the project progresses.

3.4 Business plan – structure (phase 1) for KER 4

Content of the business plan named by each partner in KER 4 guided by **Table 26**.

Table 26: Business plan for KER 4

Partner	Topic, development, new technology or outcome	Potential customer	Possible suppliers	Expected cost for implementation/invest of new technology	Savings per year achieved in industry with new technology
SSSA	Increased energy efficiency of EAF process. Decrease of heat waste. Reduction of fossil CO_2 emissions. Continuous process and product quality improvements. Economic benefits because of saving in terms of energy and material costs.	EAF process operators The market is strictly related to the number of steelworks approaching to the transition to C-lean processes	Researchers and technology providers	300k-500k for customization of control strategies, development of infrastructure and implementation of the tools	Savings in terms of energy and materials costs, and CO_2 emissions

In the **strategic and business-oriented phase** from July 2025 on, further points will be added to the business-plan according to the project progresses.

3.5 Business plan – structure (phase 1) for KER 5

Preliminary elements of business plan are not currently available for KER 5.

3.6 Business plan – structure (phase 1) for KER 6

Content of the business plan named by each partner in KER 6 guided by **Table 27**.

Table 27: Business plan for KER 6

Partner	Topic, development, new technology or outcome	Potential customer	Possible suppliers	Expected cost for implementation/invest of new technology	Savings per year achieved in industry with new technology
BFI	Contribution to reach the Green Deal, lower CO2 emissions towards 2050, contribution to improve the leadership for clean products, process optimisation, enhanced efficiency	Energy intensive producer, as Steel plants with EAF 44 EAFs in Europe	Plant manufacturer, supplier of furnace equipment and exhaust tubes	80000 Euro	3026765.3 MW/year if it will be implemented in all EAFs in Europe

In the **strategic and business-oriented phase** from July 2025 on, further points will be added to the business-plan according to the project progresses.

3.7 Business plan – structure (phase 1) for KER 7

Preliminary elements of business plan are not currently available for KER 7.

3.8 Business plan – structure (phase 1) for KER 8

Content of the business plan named by each partner in KER 8 guided by **Table 28**.

Table 28: Business plan for KER 8

Partners	Topic, development, new technology or outcome	Potential customer	Possible suppliers	Expected cost for implementation/invest of new technology	Savings per year achieved in industry with new technology
BFI, **SWERIM**	New technology, energy efficiency of the EAF can be increased by in-process heat recovery from its off-gases by using the ceramic recuperator	Steel producers	Supplier of ceramic customised SiSIC products.		Energy savings, reduced costs.

In the **strategic and business-oriented phase** from July 2025 on, further points will be added to the business-plan according to the project progresses.

3.9 Business plan – structure (phase 1) for KER 9

Content of the business plan named by each partner in KER 9 guided by **Table 29**.

Table 29: Business plan for KER 9

Partners	Topic, development, new technology or outcome	Potential customer	Possible suppliers	Expected cost for implementation/invest of new technology	Savings per year achieved in industry with new technology
SSAB	Reduced carbon emissions when EAF-slag is replacing BF-slag as a cement raw material.	Cement industry. 10-30% of cement could be replaced with modified EAF-slag.	Steelmaker will be supplier, cement industry will be customer.	Will be a result of the project	Will be a result of the project

In the **strategic and business-oriented phase** from July 2025 on, further points will be added to the business-plan according to the project progresses.

5. IPR Strategy and Protection

This chapter is part of D4.4 and D4.5.

All outputs of creative endeavour or intellectual activity generated or used during the Project that may be capable of legal protection under relevant applicable national laws, or information that should be kept confidential due either to its nature or the way in which it was communicated. IP may include, without limitations:

a) Literary works, including publications of research results, and associated materials, including drafts, data sets and laboratory notebooks.
b) Teaching and learning materials.
c) Other original literary, dramatic, musical or artistic works, sound recordings, films, broadcasts, typographical arrangements, multimedia works, photographs, drawings, and other works.
d) Databases, tables or compilations, computer software, preparatory design material for a computer program, firmware, courseware, and related material.
e) Patentable and non-patentable technical information, technical products and processes.
f) Designs including layout designs (topographies) of integrated circuits.
g) Trade secrets.
h) Know-how, information and data associated with the above.
i) Patentable and non-patentable inventions.
j) Registered industrial designs or industrial designs that are capable of being registered.
k) Registrable and unregistered trademarks used or intended to be used in relation to the Project IP; and
l) Any other outputs of creative endeavour or intellectual activity not expressly included above.

The intent of IPR strategy and Protection Plan is to:

(i) facilitate the widespread use of, through various modalities of access to, the Project's IP;
(ii) mitigate strategic, financial and reputational risk related to IPR management;
(iii) preserve the trust of the community, which is critical for the successful delivery of the current or any future Ppoject;
(iv) encourage and support cooperation between the Partners and wider Research & Education community and
(v) coordinate protection of the Project IP and to manage and exploit the Project IP and IPR granted to it.

IPR strategy and Protection Plan of GreenHeatEAF complies with the rules defined in Grant Agreement (GA) and Consortium Agreement (CA), including the general rules and recommendations for Horizon Europe Programme. GA establishes the right and obligations between the European Commission and the GreenHeatEAF consortium partners. The GA number 101092328, Article 16 (Intellectual property right (IPR) – background and results – access rights and right of use), defines the rules for handling Intellectual Property Rights, their use, and dissemination. The GreenHeatEAF is based upon the DESCA model consortium agreement for HE. CA further defines and specifies relevant IP arrangements, in full compliance with the provisions provided in GA.

IPR-relevant key terms in the context of HE projects are: background, results, and access rights. In the following paragraphs, definitions of terms important for consideration of IPR protection as specified in GA and CA, are summarized:

Background means any data, know-how or information — whatever its form or nature (tangible or intangible), including any rights such as intellectual property rights — that is:

(a) held by the beneficiaries before they acceded to the Agreement and
(b) needed to implement the action or exploit the results."

Results means any tangible or intangible effect of the action, such as data, know-how or information, whatever its form or nature, whether or not it can be protected, as well as any rights attached to it, including intellectual property rights.

Access rights — Rights to use results or background.

Dissemination — The public disclosure of the results by appropriate means, other than resulting from protecting or exploiting the results, including by scientific publications in any medium.

Exploitation — The use of results in further research and innovation activities other than those covered by the action concerned, including among other things, commercial exploitation such as developing, creating, manufacturing, and marketing a product or process, creating and providing a service, or in standardisation activities.

Fair and reasonable conditions — Appropriate conditions, including possible financial terms or royalty-free conditions, taking into account the specific circumstances of the request for access, for example the actual or potential value of the results or background to which access is requested and/or the scope, duration or other characteristics of the exploitation envisaged.

FAIR principles — 'findability', 'accessibility', 'interoperability' and 'reusability'.

Open access — Online access to research outputs provided free of charge to the end-user.

Open science — An approach to the scientific process based on open cooperative work, tools and diffusing knowledge.

Research data management — The process within the research lifecycle that includes the organisation, storage, preservation, security, quality assurance, allocation of persistent identifiers (PIDs) and rules and procedures for sharing of data including licensing.

Research outputs — Results to which access can be given in the form of scientific publications, data or other engineered results and processes such as software, algorithms, protocols, models, workflows and electronic notebooks.

CA could be regarded as written agreement among the project partners (beneficiaries/parties) on the results ownership, including joint ownership, transfer of results, dissemination of the results, including the unpublished results or background, use of names, logos, and trademarks, and access rights. Thus, all partners agreed on rules regarding IPR ownership, access rights to results and background for the project execution and protection IPR, and confidential information, as addressed in greater detail in CA between the partners.

During the project, all partners adhered to these agreements and all project activities were compatible with them.

6. Conclusions

Within the first draft version of the exploitation strategy of GreenHeatEAF, which is presented in this document, all partners involved in a KER have set up a first version of their individual exploitation plans on a KER-by-KER basis. Such plans are based on the current status and foreseen development of the project activities.

This plans will be updated during the project according to the work development as well as to the individual and joint exploitation activities that will be carried out.

List of tables

List of acronyms and abbreviations

Acronym	Full Name
AGAM	Acoustic GAs temperature Measurement
BF	Blast Furnace
BFI	VDEh Betriebsforschungsinstitut GmbH
CA	Consortium Agreement
CFD	Computational Fluid Dynamics
DRI	Direct Reduced Iron
EAF	Electric Arc Furnace
EASES	European Academic Symposium on EAF Steelmaking
ESTEP	European Steel Technology Platform
EU	European Union
GA	Grant Agreement
GBF	Granulated Blast Furnace (referred to slag)
HBI	Hot Briquetted Iron
HEC	Hydrogen Enhanced Combustion
HHV	Higher Heating Value
IT	Information Technology
KER	Key Exploitable Result
ML	Machine Learning
MPC	Model Predictive Control
MVP	Minimum Viable Product
RFCS	Research Fund for Coal and Steel
SSSA	Scuola Superiore Sant'Anna
TRL	Technology Readiness Level
WP	Work Package