



Guidelines for transferability, and stakeholder and AB consultations report

Stefano Dettori, Ismael Matino, Valentina Colla, Henrik Saxén, Carl
Haikarainen, Maximilian Bernds

15.06.2026



Project co-funded by the Horizon Europe programme

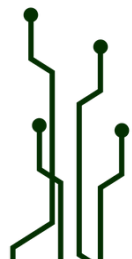
G.A. 101138813

Version	Date	Authors	Partners	Description
0.1	09.06.2026	Stefano Dettori	SSSA	First draft
1.0	15.06.2026	Stefano Dettori, Ismael Matino, Valentina Colla, Henrik Saxén, Carl Haikarainen, Maximilian Bernds	SSSA ÅAU BFI	Submitted version

The information and views set out in this document do not necessarily reflect the official opinion of the European Commission. The European Commission does not guarantee the accuracy of the data included in this document. Neither the European Commission nor any person acting on the European Commission's behalf may be held responsible for the use which may be made of the information contained therein.

Table of content

Table of content	3
1 Introduction.....	5
2 Stakeholders and Advisory Board	6
2.1 Stakeholder and Advisory Board engagement approach	6
2.2 Advisory Board Composition, Expertise, and Roles	7
2.3 First Advisory Board Consultation Workshop	9
2.4 Results of the First Advisory Board Consultation.....	11
2.4.1 Software architecture, modularity and transferability	11
2.4.2 Digital Twin concept and system representation	11
2.4.3 Optimization, Decision Support and multi-time-scale Planning.....	12
2.4.4 Decarbonization pathways and future steelmaking scenarios	12
2.4.5 Business cases, regulatory frameworks and industrial adoption	13
2.4.6 Key recommendations	13
3 Transferability analysis	15
3.1 Transferability of Digital Twins and models.....	15
3.2 Transferability of the multi-agent optimization framework.....	15
3.3 Transferability of the software platform architecture.....	16
3.4 Transferability of User Interfaces and the decision-support layer	16
3.5 Transferability of optimization objectives and KPIs.....	17
3.6 Additional transferability dimensions and critical aspects	18
3.6.1 Data heterogeneity and integration challenges	18
3.6.2 Scenario configuration and model adaptation	18
3.6.3 Explainability and transparency	19
3.6.4 Maintainability and extensibility.....	19
3.6.5 Interoperability with external Decision Support Systems	19
4 Next steps.....	21
5 Conclusions.....	23
6 List of Tables.....	25
7 List of acronyms and abbreviations	25
8 Annex 1.....	26



1 Introduction

This document reports the outcomes of *Task 6.3 Stakeholder and public consultation to maximize transfer of results* in the AgiFlex project.

AgiFlex develops a multi-agent environment for integrated steelmaking plants, intended to support energy optimization, future plant configuration studies, and decarbonization roadmaps, including pathways involving direct reduction (DRI/HBI), electric arc furnace (EAF) integration and carbon capture systems. The document first presents initial results and analyses related to project transferability and sessions of consultation with the public, stakeholders and the project Advisory Board, with comments and analyses of received suggestions. The consultation activities involved industrial, operational, process, digitalization, and strategy-oriented stakeholders as well as an Advisory Board selected for guiding the project from an external perspective. The main outcome of the consultation is a prioritized set of requirements and assumptions that will guide subsequent model development, scenario design, and validation activities. Finally, the focus will be on maximizing the exploitation of the Key Exploitable Results (KERs).

The deliverable does not provide a specification of the platform; instead, it focuses on transferability assumptions, stakeholder requirements, consultation evidence, and implications for future development and validation work.

Section 2 describes the activities with the stakeholders and Advisory Board, including composition, methodologies, meetings, suggestions and first results. Section 3 discusses the first transferability analysis, Section 4 the next steps, while Section 5 finally summarizes some concluding remarks. Annex 1 reports the documents available for the Advisory Board.

2 Stakeholders and Advisory Board

This section presents the work that includes stakeholders and an external Advisory Board (AB) as information source for guiding the project on technical aspects, objectives, methodologies, and identification of scenarios. Moreover, this section discusses the mechanisms implemented for the consultation and an analysis of the first outcomes.

2.1 Stakeholder and Advisory Board engagement approach

The stakeholder engagement strategy has been designed to ensure that the development of the software platform remains aligned with industrial needs, operational practices, and future transformation pathways of the steel industry. The engagement process involves both industrial stakeholders directly associated with the project use cases and the external AB providing independent strategic and technical guidance throughout the project lifecycle.

The primary stakeholder group consists of representatives from the industrial partners involved in the project case studies, including plant managers, production planners, process engineers, energy managers, digitalization experts, and other professionals who are expected to be either direct users or beneficiaries of the AgiFlex platform. Their involvement is considered essential to guarantee that the developed multi-agent-based software reflects real industrial constraints, operational procedures, decision-making processes, and long-term strategic objectives.

During the initial phase of the project, stakeholder engagement has been primarily focused on the identification of requirements. Structured interactions were organized with the industrial partners to collect information regarding operational workflows, production planning practices, process constraints, performance indicators, decarbonization objectives, and future plant transformation scenarios. The collection of information is currently ongoing and will be consolidated into a comprehensive requirements specification document, including functional requirements, non-functional requirements, expected system capabilities, business objectives, and performance indicators of the software.

In parallel, an AB has been established to provide independent expertise and external perspectives. The AB includes experts from industry, research organizations, and related technological domains, covering competencies in steelmaking operations, process optimization, digital transformation, industrial artificial intelligence, energy systems, sustainability, and business strategy. The AB's role extends beyond technical review and includes providing recommendations on project organization, methodological approaches, validation procedures, dissemination activities, and exploitation opportunities. Through

periodic consultations, the AB contributes to ensuring the scientific robustness, industrial relevance, and long-term impact of the AgiFlex project.

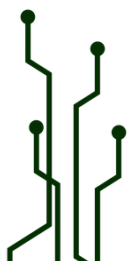
The stakeholder and AB engagement process follows a continuous and iterative methodology. Rather than relying on isolated consultation events, AgiFlex aims at adopting a feedback-driven approach in which stakeholder inputs are progressively integrated into the design, development, validation, and demonstration phases of the project. This iterative process allows the consortium to continuously refine assumptions, identify emerging requirements, validate modelling choices, and assess the practical applicability of the developed solutions. To support this process, several engagement methodologies are employed throughout the project:

- Workshops aimed at identifying functional and non-functional system/software requirements and capturing domain knowledge from industrial experts.
- Semi-structured interviews, allowing detailed discussions on operational challenges, decision-making procedures, and future industrial needs.
- Meetings and consultations, where stakeholders evaluate representative steelmaking and transition scenarios to assess realism and relevance.
- Technical review meetings, involving the AB to evaluate methodological choices, modelling assumptions, and validation strategies.
- Demonstration and validation workshops and meetings, during which stakeholders assess platform outputs, usability, explainability, and decision-support capabilities.
- Exploitation and impact consultations, focused on identifying potential adoption pathways, business opportunities, scalability aspects, and transferability to other industrial contexts.
- Journal publications, conference presentations and technical presentations in conjunction with visits, with feedback from academia and industry.

This structured engagement framework aims at ensuring that AgiFlex remains grounded in industrial reality while simultaneously benefiting from external expert guidance. It also supports the project's objective of developing a transferable decision-support platform capable of addressing the evolving challenges of future low-carbon steel production systems.

2.2 Advisory Board Composition, Expertise, and Roles

To ensure the scientific excellence, industrial relevance, and long-term impact of AgiFlex, the consortium established an AB composed of internationally recognized experts from academia, industry, and technology providers operating in the steelmaking and industrial digitalization sectors. The AB has been established to provide complementary expertise covering the main dimensions addressed by AgiFlex, including steel production processes, production planning and optimization, digital transformation, industrial artificial intelligence, energy management,



decarbonization strategies, and industrial innovation. The combination of academic researchers, industrial end-users, and technology providers allows the project to benefit from multiple perspectives, ensuring that methodological developments remain scientifically sound while addressing practical industrial needs and future market requirements.

Unlike project partners, AB members are not directly involved in the implementation of project activities. Their role is to provide independent assessments and recommendations throughout the project lifecycle. They support the consortium in evaluating the consistency of modelling assumptions, identifying potential technological and organizational risks, validating strategic directions, and assessing the transferability of project outcomes to different industrial contexts and steel production routes. The AB also contributes to the evaluation of emerging trends in the steel industry, including decarbonization pathways, the integration of direct reduction technologies, the increasing role of electric arc furnaces, industrial energy flexibility, and the adoption of advanced digital decision-support systems. Through periodic consultations and review meetings, members provide guidance on methodological choices, validation strategies, stakeholder engagement activities, and future exploitation opportunities.

The composition of the AB reflects the multidisciplinary nature of AgiFlex and ensures that the project benefits from expertise spanning the entire value chain, from metallurgical process understanding to industrial software deployment and strategic innovation management. The composition of the AB is reported in Table 1.

Table 1: Composition of the Advisory Board.

Name	Organization	Role
Prof. Johannes Schenck	Montanuniversität Leoben	Head of Chair of Ferrous Metallurgy
Dr. Martin Schlautmann	PSI Metals	Product Manager Liquid Production, Decarbonization & Energy Services
Dr. Marcus Neuer	Aachen University	Lecturer
	innoRIID GmbH	Department Head
Dr. Frank Schaub	ArcelorMittal	Head of R&D Germany
Dr. Costanzo Pietrosanti	Danieli automation	Industry 4.0 Consultant

The expertise represented within the AB covers all strategic areas relevant to AgiFlex. Prof. Johannes Schenck contributes extensive knowledge in ferrous metallurgy, steelmaking

processes and technologies, and future production routes, supporting the evaluation of process modelling assumptions and transition scenarios. Dr. Martin Schlautmann brings significant experience in production planning systems, manufacturing execution systems, industrial software solutions, and decarbonization-oriented modelling and optimization. Dr. Marcus Neuer provides expertise in industrial innovation, digital transformation, artificial intelligence, automation, optimization and control solutions. Dr. Frank Schaub contributes by a strong industrial perspective on steel production, research and development, technology deployment, and the practical challenges associated with decarbonization and process transformation in large-scale steel plants. Dr. Costanzo Pietrosanti provides expertise in Industry 4.0 technologies, automation systems, digital manufacturing architectures, industrial integration challenges, and quality control. He is currently research and development project evaluator at the Research Fund for Coal and Steel (RFCS).

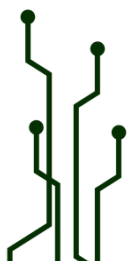
Collectively, the AB supports AgiFlex in maintaining a balanced perspective between scientific innovation and industrial applicability. Their recommendations are expected to contribute significantly to the robustness of the developed methodologies, the realism of the simulated scenarios, the transferability of the platform across different steelmaking contexts, and the identification of pathways for future industrial adoption and exploitation.

2.3 First Advisory Board Consultation Workshop

At the current stage of the project, the first AB consultation meeting was conducted with the objective of presenting the overall project framework, including its strategic goals, organizational structure, methodological foundations, and planned technical activities. The meeting also served as an interactive workshop aimed at collecting expert feedback, identifying opportunities for improvement, and gathering recommendations to support both the technical development and the overall project execution. Emphasis was placed on discussing the proposed approaches from scientific, technological, and industrial perspectives, with the objective of validating key assumptions, identifying potential risks and limitations, and assessing the adequacy of the planned methodologies with respect to the project objectives. The consultation additionally provided an opportunity to highlight strengths, potential weaknesses, and areas requiring further investigation in future project phases.

The meeting was held on 27 May 2026 in an online format and had a duration of approximately 90 minutes. A total of 13 participants attended the meeting, including 9 representatives from the project consortium and 4 members of the AB. Representatives of the coordinating institution, Åbo Akademi University (ÅAU), acted as facilitators and moderators of the session, ensuring a structured discussion and promoting focused exchanges on the key technical, organizational, and strategic topics under consideration.

To maximize the effectiveness of the consultation process, the meeting followed a predefined agenda covering project objectives, use cases, methodological approaches, stakeholder expectations, and future development plans. The facilitated discussion enabled the collection



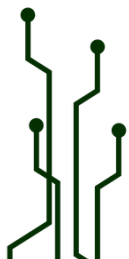
of valuable recommendations, which will be subsequently consolidated and translated into actions and considerations for the ongoing development of the AgiFlex platform.

The presentation material shared with the AB included a comprehensive overview of the project objectives, methodological framework, technological developments, demonstrator activities, and planned exploitation strategy. The objective was to provide the Advisory Board members with sufficient background information to enable informed discussions and targeted feedback on the project's technical and strategic directions.

To facilitate the consultation process, a set of guiding questions was prepared by the consortium and discussed internally prior to the meeting. These questions were designed to stimulate discussion on industrial relevance, software usability, technology differentiation, exploitation opportunities, energy transition challenges, and future steelmaking scenarios:

- What is your interest in the project?
- What do you consider to be the most important aspects of the project?
- What should be taken into account regarding usability when developing the software?
- From your perspective, which application of the software has the greatest potential?
- What similar developments are you already familiar with and how should we differentiate ourselves from them?
- What are the main barriers or risks for industrial adoption and what are the main reasons for failure among pilot projects in this area?
- With the objective of developing a high TRL product/software, what and how should we develop for achieving each Key Exploitable Result (KER)?
- What key aspects of energy management for integrated steelmaking – also during the transition period – should we consider? (e.g., due to a different production setup, process off-gases may be less available in the future)
- Assuming that hydrogen becomes available in the future, what would be the first processes ready to use it, even if only a small amount was available?
- What do you think would be the most relevant features to include in the AgiFlex software and the most important scenarios to study?

The presentation slides used during the workshop are provided in Annex 1. The following section summarizes the feedback collected during the consultation process, including observations, recommendations, annotated responses, and key discussion points raised by the AB members.



2.4 Results of the First Advisory Board Consultation

The first Advisory Board consultation generated valuable feedback regarding the strategic direction of the project, the proposed software architecture, the industrial applicability of the developed solutions, and the long-term exploitation potential of AgiFlex. Although the individual comments originated from different areas of expertise, several common themes emerged during the discussion.

2.4.1 Software architecture, modularity and transferability

A recurring recommendation concerned the importance of designing the AgiFlex platform as a highly modular software ecosystem. The AB members emphasized that transferability across different steel plants, production routes, and future industrial configurations will strongly depend on the modularity of the implemented architecture. A modular design would facilitate adaptation to different operational environments while reducing customization efforts and increasing maintainability.

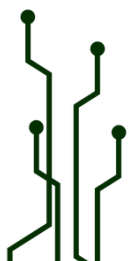
Particular attention was also given to the evolution of modern software engineering practices. The AB members highlighted the rapid changes currently taking place in software development, including the growing adoption of AI-assisted programming approaches and Large Language Models (LLMs). Consequently, the project should aim to develop interoperable and extensible software components that remain compatible with emerging programming paradigms and future digital ecosystems.

Another recommendation concerned the separation between back-end functionalities and front-end applications available for the users. The AB stressed that efforts should focus on developing robust back-end services, simulation engines, optimization modules, and data integration capabilities, while avoiding excessive dependence on specific graphical user interfaces. Such an approach would improve long-term maintainability and facilitate future integration with external software platforms.

2.4.2 Digital Twin concept and system representation

Several comments focused on the conceptual positioning of Digital Twins (DT) within AgiFlex. The AB highlighted that DTs should not be viewed solely as static simulation models but rather as dynamic representations continuously connected to the state of the physical system. In this perspective, DTs constitute an operational framework integrating real-time information, predictive models, simulation capabilities, and intelligent agents.

The discussion suggested that the relationship between DTs and Multi-Agent Systems (MAS) should be clarified in future project communications and dissemination material. Rather than considering the two concepts as separate entities, agents should be presented as components



operating within a broader DT ecosystem capable of supporting monitoring, simulation, optimization, and decision-making activities.

The availability and quality of industrial data were also identified as potential risks for successful deployment. Several participants highlighted that data accessibility, data consistency, and system integration challenges could become significant bottlenecks during industrial implementation and should therefore be considered from the early stages of development.

2.4.3 Optimization, Decision Support and multi-time-scale Planning

The optimization capabilities of the AgiFlex platform were identified as one of the most innovative and valuable aspects of the project. The AB members expressed particular interest in the possibility of implementing optimization agents operating across different planning horizons, ranging from operational and tactical scheduling activities to strategic transformation planning.

The discussion highlighted the importance of clearly defining the decision-making layers addressed by the platform and the corresponding optimization objectives. The AB collectively recommended further clarification regarding the temporal scope of the proposed optimization framework, including long-term planning, production scheduling, energy management, investment planning, and decarbonization pathway assessment.

Another relevant recommendation concerned the explicit representation of controllable variables and decision levers within the simulated system. According to the AB, the platform should clearly identify which process parameters, operational settings, and planning decisions can be manipulated by the optimization agents and how such decisions influence technical, economic, and environmental performance indicators.

2.4.4 Decarbonization pathways and future steelmaking scenarios

The AB strongly emphasized the importance of addressing future steelmaking transformation pathways. Members highlighted that one of the main strengths of AgiFlex lies in its capability to evaluate alternative production configurations and support decision-making under uncertainty. Several future-oriented scenarios were proposed as particularly relevant for industrial stakeholders. These include the progressive integration of Direct Reduced Iron (DRI) and Electric Arc Furnace (EAF) technologies, carbon capture and utilization/storage solutions, hydrogen-based production routes, and emerging process technologies such as electrolytic ironmaking.

Particular interest was expressed in evaluating the environmental and economic implications of alternative steel production routes, including comparative assessments of carbon dioxide emissions, energy consumption, production costs, and operational flexibility. The AB also

highlighted the need to investigate transitional scenarios in which traditional blast furnace operations coexist with emerging low-carbon technologies.

2.4.5 Business cases, regulatory frameworks and industrial adoption

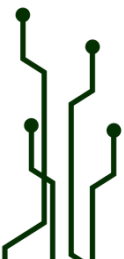
A significant portion of the discussion focused on the influence of regulatory frameworks on industrial decision-making. The AB members emphasized that future business cases for decarbonization technologies are strongly dependent on evolving regulations, carbon pricing mechanisms, energy policies, and incentives related to green hydrogen and low-carbon steel production. Consequently, participants suggested that the AgiFlex platform should support the analysis of alternative regulatory scenarios and quantify their impact on investment decisions, operational strategies, and technology adoption pathways. Such capabilities could provide valuable support to industrial stakeholders when evaluating future transformation strategies and interacting with policymakers.

The AB also stressed the importance of maintaining a strong focus on practical implementation and industrial exploitation. Several members emphasized that the project should prioritize the development of robust, maintainable, and demonstrable software solutions capable of achieving a high Technology Readiness Level (TRL). In this context, the flexibility of the platform, its scalability, and its ability to generate tangible value for industrial users were identified as key success factors.

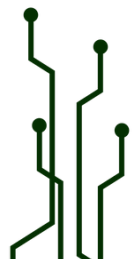
2.4.6 Key recommendations

The consultation resulted in several recommendations that will be considered during the next phases of the project:

- Strengthen the modular architecture of the AgiFlex platform to maximize transferability and maintainability.
- Clarify the relationship between DTs and MAS within the project methodology.
- Prioritize robust back-end services and interoperable software components.
- Explicitly define decision-making layers, planning horizons, and controllable variables addressed by the optimization framework.
- Incorporate future steelmaking transformation scenarios, including DRI, EAF, hydrogen-based processes, carbon capture technologies, and emerging production routes.
- Evaluate the impact of regulatory and policy frameworks on decarbonization business cases.
- Investigate forecasting capabilities for CO₂ emissions, energy consumption, and resource utilization.
- Maintain a strong focus on industrial applicability, usability, scalability, and long-term software sustainability.



Overall, the feedback provided by the AB confirmed the relevance of the project objectives and highlighted several opportunities to strengthen the methodological framework, increase industrial impact, and improve the long-term transferability of the AgiFlex platform.



3 Transferability analysis

The transferability analysis of AgiFlex aims at defining the key design principles and methodological guidelines that enable the deployment of the platform across different industrial contexts, steel production routes, and decision-making horizons. In particular, the analysis focuses on identifying the architectural, algorithmic, and operational characteristics that ensure adaptability, scalability, and reusability of the developed digital solutions beyond the specific case studies considered in the project. This transferability analysis extends the recommendations gained through the collaboration with stakeholders and the Advisory Board, considering the current stage of the project.

The platform has been conceived as a modular and extensible ecosystem composed of interoperable components, including digital twins of processes and main equipment, multi-agent optimization algorithms, data management services, and user interaction interfaces. This modularity is a fundamental enabler of transferability, as it allows individual components to be replaced, extended, or reconfigured without affecting the overall system architecture.

3.1 Transferability of Digital Twins and models

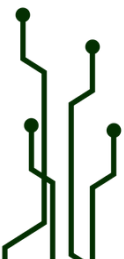
A core element of AgiFlex transferability is the design of DTs representing the main steelmaking processes and energy transformation equipment involved in integrated steelmaking routes. These include primary ironmaking routes (blast furnace-based systems), secondary steelmaking processes, direct reduction technologies, EAFs, and associated energy and material flow systems. Each digital twin is developed as a process-agnostic modelling unit characterized by:

- Standardized input/output interfaces.
- Configurable physical and operational parameters.
- Scenario-dependent boundary conditions.
- Compatibility with several levels of data availability.

This abstraction layer ensures that DTs can be transferred and reused across different plant configurations and industrial environments with minimal adaptation. In addition, the same modelling structure can support both existing brownfield plants and future greenfield or hybrid production routes, enabling consistent scenario comparison and long-term transition analysis.

3.2 Transferability of the multi-agent optimization framework

The optimization layer of AgiFlex is based on a multi-agent system architecture, where each agent represents a specific active decision entity, process unit, or operational objective. This



design inherently supports transferability, as agents can be added, removed, or reconfigured depending on the complexity and characteristics of the target industrial system.

Transferability of the optimization framework could be ensured through:

- Decomposition of decision-making into modular agents.
- Separation between local decision rules and global coordination mechanisms.
- Ability to operate across multiple time scales (operational, tactical, and strategic),
- Configurability of graph describing the connection between processes and production steps, including energy and material flows.

This structure allows the same optimization methodology to be applied to different steelmaking pathways, including traditional blast furnace/basic oxygen furnace routes, hybrid configurations with EAFs, and future hydrogen-based direct reduction systems. The main objective is to reduce the adaptation of the optimization framework to different case studies, describing the optimization objectives and constraints in terms of the main energy and material flows.

3.3 Transferability of the software platform architecture

From a software engineering perspective, AgiFlex is designed as a service-oriented and modular platform based on interoperable web services. This architectural choice ensures scalability, maintainability, and ease of integration in heterogeneous industrial IT environments.

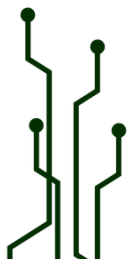
Key transferability enablers include:

- Modular back-end services exposing standardized and clear Application Programming Interfaces (APIs).
- Decoupling between simulation engines, optimization modules, and data layers.
- Containerized deployment enabling cloud or on-premises execution.
- Interoperability with external industrial systems, such as Manufacturing Execution System (MES), Enterprise Resource Planning (ERP), and historic databases.

This architecture ensures that AgiFlex can be deployed in different industrial ecosystems without requiring substantial redesign of the main software components.

3.4 Transferability of User Interfaces and the decision-support layer

The Graphical User Interface (GUI) and the associated decision-support layer represent one of the most case-study-dependent components of the AgiFlex platform. Unlike the DT models and the multi-agent optimization framework, which are designed with a high degree of abstraction and modularity, the user interface is inherently influenced by the specific



operational context, decision workflows, and organizational practices of the target industrial environment. For this reason, the GUI is considered the least directly transferable component of the overall architecture. Its structure, layout, and interaction paradigms are strongly shaped by the characteristics of the demonstrator cases, including differences in production planning practices, key performance indicators used at plant level, hierarchy of decision-making, and the level of digital maturity of the end users.

While the back-end components of AgiFlex are designed to ensure reusability across different steelmaking routes and plant configurations, the interface layer is expected to require a certain degree of customization when deployed in new industrial contexts. This customization may include adaptation of visual dashboards, redefinition of user workflows, restructuring of scenario comparison views, and tailoring of visualization of Key Performance Indicators (KPIs) to match site-specific decision priorities.

Nevertheless, a clear separation between back-end logic and front-end implementation will be adopted to mitigate this limitation and improve portability. By exposing functionalities through standardized APIs and service interfaces, the core simulation and optimization capabilities remain fully reusable, while the GUI can be independently redesigned or extended without modifying the underlying computational components.

In this perspective, the transferability strategy for the decision-support layer is not based on strict replication across sites, but rather on the provision of a flexible and configurable front-end framework. This framework is intended to support partial reuse of interface components, while explicitly acknowledging that full transferability will require co-design activities with end users and domain experts in each deployment context.

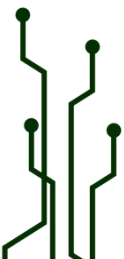
Overall, the user interface should be regarded as an adaptive layer of the AgiFlex ecosystem, where transferability is achieved through reconfiguration and customization rather than direct reuse, reflecting the diversity of industrial workflows and decision-support requirements across different steelmaking environments.

3.5 Transferability of optimization objectives and KPIs

An important aspect of AgiFlex transferability is the definition of a flexible and extensible set of optimization objectives and KPIs. These KPIs are designed to capture both operational performance and sustainability targets.

The main KPI categories include:

- Economic indicators, such as production cost, energy cost, and operational efficiency.
- Environmental impacts, focused on CO₂ emissions.
- Operational indicators, including throughput and resource utilization.



The optimization framework will enable the evaluation of trade-offs between cost efficiency and decarbonization targets, which is essential for supporting industrial transition strategies under uncertain regulatory and market conditions.

3.6 Additional transferability dimensions and critical aspects

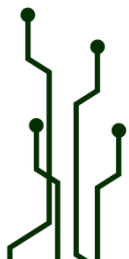
Beyond the transferability considerations related to digital twins, optimization agents, software services, and user interfaces, several additional dimensions have been identified that may significantly influence the adoption and replication of AgiFlex in different industrial environments. These dimensions represent both opportunities and potential limitations that should be carefully considered when assessing the transferability of the developed platform.

3.6.1 Data heterogeneity and integration challenges

Data availability and data interoperability represent the most significant challenges for the transferability of the AgiFlex platform. The steel industry is characterized by a high degree of technological heterogeneity, resulting from decades of plant-specific developments, vendor-specific automation solutions, and evolving digital infrastructures. Industrial facilities often employ different process automation systems, manufacturing execution systems, ERP solutions, and proprietary databases. Furthermore, data models, naming conventions, sampling frequencies, and data quality standards may vary substantially not only between companies but also between production sites belonging to the same industrial group. As a consequence, the deployment of AgiFlex in a new industrial environment is expected to require significant effort in terms of data mapping, integration, validation, and harmonization. While the project aims to adopt standardized interfaces whenever possible, the lack of widely adopted data standards across the steel sector remains a major challenge that limits full transferability and should be considered a relevant deployment risk.

3.6.2 Scenario configuration and model adaptation

Another important transferability challenge may concern the configuration of simulation and optimization scenarios. Although the platform is designed to support different steelmaking routes and transition pathways, the creation of meaningful and realistic scenarios requires extensive domain knowledge and detailed understanding of site-specific constraints. Scenario definition typically involves assumptions regarding production capacities, process configurations, energy infrastructures, raw material availability, operational constraints, market conditions, and regulatory frameworks. Such information is often highly context-dependent and cannot be automatically transferred from one industrial environment to another. Consequently, the adaptation of the platform to new use cases may require dedicated engineering activities for model calibration, specific parameterization, and scenario definition. This aspect is particularly relevant given the prototype nature of the platform,



which prioritizes methodological validation and proof-of-concept demonstration over fully automated scenario generation capabilities.

3.6.3 Explainability and transparency

In contrast to the challenges discussed above, explainability and transparency are considered dimensions with a relatively high degree of transferability. The multi-agent architecture and DT framework adopted may naturally support traceability of decisions, simulation outcomes, and optimization recommendations. The project aims to provide clear visibility of the assumptions, constraints, objectives, and decision variables involved in each simulation and optimization run. Such transparency is essential for industrial acceptance and facilitates validation by process experts, planners, and decision-makers. Since these capabilities are largely independent of the specific industrial configuration, they can be transferred across different deployment contexts with limited adaptation effort, owing to the physically grounded formulation of optimization problems, and the inherent explainability of modelling approaches used.

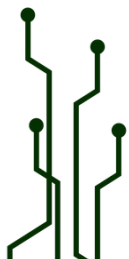
3.6.4 Maintainability and extensibility

The modular architecture adopted is expected to facilitate long-term maintainability and extensibility of the platform. Digital Twins, optimization agents, data services, and user interface components are developed as relatively independent modules, allowing future modifications and extensions without requiring substantial redesign of the overall system. This architectural approach supports the gradual incorporation of new process technologies, optimization objectives, simulation capabilities, and decision-support functionalities. As a result, maintainability and extensibility are considered among the strongest contributors to the long-term transferability of the platform.

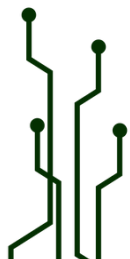
3.6.5 Interoperability with external Decision Support Systems

The interoperability of AgiFlex platform with external decision-support systems, commercial optimization tools, and third-party software ecosystems represents a desirable long-term objective. However, achieving interoperability is beyond the scope of the current project and should not be considered a guaranteed outcome of the prototype.

The diversity of software environments currently used within the steel industry, combined with proprietary interfaces and limited standardization, makes seamless integration with external decision-support systems particularly challenging. While AgiFlex adopts a service-oriented architecture that could facilitate future integrations, the current development activities are primarily focused on demonstrating the functionality of the platform itself rather than establishing comprehensive interoperability with existing industrial software solutions. Therefore, interoperability with external decision-support tools should be regarded as a



potential future development direction rather than a transferability feature that can be fully achieved within the present project.



4 Next steps

The activities described in this deliverable represent the first step in the stakeholder engagement, AB and transferability assessment process of the AgiFlex project. As the project progresses, further consultation, validation, and refinement activities will be carried out to ensure that the developed methodologies and software components remain aligned with industrial needs and technological developments within the steel sector.

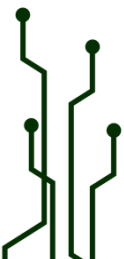
A second AB consultation meeting has already been planned and is expected to take place approximately one year after the first consultation workshop described in this deliverable. The primary objective of this meeting will be to present the progress achieved in both the organizational and technical dimensions of the project, including the status of the software platform, the development of DT and optimization agents, and the preliminary results obtained through simulations and demonstrator activities.

The second consultation cycle will also provide an opportunity to evaluate how the recommendations collected during the first AB meeting have been incorporated into the project. Particular attention will be devoted to discussing the proposed steelmaking transformation scenarios, the implemented optimization strategies, the usability of the developed tools, and the potential industrial applicability of the generated results.

An important activity in the coming months will be the completion, consolidation, and refinement of the requirements specification process involving the industrial partners participating in the project use cases. The consortium is currently collecting and reviewing detailed functional and non-functional requirements from the industrial stakeholders. These requirements will serve as a fundamental input for subsequent architectural decisions, software design activities, definition of system interfaces, prioritization of functionalities, and validation planning. As the understanding of the industrial needs evolves, the requirements documentation may be further refined and updated to ensure consistency with the project objectives and demonstrator expectations.

In addition to the planned workshops and consultation meetings, further stakeholder engagement mechanisms may be introduced if beneficial for the project. These can include structured questionnaires, targeted surveys, focused interviews, and feedback collection activities aimed at assessing the perceived quality of the project outcomes, the maturity of the developed software, the usefulness of the generated results, and the alignment of the platform with stakeholder expectations. Such activities would provide quantitative and qualitative evidence supporting both project evaluation and future exploitation activities.

The consortium will also continue monitoring transferability aspects identified in this deliverable, with particular attention to data integration challenges, scenario configuration complexity, software maintainability, and future deployment requirements. Lessons learnt from the demonstrator cases will be systematically collected and used to further refine the



transferability framework and identify potential barriers to adoption in other industrial contexts.

Overall, the next phase of the project will focus on transforming the requirements, recommendations, and feedback collected so far into concrete technical developments, validated demonstrators, and actionable industrial results. Continuous interaction with stakeholders and the AB will remain a key element of this process, ensuring that the AgiFlex platform evolves towards a robust, maintainable, and industrially relevant decision-support platform for future steelmaking systems.

5 Conclusions

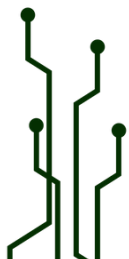
This document presents the stakeholder engagement activities and the first Advisory Board consultation carried out within the AgiFlex project, together with an initial assessment of the transferability potential of the developed methodologies and software components.

The first stakeholder and Advisory Board consultation cycle confirmed the relevance of the project objectives with respect to current challenges faced by the steel industry, particularly in the areas of production planning, operational flexibility, energy management, decarbonization, and long-term transformation towards low-carbon steelmaking routes. The involvement of industrial stakeholders from the project case studies will enable the collection of requirements and expectations directly linked to real operational environments, providing a valuable foundation for the design and development of the AgiFlex platform.

The first Advisory Board consultation further strengthened this process by providing independent technical and strategic perspectives. The discussions highlighted the importance of maintaining a modular software architecture, clarifying the role of Digital Twins within the overall multi-agent ecosystem, and focusing on robust and maintainable software components capable of generating measurable industrial value. Particular attention was given to future steelmaking transformation scenarios, including the integration of direct reduction technologies, electric arc furnaces, hydrogen-based processes, and carbon capture solutions. The Advisory Board also emphasized the need to consider regulatory and market uncertainties, as these factors increasingly influence investment decisions and decarbonization pathways within the steel sector.

The transferability analysis demonstrated that different components of the AgiFlex platform exhibit different levels of transferability. The Digital Twin models, multi-agent optimization framework, and service-oriented software architecture are expected to provide the highest transferability potential due to their modular design and technology-independent implementation principles. In contrast, the graphical user interface and decision-support layer are inherently more dependent on specific industrial workflows, user requirements, and organizational contexts, and therefore are expected to require customization when deployed in new environments. The analysis also identified several challenges that may affect future transferability and industrial adoption. Data heterogeneity remains one of the most significant barriers, reflecting the limited standardization and diversity of digital infrastructures currently present across steel production facilities and companies. Similarly, the configuration of realistic simulation and optimization scenarios may require substantial domain expertise and site-specific knowledge, limiting the possibility of fully automated deployment. On the other hand, explainability, transparency, maintainability, and extensibility are strengths of the proposed architecture and important enablers for future industrial acceptance.

Overall, the consultations and transferability assessment show that AgiFlex addresses highly relevant industrial needs and has the potential to become a valuable decision-support



platform for future steelmaking systems. At the same time, the analysis highlights the importance of maintaining realistic expectations regarding deployment efforts, customization requirements, and integration challenges. Future project activities will therefore focus on strengthening the robustness of the developed methodologies, validating the platform through the demonstrator cases, refining the identified Key Exploitable Results (KERs), and further investigating pathways for industrial adoption and exploitation beyond the project duration.

The outcomes reported in this deliverable provide important guidance for the subsequent phases of the project and establish a common understanding of both the opportunities and the limitations associated with the transferability of the AgiFlex approach across different steelmaking contexts and future decarbonization scenarios.

6 List of Tables

Table 1: Composition of the Advisory Board. 8

7 List of acronyms and abbreviations

Acronym	Full name
AAU	Åbo Akademi University
AB	Advisory Board
API	Application Programming Interface
DRI	Direct Reduced Iron
DT	Digital Twin
EAF	Electric Arc Furnace
ERP	Enterprise Resource Planning
GUI	Graphical User Interface
KER	Key Exploitable Result
KPI	Key Performance Indicator
LLM	Large Language Models
MAS	Multi-Agent System
MES	Manufacturing Execution System
RFCS	Research Fund for Coal and Steel
TRL	Technology Readiness Level

8 Annex 1

This section reports the informative documents available for the Advisory Board, presented at the first AB meeting.




AgiFlex

Agent-Based Models Minimizing Carbon Usage in Flexible and Efficient
Future Integrated Steelworks



 Project co-funded by the Horizon Europe programme
G.A. 101138813



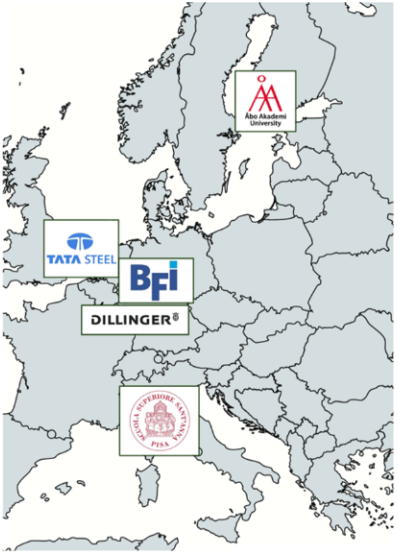
Project Overview

Partners:

- VDEh-Betriebsforschungsinstitut, BFI
- Scuola Superiore Sant'Anna, SSSA
- Dillinger Hüttenwerke, DH
- Tata Steel Nederland, TSN
- Åbo Akademi University, ÅAU (Coordinator)

Call: HORIZON-CL4-2023-TWIN-TRANSITION-01
Start date: 01/12/2024 (Initially 01/12/2023)
End date: 31/11/2028
Budget: 5.2 M€

 Project co-funded by the Horizon Europe programme
G.A. 101138813






2

AgiFlex Project Overview

- As current steelmaking practices involve considerable CO₂ emissions, with an average of almost 2 tonnes CO₂ emitted for every tonne steel produced, steel industry faces the challenge of developing production routes and processes with reduced emissions.
- Shifting to low CO₂ steelmaking routes requires substantial investments, deals with numerous uncertainties and will involve transition periods in which old and new technologies need to coexist and operate together.



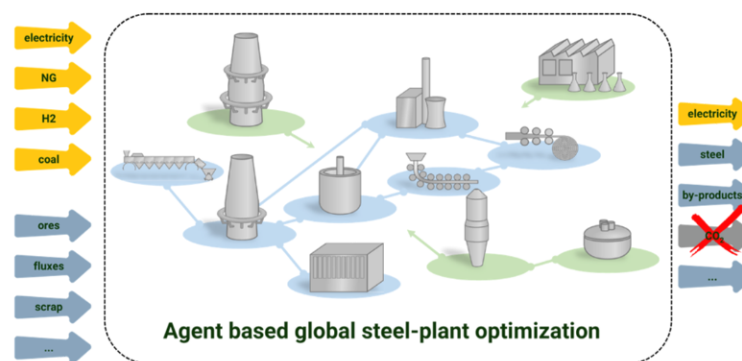
Project co-funded by the Horizon Europe programme
G.A. 101138813



3

AgiFlex Project Overview

- The AgiFlex project aims to develop an adaptable and generalized agent-based simulation tool for addressing challenges in transitioning towards low CO₂ emission steelmaking, especially when shifting from the conventional blast furnace route to a direct reduction route.



Project co-funded by the Horizon Europe programme
G.A. 101138813



4

Agiflex Project Overview



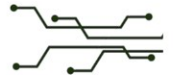
- **Key challenges in modern plant management:**
 - **Complex production chains:** Integrated steelworks increasingly operate hybrid configurations combining legacy units (e.g., BF-BOF) with new technologies (e.g., DR-EAF). Managing material and energy flows across these mixed chains requires dynamic, flexible planning tools. Even during production planning, we must carefully evaluate the costs associated with choosing one route over another. This, combined with customer constraints, makes it a highly complex planning challenge.
 - **Uncertainty and volatility:** Fluctuating energy prices, variable availability of (renewable) electricity, and evolving carbon pricing schemes introduce significant uncertainty. Static models cannot adequately capture these dynamics, leading to suboptimal or risky investment and operational decisions.
 - **Scenario planning and investment strategies:** Long-term strategic decisions—such as when and how to invest in new technologies or when to plan downtimes—must be made under uncertain future conditions. Existing tools lack the capability to evaluate multiple scenarios with probabilistic inputs and structural flexibility.



Project co-funded by the Horizon Europe programme
G.A. 101138813



Agiflex Project Overview



- **Key challenges in modern plant management:**
 - **Demand-side response:** As steel plants become major consumers of electricity, their ability to adapt to grid conditions becomes critical. Current systems, however, do not support flexible operation strategies that align production with energy market signals.
 - **Process integration and emissions management:** The transition to the EAF-route affects internal gas and energy flows, requiring re-optimization of process integration to minimize emissions. This includes the valorisation of by-product gases and the integration of CCS/CCU technologies.
 - **Multi-level planning requirements:** Plant management spans strategic (years), tactical (months), and operational (days to hours) horizons. Each level demands tailored models and optimization strategies, which are rarely integrated in existing solutions.

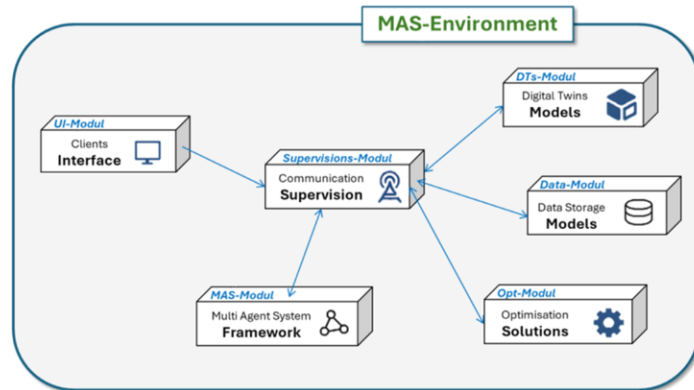


Project co-funded by the Horizon Europe programme
G.A. 101138813



AgiFlex Multi-Agent System

- The developed multi-agent system (MAS) environment will have a modular structure, with different modules developed in parallel. The overall software tool will enable simulation and analysis of both present and potential future steel plant configurations.

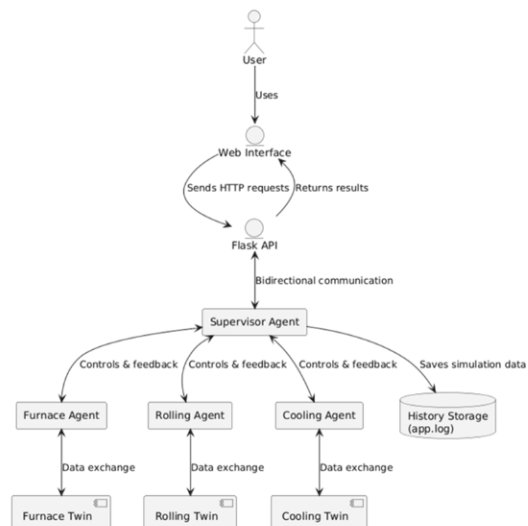


Project co-funded by the Horizon Europe programme
G.A. 101138813

7

AgiFlex Multi-Agent System

- A custom-built MAS framework with a layered architecture is developed for high degrees of flexibility, modularity and scalability
- Digital twins simulate physical processes while different types of agents handle decisions, information exchange and coordination

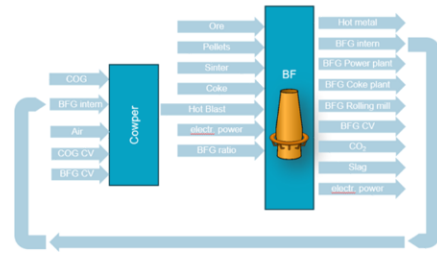
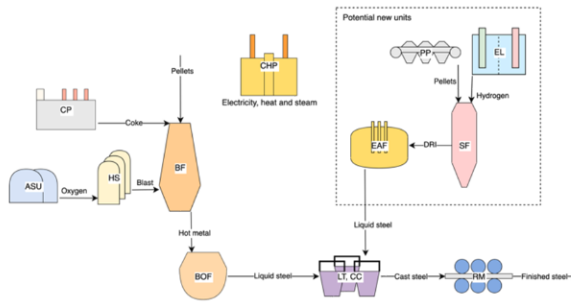


Project co-funded by the Horizon Europe programme
G.A. 101138813

8

Agiflex Digital Twins

- Various mathematical models functioning as digital twins of steel plant units are developed and implemented in the agent system. To ensure efficient computation, simplified surrogate models will be developed from more complex simulation models and from operational data.



Project co-funded by the Horizon Europe programme
G.A. 101138813

9

Agiflex Optimization strategies

- Initial implementations at the strategical planning level.
- The tool may later be developed to handle tactical or operative planning.
- Designs accommodated to the needs of specific potential user groups (e.g., plant managers, energy managers, production engineers).

Planning:

- Strategical** planning for transformation (e.g. 5 – 10 years):
- decision which plants to build
 - new production layout
 - time of investment, ramp up phase

Tactical

- planning (3 – 12 months):
- optimization of operating point: size and type of orders to produce
 - decisions of acceptable orders according to green steel demands, prices, operating costs, production capacities, raw material prices, ...

Operative

- (1 – 7 days):
- planning of the production for the next days
 - machine availability and suitability according to product quality
 - shift/staff availability
 - optimization of load peaks

Control:

- realtime control of production with time steps of 15 min
- optimization of load peaks (e.g. power on vs. rolling)
- optimization of energy and media distribution (short time storage)
- optimization to production and energy price fluctuations

mainly defined but
details left open
(e.g. auxiliary units,
timing)

commercial
importance
and
complexity

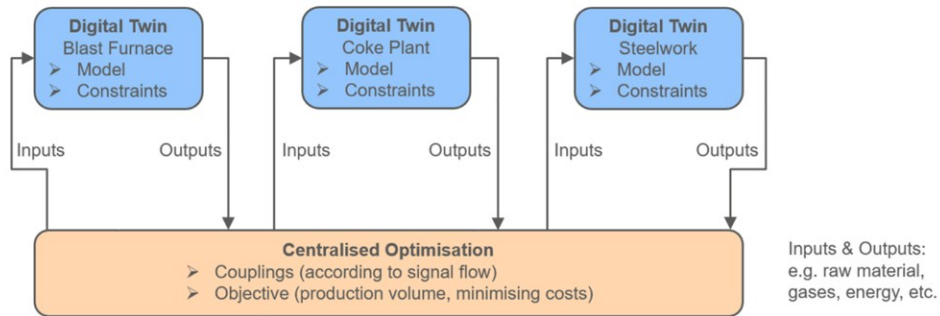


Project co-funded by the Horizon Europe programme
G.A. 101138813

10

AgiFlex Optimization strategies

- Centralized optimization strategies function as references for following decentralized optimization, with regards to both simulation results and computational efficiency.

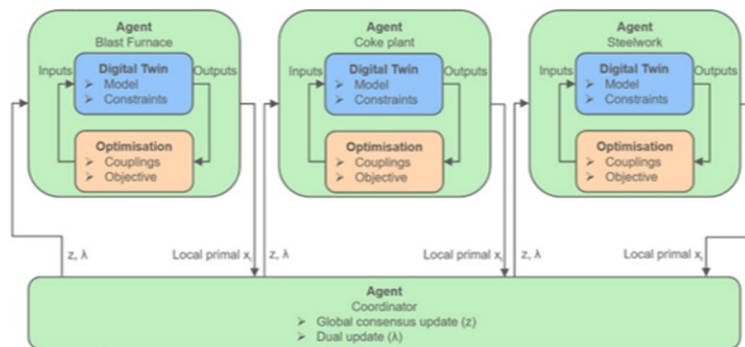


Project co-funded by the Horizon Europe programme
G.A. 101138813

11

AgiFlex Optimization strategies

- Different decentralized optimization strategies are tested for the multi-agent system, considering different KPIs, adaptability to different cases and system configurations, scalability and uncertainties in model parameters.

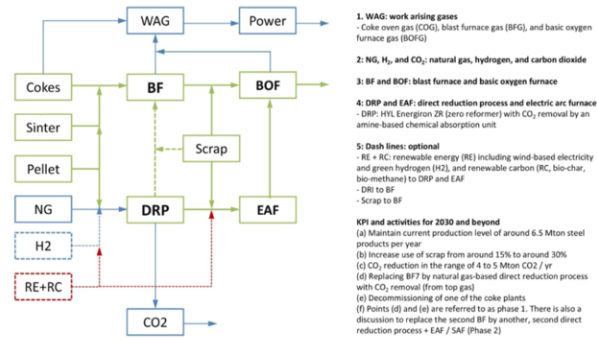


Project co-funded by the Horizon Europe programme
G.A. 101138813

12

AgiFlex Demonstrator cases

- Two demonstrators planned, one at Dillinger and one at Tata Steel.
- The multi-agent system will be adapted to both cases and implemented at both sites, considering the needs of the specific cases.



Simplified overview of the anticipated future configuration at Tata Steel in IJmuiden



Project co-funded by the Horizon Europe programme
G.A. 101138813



13

AgiFlex Planned key exploitable results

KER No.	Short description	KER Type	Exploitation path	Owner
KER 1	Framework of multi-agent system using digital twins for site-wide production and energy management	know-how	Use	BFI, AAU, SSSA
KER 2	Digital twins for each process step	product	Use	All (creator)
KER 3	Sustainable and resilient decarbonisation strategies	know-how	Use	All
KER 4	AgiFlex software for strategic and tactical production and energy management of integrated steelworks	product	Licence	BFI, AAU, SSSA
KER 5	Measures to optimize process integration of mixed production chains	know-how	Use	All
KER 6	Demand-side response measures for intermittent energy supply	know-how	Use	All

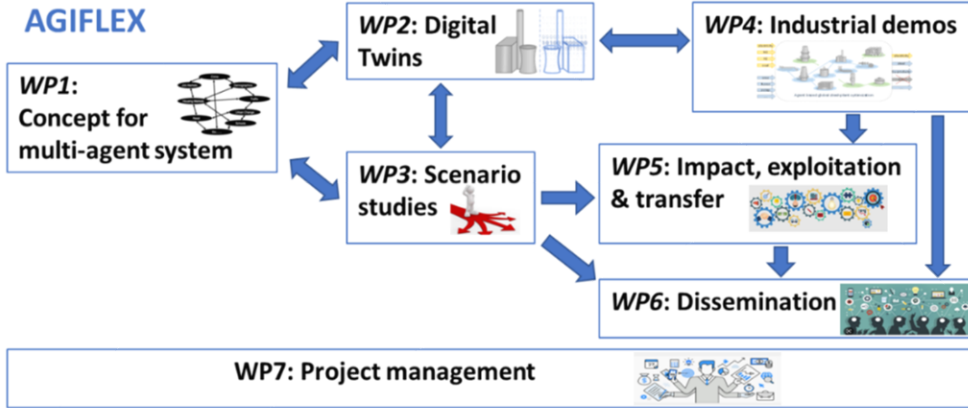


Project co-funded by the Horizon Europe programme
G.A. 101138813



14

AgiFlex Project structure



Project co-funded by the Horizon Europe programme
G.A. 101138813

15

AgiFlex Gantt chart of the project progress

- Work in the project running from December 2024 until November 2028

WPs & Tasks	Work package title	Deliv.	Year 1				Year 2				Year 3				Year 4				Year 5			
			I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
WP 1	Advanced ICT tool concept for multi-agent systems utilising digital twins																					
1.1	Current tools and future requirements on different time horizons									M												
1.2	Specification of plant performance KPIs and relevant data sources	D1.1								D												
1.3	Scalability of smart agents to plant demonstrator demands																					
1.4	Determination of system architecture and definition of smart agent design																					
1.5	Optimisation strategy considering uncertainties and probabilities	D1.2											M					D				
WP 2	Digital twins for production and energy management																					
2.1	Ironmaking and smelting processes									M										M		
2.2	Steelmaking and downstream processing agents									M										M		
2.3	Gas storage, handling and conversion									M										M		
2.4	Auxiliary units and external energy flow	D2.1/2								M			D							M	D	
WP 3	Scenario studies to re-optimize process integration in future integrated steelworks																					
3.1	Analysis of framework conditions and definition of future scenarios																					
3.2	Design of human-machine interfaces (HMIs)																					
3.3	Implementation of AgiFlex within simulation framework and verification with current plant data	D3.1											D									
3.4	Re-optimisation of process integration for mixed production chains (scenario studies)																					
3.5	Derivation of sustainable and resilient decarbonisation strategies																					
3.6	Adaptation and demand-side response to dynamic national and European market conditions	D3.2																				D
WP 4	Demonstration of production and energy management at industrial sites																					
4.1	Implementation of AgiFlex system and interfaces to data processing	D4.1																M	D			M
4.2	Test, adaption and tuning of the system																					
4.3	Staff training and documentation	D4.2																				D
4.4	Demonstration of AgiFlex applicability in operational environment	D4.3																				D

Project co-funded by the Horizon Europe programme
G.A. 101138813

May 2026

16

Agiflex Gantt chart of the project progress

- Work in the project running from December 2024 until November 2028

WPs & Tasks	Work package title	Deliv.	Year 1				Year 2				Year 3				Year 4				Year 5			
			I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
WP 5	Impact assessment, exploitation and transferability																					
5.1	Assessment of demonstrator results including advantages and limitations	D5.1																				D
5.2	Maximise transferability with respect to agents scalability and optimisation strategy																					
5.3	Agiflex business case and assessment of impact on fossil fuel and reductant use and CO2 emissions	D5.2																				D
5.4	Assessment of social impact and gender neutrality	D5.3																			D	
5.5	Exploitation strategy and IPR management	D5.4/5												D								D
WP 6	Dissemination and communication																					
6.1	Dissemination and Communication Plan	D6.1	D																			
6.2	Communication activities including project branding and website			M																		
6.3	Stakeholder and public consultation to maximize transfer of results	D6.2/3								D												D
6.4	Dissemination activities	D6.4/5									D											D
WP 7	Project Management																					
7.1	Project management and reporting	D7.1		D																		
7.2	Administrative and financial management																					
7.3	Quality control and risk management	D7.2					D															
7.4	Legal support, ethical support, and data access policy	D7.3					D															

May 2026



Project co-funded by the Horizon Europe programme
G.A. 101138813



17

Agiflex Advisory Board

- An Advisory Board (AB) of 5 – 6 experts from the academic and industrial fields will be formed for the project.
- The AB will review project outcomes by providing suggestions and supporting quality and innovation management.
- Participation in one on-site meeting can be expected.
- AB suggestions will be part of Deliverable 6.2 “Guidelines for transferability”, to be submitted in May 2026, as well as in a summary of stakeholder consultations at the end of the project.
- AB consultation also expected in tasks concerning assessment of demonstrator results and project exploitation strategies, as well as in suggesting potential future steel production scenarios to be evaluated within the project.



Project co-funded by the Horizon Europe programme
G.A. 101138813



18

AgiFlex Questions



- What is your interest in the project?
- What do you consider to be the most important aspects of the project?
- What should be taken into account regarding usability when developing the software?
- From your perspective, which application of the software has the greatest potential?
- What similar developments are you already familiar with and how should we differentiate ourselves from them?
- What are the main barriers or risks for industrial adoption and what are the main reasons for failure among pilot projects in this area?



Project co-funded by the Horizon Europe programme
G.A. 101138813



19

AgiFlex Questions



- With the objective of developing a high TRL product/software, what and how should we develop for achieving each KER?
- What key aspects of energy management for integrated steelmaking – also during the transition period – should we consider? (e.g., due to a different production setup, process off-gases may be less available in the future)
- Assuming that hydrogen becomes available in the future, what would be the first processes ready to use it, even if only a small amount was available?
- What do you think would be the most relevant features to include in the AgiFlex software and the most important scenarios to study?



Project co-funded by the Horizon Europe programme
G.A. 101138813



20

Agiflex Next meeting

- Next meeting likely to be scheduled for 2027



Project co-funded by the Horizon Europe programme
G.A. 101138813



21