D6.5 Project Exploitation and Sustainability

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List of Acronyms

Abbreviation / acronym	Description
AGPL	GNU Affero General Public License
AI	Artificial Intelligence
CSR	Corporate Social Responsibility
Dx.y	Deliverable number y belonging to WP x
EU	European Union
FAU	Friedrich-Alexander-Universität Erlangen-Nürnberg
FN	Future Needs

GPL	General Public License
HPC	High Performance Computing
IP	Intellectual Property
IPR	Intellectual Property Rights
LGPL	GNU Lesser General Public License
ML	Machine Learning
MTG	MeteoGRID
MUQSA	multiscale uncertainty quantification and sensitivity analysis
NGO	Non- Governmental Organization
OSS	Open System Solutions
PCC	Project Coordination Committee
PESTLE	Political, Economic, Sociological, Technological, Legal, Environmental
PPAA	Public Policy and Arts Administration
PSNC	Poznan Supercomputing and Networking Center
SME	Small Medium Enterprise
SWOT	Strengths, Weaknesses, Opportunities & Threats
SZE	Széchenyi István Egyetem
TCC	Technical Coordination Committee
TRL	Technology Readiness Level
UNISTRA	University of Strasburg
USTUTT	University of Stuttgart
WP	Work Package
NCAR	National Center for Atmospheric Research - USA

Executive Summary

The primary goal of the WP6 is to maximise the project's impact and facilitate effective communication and dissemination of its results and offerings. A key focus is placed on ensuring the long-term sustainability of the project outcomes beyond its completion, aligning with the individual and joint exploitation plans of the partners. Exploitation and sustainability are part of Tasks 6.1 - Market analysis and Sustainability Roadmap and 6.2 - Project Exploitation and IPR Management, which are the tasks we are focusing on in this deliverable.

Exploitation in HiDALGO2 ensures that research results create lasting impact beyond the project's duration. It maximises economic, societal, and policy benefits by enabling commercialisation, fostering innovation, and supporting sustainability. Through patents, business opportunities, policy recommendations, and open knowledge sharing, HiDALGO2 tools contribute to EuroHPC JU's mission and technological advancement. This document is dedicated to present an effective exploitation and IPR strategy along with the results the project has achieved so far.

The sustainability and business plan we have set in HiDALGO2 ensures that EU project results remain impactful beyond the funding period by securing financial stability, fostering commercialisation, and integrating innovations into policy and society. It helps attract additional funding and aligns project outcomes with market needs. By embedding results into industry standards, mitigating risks, and creating a strategic roadmap, HiDALGO2 can achieve long-term viability.

1 Introduction

1.1 Purpose of the document

The main purpose of this document is to present the initial findings of the exploitation and sustainability strategy for HiDALGO2, considering the future capabilities of its exploitable results, use cases and project partner collaborations. The report aims to explain the strategic plan for market analysis, sustainability roadmap and IPR management while mapping out all the related work done throughout the project until now. It is important to note that this deliverable serves as an initial version of the presentation of the project's exploitation and sustainability strategy. All information in this document is updated until the 31st of January 2025.

1.2 Relation to other project work

This deliverable "Project exploitation and sustainability" is directly related to two tasks in Work Package 6 and one deliverable of the project.

- **Task 6.1: Market analysis and Sustainability Roadmap** involves a comprehensive market analysis for all exploitable solutions produced by the project, followed by the development of business plans covering key elements such as cost-benefit analysis, partnerships, resources, customer targeting, and revenue forecasting. Mid- and long-term strategies will be outlined based on historical bid analysis, funding opportunities, and global actor assessments. A final report will summarize the findings, addressing data quality, technical improvements, and communication needs, with recommendations for national preparedness plans, impact assessment, and ethical considerations, culminating in a Sustainability Roadmap to be presented at the HiDALGO2 EU Clustering Event.
- **Task 6.2: Project Exploitation and IPR Management** focuses on ensuring the future exploitation, deployment, and continuation of the project's research and innovation outcomes. Key activities include developing individual exploitation plans for each solution, creating a research roadmap extending to 2030, and tracking Intellectual Property Rights (IPR) for each solution. Regular reviews of the state-of-the-art and patents will assess the novelty and freedom to exploit results, with protection procedures implemented as necessary, including cataloguing IPR and filing patents or other relevant protections.
- **Deliverable 6.6: Project Exploitation and Sustainability (M46)** Within this document, the final outcomes of the exploitation and sustainability strategy for HiDALGO2 will be presented, considering the present capabilities of certain use cases, stakeholders, and customer groups. This Deliverable serves as a more detailed version of the Deliverable 6.5. The report will include all the updates of

the previous sections, more details on the project results and analytical individual exploitation plans will be available as we will be approaching the end of the project.

Beyond these relational points, the exploitation and sustainability tasks serve as the central connection for all project results. Consequently, this deliverable is linked to all Work Packages and Tasks.

1.3 Structure of the document

This document is structured in **5** major chapters in addition to the introduction (1).

Chapter 2 presents the methodology and framework that was set for the exploitation and sustainability plan.

Chapter 3 presents the Market Analysis & Sustainability Report.

Chapter 4 presents the Exploitation and IPR Report.

Chapter 5 presents the Risk Assessment and Mitigation actions taken within the project.

Chapter 6 describes briefly the conclusions.

2 Methodology and framework

Section 2 focuses on the general process used to develop the HiDALGO2 Exploitation and Sustainability Plan. It provides detailed insights into the foundational methodology of the tasks related and the approach taken during our work in the project.

2.1 Market assessment and sustainability plan

Market assessment, along with a sustainability plan and risk assessment, are fundamental elements in preparing a product for commercialization. The methodology used in these three areas is presented below.

The market analysis is supported by SWOT [1] and PESTLE [2] analyses, which will allow for the assessment of the possibilities and competitiveness of the HiDALGO2 project offer.

SWOT analysis is a strategic planning tool that allows to assess the strengths and weaknesses of a given offer or undertaking by estimating the impact of internal and external factors that may affect success of business goals. It involves examination within four categories: strengths (advantages that provide a competitive advantage), weaknesses (limitations or areas for improvement), opportunities (factors that can be used for growth), threats (risks that may harm success).

PESTLE (or PESTEL) analysis serves as a strategic tool for evaluating the external macro-environmental factors that impact an organization or industry. This analysis encompasses six key areas: political factors, which include government policies, taxation, political influence, and stability; economic factors, such as economic growth, unemployment rates, inflation, exchange rates, and interest rates; social factors, which cover cultural trends, consumer behaviour, demographics, and lifestyle shifts; technological factors, focusing on advancements in technology, research and development, automation, and innovation; legal factors, including trade laws, industry regulations, labour laws, consumer protection laws, and health and safety regulations; and environmental factors, which address environmental regulations, climate change, sustainability, and carbon footprints.

The Sustainability Plan describes the strategies for continuing the activities of the consortium by offering services developed during the project. Sustainability includes maintaining the services offered, staff members and dissemination activities. It should be assumed that the Sustainability Plan will be adapted to specific needs and in relation to the scope of work being carried out. In general, the following key issues should be considered when planning for sustainability:

- Developing an organizational plan for the use of human, financial and material resources

- Obtaining input and acceptance from partners and stakeholders in the context of their use (data licensing)
- Planning for ongoing engagement with partners and stakeholders, e.g. through dissemination activities
- Occasional and periodic sharing of information on the results of activities with consortium members and other key stakeholders
- Identifying short-term and long-term financing and/or reimbursement options

In addition to sustainability plans, the service integration programs offered by the project consortium need a risk management plan. Risk analysis facilitates the identification, evaluation, and mitigation of potential threats that may emerge during the execution of scientific and business initiatives. In the context of HiDALGO2, the objective is to prepare for unforeseen circumstances, such as inadequate funding due to insufficient customer interest, the loss of a partner, or alterations in government policy. The initial phase of the definition encompasses the purpose of the plan and its scope concerning the operational area. Another critical component is the identification of key stakeholders engaged in various activities, including business, preparatory, implementation, and dissemination phases. Subsequently, it is imperative to evaluate the risk level associated with each stage of the plan's execution. This evaluation is conducted through qualitative analysis, which involves the creation of a probability and risk impact matrix, as well as quantitative analysis, which employs numerical risk assessment techniques, Monte Carlo simulations, and decision trees. The consecutive phase in formulating a risk assessment plan entails the creation of response strategies for emerging threats. Generally, four approaches to managing adverse events are considered: avoidance (eliminating the risk), mitigation (diminishing the impact or likelihood), transfer (utilizing insurance, outsourcing, or contractual agreements), and acceptance (recognizing and preparing for the risk).

The effective execution of these strategies necessitates the assignment of roles and responsibilities to designated individuals, referred to as risk owners. It is essential to clarify who is responsible for making specific decisions, thereby identifying the members of the risk management team. The entire procedure should be subject to oversight through risk monitoring. This involves the identification of Key Risk Indicators (KRI), the ongoing surveillance of potential threats, and the establishment of appropriate escalation protocols to ensure a timely response when risks materialize. This aspect particularly necessitates the development of action plans for high-impact risks, supported by suitable emergency response strategies. For the aforementioned elements of the risk management plan to operate effectively, robust communication is imperative, facilitated through reporting in accordance with established documentation procedures. The method of reporting risks and the appropriate hierarchy for such reports must be clearly defined. Lastly, it is important to highlight that this process

requires ongoing evaluation, thus it is advisable to determine a suitable frequency for meetings dedicated to this purpose.

2.2 Exploitation plan and IPR management plan

The project's exploitation approach consists of multiple elements. Finding important exploitable outcomes is the first stage, and these are listed in the section 2.3 that follows. These results may be presented as copyrights, patents, trademarks, or other forms of IPR. Establishing a technology and market watch is the second step. Partners in the project will monitor, track, weed out, and evaluate possible technologies from a broad range of fields that go beyond the typical boundaries of the industry. They will specifically monitor the following: potential effects of technological change, new market opportunities, active companies and their strategies, start-ups and inventors, and the most recent innovations and IP developing trends and developments. The creation of a structure for overseeing and protecting the project's intellectual property rights constitutes the third element, IPR management. Identifying possible licenses or patents, outlining the project's intellectual property rights, and creating a licensing or partnership agreement that aligns with the project's aims and objectives are all included in this framework. The ensuing sections go into greater detail on IPR. By spotting possible business opportunities and cultivating relationships with pertinent stakeholders, the exploitation strategy seeks to maximize the value and influence of the project's outcomes.

Stakeholders are the groups we want to target as possible users of our project's results. In the HiDALGO2 Project, these are public administrators, researchers and industrial partners.

There are four main service categories applying to these stakeholders:

- **Consultancy:** Analyse the problem described by the stakeholder and propose concrete solutions to solve it, including the usage of existing tools and developments of new ones, guiding them in the process;
- **Training:** In general, training activities in those topics addressed by the project;
- **Infrastructure:** This is a set of horizontal services, such as the HPCaaS, the original
- **HiDALGO Portal** (with premium subscriptions), user support and others;
- **Development:** Adapt the existing tools according to the stakeholder's requirements (including new architectures), optimise other tools or develop new ones (from scratch), as needed.

The following sections of the document are going to analyse the results HiDALGO2 is producing, according to the categories above and report on the exploitation status, according to the plan.

2.3 Dissemination and communication of exploitable results

To effectively disseminate all exploitable results, we have identified the following target groups as subcategories within the three main stakeholder groups:

- **Big companies:** industrial partners whose main goal is the commercial use of the offered solutions.
- **Research/Academia:** research institutions interested in developing research projects in the area of simulation modelling and knowledge transfers,
- **National and local government:** representing public administrations, especially policy makers responsible for creating and implementing new environmental protection law,

Table 1 aims to explain the value that each category of stakeholder gets from the HiDALGO2 tools.

Table 1. Benefits of HiDALGO2 services for stakeholders

Stakeholders categories	Benefits from HiDALGO2 services
Big Companies	Enables innovation and efficiency in companies and also reduces costs. It aligns with sustainability and CSR goals, enhancing reputation, while fostering competitive advantage through advanced tools and solutions for complex, large-scale simulations.
Researcher/ Academia	Groundbreaking research in areas like climate modelling, urban planning, and disaster response. HiDALGO2 promotes open science by developing tools, datasets, and methodologies that can be shared across the academic community.
National and local government	Enables innovation and efficiency in public institutions and also reduces costs. It aligns with sustainability and CSR goals, enhancing reputation, while fostering competitive advantage through advanced tools and solutions for complex, large-scale simulations. Government decision-makers can rely on accurate, data-backed information to assess the potential effects of different policies.

All the target groups mentioned above are engaged through HiDALGO2's various channels, both online and offline. We maintain an active presence on social media platforms such as LinkedIn, X, and BlueSky, regularly publishing newsletters and updating our website. Our project frequently participates in events and organizes training sessions. One significant event we are planning is the Clustering Event, which will take place in December 2026. At this event, we will showcase the entire HiDALGO2 toolset, and the attendees will include the target groups previously identified.

2.4 Monitoring and evaluation

Monitoring and evaluation is an important process HiDALGO2 is following, to ensure the delivery of high quality and quantity and further the outreach of the results. This is an ongoing effort, integrated into various working groups, both directly and indirectly, throughout the project's duration. Responsible working groups for the monitoring and evaluation of the results of the project are the: Technical Coordination Committee, Project Coordination Committee, WP Leaders from WP4, WP5 and WP6. Monthly meetings are held within all the mentioned working groups to manage information flow and track progress. Additionally, an overview, feedback, and updates on progress are presented during plenary meetings, which occur every six months.

3 Market assessment and sustainability plan

This chapter presents a preliminary approach to the market assessment and definition of the sustainability plan, outlining initial areas that will be subject to further analysis during the ongoing work and the outcome of which will be presented in the next D6.6 (M46) report.

3.1 Strategy Analysis

This chapter presents a preliminary analysis that is an introduction to the creation of a full-fledged business plan as an integral element of a sustainability strategy. This study is based on two analyses, SWOT and PESTLE, showing the strengths and weaknesses of the consortium's offer as well as the impact of macroeconomic factors.

3.1.1 SWOT analysis

As mentioned in the section 2.1, SWOT analysis identifies strengths, weaknesses, opportunities, and threats. It includes internal and external factors that affect the operation of the enterprise. All four aspects can be placed on a diagram divided into horizontal positive or negative aspects and vertical internal and external. The combination of internal positive factors are strengths, while internal negative factors are weaknesses. Moving on to external factors, the strong elements are opportunities, while the negative elements are threats. This is illustrated in the diagram below.

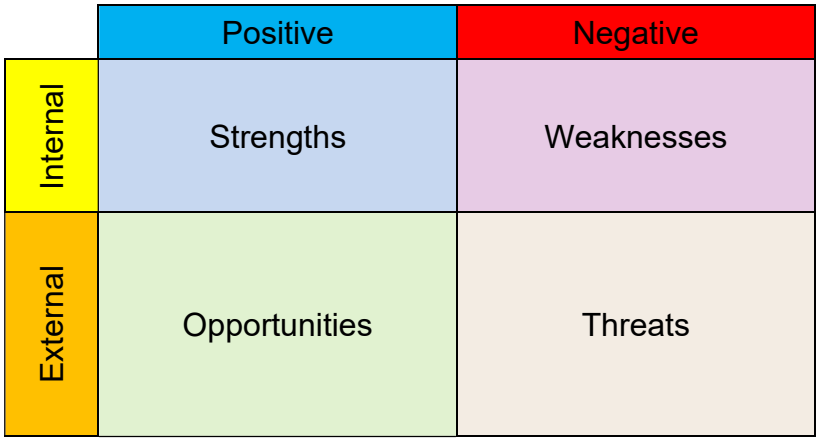

Figure 1. Diagram presenting of SWOT factors to positive/negative and internal/external aspects

Strengths are all the resources and skills that allow to build a strong position on the market. These are the elements that influence building an advantage over the competition. In the case of HiDALGO2, these are:

1) High qualifications of partners - team members are specialists in their field from renowned European institutes.
2) Access to the latest technologies - solutions are created for the fastest supercomputers in the world (EuroHPC JU machines) and using the latest technologies
3) Unique know-how - high level of readiness in the scope of the offered solutions

Weaknesses concern elements that inhibit development and have a negative impact on the operation of the project. For HiDALGO2, they are related to:

1) Lack of experience in conducting business activities - most consortium members are scientists with little experience in commercializing solutions
2) Lack of sufficient financial resources - in the absence of external financing, the consortium will not have the resources needed for start-up
3) Lack of established reputation on the market (regular customers) - the consortium has not offered its solutions commercially so far, therefore it does not have a customer base and must create its reputation from scratch

Opportunities are seen as all changes in the organization's environment that may have a positive impact on its functioning. For HiDALGO2, these include:

1) Increased demand related to greater awareness of threats resulting from climate change and social development - in the current situation, such demand should be assessed highly
2) Low competition - due to the high qualifications required, there are currently few groups that can provide similar services, but the market should be monitored for threats related to increased competition
3) Favourable law in EU - the adopted direction of energy transformation imposes the use of conscious solutions offered by the organization
4) Emergence of a new group of customers - after positive first implementations and receiving references, it should be assumed that new interested parties will appear
5) Changes in consumer behaviour - growing awareness of customers regarding the consequences of climate change favours the implementation of developed recommendations and compliance with them
6) Economic situation in the EU - European countries, as quite wealthy, are willing to invest in means to improve the quality of life of citizens.

Threats are external aspects and therefore do not result from factors dependent on HiDALGO2 activities. They create a risk of negative changes, in particular:

1) Low demand for the offered product - there is a risk that, especially in the initial period, it will be difficult to find buyers for the offered product

2) Any crises - in the event of crises of much greater significance than the observed climate changes (e.g. wars), interest in scientific consultation on natural hazards may decrease
3) Numerous competitors - emerging competition, especially from commercial companies offering similar analyses but at a lower level of advancement
4) The presence of a monopolist on the market - this threat is a specific occurrence of above risk and is related to the emergence of a large government institute that will take over the execution of orders for local governments, along with the order to use services exclusively from this supplier
5) Unfavourable law - states might define general principles that local governments should follow in their policy of mitigating natural hazards without performing detailed profiled analyses
6) Changes in trends - a change in interest in performing analyses due to, for example, their low effectiveness

In the next step (D6.6), the factors presented above will be determined by weights, which in turn will help to select the most appropriate strategy out of four possible ones: aggressive, conservative, competitive and defensive.

3.1.2 PESTLE analysis

PESTLE analysis is perceived as an extension of the SWOT analysis and concerns the analysis of the macro-environment. It should be taken into account that during the durability period the activities of the consortium established to implement the commissioned projects will be subject to market conditions, including the influence of economic trends, labour law for the employment of specialists or social factors determining the investment attitude, e.g. local government. The initial step in formulating a marketing strategy for HiDALGO2 products involves conducting an audit and analysis of the organization's environment. Prior to establishing our objectives and desired outcomes, it is essential to assess our current position. This assessment is particularly crucial in today's rapidly evolving business landscape, which continuously presents new challenges to organizations. The downfall of numerous companies (e.g. Kodak and MySpace) can be attributed to their failure to consistently monitor their environment and their reluctance to adapt to changing circumstances. These evolving conditions primarily manifest in the macro environment of the organization, encompassing a wide range of factors that influence customers, suppliers, and employees. Notable examples include advancements in technology, fluctuations in average income levels, changes in legal regulations, and variations in exchange rates.

Table 2. PESTLE Analysis

POLITICAL	
Relevance to HiDALGO2: The most important issue that may affect the demand for HiDALGO2 services is maintaining a political course consistent with the scientific consensus and systemic support in the fight against the effects of climate change. The growing popularity of political parties both in Europe and worldwide (USA, China) questioning the chosen direction of caring for the environment, including reducing CO2 emissions, may have a negative impact on the willingness to undertake initiatives related to this. Customs wars may translate into a decrease in the ability to finance ecological projects (including pro-ecological tax support) and hinder international cooperation. The threats related to corruption and employment laws should be assessed as low due to the strong anchoring in adopted practices and EU law supported by numerous government institutions.	
Government stability and policies	Europe's political stability and development path in the current and future years will be shaped by domestic political changes, proactive political reforms and significant external geopolitical changes. However, no abrupt changes are expected in the context of the approach to combating climate change.
Tax regulations	Uncertainty about future environmental regulations, including potential emission reduction targets and taxes, is causing hesitancy to invest in this sector. Moreover, the new EU fiscal framework places emphasis on fiscal consolidation, with public investment rates set to increase by less than 0.2% of GDP. This cautious approach reflects efforts to balance fiscal responsibility with the need for investment.
Trade tariffs and restrictions	The reimplementation of reciprocal tariffs by the United States presents a significant challenge to the stability of the European Union's tax framework. Considering the varied trade interests among Member States, these tariffs could jeopardize internal unity and necessitate a unified approach to safeguard economic interests.
Political conflicts or corruption	Europe is experiencing political fragmentation, with mainstream parties losing ground to populist and far-right movements. This shift is leading to challenges in forming stable governments and achieving consensus on key policies, including economic reform and immigration. Political uncertainty, exemplified by leadership changes in key Member States, is posing risks to EU cohesion and decision-making. Recent studies point to a worrying rise in corruption across EU member states. Transparency International's 2024 Corruption Perceptions Index reveals that corruption has worsened for the second year in a row, undermining public trust in institutions and hampering economic growth.
Employment laws	The EU has a proactive approach to modernising labour laws, responding to technological advances and promoting fair labour practices in all Member States. The EU is currently implementing a number of significant labour law reforms to meet societal expectations, for example:

	• European Works Council (EWC) Directive Amendments • Regulation of Artificial Intelligence (AI) in the Workplace • Minimum Wage Adjustments • Employment Classification and Contract Reforms • Forced Labor Prohibition
ECONOMIC	
Relevance to HiDALGO2: The willingness to finance scientific projects supporting the implementation of energy transformation and environmental projects, especially by government institutions (which are among the main potential clients) is closely linked to the economic situation, i.e. economic growth. The most important factors illustrating the state of the economy, apart from GDP, are also inflation, the level of interest rates, unemployment and consumer spending power. In addition, it should be taken into account that the level of estimated rates for HiDALGO2 services may also be influenced by the fact of cooperation in international teams with a non-uniform currency system (exchange rates and currency fluctuations).	
Economic growth rates (GDP)	EU real GDP is expected to grow by 1.5% in 2025, up from 0.9% in 2024. This growth is attributed to increased consumer spending and a rebound in investment.
Inflation and interest rates	The annual inflation rate in the euro area rose to 2.5% in January 2025 from 2.4% in December 2024, slightly above market expectations. The ECB staff forecasts from December 2024 projected inflation to average 2.1% in 2025, consistent with the ECB's 2% target.
Exchange rates and currency fluctuations	The euro has been subject to fluctuations influenced by numerous economic and geopolitical elements. The volatility of the exchange rate can be attributed to persistent geopolitical tensions, notably the conflict between Russia and Ukraine, as well as uncertainties surrounding trade policies. These circumstances have led to a rise in the value of the US dollar, as investors gravitate towards safer assets.
Employment rates and wage levels	The unemployment rate remains relatively stable in the EU, with the eurozone recording 6.3% in December 2024. The EU employment rate reached a record high of 75.8% in the second quarter of 2024. A survey of the European Central Bank's professional forecasters predicts a gradual decline in unemployment rates, forecasting 6.5% in 2025, 6.4% in 2026 and 6.3% in 2027.
Consumer confidence and spending power	The latest forecast from the European Commission indicates that consumer confidence in the EU remains steady, with a modest rise of 0.3 percentage points in the eurozone, bringing the figures to -13.3 and 14.2 points, respectively. However, despite this minor improvement, confidence levels continue to fall short of historical averages. Conversely, the Ipsos Global Consumer Confidence Index for January 2025 reveals a rise in consumer sentiment in both Latin America and Europe, whereas North America experienced a downturn.

SOCIAL	
Relevance to HiDALGO2: The influence of macroeconomic factors related to social aspects translates indirectly into the willingness to invest in environmental projects by decision makers. This is related to the growing social awareness of the importance of proper care for the environment through digital and energy transformation and ongoing urbanization. The need to implement projects that improve the quality of life of citizens is a direct translation of the noticeable increase in negative health effects resulting from, for example, poor air quality. Social involvement and understanding increase with the increase in the level of education, including digital skills.	
Demographics (age, gender, population growth)	The EU population is expected to reach around 450.41 million by the end of 2024. It should be noted that the EU is experiencing significant demographic changes, characterized by a decline in population due to an ageing population. The population is expected to peak at 453.3 million in 2026, and then gradually decline to 447.9 million by 2050 and 419.5 million by 2100, which means a decrease of 6.1% from 2022 to 2100.
Cultural attitudes and lifestyles	The EU is likely to become a more connected but complex social landscape, shaped by technology, migration, sustainability efforts and evolving attitudes towards diversity, well-being and integration. This is linked to current technological and socio-political trends such as: • environmental awareness - sustainability has become a strong part of European cultural identity. Green policies, promoted by both governments and social movements, are likely to influence not only consumption habits but also broader cultural values. • Digital transformation - as the digital age continues to evolve, EU countries will see technology become more integrated into everyday life. Social media platforms are likely to continue to shape political discourse, personal relationships and cultural norms. • Urbanisation and mobility – Europe continues to urbanise, so cities will become increasingly connected through smart technologies. This will impact the way people live, work and interact. Urban mobility could include more autonomous public transport, electric scooters and bike sharing schemes.
Health consciousness and consumer preferences	Health awareness and consumer preferences in the EU are increasingly influenced by cultural changes, technological progress and global trends. Several selected aspects can be highlighted: • Preventive healthcare where the main role is played by a holistic approach to health, personalized medicine and, in terms of technology, wearable devices that allow for continuous health monitoring. • Mental health and well-being implemented through therapy, mindfulness practices, meditation apps and stress-reducing activities. More and more attention is being paid to work-life balance to reduce burnout and maintain mental health. This will be associated with a greater demand for anti-stress and relaxation products.

Education levels and workforce skills	Education and professional skills in the EU are closely linked to technological advances, demographic changes and changing societal needs. Workers will be expected to continuously improve their skills to remain competitive in the job market. This will be supported by increased access to online learning platforms and micro-credential systems that offer short courses and certificates. In addition, workers will have to adapt to increasingly automated and AI-powered environments. People with skills in AI development, robotics and machine learning will be in high demand to build and maintain IT systems. Another issue is related to cybersecurity resulting from the growing importance of IT systems and the threats affecting their stable operation. The demand for cybersecurity specialists protecting critical infrastructure, financial systems and personal data will increase.
TECHNOLOGICAL	
Relevance to HiDALGO2: Technological advancement is directly inscribed in the DNA of both the project and the HiDALGO2 services themselves. It results from the need to use the latest solutions from the HPC, HPDA and AI areas to build and run simulation models. Therefore, it is necessary to monitor current progress in this area in hardware areas (new processors, GPU cards) as well as legal regulations specifying the use of implemented solutions (e.g. AI Act). It is necessary to ensure the resistance of developed systems to hacker attack threats. Another issue is to take care of updating the software solutions used (not only in terms of security) allowing to keep up with the increasingly faster and automated technological progress.	
Innovation and R&D developments	The EU is expected to promote sustainable innovation, driven by ambitious climate goals (such as the Green Deal and carbon neutrality by 2050). Investments in renewable energy, sustainable agriculture, circular economy models and climate-resilient technologies will dominate R&D initiatives. Efforts to diminish reliance on fossil fuels will prioritize the development of green hydrogen and other sustainable energy alternatives. Furthermore, there will be a heightened emphasis on innovations that promote a circular economy, wherein materials are reused, recycled, or repurposed instead of discarded. Research and development initiatives will concentrate on new materials, waste-to-energy technologies, and strategies aimed at minimizing resource consumption.
Automation and AI adoption	It is expected that the area of transformation in this aspect will include, among others: • Smart Cities and Urban Planning which will accelerate the development of smart cities in which artificial intelligence and automation are used to optimize traffic management, waste management, energy consumption and public safety. • AI-based crisis management will be used to predict and manage disasters, enabling more effective responses to natural disasters or health crises.

Internet penetration and digital transformation	Internet penetration in the EU will continue to grow, with the aim of achieving universal access to high-speed broadband by 2030. The plan aims to ensure that every household has access to fast, reliable internet, with a particular focus on rural and underserved areas that have historically lagged behind urban centres in terms of digital connectivity. Digital transformation will increasingly progress and will concern areas such as: smart cities, e-government services, industry 4.0, blockchain, business driven by AI, FinTech (digital payments).
Cybersecurity threats	IT systems are expected to face increasing challenges in securing critical infrastructure, data, and digital systems. Cybercriminals will increasingly use AI and machine learning to automate and refine their attacks. AI-based malware will adapt to counter defence systems, making it harder to detect and defend against. And the rise of deepfake technology will enable more convincing social engineering attacks, using deepfake videos or voice recordings to impersonate specific individuals, potentially leading to data breaches and financial losses.
Technology life cycle and obsolescence	As technology advances and the pace of innovation accelerates, it is expected that older technologies will become obsolete faster. Innovations that once took several years to emerge now appear in new versions every few months. This will be driven by new phases of technological revolutions such as artificial intelligence (AI), quantum computers, and blockchain. This is especially true for older technologies that rely on manual processes or less advanced procedures, which will be replaced by AI-based systems.
LEGAL	
Relevance to HiDALGO2: It should be remembered that HiDALGO2 services are provided within consortia employing various specialists. Consortia as such are subject to the law both in the context of hiring employees and regulations protecting consumers. Aspects resulting from the law establishing standards in health care (e.g. permissible emission of buildings or air quality) should be taken into account in the designed simulation models and as such be subject to monitoring. Another topic subject to the legal domain is the proper protection of intellectual property. It concerns both created codes (licensing), filed patents and content (data) generated by artificial intelligence.	
Labour laws and employee rights	As the labour market evolves with technological advancements, significant changes in labour laws and employee rights are anticipated. This transformation will be influenced by factors such as the rise of remote work, the integration of artificial intelligence, automation, and shifting employee expectations. Future labour policies are expected to prioritize a balance between flexibility, job security, and the adaptation to new technologies. The European Union is likely to establish regulations governing remote work, mandating that employers offer fair compensation for expenses incurred while working from home, such as internet and electricity costs. Furthermore, for individuals working remotely across different countries, there may be a need to harmonize tax laws, labour regulations, and social security contributions among member states to prevent legal discrepancies. As organizations increasingly

	implement AI-driven employee monitoring systems, it is anticipated that more stringent regulations will be introduced to safeguard privacy and mitigate excessive surveillance.
Consumer protection regulations	Regulations in this domain are anticipated to adapt in response to advancements in digital technology, the rise of artificial intelligence, concerns regarding sustainability, and shifts in market dynamics. One can expect the establishment of regulations that mandate complete transparency in algorithmic decision-making related to pricing, advertisement personalization, and product recommendations. There is a growing trend towards increasing retailer accountability for counterfeit, defective, or misleading products available on their platforms. Enhanced labelling will be essential to differentiate between official and third-party sellers, thereby minimizing consumer confusion. E-commerce platforms may face legal obligations to authenticate reviews and to clearly indicate sponsored content. Additionally, consumers might gain greater authority over their personal data, including the option to request the automatic deletion of their information held by companies. Manufacturers will be compelled to substantiate environmental claims, such as "green" or "carbon neutral," through third-party certifications prior to promoting these assertions.
Health and safety standards	Future changes to health standards will focus on climate change adaptation, AI-driven workplace safety, pandemic preparedness, and more stringent consumer product standards. Future changes in health standards will focus on climate change adaptation, AI-based workplace safety, pandemic preparedness, and more stringent consumer product standards. There will be stricter air quality standards for public spaces and workplaces (air ventilation and filtration in offices, public buildings, and schools). In addition, companies may be legally required to develop pandemic contingency plans. AI-based employee monitoring systems will be regulated to prevent over-surveillance and ensure employee privacy, and their use will need to be justified. Mental health regulations will potentially be introduced for high-stress industries, and employers will be required to provide mandatory breaks and psychological support.
Intellectual property (IP) laws	This domain will also undergo modifications in response to swift technological progress. In this regard, AI-generated content and digital marketplaces will be closely examined. It is essential to clarify copyright concerns surrounding AI-generated materials, including art, music, text, and code. Additionally, this issue pertains to emerging guidelines regarding the compensation of artists, writers, and musicians whose works are utilized for training AI models. Intellectual property laws will extend to AI-generated deepfakes that mimic real individuals, such as celebrities, politicians, and influencers, for commercial gain. Furthermore, platforms may be mandated to automatically identify and label AI-generated content.

Industry-specific regulations	Since February 2025, the EU has been implementing a range of sector-specific environmental rules to promote sustainable development and address environmental challenges: • The European Union has enacted legislation (deforestation-free products) prohibiting the sale of goods associated with deforestation. Businesses dealing in commodities such as cattle, cocoa, coffee, palm oil, rubber, soy, and timber are required to perform due diligence to confirm that their products are not connected to deforestation or the degradation of forests. • The European Union has revised the Industrial Emissions Directive as of July 2024, introducing more stringent pollution regulations for industrial sectors. This revised directive is designed to decrease emissions resulting from industrial operations, guarantee adherence to environmental standards, and encourage the implementation of cleaner technologies. • Agriculture Sector - a strategic plan for reforming the agriculture sector, focusing on reducing administrative burdens and more equitable distribution of subsidies. • Textile and Fast Fashion Industry – legislation targeting the fast fashion sector to reduce textile waste. These measures require manufacturers to finance the collection, sorting and recycling of textile products through extended producer responsibility programs. • Packaging industry - taking steps to foster a more sustainable packaging economy by encouraging the reuse and refilling of packaging as viable alternatives to single-use options. Additionally, there is a concerted effort to enhance recycling initiatives and diminish reliance on virgin resources.
ENVIRONMENTAL	
Relevance to HiDALGO2: The environmental perspective is the next one after the technological one, which is closely related to the scope of HiDALGO2. Detailed tracking of the effects of global warming and the resulting climate change is necessary in connection with the design of computational simulations in the area of renewable energy sources and urban planning. In the area of interest of HiDALGO2 in connection with the implementation of the Wildfires and Material Transport in Water use cases, there are also natural disasters and combating their effects. Verification of computational models based on changing conditions and newly acquired data is necessary to maintain competitiveness.	
Climate change and global warming	Climate change is one of the biggest challenges facing the world in the coming years, affecting politics, the economy, infrastructure and everyday life. Achieving ambitious climate goals will require major changes in energy, transport, agriculture and urban planning. The mechanisms to achieve this include higher carbon taxes and an expansion of the EU Emissions Trading System (ETS), tougher limits on industrial emissions, and expanded “green finance” and sustainability reporting.
Carbon footprint and sustainability policies	The EU plans to cut carbon emissions by 55% by 2030 and reach net zero emissions by 2050. The next decade will see more stringent carbon policies, massive investments in green technologies and

	fundamental changes in industry, energy and lifestyles. In addition, renewable energy generation capacity will be significantly increased, with the aim that by 2030 at least 45% of energy will come from renewable sources. Natural gas will be phased out, replaced by heat pumps and district heating. Coal-fired power plants are planned to be closed across the EU by 2035. Green hydrogen (produced using renewable energy) is expected to replace coal and gas in heavy industry.
Natural disasters and resource availability	Recently, we have observed more frequent and severe natural disasters related to the intensification of heat waves and fires, floods and storms, droughts and desertification of agricultural fields, hurricanes and extreme storms. This causes shortages of resources such as water, food and energy. More frequent droughts will force more stringent water management in agriculture and cities. Extreme weather conditions will reduce crop yields in Spain, Italy and France, affecting cereals, olives and vineyards. Lack of hydropower may result from lower river levels.
Waste management and recycling trends	Changing environmental regulations are driving trends in waste management and recycling. Increasingly, regulations require producers to take responsibility for waste collection and recycling (Extended Producer Responsibility - EPR). In addition, the EU is banning or restricting certain plastic items (Single-Use Plastics Directive), pushing for sustainable alternatives. Many industries are incorporating more recycled materials due to regulations and consumer demand. New circular business models are emerging, such as leasing and repair services that reduce waste generation. Consumers are also demanding sustainable products and responsible waste management thanks to growing awareness and changes in behaviour.

The chart below presents an assessment of the impact of individual macro-environmental trends in different terms (short, medium and long) on the HiDALGO2 offer.

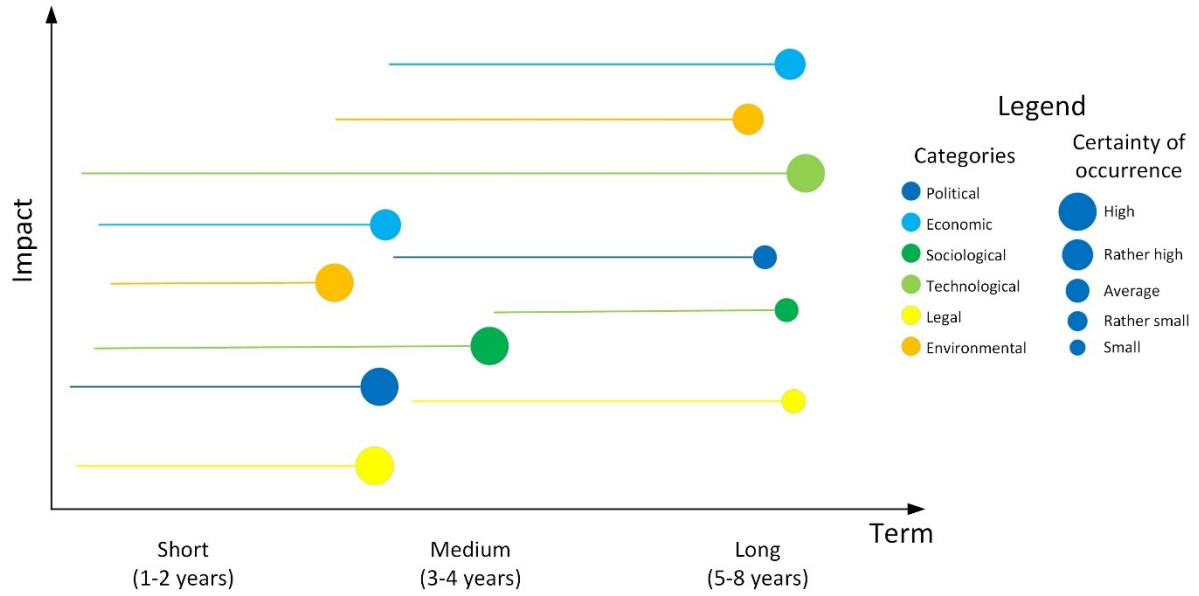

Figure 2. The impact of macro-environmental trends in time perspective on HiDALGO2 tender

The following assumptions were made when developing the above chart:

- political - the impact on a potential business venture in the first period is small with high certainty assuming currently positive attitudes in Europe, the impact may be larger in the later period (with lower certainty) due to potentially changing attitudes favouring economic efficiency,
- economic - the macroeconomic situation and the related economic situation of potential customers is always a significant factor determining the willingness and possibility of purchasing services such as those offered by HiDALGO2; initially, its moderate impact should be assumed (with rather high certainty) due to the not-so-bad (slow development) state of the economy; later, the importance of this aspect will increase due to the uncertainty related to customs tariffs and armed conflicts affecting, for example, supply chains,
- sociological - social expectations related to development and improvement of living conditions influence the decisions of the government in the context of better management of crises resulting from natural disasters (e.g. fires, floods) and social development (e.g. clean air, low-emission buildings); initially, the impact of this phenomenon should be assessed with great certainty as moderate (due to its current, positively high value), in the later period, no major change should be assumed (people will always expect improvement of conditions), however, the value of the level of certainty due to the time horizon is already lower,
- technological - the technological aspect will remain at a consistently high level throughout the duration of the project; it is important both during the development of services and their subsequent offering to customers, additionally guaranteeing a competitive advantage on the market; however, it

should be remembered that offering high-quality technological services in the perspective of several or a dozen years requires investment outlays for development,

- legal - the impact of the legal aspect should be assessed as low due to the highly developed regulation already at this stage; meeting legislative requirements both in terms of the quality of the services offered and the rights of employees employed in the provision of services to clients must be included in the costs of the service; in the later period the value of this aspect increases to a small extent due to the uncertainty resulting from the general macroeconomic situation, however, a revolution should not be expected,
- environmental - all forecasts related to the dynamics of environmental changes indicate their intensification; this should be associated with the growing importance of services reducing the risk of their impact on the lives of citizens; in the initial period, this aspect is of moderate importance (with high certainty) due to the announced numerous investments at the government and local government level in risk mitigation; later, the importance will increase due to the uncertainty regarding investment plans, which may be limited by the deterioration of the economic situation.

3.2 Customer segments

The challenge of identifying the appropriate client categories is complex, primarily due to the necessity of balancing various interests. The consortium aims to maximize its impact across a broad socio-economic spectrum. However, it must also operate within the constraints of its limited resources, necessitating a focus on economic viability. Initially, six recipient groups were identified big companies, small and medium-sized enterprises (SMEs), research institutions and academia, policymakers, public entities, and civil society. After evaluating the advantages and costs associated with collaboration with each group, the decision was made to concentrate efforts only on three of them: big companies, research/academia, and both national and local government entities. The following table (Table 3) outlines the thematic framework for each category, which serves as the foundation for establishing partnerships.

Table 3. Potential thematic scope of cooperation within selected customer categories

		
Big companies	**Research/Academia**	**National and local government**
Preparation of a new simulation model of the phenomenon for the needs of the business use case Adaptation of the existing model to meet the requirements of a broader business scenario Regular running of HiDALGO2 models and provision of simulation data Profiling of a large-scale application for optimization on cluster systems	Collaboration in developing simulation models to increase their accuracy Searching for synergy between existing models by exchanging data and increasing the offered functionality Working together to improve performance through profiling, surrogate models and the use of modern infrastructures	Preparation of simulations verifying the assumptions of planned communication or construction policies in the context of mitigating negative environmental and social phenomena. Searching for causes preventing sustainable development in existing urban infrastructure solutions in order to mitigate or eliminate them. Support in preparing plans for civil services in the event of the occurrence of dangerous natural disasters (e.g. wildfires).

3.3 Key partners

The table below presents key customers who are potentially interested in either purchasing HiDALGO2 services (e.g. consulting, reports on the impact of individual strategies) or jointly implementing modern solutions in their areas, thus enabling the reduction of the impact of adverse phenomena on society. In the current form, groups of stakeholders are presented without providing specific their names, which will probably be clarified in the next WP6 report (D6.6).

Table 4. Table of Stakeholders per Use Case

Use case	Stakeholders
Urban Air Project	EU cities, urban planning, local authorities, governments, road operators
Urban Buildings Model	city hall, urban planning, local authorities, companies, research institutions
Renewable Energy Sources	distribution system operators (DSO), local authorities, companies, research institutions
Wildfires	regional forest administration, local authorities, companies, research institutions
Material Transport in Water	water administration institutions, water management companies, NGOs, local authorities, companies, research institutions

3.4 Market size estimation

The table below presents information on the market size for individual areas corresponding to the use case topics. It should be noted that the values given concern a broadly defined area (research, production, installation, implementation and supervision), while the activities of HiDALGO2 focus on only one of them. Unfortunately, it is extremely difficult to find estimates regarding the scope covering the project's activities only.

Table 5. Market size estimation per use case

Use case	Market	
	Present	Forecast
Urban Air Project	Air Quality Monitoring Systems is estimated at 3.47 Billion EUR	4.63 Billion EUR by 2027
Urban Buildings Model	Building Information Modeling (BIM) Market Size, valued at USD 6.85 billion in 2022	Market is poised for substantial growth, with an anticipated value of USD 17.32 billion by 2030
Renewable Energy Sources	USD 885 billion in 2021	USD 1980 billion by 2030
Wildfires	• Global Forest Wildfire Detection System Market was valued at US$ 740.18 million in 2023 • Aerial Firefighting 4946.77 million $ (2022)	• GFWDSM is projected to surpass the market valuation of US$ 1,259.81 million by 2032 at a CAGR of 6.30% during the forecast period 2024-2032. • AF - 6262.25 million $ by 2028
Material Transport in Water	Water Quality Monitoring Market - USD 5.13 Billion in 2021	USD 9.12 Billion by 2030

The conclusions drawn from the presented values allow us to see the significant value of the HiDALGO2 project deposits and the forecasted increase in their value in the near future.

3.5 Sustainability plan

The Sustainability Plan (SP) is being developed by HiDALGO2 to detail how it will achieve its commercial, scientific and social/promotional objectives beyond the project period. It is intended to provide a structured approach to ensuring that the research project results remain influential, accessible and relevant, contributing to ongoing advances in the field of environmental simulation.

3.5.1 Sustainability plan goals

The **commercial goal** of the HiDALGO2 project is to obtain funding to maintain and develop the services offered by the consortium by providing commercial services to customers.

The **scientific goal** is to further develop simulation models and operational capabilities of HiDALOG2 to the extent that the commercial orders obtained allow for this. This will enable the offer to be kept in line with current trends and to expand its capabilities, increasing its attractiveness and adaptability in the context of future orders.

The **social-promotional goal** includes activities that are not directly a source of income but contribute to the dissemination of knowledge about the benefits of a reliable and responsible development of strategies for dealing with natural disasters and the adverse effects of civilization development.

3.5.2 Sustainability plan areas

3.5.2.1 Financial sustainability

Ensuring financial stability is addressed through three distinct avenues: institutional collaboration, monetization of existing solutions, and ongoing financing.

Institutional collaboration involves forming business relationships with governmental, non-governmental, or private entities that aim to enhance their strategies and operational capabilities. This is achieved by providing simulation analyses and consultations that serve as scientific support for development or modernization decisions.

Monetization of the HiDALGO2 initiative entails the sale of patent rights for developed solutions or software licenses, along with the option to utilize resources provided by consortium partners or EuroHPC JU (commercial track [4]).

Lastly, ongoing financing pertains to the pursuit of additional grants, sponsorships, or partnerships to sustain research applications.

3.5.2.2 Operational sustainability

A crucial aspect of ensuring the longevity of project outcomes is the maintenance of operational readiness concerning service activities and data accessibility. It is essential to note that project partners are required to uphold the project results for a duration of five years following its conclusion. This obligation necessitates that all developed services remain in a condition that permits their utilization promptly when the need arises. Services integral to dissemination efforts, such as the website, training materials (Moodle), the question and answer portal (Askbot), and informational and educational resources (Wiki), must be consistently available. The project is supported by two supercomputing centres, PSNC and HLRS, which are partners in the project and possess the resources and capabilities to provide these services at no cost. In instances where commercial clients are acquired for services, particularly HPC computations, it is anticipated that the associated costs will be financed through the funding obtained. Research data generated from the project will be adequately safeguarded and stored in secure repositories at the supercomputing centres, equipped with suitable backup solutions. Furthermore, selected codes and related data will be accessible through the European Zenodo repository.

3.5.2.3 Dissemination and sustaining engagement

The dissemination activities and opportunities of the project will be implemented mainly through knowledge transfer and dissemination in three areas: publications, conferences and public engagement. In the first area, it should be assumed that the project partners who are scientists are interested in publishing the results obtained during the project and as such they will be published either as peer-reviewed articles or review reports. Another channel of communication with the scientific and professional community will be conferences and workshops, where in addition to giving presentations, there is the possibility of organizing practical demonstrations and trainings based on the project infrastructure. The last of the presented opportunities assumes public engagement through the dissemination of simplified studies on the HiDALGO2 research areas as educational materials for non-expert audiences. This public awareness activity can be done through social media, blogs, and press releases to maintain engagement.

In addition, within the existing possibilities, cooperation with decision-makers should be considered both at the stage of providing suggestions as a preliminary material for decisions and analysing the impact of the decisions made for their most beneficial implementation. This requires the inclusion in the decision-making and analytical process, which can take place during regular meetings of stakeholders such as decision-makers, funders and industry and end users. Finally, one should not forget about monitoring the situation by analysing both existing trends in the area of mitigation of environmental phenomena and assessing the impact of dissemination activities.

4 Exploitation report

Section 4 focuses on the utilization of the outcomes generated within the HiDALGO2 project framework. These results are firstly categorized as Key Exploitable Results and Exploitable Results. Afterwards, the partners provide input with respect to the description of their exploitable results, the relevant IPR issues. Finally, the section presents the actions that will guarantee the exploitation of the HiDALGO2 results after the project's lifetime, as well as the expected exploitation pathways (i.e. exploitable result usage model).

4.1 Individual exploitation plans

In Table 5 and Table 6 below, we have indicated all the Exploitable Results of the project and highlighted the Key Exploitable Results. More specifically, a Key Exploitable Result is an identified main interesting result which has been selected and prioritised due to its high potential to be "exploited". To be "exploited" means to make use of and derive benefits from the value chain of a product, process or solution, or act as an important input to policy, further research or education. They were selected using the following criteria: a) degree of innovation, b) exploitability and c) impact. A second categorization is the type of results: Integrated Platform, Innovative Solution - SW (software in which the algorithms are embedded; standalone), AI & ML Model/ Method, System/ Model. An Integrated Platform is a software in which the algorithms are embedded, it is standalone, and its main target is to solve complex problems. Until now in the project we have identified twelve (12) Key Exploitable Results, fifteen (15) Exploitable Results and four (4) types of results.

There are two main ways through which we are exploiting the results of this project:

- **Industrial partners:** ATOS and MTG, along with the research centres SZE, FAU, ICCS, PSNC, HLRS and UNISTRA, will concentrate on engaging public administrations and industrial customers interested in specific use cases and the HiDALGO2 tools. They will receive support from academic partners who are leading investigations in various areas, including wildfires and air pollution.
- **Academic partners**: while they can offer consultancy services, they primarily focus on activities such as training and knowledge transfer. Additionally, the academic partners in HiDALGO2 possess the most advanced high-performance computing (HPC) systems. As a result, they stand to gain from HiDALGO2 by expanding their customer base, even though companies like ATOS also provide HPC as a Service (HPCaaS).

All partners in the HiDALGO2 project commit to continue exploiting the results of the project four years after its completion. This means that the partners will continue close

collaboration with all stakeholders (industry partners, companies, SMEs, academia, policy makers etc) to have the maximum impact.

Table 5 indicates the KERs of HiDALGO2, along with a categorisation of each result, based on the result's usage and a short description. Please note that during the later stages of the project, the results will be better defined, and more information will become available, completing the missing input. All the updates will be presented in D6.6 (M46).

Table 5. Key Exploitable Results List

#	Key Exploitable Results	Type of Result	Short Description
1	Data Management System	Integrated Platform	High-scalable, high-performance data management system, offering data provision and transfer, between Cloud providers and HPC data centres, underpinning the execution of pilot's simulations and the further analytics and visualization of their data outcomes.
2	High-resolution urban air comfort maps from simulations	Innovative Solution - SW (software in which the algorithms are embedded; standalone)	The service provides the user with high resolution simulation of urban air and its assessment for urban pedestrian air/wind comfort and safety.
3	Software tools for urban planning	Innovative Solution - SW (software in which the algorithms are embedded; standalone)	The service provides urban designers and policymakers with computational tools serving to mitigate or cease the negative effects of urban challenges from an easy-to-use, tailored user interface, and HPC simulations in the background
4	Ktirio-Urban-Building Services	Innovative Solution - SW (software in which the algorithms are embedded; standalone)	The Ktirio Urban Building services are a set of services that when used in a workflow allow the simulation of building energy and comfort as well as other use cases
5	Renewable Energy Sources	Innovative Solution - SW (software in which the algorithms are embedded; standalone)	Prediction of the damages to the infrastructure (e.g. overhead electrical network). Energy production estimation (from wind farms or PV systems)

#	Key Exploitable Results	Type of Result	Short Description
6	Ktirio-GUI	Innovative Solution - SW (software in which the algorithms are embedded; standalone)	Graphical User Interface that allows to generate the data for the Ktirio Urban Building services
7	Ktirio Data - CKAN.Girder	Other Dataset	A robust data management framework built on CKAN and Girder, ensuring secure, scalable storage and efficient cataloguing of building and city datasets, thereby streamlining data sharing across the UB Pilot.
8	Material Transport in Water pilot	System/ Model	The scalar transport simulations give an understanding of temperature distribution in particle-laden flows that helps in better studying aquatic systems and other large river bodies.
9	Tailored demonstrators	Innovative Solution - SW (software and simulation results integrated in an immersive 3D visualisation framework)	Several HPC simulation results integrated into an immersive 3D visualisation tool based on Unreal Engine, so that the user can have an interactive experience of how a wildfire can develop.
10	Software bridge from WRF-SFIRE to Unreal visualization	SW tool	Software tool that allows WRF outputs to be adapted to the required format for display in Unreal.
11	FSE-Ensembles	SW-model	Software for ensembles simulations using FSE and generation of Burn Probability Maps
12	3D VegeFOAM	SW tool	Application for the description of 3D vegetation and bridge to OpenFOAM/fireFoam simulations

Table 6 indicates further the Exploitable Results of HiDALGO2, along with a categorisation of each result based on the results' usage and a short description.

Table 6. Exploitable Results List

#	Exploitable Result	Type of Result	Short Description
1	MathSO portal	Integrated platform	MathSO-portal is a software framework to provide an easy-to-use graphical user interface to define, deploy, execute workflows for HPC applications. The portal is integrated with some pre- and post-processing and integration tools for simulations (e.g. mesh generation, visualization of the results, application image generation).
2	CFDR (CFD Renderer)	Innovative Solution - SW (software in which the algorithms are embedded; standalone)	CFDR is a visualization software designed and implemented for the fast visualization of CFD simulation (tailored for CFD applications) results that run on HPC machines and visualized on users servers.
3	RedSim	Innovative Solution - SW (software in which the algorithms are embedded; standalone)	RedSim (Reduced Simulations) is a native OpenMPI+CUDA code for scalable running CFD on HPC multi-GPU and CPU systems simulations for compressible fluids.
5	Ray Tracing for Solar Mask (Open Source)	Innovative Solution - SW (software in which the algorithms are embedded; standalone)	A high-performance computing framework for solving partial differential equations, providing advanced simulation and modelling capabilities that support advanced numerical methods and numerical building blocks for the Urban building pilot
6	Feel++	Innovative Solution - SW (software in which the algorithms are embedded; standalone)	A geometry-handling component tailored to complex urban building structures, facilitating accurate 3D model creation from building to cities and integration with other Ktirio modules to improve simulation accuracy.
7	Ktirio Geom	Other Dataset	An online platform where various building and city-related simulation reports are uploaded, managed, and shared, enabling stakeholders to compare and analyse different use cases within the UB Pilot.

#	Exploitable Result	Type of Result	Short Description
8	Ktirio Cases - https://cases.ktirio.fr	Other Dataset	The central entry point for the Ktirio ecosystem, offering documentation, user resources, and an overview of available services and tools for managing and analysing building performance data.
9	Ktirio Reporting	Innovative Solution - SW (software in which the algorithms are embedded; standalone)	A reporting module that generates detailed analytics and visual outputs from simulation results, helping stakeholders track and understand building performance metrics over time. It is deployed in Ktirio cases site
10	Ktirio Models	Innovative Solution - SW (software in which the algorithms are embedded; standalone)	A collection of validated simulation and data models specifically designed for urban building studies, enabling complex scenario testing and supporting evidence-based decision-making in the UB Pilot.
11	MUQSA	Integrated platform	MUQSA (Multipurpose Uncertainty Quantification and Sensitivity Analysis) is a web platform for automated UQ&SA studies of computational models. It provides intuitive interface and
12	QCG	Integrated platform	QCG is a web portal facilitating and automating remote execution of computational experiments on HPC clusters. It provides flexible and highly customisable interface; thus it may be used for many types of jobs ranging from simple serial executions, through parallel jobs and tasks with GUI, and adding with complex workflows.
13	COVISE	Innovative Solution - SW (software in which the algorithms are embedded; standalone)	COVISE, the collaborative visualization and simulation environment, is a modular distributed visualization system.
14	Vistle	Innovative Solution - SW (software in which the algorithms are	Successor of COVISE with support for parallel post processing, visualization and rendering

#	Exploitable Result	Type of Result	Short Description
		embedded; standalone)	
15	Surrogate Model	AI & ML Model/ Method	Prediction of Material Transport in Water Using a Deep Learning-Based Surrogate Model. The approach involves initially predicting the flow dynamics in water, followed by an attempt to predict both the flow and material transport together.

4.2 Research roadmap to 2030

By 2030, HiDALGO2 aims to advance environmental simulations using High-Performance Computing (HPC), big data, and Artificial Intelligence (AI) to address global challenges such as air quality, energy efficiency, and climate resilience. The research roadmap focuses on enhancing the scalability and precision of simulations, integrating emerging technologies, and aligning with EU sustainability goals. Key milestones include the development of scalable AI-driven models, expansion into new environmental applications and interdisciplinary collaboration, and the implementation of advanced predictive systems to support policy-making. Continuous funding through Horizon Europe, investment in cutting-edge infrastructure, and collaboration with academic, industry, and policy stakeholders will be essential. Regular assessments and performance metrics, including successful simulations, publications, and policy contributions, will ensure progress and adaptability. By fostering innovation and cross-sector partnerships, HiDALGO2 aims to contribute to the EuroHPC JU's long-term environmental and digital transformation, supporting a sustainable and resilient future. In the next and final version of this report D6.6 (M46) the detailed research roadmap will be presented with more information of national and EU funded research.

4.3 IPR tracking

The Consortium Agreement will govern dissemination, access rights and use of knowledge and intellectual property. The Project Coordinator and the Project Coordination Committee (PCC) will maintain an IPR Directory throughout the lifetime of the HiDALGO2 project. This document lists all items of knowledge relating to the work of the project (both pre-existing know-how and results developed in the project), and make explicit for each item:

- Confidentiality concerning the information disclosed by the partners during the project's lifetime.

- The nature of the knowledge, and its perceived potential for exploitation.
- Ownership of the assets resulting from the project execution.
- The currently agreed status of the item concerning plans to use the knowledge in exploitation, or plans to disseminate it outside the consortium.
- The link between the HiDALGO2 services and the exploitable item.
- Patent rights for protecting results.
- Commercial utilisation of results taking their ownership into account (exploitation and sustainability plans).
- Measures required, or in place, to ensure protection of IPR for the item.
- Fair licences under reasonable terms for any background necessary for exploiting project results.
- Third party limits defined by sublicenses.
- Consideration for distinguishing licences for research purposes or for commercialization.
- The directory will be regularly updated, and available to all partners. It will form a key tool to enable knowledge management.

The project coordinator is responsible for the use of IPR within the consortium, according to the terms laid out in the Consortium Agreement. In general, tools, methodology documents, benchmarks and use cases will be available to all; while some proprietary tools and algorithms developed by the partners may be available at the discretion and terms of their respective owners. The Consortium Agreement details the procedures to request access to the protected knowledge and tools, setting the conditions under which the protected knowledge is accessed and used.

Having set all the above, the two tables below present in detail, all the IPR properties each tool of HiDALGO2 will have.

Regarding the TRL Levels, they are set as Horizon Europe [1] indicates:

- TRL1: Basic Principles Observed
- TRL2: Technology concept formulated
- TRL3: Experimental proof of concept
- TRL4: Technology validated in lab
- TRL5: Technology validated in relevant environment
- TRL6: Technology demonstrated in relevant environment
- TRL7: System prototype demonstration in operational environment
- TRL8: System complete and qualified
- TRL9: Actual system proven in operational environment

The final TRL levels of each exploitable results will be presented in the final deliverable D6.6 (M46), in which we will present a detailed report on the results development.

Having set all the above, the two tables below present in detail, all the IPR properties each tool of HiDALGO2 will have.

Table 7 represents all the IPR principles of the Key Exploitable results of the project.

Table 7. IPR of Key Exploitable Results

Key Exploitable Results	Ownership	Name(s) of Owner(s)	Related Tasks	Current TRL	License Of ER	Indicative type of protection	Conditions to use within the project	Conditions to use the result after the end of the project
Data Management System	Joint	PSNC, ATOS	T4.1	TRL5	AGPL v3.0, APLv2.0	N/A	OSS licence, free to use, no restrictions	OSS licence, free to use, no restrictions
High-resolution urban air comfort maps from simulations	Single	SZE	T.5.1	TRL5	SZE	Copyright SZE	Closed Source, free to use	Upon Agreement
Software tools for urban planning	Single	SZE	T5.1	TRL5	SZE	Copyright SZE	Closed Source, free to use	Upon Agreement
Ktirio-Urban-Building Services	Single	UNISTRA	T5.2	TRL4	Closed	Copyright UNISTRA	Closed, free to use on shared EuroHPC resources	Closed, free to use on shared EuroHPC resources
Renewable Energy Sources	Single	PSNC	T5.3	TRL4	AGPLv3, PSNC	Copyright PSNC	AGPLv3, bi-lateral agreement	bi-lateral agreement

Key Exploitable Results	Ownership	Name(s) of Owner(s)	Related Tasks	Current TRL	License Of ER	Indicative type of protection	Conditions to use within the project	Conditions to use the result after the end of the project
Ktirio-GUI	Single	UNISTRA	T5.2	TRL4	GPL	Copyright UNISTRA	Closed, free to use	Closed, free to use
Ktirio Data-CKAN.Girder	Single	UNISTRA	T5.2	TRL 7	N/A	Copyright UNISTRA	Closed, free to use	Closed, open to discussions on the exploitation, NDA, licensing
Material Transport in Water pilot	Single	FAU	T5.5, T3.4	TRL7	GNU AGPLv3	AGPLv3 FSF	N/A	free to use
Tailored demonstrators encapsulating and showing HPC simulations	Single	MTG	T5.4	TRL7	GPL for the software. Results under agreement with customers.	Copyright MTG	Free to use	Agreement
Software bridge from WRF-SFIRE to Unreal visualization	Single	MTG	T5.4	TRL5	GPL	Copyright MTG	Free to use	Free to use

Key Exploitable Results	Ownership	Name(s) of Owner(s)	Related Tasks	Current TRL	License Of ER	Indicative type of protection	Conditions to use within the project	Conditions to use the result after the end of the project
Application for the description of 3D vegetation and bridge to OpenFOAM/fireFoam simulations	Single	MTG	T5.4	TRL5	GPL	Copyright MTG	Free to use	Free to use

Table 8 represents all the IPR principles of the rest of the Exploitable results of the project.

Table 8. IPR of Exploitable Results

Exploitable Results	Ownership	Name(s) of Owner(s)	Related Tasks	Current TRL	License Of ER	Indicative type of protection	Conditions to use within the project	Conditions to use the result after the end of the project
MathSO portal	Single	SZE	T5.1	TRL5	Several OSS licences: AGPL v3.0, APLv2.0	N/A	OSS licence, free to use, no restrictions	OSS licence, free to use, no restrictions

Exploitable Results	Ownership	Name(s) of Owner(s)	Related Tasks	Current TRL	License Of ER	Indicative type of protection	Conditions to use within the project	Conditions to use the result after the end of the project
CFDR (CFD Renderer)	Single	SZE	T.5.1	TRL5	SZE	Copyright SZE	Closed Source, free to use	Upon Agreement
RedSim	Single	SZE	T5.1	TRL5	SZE	Copyright SZE	Closed Source, free to use	Upon Agreement
Ray Tracing for Solar Mask (Open Source)	Single	UNISTRA	T5.2	TRL 4	GPL	Copyright UNISTRA	Open, free to use	N/A
Feel++	Single	UNISTRA	T5.2	TRL 6	LGPL & GPL	Copyright UNISTRA	Open, free to use	N/A
Ktirio Geom	Single	UNISTRA	T5.2	TRL 5	GPL	Copyright UNISTRA	Open, free to use, double licensing under study	N/A
Ktirio Cases - https://cases.ktirio.fr	Single	UNISTRA	T5.2	TRL 7	N/A	Copyright UNISTRA	free to use	N/A
Ktirio Data - CKAN.Girder	Single	UNISTRA	T5.2	TRL 7	N/A	Copyright UNISTRA	Closed, open to discussions on	N/A

Exploitable Results	Ownership	Name(s) of Owner(s)	Related Tasks	Current TRL	License Of ER	Indicative type of protection	Conditions to use within the project	Conditions to use the result after the end of the project
							the exploitation, NDA, licensing	
Ktirio Reporting	Single	UNISTRA	T5.2	TRL 7	N/A	Copyright UNISTRA	Open, free to use	N/A
Ktirio Models	Single	UNISTRA	T5.2	TRL 4	GPL	Copyright UNISTRA	Closed, open to discussions on the exploitation, NDA, licensing	N/A
MUQSA	Single	PSNC	T4.6, T2.4	TRL 7	AGPLv3	open source	free to use	free to use
QCG	Single	PSNC	T2.4	TRL 7	AGPLv3	open source	free to use	free to use
COVISE	Single	USTUTT	T4.4	TRL7	LGPL v2.1	N/A	Free to use	Free to use
Vistle	Single	USTUTT	T4.4	TRL7	LGPL v2.1	N/A	Free to use	Free to use
Surrogate Model	Single	FAU	T4.3, T3.3	TRL1	N/A	N/A	N/A	N/A

5 Risk assessment and mitigation

It is assumed that a consortium consisting of interested project partners will be established (after the completion of the HiDALGO2 project) to implement the commercial undertaking (providing a paid service). The chapter presents a study of the most important risks related to the implementation of the order and actions for their mitigation. For better organization, the risks have been divided into categories related to: market, finance, management, scientific and technical, and dissemination.

Table 9. List of potential risks along with assessment and mitigation

Risk description (Likelihood/Severity)	Proposed risk mitigation measures
Market	
Insufficient market demand: The demand for the product falls short of anticipated levels, potentially resulting from inadequate market analysis, shifts in consumer preferences, or unexpected competitive pressures. *[High/Medium]*	Conduct thorough market research to assess demand before launching your product
Competitive landscape: Current or emerging competitors may offer comparable products or services at reduced prices or with enhanced features. *[Medium/Low]*	Developing and defining a unique selling proposition (USP) will help you stand out from your competitors. Create a minimum viable product (MVP) and test it in pilot markets.
Timing in the market: wrong timing can result in the failure to capitalize on significant trends or the premature or delayed launch of a product. *[Low/Medium]*	Connect with industry pioneers and experts to get their feedback. Conduct market research to get a test group assessment.
Financial	
Insufficient funding: The project could deplete its financial resources prior to reaching the commercialization stage or may encounter challenges in obtaining additional investments.	Assess costs properly before signing a contract. Order advances sufficient to cover labour and equipment costs. Diversify funding sources: grants, venture capital, crowdfunding, partnerships.

[High/Medium]	
Overly optimistic cost estimates: Preliminary calculations regarding production, marketing, and distribution expenses may prove to be significantly less than the actual costs incurred. *[High/Medium]*	Develop a detailed financial plan and cost projections with buffer funds.
Financial liquidity challenges: The process of commercialization might necessitate greater initial expenditures (such as for product development, marketing, or patent protection) than anticipated, resulting in cash flow difficulties. *[Medium/Medium]*	Make phased investments to secure financing at key development stages.
Consortium management	
Planning problems: resources underestimated, consortium timing not appropriate, further experts needed, deliverables/milestones delayed *[Medium/Medium]*	Potential solutions are involvement of other partners with available resources, rearrangement of resources among partners, change of the plan within the self-assessment activities, and ensuring timely implementation of corrective actions.
Collaboration issues – Consortium cannot agree, interaction not satisfactory, coordination not efficient *[Medium/High]*	Consortium management provides appropriate decision making and conflict resolution procedures which should be applied. As last instance, managements of the affected organisations, including the coordinating organisation, will be involved in resolution.
Scientific and technical	
Access to innovative HPC architectures cannot be provided *[Low/High]*	Business based on modern technologies requires the latest architectures to run calculations. Ensure participation in the implementation of at least one supercomputing centre with their individual suppliers, which will provide access to different architectures, as well as individual test systems.
Solutions developed do not scale or yield much lower performance improvements than envisioned *[Low/High]*	Progress in scalability and optimization (including co-design activities) of pilot applications and exascale tools must be closely monitored through an outlined benchmarking and profiling strategy, so that early action can be taken when predicted breakthroughs in scalability do not match predictions.

HPDA methods cannot substantially assist in HPC tasks, due either to lack of scale or lack of integration points with them. *[Low/High]*	Develop clear processing and data requirements most suitable for HPDA methods for early-stage pilot applications. Scalability and effective coupling are rigorously monitored through benchmarking and integration activities and will be continuously improved throughout the project.
Availability of compute resources and data does not suffice changed requirements by the pilot owners *[Low/Medium]*	If these resources are insufficient, cooperation with external infrastructure providers (e.g. EuroHPC) is foreseen to support the required simulations and benchmarking activities. Furthermore, the risk of data shortage is low due to the already developed data acquisition mechanisms. Nevertheless, the budget should include the possibility to purchase additional data if necessary.
Unforeseen problems related the availability of data to be used by use cases *[Low/Medium]*	Data availability is crucial. For example, the data assimilation procedure performed in the WRF model of the hydro-meteorological use case requires the availability of in-situ and remotely-sensed data. The lack of this data due to unforeseen problems in the measurement instruments may cause lower precision in the weather forecasts. This also applies, for example, to the urban building models, where 3D reconstruction of building scans are required to be obtained in agreement with city councils. To mitigate this risk, support for these activities was already requested by several cities (cf. Letters of Support), and appropriate data harvesting mechanisms are set in place to track progress of availability of data.
Exploitation and dissemination	
Failed or insufficient exploitation of results by consortium members *[Low/Medium]*	HiDALGO2 has been designed to keep this risk as low as possible. The Exploitation Plan will identify an exhaustive list of opportunities for HiDALGO2 outcomes, many of them intended to be exploitable on an individual partner's basis.
Outreach to new communities and generated impact is lower than expected [*Low/High*]	The consortium is setting up at the start of the project a reasonable communication strategy and compiles a roadmap for the campaigning activities including holding an EU Clustering event organized by HiDALGO2. These objectives are revised on a regular basis to be adapted and further improved if needed.

Intellectual Property disputes: ambiguities over IP ownership between researchers, institutions and companies can cause delays or conflicts. *[Medium/Medium]*	Clearly define IP ownership in contracts (especially in collaborations). Ensure proper licensing agreements for third-party technologies.

6 Conclusions

The deliverable outlines a comprehensive overview of the of HiDALGO2's exploitation and IPR strategy and the market analysis and sustainability roadmap.

The importance of the exploitation and IPR strategy lies in maximising the impact and sustainability of project results by ensuring their effective use, protection, commercialisation, and transfer through strategic intellectual property management, market uptake, knowledge dissemination, and long-term sustainability planning. Regarding the market assessment and sustainability plan the goal was to assess market potential, identify key stakeholders, and define strategies for long-term adoption, funding, and commercialisation of project results, ensuring their continued impact beyond the funding period.

In total we have identified 27 exploitable results in the HiDALGO2 project. From these, 12 are identified as key exploitable results of the project, meaning they are the biggest most valuable achievements. They are mostly single owned (96%) and are split in various type of results. Most of them, around 56% are Innovative solutions. HiDALGO2 is also building 4 integrated platforms, 3 datasets, 2 tools and 3 models.

All topics in the current deliverable have been thoroughly analysed, with clear plan and actions presented to demonstrate how the consortium will succeed in exploitation and sustainability. All partners have collaborated to gather information and envision how their tools will be effectively utilized both during and after the project. Based on the actions and plan outlined above, we are optimistic that these goals will be achieved both during the HiDALGO2 project and in the four years following its completion.

The next and final document, D6.6, will present the results of further analyses together with a sustainability report, a road map and an operational report.

References

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