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The GLACIATION consortium consists of the following partners:

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1	MINISTERO DELL'ECONOMIA E DELLE FINANZE	MEF	IT
2	EMC INFORMATION SYSTEMS INTERNATIONAL UNLIMITED COMPANY	EISI	IE
3	HIRO MICRODATACENTERS B.V.	HIRO	NL
4	GOTTFRIED WILHELM LEIBNIZ UNIVERSITAET HANNOVER	LUH	DE
5	THE LISBON COUNCIL FOR ECONOMIC COMPETITIVENESS ASBL	LC	BE
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List of Terms and Abbreviations

Table 1 - Abbreviation Table for Deliverable 8.4

Abbreviation	Description
AI	Artificial Intelligence
D8.1	The Initial Communication, Networking, and Dissemination Plan and Activities Deliverable
D8.2	Communication, Networking, and Dissemination Plan and Activities - Intermediate
DSII	Directorate of Information Systems and Innovation
DKG	Distributed Knowledge Graph
GDPR	General Data Protection Regulation
ICT	Information and Communications Technologies
IDC	International Data Corporation
IML	Innovation Management Log
IoT	Internet of Things
IP	Intellectual Property
IPR	Intellectual Property Rights
KER	Key Exploitable Results
KPI	Key Performance Indicators
PET	Privacy-Enhancing Technologies
R&D	Research and Development
SWOT	Strengths, Weaknesses, Opportunities and Strengths
TL	Task Leader
TRL	Technology Readiness Level
WP	Work Package

Executive Summary

This is Deliverable 8.4 of the GLACIATION Project, Horizon Europe project, titled GLACIATION IPR Management, Business Models, and Business Plan – intermediate, has been primarily drafted by the leader of Work Package 8 (Communication, Exploitation, and Dissemination) with contributions from all partners. This document delivers a thorough market analysis and an evaluation of the European policy environment, pinpointing the role of legislation in promoting technological innovation and market openings.

At its core, the deliverable details the exploitation strategy, the overall business plan as well as individual business plans of most of the consortium private sector parents, presenting a blueprint for commercialising the project outcomes to extend its impact beyond the funding phase. This section also outlines how each partner intends to leverage project outcomes for social, economic, and strategic gains and hence also includes non-commercial exploitation as envisioned in the Horizon Europe Programme. It also summarises the strides made in the open-source strategy and ongoing management of the Intellectual Property Rights (IPR) registry, which guides the use of project outputs in line with legal and ethical standards. The deliverable also provides a strategy refinement plan to build on the foundation set by this deliverable.

Ultimately, the deliverable provides a consolidated overview of market evaluations, legislative context, exploitation pathways, and IPR strategies, affirming the GLACIATION project's dedication to long-term innovation and the fostering of sustainable technological progress within Europe.

1 Introduction

The GLACIATION IPR Management, Business Models, and Business Plan – Intermediate Deliverable (D8.4) serves as the foundational iteration of the Market Analysis, Exploitation Strategy, Business Plan, and Intellectual Property (IP) Management for the GLACIATION project. Value creation is a critical goal for any research and innovation endeavour, and the GLACIATION consortium is mindful of integrating this into specific, cross-project activities and targets, sustaining these efforts throughout the life of the project and thereafter, to ensure the longevity of the project results as well as the solution, both for commercial and non-commerical purposes.

A key risk identified in the Grant Agreement is the potential shortfall in achieving the anticipated impact and subsequent exploitation. To mitigate this, the outlined activities are vital for realising and maximising the project's benefits for European citizens and beyond.

The deliverable has been developed by the Work Package 8 Leader, drawing upon insights from all partners in the GLACIATION consortium. Contributions were made through structured tools such as surveys and questionnaires, as well as through formal and informal gatherings. The series of activities conducted in preparation of this document, which will be detailed herein, are set to continue and evolve beyond the submission of this deliverable. It is crucial to involve all partners in these processes to ensure the market analysis and exploitation plans are as thorough and as useful to the partners as possible.

It is essential to recognise that this document is not static but a 'living' one, subject to continual updates and refinements to incorporate new opportunities or to adjust to any changes in the project's trajectory. There will be second iteration at the project's end to further polish and solidify the plan and strategy, enhancing its potential impact.

This deliverable is intricately tied to the Communication, Networking, and Dissemination Plan and Activities. Efforts in one area naturally bolster those in another, with the strategies detailed in Deliverable 8.1, the Initial Communication, Networking, and Dissemination Plan and Activities (D8.1) as well as Deliverable 8.2, the Intermediate Communication, Networking, and Dissemination Plan and Activities (D8.2) expected to be elaborated within the business plan, along with innovation monitoring and exploitation activities.

Highlighted in the Grant Agreement is the potential for application in public administration scenarios, as demonstrated by Pilot 1 of the GLACIATION project. This case centres on deploying the GLACIATION solution in public administrative settings, offering substantial scope for expansion throughout Italy's public sector, benefiting the environment and aiding governmental objectives for 2030 and 2050.

Moreover, the European legislative framework will shape the business modelling and strategy. It provides an opportunity as both the private and public sectors must adhere to such regulations. This legislative framework includes climate goals and data privacy requirements like GDPR, necessitating solutions for sustainable as well as privacy preserving data management. At its core, GLACIATION offers a solution that meets these needs, ensuring enhanced privacy and sustainability of data movement and operations.

The **document is organised** as follows:

- The initial section details the **tools and methods** applied in crafting this early-stage plan, including workshops, target group identification, persona creation, analytical approaches for policy and market examination, a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis, and an Innovation Management Log (IML)
- **Policy Landscape** analysis exploring legislative sustainability and data centre considerations, with upcoming focus areas including privacy and the broader European Digital Agenda.
- **Market Analysis** explores public procurement, big data, data centres, cloud, and edge computing sectors, identifying key players, current trends, and specific market characteristics that present opportunities for GLACIATION.
- The **Exploitation Plan**, informed by the SWOT Analysis, examines resources, assets, stakeholders, and potential scenarios, culminating in a stakeholder and innovation matchmaking exercise to tailor plans to target group needs.
- The **Business Plans** provide strategic direction for the GLACIATION Solution as well as specific innovations with individual partner strategies, formulated through the SWOT Analysis and IML.
- **Intellectual Property Management** and **Open Source** considerations discuss the processes and methods utilised, aligning with activities like the Innovation Radar and Project Review.
- **Strategy Refinement and Upcoming Activities:** Specific measures to be undertaken to hone the exploitation strategy and business model based on the insights gathered from the deliverable's activities and the evolving market and policy landscape.

2 Objectives, Monitoring, and Key Performance Indicators

This chapter delves into the GLACIATION project's exploitation objectives, mapping out strategies for monitoring progress towards these aims. It incorporates a set of Key Performance Indicators (KPIs) to assess the project's adherence to these benchmarks.

Exploitation within Horizon Europe projects encompasses the use of project outcomes for further research, as well as commercial, societal, or political ends, essential for a project's ultimate impact. It transforms research into practical applications, policy recommendations, or innovations, aiming to generate enduring social, economic, and environmental benefits.

2.1 Exploitation Objectives

The GLACIATION project's exploitation plan, IP management, business modelling, and business planning are fundamental to achieving the project's intended socioeconomic impact, ensuring its broad adoption, and facilitating contributions to standardisation processes. These components are equally critical for the potential commercialisation by the private sector, ensuring that both the consortium partners and European citizens fully benefit from the project's outputs, thus securing the GLACIATION solution's sustainability and longevity. Beyond commercialisation, it is essential that the project's outcomes inform policy recommendations, creating enduring benefits across social, economic, and environmental spheres—an imperative aspect of exploitation that maximises the project's full potential.

The primary aim of the exploitation plan is to maximise the utilisation of the GLACIATION project's outcomes, enriching the participating organisations commercially and contributing substantially to the socioeconomic advancement of European society.

Below is a refined breakdown of the exploitation objectives:

- Develop comprehensive requirements for engineering and design methodology that identifies **end-user needs** precisely and tangibly.
- Implement a rigorous **regimen** of **measurement, testing,** and **reporting** to validate innovation concepts and ensure their full exploitation.
- Offer a **policy framework** that informs business modelling and planning, along with other exploitation routes.
- Conduct a **market analysis** that spotlight opportunities for the GLACIATION solution and identifies Key Exploitable Results (KER).
- Establish an **IP management system** that facilitates full project exploitation without hindering implementation.
- Utilise consortium expertise for nuanced **stakeholder analysis**, ensuring tailored approaches to exploitation.
- Engage in **proactive exploitation planning** to anticipate and address potential obstacles.

These objectives are crucial for the effective exploitation of the project's results, benefiting partners and, more importantly, the broader European community and beyond. Clear strategies and specific KPIs are vital to avoid missed opportunities that could compromise the project's longevity.

2.2 Monitoring and Key Performance Indicators

Rigorous monitoring of progress and impact is crucial for the full realisation of the GLACIATION project's potential. Without targeted action, there is a tangible risk that the project's valuable outcomes might go underutilised, resulting in missed advantages for both the participating organisations and the wider European community. Hence, vigilant oversight of the exploitation plan's implementation is essential, not only to gauge success but also to inform necessary adjustments that will invigorate the strategies laid out in this document.

To facilitate this, a detailed table of exploitation-related KPIs is provided, as outlined in both the initial and intermediate reports of the Communication, Networking, and Dissemination Plan and Activities (D8.1 and D8.2). This framework will track progress and ensure the strategic use of the project's results.

Table 2 - Comprehensive List of Exploitation, Business Modelling and Business Plan KPIs

Measure	KPI	Objective
Community building/ Stakeholder engagement	No. Of publications	4 articles in industry magazines produced
	No. Of contact points	50 industry contact points reached
	No. Of communities reached	5 industrial communities informed about project
Collaborations and synergies with projects	No. Of projects to liaise with	5 projects
	No. Of activities organised with other projects	4 joint activities (e.g. organisation of joint events, publication of policy briefs)
	No. Of internal training sessions	4 training sessions organised
Industry Standardisation Contribution	No. Of contributions or citations in technical reports or standards	3 contributions or standards
Open Source Component Adoption	No. Of external parties adopting OSS components	20 external adoptions
Policy Influence	No. Of policy briefs generated	4 policy briefs produced
Public Administration Integration	No. Of public administrations integrating solution	3 integrations in different regions

Technology Readiness Level Progression	No. of technologies reaching next TRL	4 technologies progressed to next TRL level
Stakeholder and Network Expansion	Increase in stakeholder network size (%)	20% growth in stakeholder network

3 Analytical Tools and Methods Employed

This section elucidates the suite of analytical tools and methodologies applied across various components of the GLACIATION project, including IPR management, policy landscape analysis, market analysis, and the crafting of the exploitation plan. The structure of this section is as follows:

- An outline of the **narrative streamlining workshops** that have been crucial in refining the GLACIATION solution's narrative, enhancing clarity and accessibility to effectively engage the audiences identified in D8.1 and D8.2 as well as providing real-world applicability scenarios and the innovative edge of the GLACIATION solution.
- A detailed **stakeholder analysis** that pinpoints specific groups with an inherent interest in the project, along with an examination of their potential needs and interests.
- The development of **personas**, informed by the stakeholder analysis, which provides distinctive characteristics to better direct networking activities and strategic exploitation efforts.
- A synopsis of the **methodology** and **approach** utilised for **policy landscape analysis**, which plays a vital role in the creation of a comprehensive market watch.
- A summary of the **market analysis methodology**, integral for generating an informed market watch and identifying opportunities.
- An account of the **SWOT analysis** process, which has been undertaken to evaluate the project's strategic position.
- A portrayal of the **IML** that has been designed and implemented, facilitating the systematic tracking, management of innovative outputs, as well as IPR management.

3.1 Narrative Streamlining Workshop

The narrative streamlining workshop has been integral to refining the GLACIATION project's communication strategy and subsequently enhancing the exploitation plan. A carefully structured questionnaire and engaging discussion sessions have provided clarity on the technical aspects of the project, focusing on problem-solving, objectives, expected technological outputs, and the innovative edge of the GLACIATION solution. Emphasising the solution's applicability in various scenarios is vital for framing its exploitation potential.

3.1.1 Narrative Streamlining Templates

The workshops began with narrative templates that helped partners translate technical details into accessible narratives, which are imperative for comprehensible stakeholder communication. The facilitated sessions fostered a dialogue that crystallised the GLACIATION project's value proposition, underscoring the need to pinpoint varied application scenarios. This exploration is essential to crafting a well-rounded exploitation strategy.

GLACIATION Project
Narrative Streamlining Mini-Workshops
Question template

We kindly request that all participants provide brief and concise answers to the questions in the template to ensure that a clear and simplified narrative can be created. Please note each question has a 150-word limit. Depending on the work package, some questions may be more challenging to answer than others, and we understand that not every participant will be able to answer all questions for each discussion. The objective is to gather your perspectives based on the specific technical elements of your respective work package responsibilities.

Discussion One: Problem Definition and Solution
Can you describe the problem that the GLACIATION project is addressing and why it is important?
How does the GLACIATION project aim to reduce energy consumption and carbon emissions in data processing while improving privacy and trust?
What are the current challenges and limitations of cloud computing, and why is there a growing need for edge computing?
Discussion Two: Expected Technological Products
What specific technologies and software tools are expected to be developed through the GLACIATION project, and how will they support large-scale data analytics and the efficient use of network and storage infrastructure from Edge to Cloud?

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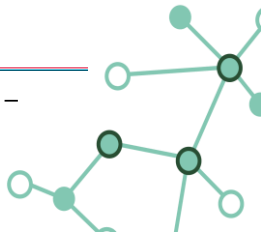
Figure 1 - Narrative Streamlining Workshop Question Template pg. 1



GLACIATION

Can you explain the role of the Distributed Knowledge Graphs in the GLACIATION project and how it will contribute to reducing power consumption in data processing?
How can swarm technology be used to coordinate applications at the edge for optimal functioning of the GLACIATION platform?
Discussion three: Expected Tangible Results of GLACIATION
Considering the packet of technology products envisioned by GLACIATION, what are the expected tangible results of these products in terms of improving privacy and energy consumption in the three use cases?
Please provide examples of how these technologies could be applied to other real-world scenarios?
How do the project's Meta Data framework and privacy and trust aspects contribute to the efficient and privacy-aware management of data operations?

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Figure 2 - Narrative Streamlining Workshop Question Template pg. 2

GLACIATION

How will the GLACIATION project contribute to the evolution of IT capabilities for the realization of AI and ML tasks, adopting edge, core, and cloud computing?
Discussion Four: Innovative Dimensions of GLACIATION
In what ways will the technologies and software tools developed by GLACIATION be novel and innovative compared to existing solutions?
Can you provide some specific examples of how the technologies and software tools developed by GLACIATION will address the challenges of metadata management, energy consumption optimization, and privacy-aware data operations?
How does the research and development of edge computing in the GLACIATION project contribute to advancing technological innovation, and what are the benefits of keeping data local in this context?

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Figure 3 - Narrative Streamlining Workshop Question Template pg. 3

3.1.2 Narrative Streamlining Workshop Sessions:

Following the completion of narrative templates, the Work Package 8 Leader initiated two planned 45-minute workshops, supplemented by a third to ensure comprehensive consolidation. These sessions were crucial in examining the technological components and capabilities while engaging the consortium to distil a refined narrative and identify different applicability scenarios to formulate a robust exploitation plan. Ultimately, the discussions were instrumental in shaping a clearer, more impactful story for dissemination as well as guiding the development of the exploitation plan, business modelling, and business plans.

The outcome of these workshops has been the development of a narrative that portrays the GLACIATION solution as being supported by four sturdy pillars: innovative energy management, advanced protection techniques, a cutting-edge Metadata Fabric, and AI-optimised data movement strategies. This analogy, refined through collaborative effort, guarantees a consistent consortium-wide as well as external actor's understanding of the GLACIATION technology and its capabilities.

3.1.3 Narrative Streamlining Workshop Outcome

The insights from these workshops have culminated in a narrative that showcases the GLACIATION project as a beacon of sustainable and privacy-conscious big data analytics. This narrative effectively communicates the project's commitment to reducing environmental impacts and enhancing data privacy, positioning GLACIATION as a leader in energy-efficient data management. It serves as a compelling narrative to support the complete exploitation of the project outcomes.

An example phrasing of this overarching narrative that focus on the technological capacity along with the components can be found below:

The GLACIATION project is at the forefront of innovation, focusing on the development of a ground-breaking metadata fabric that spans the edge-core-cloud architecture. Leveraging AI-driven optimisation of data movement and operations, GLACIATION aims to minimise environmental impact while ensuring greater privacy awareness and compliance. By strategically optimising the location of analytics, the project will achieve significant reductions in carbon emissions associated with data movement and operations, all while enhancing data privacy.

3.1.4 Exploitation Focused Narrative Development:

A series of focused discussions provided a springboard for identifying pivotal exploitation avenues, particularly considering the real-world application scenarios of the GLACIATION solution. These discussions during the workshops emphasised the importance of understanding stakeholders' needs to align the project's offerings with market demands, thereby enhancing the potential for societal impact and commercial exploitation.

3.1.5 Strategic Application Scenarios:

Participants were encouraged to contemplate specific use cases where the GLACIATION solution could have a profound impact. This led to identifying strategic application scenarios

including smart city infrastructure, renewable energy grids, and healthcare systems, each presenting unique challenges and opportunities for the project's technologies.

3.1.6 Tailoring for Target Audiences:

Discussion dedicated to tailoring the GLACIATION narrative for distinct audience segments were also conducted during the workshops, ensuring that messaging resonates effectively whether addressing industry partners, the public sector or the research community. This segmentation strategy is crucial for clear, targeted communication that supports broad-spectrum exploitation.

3.2 Stakeholders Analysis

Table 2 offers a concise mapping of stakeholders integral to the GLACIATION project, specifying their respective interests in relation to the project's progress and success. This analysis is critical for informing a thorough needs assessment, which in turn is essential for shaping the project's exploitation strategy. A more detailed stakeholder breakdown is available in D8.1 as well as D8.2, which have been pivotal in shaping both stakeholder identification and the creation of personas. These personas have informed the needs assessment, ensuring that the exploitation strategy is closely aligned with stakeholder requirements and expectations.

Table 3 - GLACIATION Stakeholder Groups and Interests

ID	Members	Description	Interest
A	Industry 4.0 sectors such as smart healthcare, smart cities, smart agriculture, and smart government agencies	Entities eager to employ edge computing for the digital transformation of their organisations; companies engaging in cascade funding opportunities	• Application of project outcomes to enhance operational efficiency • Increased visibility and recognition of assets • Asset contribution and support on the platform • Generation of innovative ideas, services, and applications • Utilisation and development of shared infrastructures for improved interoperability • Accessing financial support for innovation
B	Research community encompassing associations and infrastructures related to GLACIATION	Researchers and research organisations, as well as research and e-infrastructures engaged with GLACIATION	• Integration of project results into research workflows • Promotion of asset visibility and recognition

			• Contribution to the platform with insights and feedback • Engaging with the community to identify challenges and framework conditions • Oversight of project development on GitHub • Active participation in project-related events • Incubation of novel ideas and services
C	Industry professionals including enterprises, entrepreneurs, and developers	Profit-oriented entities and innovators keen to leverage or develop new services and applications using GLACIATION	• Collaboration on overcoming industry barriers and shaping framework conditions • Monitoring and engagement with the project's codebase on GitHub • Involvement in project events for networking and knowledge exchange • Inspiration for and development of innovative services and applications that add value
D	Policymakers, funding bodies, and standardization organisations	Policymakers at various levels, including EC directorates, ministries, governments, regulatory agencies, and standardisation bodies, as well as European Digital Innovation Hubs	• Assessment of the project's societal, technological, economic, environmental, and political (STEEP) impact • Guiding future research and innovation based on project insights • Contributions towards standardisation processes and activities
E	Relevant projects and initiatives	Participants, partners, and stakeholders from Horizon Europe projects, related initiatives, and the GAIA-X Association	• Exploration of shared topics of interest • Pursuit of synergies and collaborative promotion of results

			• Enhancement of innovation through the amalgamation of project outcomes • Informing future research and innovation strategies with project intelligence • Standardisation contributions and insights
F	General Public	Members of civil society, the youth, and the general public with an interest in the project	• Application of project findings to daily life • Comprehension of the advantages offered by the GLACIATION project • Engagement in project activities and events

3.3 Personas

Personas within the GLACIATION project act as tailored archetypes to guide the IPR management, business modelling, and business plans. They embody typical characteristics of target audience members, sharpening the understanding of user needs and preferences to inform strategic decisions.

While leveraging the benefits of personas, the Work Package Leader is conscious of their constraints, striving to ensure that content, though personalised and engaging, is also accessible to a broader audience. It is critical in a research-oriented project with technological deliverables to balance the granularity of personas with the inclusivity needed to reach a wider audience.

In communications, personas are tools for developing resonant messages, designed to reflect the perspective of the audience. Yet, there is a recognition of the risk of tailoring content too narrowly to personas, potentially missing the diversity within the audience. The project faces the ongoing task of creating content that is specific enough to engage yet comprehensive for all stakeholders.

The introduction of a new persona, representing public administrators, addresses the significant impact of policy and the role public servants play in translating research into practical public sector strategies.

For networking and exploitation, personas are instrumental in planning interactions with industry and research entities. They enable the GLACIATION project to propose engagements likely to yield beneficial outcomes. Real-world stakeholder interactions, however, may vary from these persona-based frameworks, necessitating a flexible and adaptive exploitation and networking strategy.

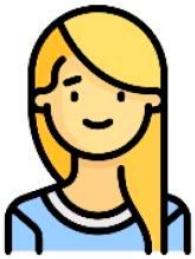
When disseminating information, personas assist in predicting the content and channel preferences of different audience segments. This understanding is utilised by the Work

Package Leader to formulate communications that are targeted yet inclusive, ensuring that research findings and technological advancements are conveyed effectively.

In sum, while personas are advantageous for the GLACIATION project, enabling tailored communication, engagement, and exploitation strategies, they are employed judiciously. There is a recognition of their limitations, and therefor it is imperative to ensure the broad reach of the exploitation plan, vital for ensuring the longevity of the project's outcomes which are deeply rooted in research and technological innovation.

Table 3 outlines all the personas developed for the GLACIATION project's communication, networking, and dissemination plans, as detailed in documents D8.1 and D8.2.

Table 4 - GLACIATION Personas

Personas		
Persona 1: Dirk De Jong (A & C) – Business partners and customers		
	**Name**	Kevin De Jong
	Age	40 to 60 years old
	Job title	Mid-senior level executive
	Level of education	Master's Degree / MBA
	Social networks	LinkedIn and Twitter
	Keywords	Cloud-to-edge infrastructure, network architecture, data operations, energy-optimisation, latency
Persona 2: Laura Smith (F) – General public		
	**Name**	Laura Smith
	Age	22 to 28 years old
	Job title	Student / Part-time job in a start-up or NGO
	Level of education	Bachelor
	Social networks	Twitter, LinkedIn, YouTube, Mastodon
	Keywords	Cloud, edge computing, artificial intelligence applications, state-of-the-art [technology_name], data privacy, data sovereignty
Persona 3: Beatrice Rossi (B & E) – Public or private researchers		
	Name	Beatrice Rossi
	Age	33 to 60 years old

	**Job title**	Researcher / Innovation manager
	Level of education	Doctorate (e.g. PhD, EdD)
	Social networks	LinkedIn, Twitter, GitHub
	Keywords	Horizon Europe projects, green data operations, semantic interoperability, distributed knowledge graph
Persona 4: Jean-Paul Laurent (D) – Policymakers		
	**Name**	Jean-Paul Laurent
	Age	40 to 54 years old
	Job title	Policy maker at European or national level
	Level of education	Doctorate (e.g. PhD, EdD)
	Social networks	Twitter, LinkedIn
	Keywords	Data sovereignty, Green New Deal, European data spaces, European Chips Act,
Persona 5: Dr. Aleksandr Ivanov – Senior Civil Servant at the National Level		
	**Name**	Alexandr Ivanov
	Age	45 years old
	Job title	Policy Director, National Ministry of Digital Transformation
	Level of education	Doctorate in Economics and Public Policy
	Social networks	Twitter, LinkedIn
	Keywords	Data Privacy, Environmental Sustainability, Big Data Analytics, Cloud-Edge Computing, Digital Innovation

3.4 Policy Analysis Method and Approach

As a Horizon Europe project, GLACIATION fundamentally integrates a strong policy dimension. To maximise the project's results and secure its enduring impact, policy-level engagement is critical. Such engagement will position the GLACIATION solution as instrumental in aligning environmental sustainability with data privacy, which is particularly pertinent within the European Union's digital transition agenda.

The policy landscape analysis, which is integral to the project's Market Watch, IML, and Applicability Analysis tasks, ensures that GLACIATION stays abreast of the global, especially European, policy context. This includes adherence to data protection legislation like GDPR and sustainability regulations such as the Ecodesign Directive, alongside emerging frameworks like the Digital Services Act and the Digital Markets Act. Compliance with these policies not only meets regulatory requirements but also enhances the GLACIATION solution's appeal for industry uptake.

This analysis is a key element of the policy engagement strategy outlined in D8.2, encompassing comprehensive policy documents and reading lists located in the GLACIATION share repository. In addition, this analysis forms a key dimension of the Market, Innovation and Applicability Analysis as delineated in the GLACIATION grant agreement as task 8.3. Ultimately, these tools are crafted to guide through the intricacies of green computing and data privacy legislation, clarifying the path for industry compliance and underscoring the GLACIATION solution's pertinence within the market as well as different real world applicability scenarios.

Supplementing the policy documentation is a stakeholder map that profiles influential organisations within the policy arena, shifting the focus from individuals to collective entities that drive policy dialogue.

Components of the Policy Engagement Plan include:

- A **Policy Landscape Document** that provides a thorough overview of relevant current and forthcoming policies related to the GLACIATION solution, with a focus on environmental and privacy legislation.
- A **Reading List** offering curated materials to deepen understanding of the policy context for informed engagement and strategic decision-making.
- **Stakeholder Mapping** at the organisational level to identify key policy players, potential allies, and channels for engagement.
- A **Communication Strategy** designed to emphasise the significance of environmental impacts and privacy in data operations within policy discourse.

The Work Package Leader is instrumental in promoting dialogue on environmental and data privacy considerations in data operations within the policy sphere, supporting the comprehensive exploitation of the GLACIATION solution. By building a compelling narrative and showcasing alignment with policy trends, the project increases its visibility and value proposition.

Through proactive policy engagement, GLACIATION seeks to inform policy-making, encouraging the widespread adoption of its solution during the exploitation phase. This proactive stance ensures that the GLACIATION project outcomes contribute significantly to the technological landscape while also positively influencing the policy framework, benefiting industry, European society, and beyond.

3.5 Market, Innovation and Applicability Analysis

As part of the strategic evolution of the GLACIATION project, a robust Market, Innovation, and Applicability Analysis is currently being executed in line with Task 8.3 of the GLACIATION

grant agreement. This analysis, while fulfilling a key task, establishes the project's information bedrock, crucial for steering decisions and strategic planning, particularly in exploiting project outcomes. An initial framework for this analysis has been outlined, embodying a thorough exploration of market opportunities for GLACIATION and a commitment to refine this analysis as the project progresses.

The methodological approach adopted is systematic and iterative, ensuring comprehensive coverage:

- **Research and Data Extraction:** The foundation of the analysis begins with a clear definition of objectives, ensuring that the insights gathered are aligned with the overarching goals of the GLACIATION project. The Work Package Leader has initiated the co-creation process, incorporating the expertise of the Lisbon Council team and consortium partners, employing design thinking methodologies for a user-centric approach to data organisation.

- **Policy Landscape Document:** An integral component of the data extraction phase is the assembly of a policy landscape document. This document encapsulates the green and privacy-related legislation crucial for compliance providing industry applicability of the GLACIATION solution.

- **Reading and Source List:** Concurrently, the team has compiled a robust reading list that includes research papers, articles, and market reports, which will serve as a resource for understanding the current market and innovation environment.

- **Stakeholder Mapping:** A stakeholder map has been developed to identify key organisational actors within the policy and market spheres. This map will guide the GLACIATION project's engagement and inform the dissemination strategy.

- **Market Landscape Document:** This document provides an in-depth analysis of the existing market, identifying current trends, competitors, and potential opportunities for the positioning of the GLACIATION solution.

- **Innovation Management Log:** A log is maintained to record all innovative developments and findings throughout the project, ensuring systematic tracking and management of intellectual property.

- **Business Modelling Options:** A set of business modelling options has been drafted, detailing various scenarios and strategies to facilitate the commercial viability of the GLACIATION solution as well as particular innovation of the project.

- **Data Visualisation and Analysis:** With the relevant data extracted and categorised, the team will move towards the visualisation phase, where the data will be presented in formats that enhance understanding and provide actionable insights. This work will be executed over the next few months

- **Feedback and Iteration:** The initial visual representations will undergo rigorous feedback cycles, ensuring clarity and efficacy. The Work Package Leader will refine this approach based on consortium input and stakeholder interactions.

- **Long-Term Strategy:** Recognising the dynamic nature of the market and policy landscapes, the analysis is designed to be flexible, with the capability to evolve as trends and regulations change.

The Market, Innovation, and Applicability Analysis encapsulates the GLACIATION project's forward-thinking stance, underpinning its proactive integration within a dynamic market and regulatory environment. The findings from this analysis will be instrumental in charting a course for the GLACIATION project's successful exploitation, a cornerstone for its enduring impact and legacy. The market analysis, including identification of market opportunities for the GLACIATION solution, are provided in Chapter 5 of this deliverable.

3.6 Standardisation

Standards are the linchpins of the technological ecosystem, underpinning the quality, consistency, compatibility, interoperability, and safety of innovations across different industries. In the realm of computing, particularly, standardisation forms the foundation enabling technologies to evolve and synergise, driving widespread adoption and cumulative advancement. These are the touchstones that maximise the benefits and accessibility of technological progress as well as ensuring the longevity of a particular innovation.

As part of the GLACIATION project's exploitation narrative, its alignment with ongoing standardisation processes enhances the project's credibility and utility in the broader technological landscape. By contributing to standardisation, the project not only bolsters its societal and research impact but also propels the commercialisation of its solutions. The engagement with established standards bodies is key to embedding GLACIATION's innovative practices within the global computing infrastructure, catalysing adoption and integration. In fact, a key GLACIATION partner in this regard is ERCIM and W3C which are focused on creating open web standards to ensure the web's accessibility, inclusivity, and interoperability.

Key standard bodies pertinent to technology and, specifically, data centres, include:

- **American National Standards Institute (ANSI):** Oversees U.S. standards for a variety of sectors, ensuring quality and consistency.
- **Institute of Electrical and Electronics Engineers (IEEE):** Establishes standards that often become national and international benchmarks in electro-technology.
- **International Telecommunication Union (ITU):** Sets standards for connecting networks and telecommunications globally.
- **Internet Engineering Task Force (IETF):** Defines internet operating protocols, crucial for online interoperability.
- **National Institute of Standards and Technology (NIST):** Aims to promote innovation in technology, enhancing security and precision in several scientific areas.
- **International Organisation for Standardisation (ISO):** Develops international standards for all aspects of technology and business.

- **European Telecommunications Standards Institute (ETSI):** Provides globally applicable standards for Information and Communications Technologies (ICT), including fixed, mobile, radio, broadcast, and internet technologies.
- **Open Compute Project (OCP):** Drives design and enables the delivery of the most efficient server, storage, and data centre hardware designs for scalable computing.
- **3rd Generation Partnership Project (3GPP):** Develops protocols for mobile telecommunications.
- **Open Networking Foundation (ONF):** Advocates for software-defined networking and standardising the interfaces of network devices.
- **Metro Ethernet Forum (MEF):** Defines standards to accelerate the adoption of Carrier Ethernet networks and services.
- **Open Radio Access Network (ORAN):** Works on creating standards for more intelligent, open, virtualised, and fully interoperable mobile networks.
- **World Wide Web Consortium (W3C):** Creates open Web standards to ensure the Web's accessibility, inclusivity, and interoperability

The GLACIATION project, by actively participating in these standardisation communities, aims to position its research outcomes and technological products as benchmarks in the industry. The aim is to embed the GLACIATION solution into the evolving tapestry of global standards, thereby facilitating its broad adoption and integration into future technological solutions, infrastructure, and policy guidelines.

This proactive approach towards standardisation is detailed in Chapter 6 of this deliverable, indicating the strategic path the project will follow. The chapter also outlines how GLACIATION's engagement in standardisation will underpin the exploitation of its innovative results, contributing enduringly to the industry and society at large. Through this engagement, GLACIATION aspires to influence the standards that shape tomorrow's computing landscape, ensuring that its pioneering solution becomes part of the global technological narrative.

3.7 SWOT Analysis

For the GLACIATION project, a SWOT analysis provides a crucial framework to evaluate and leverage the unique characteristics of each innovation within the broader context of business modelling and value proposition creation. This analysis examines the internal and external environments, enabling project partners to strategise effectively around the Strengths, Weaknesses, Opportunities, and Threats associated with both the GLACIATION solution and its individual innovations.

As project partners from diverse organisational and geographical backgrounds conduct their individual SWOT analyses, they contribute nuanced insights that are critical for shaping the GLACIATION project's strategy. This mosaic of perspectives enriches the collective understanding of where the GLACIATION solution stands in the current market and where it can potentially lead in terms of impact and growth. Furthermore, its potential exploitation to lead to further research or to be scaled up in the current pilots.

The Work Package 8 leader's role is to amalgamate these varied analyses into a cohesive strategy document. This unified analysis will play an integral role in informing the market analysis and crafting D8.4, which outlines the IPR management, business models, and intermediate business plans per private sector partner as well as exploitation plans for public sector partner groupings. This integration ensures a robust, scalable approach to achieving sustainable revenue streams and non-commercial exploitation by encouraging the adoption of the solution, highlighting the full potential of the GLACIATION project's key exploitable results.

Each stage of the SWOT process, from identifying initial and projected Technology Readiness Levels (TRLs) to identifying strengths and weaknesses serves to align the innovation's trajectory with possibilities both commercial as well as in terms of research, scale up, and other forms of non-commercial exploitation.

In essence, the SWOT analysis is not just an evaluative process; it is a strategic tool that propels the business modelling and non-commercial exploitation planning, maximising the potential benefits of the GLACIATION solution and its innovations for European citizens and beyond.

3.7.1 SWOT Analysis Template and Instructions

To strategically navigate the market and business landscape, the GLACIATION project partners employed a comprehensive SWOT analysis template. This structured approach provided a clear framework for evaluating the intrinsic strengths, weaknesses, external opportunities, and threats associated with the project's innovations. The template, accompanied by detailed instructions, ensured that each partner could conduct their analysis in a consistent and thorough manner.

Furthermore, an illustrative example was provided, demonstrating a completed SWOT analysis. This example served as a practical reference, guiding partners in considering the diverse factors that could influence the commercial success and market penetration of the GLACIATION solution. The ensuing analysis played a pivotal role in shaping the business modelling and articulating the value proposition for the project's innovations, thus laying the groundwork for their successful exploitation in the market.

By mapping out each innovation’s journey from its current state of technological readiness to its projected maturity, the partners could strategically assess and plan for the commercialisation and business application of each key exploitable result. This process was vital to aligning the GLACIATION project's outcomes with market needs and opportunities, thereby enhancing the potential impact and sustainability of the project's solutions.

Below is a comprehensive list of fields in the template with a corresponding definition:

- **Innovation:** This is the definition or naming of the specific innovation or project component being analysed. It sets the stage for a detailed examination of the project's various aspects, such as technology maturity, market potential, and strategic planning.
- **Owner:** This indicates the GLACIATION consortium partner or entity that holds the responsibility and oversight for the development and success of the innovation.

- **Type of Commercial/Business Exploitation:** This discusses how the innovation could be monetized or utilized within a business context, such as licensing, direct sales, or incorporation into existing product lines.
- **Exploitation Potential:** This evaluates the potential success of the innovation in the market, including how likely it is to be widely adopted and the benefits it could bring to the European market and beyond.
- **Conflicting IP:** This addresses any potential intellectual property issues that could arise, such as patent infringement or disputes over technology ownership between GLACIATION consortium partners
- **Strengths:** Identifies the unique advantages or core competencies of the innovation, such as proprietary technology, cost advantages, or superior performance.
- **Weaknesses:** These are areas where the innovation may be lacking or could be improved, potentially leading to competitive disadvantages.
- **Opportunities:** This includes external factors that the innovation could capitalize on, such as market gaps, emerging trends, or partnerships.
- **Threats:** External challenges that could jeopardise the success of the innovation, like regulatory changes, market volatility, or competitive actions.
- **Competition:** Analysing who else in the market offers similar products, technologies, or solutions, and understanding the overall competitive environment.
- **Targeted Market:** Defining the specific segment of the market that the innovation aims to serve.
- **Time to Market Estimate:** How long it is expected to take before the innovation can be introduced to the market or scaled up.
- **Path to Market:** Outlining strategies for how the innovation will be incorporated within the private sector partner or how it might lead to the development of new products as well as non-commercial scale-up and exploitation maximisation.

3.7.2 Technology Readiness Levels (TRL):

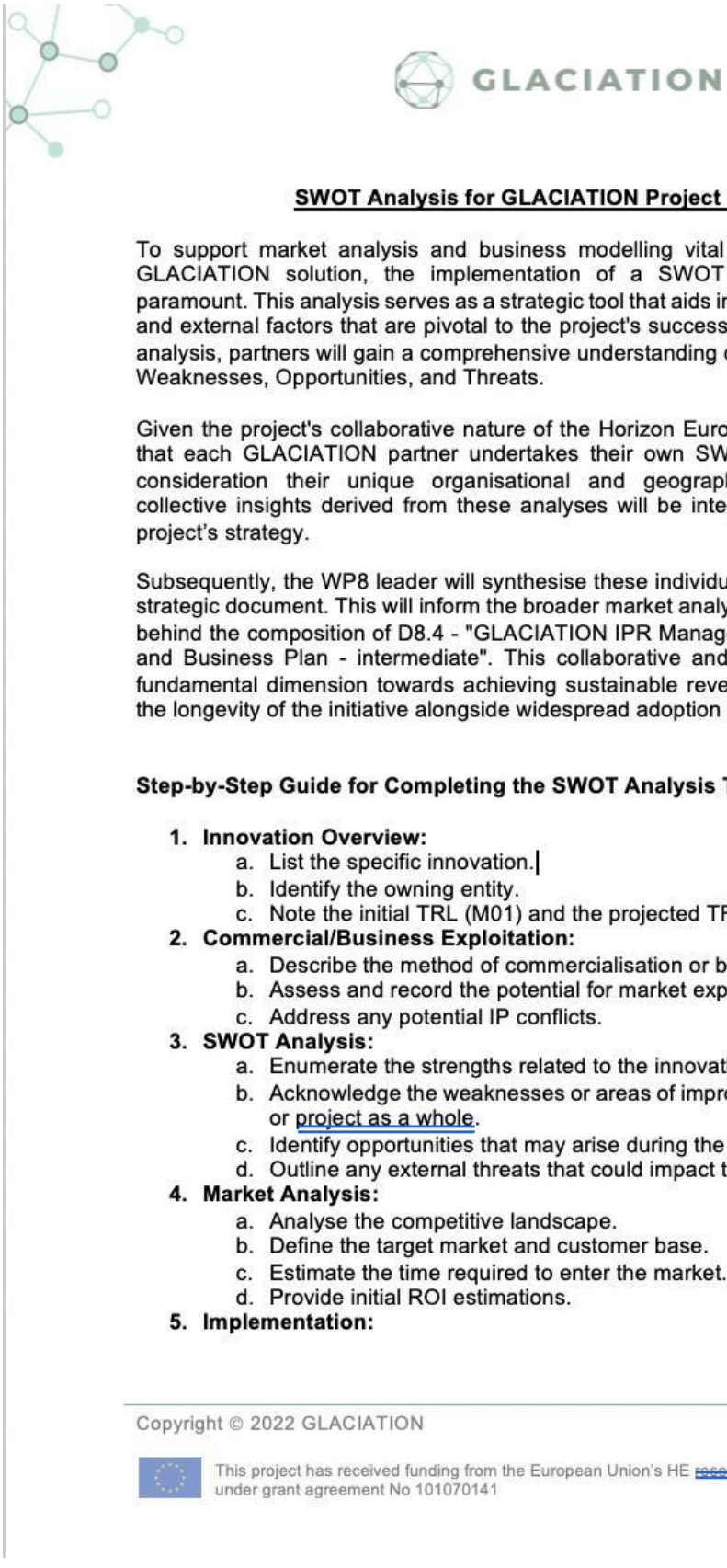
Technology Readiness Levels are a method of estimating the maturity of technologies during the acquisition phase of a program, developed by NASA in the 1970s. The scale ranges from 1 to 9, with 9 being the most mature technology. The SWOT analysis asked partners to evaluate the envisioned TRL of the GLACIATION solution or a particular technology which is paramount in order to formulate an appropriate exploitation plan as well as business modelling for each private sector partner.

The two TRL related fields in the SWOT analysis request:

- **TRL M01:** This would be the TRL at the start of the project (M01). It represents the initial maturity level of the technology.
- **TRL M36:** This is the projected TRL at the end of the project (M36). It signifies where the technology is expected to be in terms of development and readiness after 3 years.

Below please provide a brief overview of what each TRL means according to NASA:

1. Basic principles observed (e.g., discovery of phenomena).
2. Technology concept formulated (e.g., concept and application have been considered).
3. Experimental proof of concept (e.g., proof-of-concept in a laboratory environment).
4. Technology validated in lab (e.g., components tested in a lab environment).
5. Technology validated in relevant environment (e.g., technology tested in a simulated operational environment).
6. Technology demonstrated in relevant environment (e.g., prototype demonstration in an operational environment).
7. System prototype demonstration in an operational environment (e.g., near or at planned operational system).
8. System complete and qualified (e.g., final design is tested and ready for mass production).
9. Actual system proven in operational environment (e.g., actual system operated in operational environment).



GLACIATION

SWOT Analysis for GLACIATION Project Partners

To support market analysis and business modelling vital for the longevity of the GLACIATION solution, the implementation of a SWOT analysis is considered paramount. This analysis serves as a strategic tool that aids in the evaluation of internal and external factors that are pivotal to the project's success. By conducting a SWOT analysis, partners will gain a comprehensive understanding of the project's Strengths, Weaknesses, Opportunities, and Threats.

Given the project's collaborative nature of the Horizon Europe ethos, it is imperative that each GLACIATION partner undertakes their own SWOT analysis, taking into consideration their unique organisational and geographical perspectives. The collective insights derived from these analyses will be integral to the GLACIATION project's strategy.

Subsequently, the WP8 leader will synthesise these individual analyses into a unified strategic document. This will inform the broader market analysis and be a driving force behind the composition of D8.4 - "GLACIATION IPR Management, Business Models, and Business Plan - intermediate". This collaborative and strategic approach is a fundamental dimension towards achieving sustainable revenues streams to support the longevity of the initiative alongside widespread adoption of open source solution.

Step-by-Step Guide for Completing the SWOT Analysis Template:

1. **Innovation Overview:**
   a. List the specific innovation.
   b. Identify the owning entity.
   c. Note the initial TRL (M01) and the projected TRL (M36).
2. **Commercial/Business Exploitation:**
   a. Describe the method of commercialisation or business application.
   b. Assess and record the potential for market exploitation.
   c. Address any potential IP conflicts.
3. **SWOT Analysis:**
   a. Enumerate the strengths related to the innovation or project as a whole.
   b. Acknowledge the weaknesses or areas of improvement to the innovation or project as a whole.
   c. Identify opportunities that may arise during the project lifecycle.
   d. Outline any external threats that could impact the project.
4. **Market Analysis:**
   a. Analyse the competitive landscape.
   b. Define the target market and customer base.
   c. Estimate the time required to enter the market.
   d. Provide initial ROI estimations.
5. **Implementation:**

This project has received funding from the European Union's HE ~~research~~ and innovation programme under grant agreement No 101070141

Figure 4 - GLACIATION SWOT Analysis Instructions Page 1

GLACIATION

a. Develop a rough path-to-market strategy, including how the innovation will be integrated within your organisation or how it may influence the development of new products.

Glossary of Acronyms:

- **SWOT:** Strengths, Weaknesses, Opportunities, Threats
- **TRL:** Technology Readiness Level
- **TRL M01:** Technology Readiness Level at Month 1
- **TRL M36:** Technology Readiness Level at Month 36
- **IP:** Intellectual Property
- **KER:** Key Exploitable Results
- **ROI:** Return on Investment
- **EC:** European Commission
- **WP8:** Work Package 8
- **WP8 Leader:** Work Package 8 Leader

This project has received funding from the European Union's HE ~~research~~ and innovation programme under grant agreement No 101070141

Figure 5 - GLACIATION SWOT Analysis Instructions Page 2

GLACIATION

Innovation	Owner	TRL M01	TRL M36
Type of Commercial/Business Exploitation			
Exploitation potential			
Conflicting IP			
Strengths (*What we do well*)			
Weaknesses (*Are we competitive?*)			
Opportunities (*New stakeholders, Market trends*)			
Threats (*What are the risks*)			
Competition ***Other competitive technologies/ products/ solutions***			
Targeted Market ***Who are the customers?***			
Time to Market estimate			
Expected ROI ***Initial estimations***			
Path to market ***How do you plan to embed results in your organisations (i.e. extend the company's product portfolio, develop new products, etc.)***			

This project has received funding from the European Union's HE research and innovation programme under grant agreement No 101070141

Figure 6 - GLACIATION SWOT Analysis Template

3.8 Innovation Management Log

The GLACIATION Innovation Management Log (IML) is an essential process within the project framework, critical for the strategic management of the project's innovative outcomes. It serves as a centralised record for tracking progress, establishing ownership, and managing the IP that is fundamental to the project's advancements.

The IML functions as a dynamic catalogue of innovations and their evolution within the GLACIATION project. By documenting each innovation's current and projected TRL, partners maintain a transparent record of development and potential for commercial and non-commercial exploitation. This is essential for shaping business models and strategies for market applicability. The KERs identified within the IML are crucial in crafting compelling value propositions that resonate with stakeholders and align with market demands.

The IML provides a clear statement of result ownership and associated IP rights, crucial for effective IPR management. It ensures that IP brought into the project is correctly leveraged, safeguarding partner interests while facilitating the development of robust exploitation strategies. This process outlines how each innovation fits within the broader business strategies of private sector consortium partners, which is pivotal for integrating results into their existing product portfolios or for the development of new products, thereby reinforcing the project's competitive position in the market.

Moreover, the collaborative nature of the GLACIATION project means that the IML is a shared resource, fostering transparency and cooperation among partners. This collaborative approach ensures that everyone is aligned with the project's objectives and adheres to the Horizon Europe Programme's stipulations.

Regular updates and maintenance of the IML are imperative to ensure that the consortium's innovations are accurately represented and aligned with ongoing project developments and European Commission standards. The process of review and submission to the WP8 Leader is crucial for preparing the consortium's innovations for wider dissemination and exploitation.

Ultimately, the IML is integral to realising the commercial and societal potential of the GLACIATION project's innovations. It underpins the development of tailored business strategies, informs the creation of unique selling and non-commercial exploitation propositions for distinct innovations, and aids in navigating the complex landscape of IP rights. The IML is key to maximising the impact of the project's technological advancements and ensuring their sustainable exploitation in the market as well as for societal benefits for European citizens and beyond.

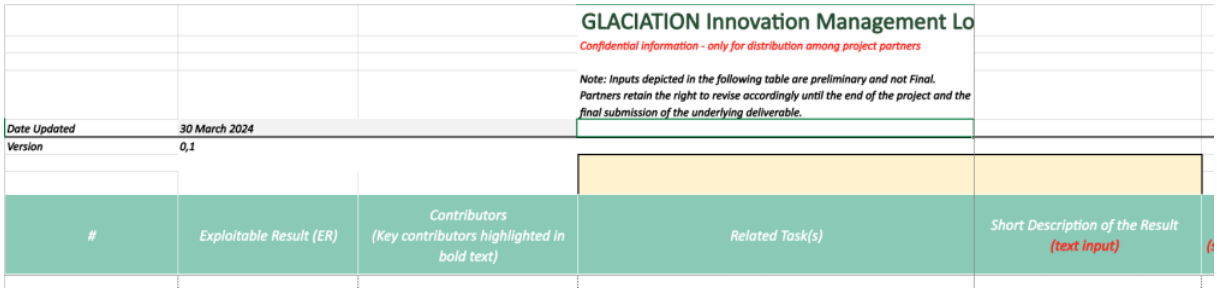


Figure 7 - Innovation Management Log Fields 1

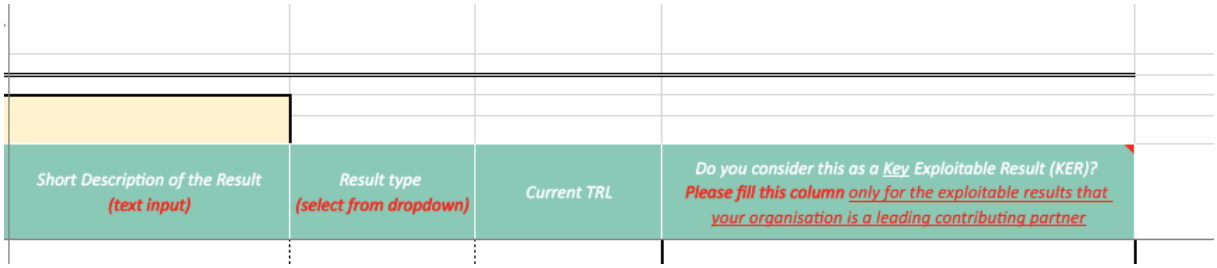


Figure 8 - Innovation Management Log Fields 2

4 Policy Landscape Analysis

In an era where commercial exploitation hinges on compliance with legislation, industry players as well as public sector and research organisations must navigate the complexities of the policy landscape. Understanding this legislative environment is not just fundamental; it's a cornerstone for identifying market opportunities, particularly for initiatives like GLACIATION, which have a cross cutting application amongst various Information and Communication Technology (ICT) markets.

The European Commission has placed great emphasis on **green cloud computing** and the reduction of the environmental footprint of data centres, pivotal elements in its quest for a climate-neutral Europe by 2050. This emphasis is interwoven with the vision for smart cities, where edge computing becomes indispensable to optimally harnessing IoT data. The policy framework outlined in the "Energy-efficient Cloud Computing Technologies and Policies for an Eco-Friendly Cloud Market" initiative resonates with the ambition to integrate renewable energy sources within IT practices and attain carbon neutrality in data centres by 2030[1]. In this context, the GLACIATION solution is particularly pertinent. It aligns with the Commission's focus on energy-efficient edge computing as a key to unleashing the full potential of IoT for smart urban ecosystems. By offering sustainable and energy-efficient data processing capabilities, GLACIATION not only complies with but actively contributes to the European vision of an eco-friendly digital infrastructure.

The **Ecodesign Directive** establishes a comprehensive framework mandating manufacturers of energy-using products to prioritise energy efficiency and environmental considerations from the design stage, significantly influencing lifetime energy consumption. This directive is complemented by the Energy Labelling Directive, which informs consumers about the energy and environmental performance of products, extending to the commercial and industrial sectors. Together, these directives, including Ecodesign Requirements for Servers and Data Storage Products Directive, form a robust policy infrastructure that dictates performance criteria for market entry in the EU[2], fostering opportunities for solutions like GLACIATION that promise eco-friendly data processing and management.

The **General Data Protection Regulation** (GDPR) is another important piece of European legislation in terms of the GLACIATION solution. It is a pivotal piece of EU legislation that sets a global benchmark for data privacy and security. It was adopted in 2016 and became applicable on the 25th of May 2018, overhauling privacy laws by reinforcing individuals' rights and outlining stringent obligations for data processors and controllers. GDPR demands clear consent for personal data processing and grants individuals greater autonomy over their information, including rights to access, rectification, erasure, and data portability. It introduces

[1] European Commission, "Green Cloud," [Online]. Available: https://digital-strategy.ec.europa.eu/en/policies/green-cloud.

[2] European Union, "Commission Regulation (EU) 2019/424 laying down ecodesign requirements for servers and data storage products pursuant to Directive 2009/125/EC of the European Parliament and of the Council and amending Commission Regulation (EU) No 617/2013," Official Journal of the European Union, [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32019R0424.

significant penalties for non-compliance, with fines up to €20 million or 4% of global annual turnover for breaches[3].

For the GLACIATION solution, GDPR's privacy requirements represent a critical opportunity rather than a constraint. While privacy typically necessitates encryption, and consequently more energy, GLACIATION's innovation lies in achieving greater data privacy in a sustainable manner. By integrating privacy-preserving technologies that do not disproportionately increase energy consumption, GLACIATION aligns with GDPR's mandate effectively. The solution demonstrates that adherence to privacy regulations can go hand in hand with environmental sustainability, positioning it as a leading edge in a market where data protection and energy efficiency are paramount.

Adopted in 2021, the **Corporate Sustainability Reporting Directive** aligns with the European Green Deal's commitments. It expands the scope of sustainability reporting, requiring a broad spectrum of companies to disclose their social and environmental impacts comprehensively. With reporting requirements set to begin in 2024, this directive presents a clear opportunity for GLACIATION to provide solutions aligned with sustainability objectives while ensuring privacy preservation.

The **voluntary European Code of Conduct for Data Centres** addresses the energy use and environmental impact of data centres. It encourages participants to undertake energy audits and improve efficiency, creating a supportive backdrop for the implementation of GLACIATION's privacy enhancing, energy-conscious and sustainable computing technologies.

The **EU Data Strategy**, formulated to bolster the move towards edge computing, promotes the development of interoperable cloud and edge services essential for European data spaces. Key actions include the investment in energy-efficient and trustworthy cloud infrastructures, the launch of SIMPL as a secure middleware for cloud-to-edge federations, and the compilation of the EU Cloud Rulebook to establish a comprehensive framework for users and providers. The Strategy also outlines the formation of a European cybersecurity certification scheme for cloud services under the Cybersecurity Act, which is pivotal for ensuring secure data storage and processing. These regulatory actions set the stage for the GLACIATION solution to thrive, offering it ample opportunity to contribute to a secure, competitive, and sustainable data processing ecosystem.

Aligning with the sustainability goals of the European Green Deal, cloud and edge computing are identified as key enablers for sustainable digital solutions. Measures targeting the resource efficiency of data centres are underway, such as the EU taxonomy for sustainable activities and the Energy Efficiency Directive, which mandate climate neutrality and high energy efficiency by 2030. GLACIATION's focus on sustainability can help it to position itself as part of a solution to achieving the EU's ambitious targets.

The **Digital Decade policy** programme incorporates multi-country projects like the IPCEI on Next Generation Cloud and Edge Computing Services, aimed at establishing European Common Data Infrastructures and Services. It sets out to invest in novel cloud-edge technologies that will underpin future cloud-edge infrastructures, adhering to stringent

[3] Council of the European Union, "General Data Protection Regulation (GDPR)," [Online]. Available: https://www.consilium.europa.eu/en/policies/data-protection/data-protection-regulation/#:~:text=The%20GDPR%20lists%20the%20rights,his%20or%20her%20personal%20data.

standards of data protection, performance, resilience, and energy efficiency. GLACIATION's alignment with these targets emphasises its relevance in a legislative environment that is conducive to innovation and investment in digital infrastructure.

Furthermore, the **Digital Single Market** strategy has reconfirmed the strategic role of cloud computing in enhancing innovation and access to content, with the goal of 75% enterprise cloud uptake by 2030. Additionally, the European Alliance on Industrial Data, Edge, and Cloud, as part of the Industrial Strategy, is shaping the next generation of secure, low-carbon cloud and edge services, creating a market ripe for the GLACIATION solution to deliver its secure and sustainable computing capabilities.

Overall, the legislative frameworks underpinning the European Union’s digital and sustainability ambitions serve as a catalyst for market opportunities and non-commercial exploitation. They underscore the potential for solutions like GLACIATION to carve out a niche in a policy-driven market, aligning technological innovation with legislative compliance.

5 Market Analysis

The following section provide a detailed market analysis to contextualise different market potential for the GLACIATION solution as well as specific innovations within the GLACIATION research project. Without a thorough market analysis, identifying KERs, target groups, and market needs and opportunities as well as developing non-commercial exploitation plans, business modelling and business plans per private sector partner would not be possible. The market analysis is organised as follows:

- An analysis of the **public procurement digital innovation market**, detailing its essence, distinctive market traits and vital statistics, prevalent trends, and the specific opportunities that the GLACIATION project outcomes presents within this sphere.
- A detailed examination of the **big data analytics market**, encapsulating its definition, market features and significant statistics, current trends shaping the market, leading players, and the unique opportunities for GLACIATION within this sector.
- An expansive overview of the **data centre market,** providing insight into its nature, characteristic market features and statistics, trends currently influencing the market, principal industry players, and the specific prospects for GLACIATION in this arena.
- An in-depth look at the **cloud computing market**, explaining its fundamental concept, distinct market characteristics and relevant statistics, notable trends, primary stakeholders, and the tailored opportunities for GLACIATION in this domain.
- An extensive survey of the **edge computing market** and **IoT applications**, outlining what they encompass, their market attributes and key statistics, critical market trends, leading entities, and the bespoke market opportunities for GLACIATION.

5.1 Public Procurement

Public procurement, the process by which public authorities purchase goods, services, and works from the private sector, is a critical market to consider in terms of the GLACIATION solution. In 2017, more than six years ago, the European Union's public procurement represented a noteworthy €2 trillion, about 13.3% of its GDP, signifying its impact on the economy and market dynamics[4]. The EU's efforts to streamline public procurement have made it notably accessible, encouraging smaller businesses to engage with the public sector. Looking at the integration of just one technology, McKinsey Global Institute, in 2022, estimated that data analytics could generate approximately $1.2 trillion a year in value across the public and social sectors.[5]

[4] European Commission, "Public procurement - Accessing markets," [Online]. Available: https://policy.trade.ec.europa.eu/help-exporters-and-importers/accessing-markets/public-procurement_en#:~:text=In%20the%20EU%2C%20in%202017,market%20within%20Europe%20in%202016.

[5] McKinsey & Company, "Accelerating data and analytics maturity in the US public sector," 2022 [Online]. Available: https://www.mckinsey.com/industries/public-sector/our-insights/accelerating-data-and-analytics-maturity-in-the-us-public-sector.

5.1.1 European Digital Public Procurement Market Characteristics

In the European context, public procurement tends to focus on efficiency and modernisation. In this regard, a notable trend within EU digital innovation public procurement is the burgeoning field of GovTech. This sector is specifically geared towards creating innovative digital solutions for public services, addressing this dual demand for efficiency and modernisation, generally from smaller and newer players on the market. GovTech is on the rise due to its potential to deliver faster, more convenient services, which in turn can stimulate economic growth and bolster the tech ecosystem. Using the analysis from GovTech related organisations, it is evident that the Public Procurement market for digital innovation is a highly valuable market with a lot of potential for solutions like GLACIATION.

In particular, the Public Procurement market for digital innovations present ample opportunities for the GLACIATION solution as it places a focus on ensuring that procurement spending is directed toward optimising and modernising operations across various government functions.

5.1.2 The European Union Digital Public Procurement Market Size and Opportunities

The size and openness of the EU's public procurement market have set a global benchmark[6]. Taking analysis conducted for GovTech potential it is evident that there is a huge untapped market for digital innovation with both commercial and non-commercial avenues to exploit the GLACIATION solution within this domain.

Put in numbers, the actual utilisation of this market for GovTech appears to remain relatively small, with just 0.23% of the total volume, according to venture insights, totalling €6.4 billion euro, used for GovTech products[7]. This disparity between current use and potential indicates a vast, untapped market opportunity for digital solutions in public administrations across the EU, estimated between €206 to €247 billion[8]. Furthermore, the dispersion of GovTech providers across Europe further underscores the potential market opportunities for digital solution across public administration considering their current low penetration. In fact, these providers have nearly quadrupled over a decade, reflecting a burgeoning industry ripe for integration into the public sector's procurement strategies[9].

5.1.3 GLACIATION Public Sector Market Potential

The GLACIATION solution, with its focus on energy-efficient and privacy-protecting data management, fits perfectly into the market gap for sustainable digital solutions in public administrations and the public sector. Pilot 1, involving the Ministero dell'Economia e delle Finanze of Italy (MEF), demonstrates GLACIATION's practical applicability within a public administration, underscoring its market viability and potential for broader deployment as well

[6] European Commission, "Public procurement - Accessing markets," [Online]. Available: https://policy.trade.ec.europa.eu/help-exporters-and-importers/accessing-markets/public-procurement_en#:~:text=In%20the%20EU%2C%20in%202017,market%20within%20Europe%20in%202016.
[7] Venture Insights, "European GovTech," [Online]. Available: https://www.venture-insights.de/european-govtech-publication.
[8] Ibid
[9] Ibid

as scale up. By streamlining public administration activities with GLACIATION's innovative edge technology, the MEF use case demonstrates the project's capability to make data processing more sustainable and privacy-aware, making it an attractive solutions for public sectors across Europe, particularly in relation to sustainability goals and privacy compliance obligations defined in European Union legislation.

This context sets the stage for the GLACIATION solution to not just participate but significantly shape the digital public procurement market. With proven practical applicability, such as demonstrated by the MEF use case, and alignment with EU policy objectives, GLACIATION stands ready to tap into the considerable market potential, supporting the next wave of sustainable public sector innovation as well as potential non-commercial exploitation within the Italian public administration and potentially beyond.

5.2 Big Data Analytics

Big Data refers to the substantial volumes of data produced at a high velocity from varied sources[10]. This data is generated by both individuals and machines, such as sensors, satellite imagery, videos, GPS signals, and more, encompassing numerous sectors. Big Data analytics scrutinises both unstructured and structured databases to unearth and provide insights by identifying correlations, clandestine patterns, market trends, and beyond. Predominant sectors of the contemporary era increasingly depend on big data analytics to acquire customer insights and develop business acumen for analysing this data.

Big Data empowers firms to access, store, and process vast troves of data through technological innovation. These organisations can analyse data sets and produce pivotal insights that can be integrated into their operations, showcasing versatility across a spectrum of sectors with potential benefits that are almost unfathomable. In the perspective of many, big data analytics has become an indispensable business acumen for companies seeking to extract value from the ever-augmenting volume of data, which is frequently likened to the new oil. Firms with an enhanced capacity to process data are inherently more competitive. Supply chain management is a quintessential application for big data analytics, which can confront significant challenges such as delayed shipments, surging fuel costs, inconsistent suppliers, and mounting customer expectations.

Big data analytics presents unparalleled opportunities to more traditional sectors within Europe’s economy, such as transport, health, and manufacturing. Enhanced analytics and processing capabilities can:

- Transform Europe’s service industries by creating an extensive array of innovative information products and services;
- Augment the productivity of all economic sectors through improved business intelligence;
- Address societal challenges with heightened efficiency;

[10] European Commission, "Big data." [Online]. Available: https://digitalstrategy.ec.europa.eu/en/policies/big-data.

- Accelerate research and expedite innovation;
- Attain cost reductions via more personalised services;
- Amplify public sector efficiency.

In Europe, an immense volume of data is produced daily. Integrating and analysing these data can yield novel insights and ground-breaking solutions for the economy and society. Data has become an essential resource for the economy and society, with technological innovations surfacing to navigate big data challenges[11].

Large-scale data analytics and AI models are often touted for their potential to drive economic growth, social well-being, and support sustainability measures in the context of the climate crisis. Big data analytics have already played a significant role in achieving efficiency gains, managing energy systems, and reducing green house gas emissions[12]. However, there are also serious negative environmental implications associated with the extensive computational resources required for training and deploying these AI models[13].

In this context, the GLACIATION solution represents an opportunity to rationalise big data, ensuring it is environmentally congenial while upholding privacy imperatives. Harnessing the full potential of data is pivotal to the prospective knowledge economy and innovation ecosystem, but it must be undertaken in a manner that conserves privacy and promotes sustainability[14].

5.2.1 Market in Numbers

According to a recent KPMG report, 29% of businesses say they have seen a profitability or performance gain of at least 11 percent from investments in data and analytics[15]. In fact, the same report found that AI is now viewed as the most crucial technology for achieving organisations' short-term goals, and companies are swiftly adopting advancements in areas like generative AI[16].

The popularity of big data analytics has increased considerably due to the immense growth in computing, abundant data, and available infrastructure that enable knowledge creation. Employing analytics to big data establishes vast opportunities for various businesses to gain numerous insights for better future outcomes. Ultimately, big data analytics is playing a crucial role for global key players to outperform their competitors across various sectors.

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[11] Ibid
[12] Peter Gailhoffer et al, “The Role of Artificial Intelligence in the European Green Deal,” European Union, May 2021. Available online: https://www.europarl.europa.eu/RegData/etudes/STUD/2021/662906/IPOL_STU(2021)662906_EN.pdf
[13] The Organisation for Economic Co-operation and Development, “Measuring the Environmental Impacts of Artificial Intelligence Compute and Applications, The AI Foot Print,” OECD Publishing, November 2022.
[14] European Commission, "Big data." [Online]. Available: https://digital-strategy.ec.europa.eu/en/policies/big-data.
[15] KPMG, "KPMG global tech report 2023." [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/nl/pdf/2024/services/kpmg-global-tech-report.pdf.
[16] KPMG, "KPMG global tech report 2023." [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/nl/pdf/2024/services/kpmg-global-tech-report.pdf.

Another important emerging market trend is the growth of edge computing, which is increasing the demand for big data analytics tools connected to the Internet of Things (IoT). This is due to the surging adoption of machine learning algorithms, IoT, and AI. According to International Data Corporation (IDC) data in 2016, it was predicted that 152,200 IoT devices will be connected per minute by 2025[17]. The increasing requirement for connected devices accelerates the execution of edge computing. Edge computing is also predicted to create lucrative market opportunities by boosting database quantity. The capacity of devices to perceive and transmit data through networks and connections is generating extensive volumes of data that allow companies to realise considerable benefits, which would be challenging for humans to manage.

5.2.2 Main Players

The global big data market is commanded by influential corporations that set the bar for innovation and data-driven solutions. Industry titans such as Amazon Web Services, IBM Corporation, Microsoft Corporation, and Oracle Corporation lead this space, offering a breadth of technologies that cater to a vast array of enterprise needs. These key players, along with others like FICO and TIBCO Software Inc., continue to expand their reach and enhance their offerings, solidifying their positions in the market.

Turning to the European market, on a regional analysis basis, the landscape features main players such as Excadel in Poland, SAP SE in Germany, and Cortical.io in Austria. These companies, along with others from Belarus, Belgium, Bosnia and Herzegovina, Denmark, Finland, and France, exemplify Europe's regional prowess in big data applications and solutions. This regional dynamism, coupled with the global influence of corporations like Salesforce Inc and Fair Isaac Corporation, showcases a robust ecosystem that fuels both regional and global advancements in big data technologies.

Organisation	Country	Description
Amazon Web Services	Global	Leader in cloud computing and big data services
IBM Corporation	Global	Pioneer in AI and big data analytics
Microsoft Corporation	Global	Major provider of enterprise cloud services and big data solutions
Oracle Corporation	Global	Top provider of database software and technology, cloud engineered systems, and enterprise software products
FICO	Global	Analytics software firm specializing in credit scoring services

[17] Kanellos, M., "152,000 Smart Devices Every Minute In 2025: IDC Outlines The Future of Smart Things," Forbes, 2016. [Online]. Available: https://www.forbes.com/sites/michaelkanellos/2016/03/03/152000-smart-devices-every-minute-in-2025-idc-outlines-the-future-of-smart-things/?sh=715c48f4b63e.

TIBCO Software Inc.	Global	Provides integration, analytics, and event-processing software for companies
Excadel	Poland	Specializes in custom development and big data consulting
SAP SE	Germany	European multinational software corporation that makes enterprise software to manage business operations and customer relations
Cortical.io	Austria	Focuses on natural language understanding and artificial intelligence
Salesforce Inc	Global	Provider of CRM and cloud computing solutions
Fair Isaac Corporation	Global	Known for credit scoring and analytics

5.2.3 GLACIATION Big Data Market Opportunities

Building on the insights from Pilot 3, the GLACIATION solution represents a critical advancement in the Big Data Analytics market by delivering on two key contemporary demands: enhanced privacy and energy sustainability. As the Internet of Things (IoT) applications expand, they introduce heightened privacy risks including deceptive data creation, real-time security compliance, and susceptibilities in storage and identity management.

The market opportunity for GLACIATION is amplified by the challenges presented by cyber-attacks targeting customer data as well as the need for compliance with rigorous data protection regulations such as GDPR. These regulations, although vital for consumer protection, can inhibit the fluid adoption of big data solutions. Furthermore, the inherent strengths of big data simultaneously introduce security vulnerabilities, with systems increasingly at risk of sophisticated attacks exploiting existing gaps.

GLACIATION steps into this landscape as a holistic solution adept at reinforcing data privacy and security in an era where both are increasingly indispensable. It achieves this while concurrently addressing the urgent call for sustainable technology, reducing environmental impact without compromising on performance or compliance. This strategic alignment with current market requirements and regulatory expectations solidifies GLACIATION as an attractive proposition for organisations striving to balance the intricate relationship between data privacy and environmental sustainability.

As both public and private sector organisations become more data-driven and environmentally conscious, GLACIATION's market viability surges. By embodying a solution that is both privacy-aware and green, GLACIATION not only captures the burgeoning market potential within the European sphere but also sets a precedent for global big data analytics practices. It embodies a forward-thinking paradigm where data analytics is not only smart and secure but also responsible, catering to the needs of a society that values both data privacy and reducing ecological footprints.

5.3 Data Centres

Data centres are critical infrastructures that serve as the backbone of our increasingly digital world, essential for the functionality of online businesses and services. They are immense warehouses filled with servers that store, process, and manage the deluge of digital data generated from various sources. With every email sent, every photo taken, every video streamed, and every online transaction made, including cryptocurrency trading, the volume of data expands, driving an insatiable demand for more extensive and advanced data centres.

The surge in digital activities, such as millions concurrently streaming on services like Netflix and Spotify, has led to a race among developers to expand existing data centres or construct new ones to keep pace with the burgeoning demand. Moreover, the energy-intensive process of cryptocurrency mining, for instance, has contributed significantly to this strain.

A data centre amalgamates the fundamental components of a personal computer, such as storage, processing power, networking capabilities, and power supply, but on a much larger scale. Instead of a single hard drive, a data centre may house thousands, along with potent processors within servers that handle vast amounts of data, such as YouTube's entire video catalogue.

Data centres consume vast quantities of electricity, primarily due to the heat produced by their numerous servers. These servers are arranged in "racks" and require sophisticated cooling systems to maintain optimal temperatures for hardware longevity. While strides have been made in improving the energy efficiency of data centres, the relentless growth in data demand has nevertheless resulted in overall increases in power usage. In fact, in 2022, data centres in the Republic of Ireland were responsible for consuming nearly one-fifth of the country's total electricity, as much as the combined usage of all urban households, which highlights the scale of their impact on national power grids[18]. This raises concerns about their impact on global efforts to achieve net zero carbon emissions[19].

Ownership of data centres varies. Some organisations opt to build and operate their own facilities, which is often the case for security-sensitive operations like government or military uses. Conversely, cloud providers like Amazon Web Services or Google Cloud offer server space rental for various durations. Regardless of the ownership structure, all data centres rely on a steady and substantial electricity supply for both their hardware and cooling systems[20].

The prominence of data centres is also marked by the presence of tech giants. Companies such as Facebook, Google, and Microsoft have established significant data centre operations in Ireland, with plans for further expansion. This not only emphasises Ireland's strategic importance in the global data infrastructure but also brings to the forefront the concept of data sovereignty.

[18] BBC: John Campbell, "Data centres use almost a fifth of Irish electricity," 12 June 2023. [Online]. Available: https://www.bbc.com/news/articles/cpe9l5ke5jvo.\
[19] PWC, "Edge data centers: Riding the 5G and IoT wave," July 2019. [Online]. Available: https://www.pwc.com/us/en/industries/capital-projects-infrastructure/library/assets/pwc-edge-data-centers.pdf.
[20] BBC: John Campbell, "Data centres use almost a fifth of Irish electricity," 12 June 2023. [Online]. Available: https://www.bbc.com/news/articles/cpe9l5ke5jvo.

Incorporating these concerns, data centres present both an operational necessity for our modern digital services and a challenge for sustainable energy use and data governance. Balancing the need for these massive data-processing warehouses with their electricity demands, their environmental impact and the implications for data sovereignty is a critical aspect of the contemporary discourse on digital infrastructure and its future development.

5.3.1 Data Centre Market in Numbers:

The narrative of data production and consumption is one of exponential growth. In the past year, 100 trillion gigabytes of data were generated, a figure expected to double by 2025, with data centres increasingly reaching capacity limits, signalling an urgent need for expansion[21]. With 5.28 billion internet users in 2022, representing 66.3% of the global population, the potential for further growth in data centre demand is substantial as internet penetration continues to rise[22].

AI poses a significant challenge to the sector's energy efficiency efforts. While global electricity consumption by data centres has stabilised, the rising demand for AI could increase ICT's carbon emissions, which are already estimated at 3-5%[23]. Integrating technologies such as 5G and edge computing requires balancing AI's benefits with sustainable practices and privacy enhancing technologies. This presents an important market and exploitation opportunity for the GLACIATION solution which could potentially address these market and exploitation restraints by reducing the environmental footprint of data management while enhancing privacy.

5.3.2 Data Centres Market Trends and Growth Projections

Investment in European data centre colocation is robust, with Western Europe and the Nordics attracting substantial investments due to favourable policies. Central and Eastern Europe are not far behind, with significant investments aimed at expanding infrastructure to meet growing demands[24]. However, Europe still lags behind the US in data centre capacity, with double-digit growth required over the next decade to ensure data resiliency as various sectors become more reliant on data and cloud services[25].

Growth forecasts for European data centres are strong, with a ~15% CAGR through to 2025 and ~11% CAGR over the next decade, driven by enterprise cloud adoption and data

[21] Financial Times: Kristo Mikkonen and Alex Wilson, "The looming data centre crunch," 5 October 2023. [Online]. Available: https://www.ft.com/content/e597a8b5-f71a-4099-9add-d0e3c1613348.
[22] Ibid
[23] Financial Times: Kristo Mikkonen and Alex Wilson, "The looming data centre crunch," 5 October 2023. [Online]. Available: https://www.ft.com/content/e597a8b5-f71a-4099-9add-d0e3c1613348.
[24] Business Wire, "Global Data Center Colocation Market Outlook & Forecast: A USD 46.3 Billion Market by 2028, Registering CAGR of 7.25% from 2022 to 2028 - ResearchAndMarkets.com," March 2024. [Online]. Available: https://www.businesswire.com/news/home/20240320375639/en/Global-Data-Center-Colocation-Market-Outlook-Forecast-A-USD-46.3-Billion-Market-by-2028-Registering-CAGR-of-7.25-from-2022-to-2028---ResearchAndMarkets.com.
[25] Business Wire, "Global Data Center Colocation Market Outlook & Forecast: A USD 46.3 Billion Market by 2028, Registering CAGR of 7.25% from 2022 to 2028 - ResearchAndMarkets.com," March 2024. [Online]. Available: https://www.businesswire.com/news/home/20240320375639/en/Global-Data-Center-Colocation-Market-Outlook-Forecast-A-USD-46.3-Billion-Market-by-2028-Registering-CAGR-of-7.25-from-2022-to-2028---ResearchAndMarkets.com.

sovereignty requirements, and later by technologies like IoT, AI, XR, AV, and AAM. Investment is expected to spread across Europe as the expansion of 5G mobile edge, AI, and low-latency services necessitate resources closer to consumers, along with the operational savings from lower power costs compared to FLAP locations[26].

This integrated view of data centres reflects their operational necessity, their challenging energy demands, the rapid market growth, and the critical discourse on sustainable practices and data governance shaping the future of digital infrastructure in Europe[27].

5.3.3 Main Players

Globally, major corporations such as Equinix, Inc. and Global Switch lead the charge in the data centre market, along with others like Interxion and CoreSite Realty Corporation. With an extensive international presence, these companies are joined by Colt Group S.A., CyrusOne, Telehouse, CenturyLink, Iron Mountain Incorporated, and NTT Communications Corporation in underpinning the global data centre infrastructure. Firms such as RACKSPACE TECHNOLOGY, Cyxtera Technologies, Inc., Digital Realty Trust, Inc., and China Telecom Corporation Limited further amplify the global reach of data centre operations, showcasing the industry's extensive capabilities and influence.

The European data centre market is characterised by a dynamic and diverse array of stakeholders, including IT Infrastructure Providers, Support Infrastructure Providers, Data Centre Contractors & Subcontractors, Data Centre Investors, and New Entrants. Their collaborative efforts are central to driving the sector's innovation and growth. While the market is fragmented, the top five companies—CyrusOne Inc., Equinix, Inc., Global Switch Holdings Limited, NTT Ltd., and Vantage Data Centers, LLC—command a significant 25.33% share. This indicates a competitive yet concentrated market landscape within Europe[28].

Company Name	Type	Pertinent Information
Equinix, Inc.	Global	One of the largest multinational data centre providers.

[26] Business Wire, "Global Data Center Colocation Market Outlook & Forecast: A USD 46.3 Billion Market by 2028, Registering CAGR of 7.25% from 2022 to 2028 - ResearchAndMarkets.com," March 2024. [Online]. Available: https://www.businesswire.com/news/home/20240320375639/en/Global-Data-Center-Colocation-Market-Outlook-Forecast-A-USD-46.3-Billion-Market-by-2028-Registering-CAGR-of-7.25-from-2022-to-2028---ResearchAndMarkets.com.

[27] Research and Markets, "Europe Data Center Market Overview and Forecast 2023-2029: Top Five Companies Hold 25.33% Share, Led by CyrusOne, Equinix, Global Switch Holdings, NTT, and Vantage Data Centers," 21 February 2024. [Online]. Available: https://www.globenewswire.com/news-release/2024/02/21/2832512/28124/en/Europe-Data-Center-Market-Overview-and-Forecast-2023-2029-Top-Five-Companies-Hold-25.33-Share-Led-by-CyrusOne-Equinix-Global-Switch-Holdings-NTT-and-Vantage-Data-Centers.html.

[28] Research and Markets, "Europe Data Center Market Overview and Forecast 2023-2029: Top Five Companies Hold 25.33% Share, Led by CyrusOne, Equinix, Global Switch Holdings, NTT, and Vantage Data Centers," 21 February 2024. [Online]. Available: https://www.globenewswire.com/news-release/2024/02/21/2832512/28124/en/Europe-Data-Center-Market-Overview-and-Forecast-2023-2029-Top-Five-Companies-Hold-25.33-Share-Led-by-CyrusOne-Equinix-Global-Switch-Holdings-NTT-and-Vantage-Data-Centers.html.

Global Switch	Global	Owner, operator, and developer of large scale data centres in Europe and Asia-Pacific.
Interxion	Global	Provider of carrier- and cloud-neutral colocation data centre services in Europe.
CoreSite Realty Corporation	Global	Provides reliable and secure data centre solutions.
Colt Group S.A.	Global	Offers high-bandwidth connectivity, colocation, and cloud services.
CyrusOne	Global	Provides flexible colocation data centre spaces.
Telehouse	Global	Offers secure data centre facilities and managed ICT solutions.
CenturyLink	Global	Telecommunications company with data hosting services.
Iron Mountain Incorporated	Global	Specializes in records storage, information management, and data centre services.
NTT Communications Corporation	Global	Delivers ICT solutions including cloud, network, and data centre services.
RACKSPACE TECHNOLOGY	Global	Manages apps, data, security, and cloud services.
Cyxtera Technologies, Inc.	Global	Data centre services and cybersecurity solutions.
Digital Realty Trust, Inc.	Global	Acquires, develops, and operates data centres.
China Telecom Corporation Limited	Global	State-owned company providing telecommunications and internet services.
CyrusOne Inc.	European	Premier colocation provider in Europe.
Equinix, Inc.	European	Global colocation services provider.
Global Switch Holdings Limited	European	High-quality data centre space in Europe.
NTT Ltd.	European	Specializes in IT infrastructure and global data centre services.
Vantage Data Centers, LLC	European	Offers advanced data centre facilities for service providers and enterprises.

5.3.4 GLACIATION Data Centre Market Opportunity

Amid the escalating energy requirements of data centres, the GLACIATION project emerges as an essential innovation geared towards sustainable operations. Ireland's data centres, which in 2022 consumed nearly as much electricity as all urban households combined, spotlight the significant energy footprint of such infrastructures[29]. With energy usage in these centres rising by 400% since 2015, the urgency for solutions that address both the environmental impacts and soaring energy demands is more acute than ever[30].

The GLACIATION project offers a glimpse into the future of energy optimisation across technological sectors, as evidenced by the energy efficiency improvements demonstrated in the DELL manufacturing robotics use case, Pilot 2 of the GLACIATION project. Such innovations are crucial, especially considering stringent energy regulations requiring data centres to employ backup generators and reduce power consumption upon request.

The sustainability challenge in the data centre sector is becoming more prominent, with its energy and emissions impact now comparable to that of the aviation industry, each contributing roughly 3% of annual global carbon emissions from human activity[31]. The European Commission's ambition for data centres in the region to achieve carbon neutrality by 2030 is placing operators under immense pressure to adopt greener practices. The European data centre market is distinguished by its smaller, more efficient builds, but renewable energy availability is increasingly becoming a critical component of sustainability strategies, with many new hyperscale projects including their own energy generation capacity[32].

In Ireland, there are projections that data centres could consume 70% of the energy produced by the national grid by 2030 if current trends continue unchecked. Such concerns have already led to restrictions in some energy-constrained urban areas, such as a de facto moratorium on new data centres in the Dublin region by Eirgrid[33]. Amsterdam, once a rising data centre hub, is now creating regulations to limit data centre demands for energy and land, which may redirect builds to other cities[34].

As Europe advances in AI and IoT, aligning with edge computing and addressing sustainability and privacy concerns becomes even more essential. The GLACIATION project's innovative approach is poised to address these pressures, providing resilience and efficiency for data

[29] BBC: John Campbell, "Data centres use almost a fifth of Irish electricity," 12 June 2023. [Online]. Available: https://www.bbc.com/news/articles/cpe9l5ke5jvo.
[30] BBC: John Campbell, "Data centres use almost a fifth of Irish electricity," 12 June 2023. [Online]. Available: https://www.bbc.com/news/articles/cpe9l5ke5jvo.
[31] World Economic Forum, "What is 'dark data' and how is it adding to all of our carbon footprints?" 5 October 2022. [Online]. Available: https://www.weforum.org/agenda/2022/10/dark-data-is-killing-the-planet-we-need-digital-decarbonisation/?utm_campaign=social_video_2022&utm_content=27617_dark_data&utm_medium=social_video&utm_source=linkedin&utm_term=1_1.
[32] KPMG, "The evolving data centre landscape," March 2024. [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/ie/pdf/2022/11/ie-the-evolving-data-centre-landscape.pdf.
[33] KPMG, "The evolving data centre landscape," March 2024. [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/ie/pdf/2022/11/ie-the-evolving-data-centre-landscape.pdf.
[34] KPMG, "The evolving data centre landscape," March 2024. [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/ie/pdf/2022/11/ie-the-evolving-data-centre-landscape.pdf.

centres in a market that demands both environmental consciousness and compliance with rigorous data protection laws.

5.4 Cloud

Cloud computing represents a paradigm shift in the delivery of IT services, facilitating on-demand access to a spectrum of computing resources—including servers, storage, databases, networking, software, analytics, and intelligence—via the cloud. This model champions innovation, flexible resources, and economies of scale. The versatility of cloud computing lies in its accessibility; resources are not confined to a local device but are instead available from any location and device, promoting efficiency across organisations.

By leveraging the cloud, enterprises sidestep the need for substantial investments in building or expanding physical IT infrastructures. The model provides a virtual pool of configurable computing resources, enabling seamless scaling of services to meet the fluctuating demands of big data analytics. In this evolving landscape, the cloud essentially acts as a vast, interconnected server, transforming the way enterprises deploy server-based computing[35].

With cloud computing, the approach to big data analytics and data centres is cost-effective and usage-based. Customers pay only for the computing time and resources they utilise, aligning operational costs directly with demand. This service model underpins the intersection of cloud computing with big data analytics, where the cloud serves as a dynamic repository for the immense volumes of information processed and analysed.

Furthermore, cloud services can be tailored to specific needs through public clouds that serve a wide array of clients or private clouds designed exclusively for a single enterprise, ensuring customisation and privacy where necessary[36]. This flexibility positions cloud computing as an essential backbone for big data analytics and the operation of modern data centres, underpinning the scalable, efficient, and cost-effective IT solutions essential for contemporary business success.

5.4.1 Market in Numbers

Globally, the realm of cloud computing has seen substantial growth, a trend distinctly reflected in the European market.

This expansion aligns with the increasing adoption of cloud services by European enterprises, with 45.2% utilising these services in 2023, predominantly for essential functions such as email systems, electronic file storage, and office software. Furthermore, 75.3% of these enterprises are engaged in sophisticated cloud services, encompassing security software applications, database hosting, and platforms for software development[37].

From 2021 to 2023, the uptake of cloud computing services among EU enterprises experienced a notable hike of 4.2 percentage points, indicative of the growing reliance on

[35] EuroStat, "Cloud computing - statistics on the use by enterprises," December 2023. [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Cloud_computing_-_statistics_on_the_use_by_enterprises#Cloud_computing_in_enterprises:_highlights.
[36] Ibid
[37] ibid

digital infrastructure[38]. Nearly all enterprises with ten or more employees now have internet access, laying the groundwork for continued cloud integration[39].

A breakdown by enterprise size shows a stark difference in cloud service procurement. Large enterprises lead the charge, with 77.6% purchasing such services in 2023—an increase of 6 percentage points from 2021. Medium-sized enterprises are not far behind at 59%, and even small enterprises have shown a marked increase in cloud adoption, reaching 41.7%[40].

The European cloud computing market, already valued at $60 billion in 2022, is forecast to expand at a CAGR of 25% between 2023 and 2032, underscoring the market's vitality and the region's commitment to embracing cloud-based solutions[41]. This trend not only showcases Europe's increasing demand for cloud services but also emphasises the growing importance of cloud computing as a foundational element for businesses aiming to innovate and scale efficiently.

5.4.2 Main Players

In the global arena, the cloud computing market is dominated by a constellation of powerhouse corporations that have become synonymous with digital transformation. Amazon Web Services leads as a titan, with Alibaba Group Holding Limited and Google LLC not far behind, each providing a vast array of cloud solutions. Microsoft Corporation and IBM Corporation are also integral, offering a blend of cloud services that span from infrastructure to platform and software. Other notable global entities like Fujitsu, Hewlett Packard Enterprise Development LP, and Oracle Corporation continue to push the boundaries of cloud computing capabilities. The list is further enriched by specialists like Rackspace Inc, Salesforce.com Inc, and VMware, which cater to specific cloud computing needs[42].

Transitioning to the European landscape, the cloud computing sector features prominent players that contribute significantly to the region's technological ecosystem. Deutsche Telekom stands out with its robust infrastructure and cloud services, while OVHCloud and Orange S.A represent the French prowess in cloud computing. German giant SAP is known for its enterprise software and cloud services, further solidifying Europe's position in the global market. Emerging players like Digital Ocean and Fuga Cloud, along with Cloud Sigma, are making their mark with innovative cloud solutions tailored to the diverse needs of European businesses.

These main players exemplify the dynamic nature of the cloud computing industry, where established global leaders and European specialists collectively drive innovation, shaping the future of cloud services and their integration into the broader digital economy.

Company Name	Country	Pertinent Information

[38] Ibid
[39] Ibid
[40] Ibid
[41] Global Market Insights, "Europe Cloud Computing Market Size By Service (Software-as-a-Service, Infrastructure-as-a-Service, Platform-as-a-Service), By Organization (Large Enterprises, SMEs), By Deployment Model (Public Cloud, Private Cloud, Hybrid Cloud), Application, 2023-2032," December 2022. [Online]. Available: https://www.gminsights.com/industry-analysis/europe-cloud-computing-market.
[42] Ibid

Amazon Web Services	Global	Leader in cloud services, offering extensive solutions.
Alibaba Group Holding Limited	Global	Chinese multinational company specialising in e-commerce, retail, and technology.
Google LLC	Global	Offers a suite of cloud solutions, data analytics, and machine learning.
Microsoft Corporation	Global	Provides a wide range of cloud services including Azure.
IBM Corporation	Global	Offers cloud and data services and known for AI and cognitive computing.
Fujitsu	Global	Japanese multinational IT equipment and services company.
Hewlett Packard Enterprise Development LP	Global	American multinational enterprise IT company.
Oracle Corporation	Global	Specialises in database software, cloud engineered systems, and enterprise software products.
Rackspace Inc	Global	Cloud computing company offering multi-cloud solutions.
Salesforce.com Inc	Global	Provides CRM and enterprise cloud computing solutions.
VMware	Global	Cloud infrastructure and digital workspace technology company.
Deutsche Telekom	Germany	Leading telecommunications provider with robust cloud infrastructure services.
OVHCloud	France	Cloud computing service provider known for dedicated servers.
Orange S.A	France	Multinational corporation that provides a variety of cloud services.
SAP SE	Germany	Known for its enterprise resource planning software and cloud services.
Digital Ocean	Global	Cloud infrastructure provider offering cloud computing solutions.
Fuga Cloud	Europe	Provides cloud computing services with a focus on European data protection standards.

Cloud Sigma	Europe	Known for high customization and flexibility in cloud services.

5.4.3 GLACIATION Cloud Computing Market Opportunity

In the rapidly evolving landscape of cloud computing, while the benefits are manifold, the limitations are becoming increasingly apparent, particularly regarding environmental impact and privacy risks. The surge in energy demand required for data movement and cloud operations is a pressing concern. As organisations migrate vast volumes of data to the cloud, the energy-intensive nature of maintaining and processing this data becomes more pronounced, contributing significantly to the sector's carbon footprint.

The growing proliferation of IoT devices amplifies these concerns, as each device adds to the volume of data transferred and stored, intensifying the energy used by data centres. This rise in IoT adoption, coupled with the expansion of cloud computing, creates a dual challenge of sustainability and privacy preservation. Organisations grapple with robust security measures and strict compliance with data protection regulations amid escalating volumes and values of data.

Unauthorised access and data breaches remain significant concerns, particularly in sensitive industries like finance and healthcare, where data residency and protection are paramount. These industries find their cloud adoption hindered by the inherent privacy risks of the cloud, where the off-premises storage and processing of data can potentially expose sensitive information to cyber threats.

In this context, solutions like GLACIATION that can minimise the environmental impact of data movement and operations, while bolstering privacy, are not just advantageous but essential. As cloud computing continues to intersect with big data analytics and the operational needs of data centres, the ability to address these privacy and sustainability concerns will be critical. GLACIATION's approach to mitigating these challenges presents an opportunity for more responsible and secure cloud engagement in the face of the expansion of cloud service utilisation as well as the increasing IoT integration.

5.5 Edge Computing and Internet of Things

Edge computing marks a significant transition in digital infrastructure, driving forward the paradigm of processing and analysing data closer to its point of creation, the very ethos of the GLACIATION solution. This strategic placement of computational resources facilitates immediate data analysis, essential for applications that depend on rapid response and action. Edge computing forms an operational continuum with cloud computing, presenting local storage solutions at the device or nearby facilities, allowing for heightened real-time analytics and processing power, emphasising distributed intelligence and local decision-making processes[43]. While edge computing predominantly focuses on exploiting this continuum for

[43] European Commission, "Investing in Cloud, Edge and the Internet of Things," September 2023. [Online]. Available: https://digital-strategy.ec.europa.eu/en/policies/iot-investing.

various purposes, including real-time analytics and enhanced processing capabilities, it also underscores the importance of distributed intelligence and localised decision-making[44].

The emergence of edge computing signifies a leap in digital innovation, enhancing performance and productivity across various industries. By situating computation and data storage nearer to the data's origin, edge computing promotes swift, efficient data analysis, enabling organisations to make timely and informed decisions.

In the transportation sector, for example, edge computing supports the implementation of pedestrian automatic emergency braking systems, using IoT data to improve safety measures. In agriculture, it offers farmers real-time information, aiding them in protecting crops and optimising yields. Furthermore, it is pivotal in the development of autonomous vehicles, providing the necessary local processing of extensive data sets to make instantaneous decisions, thereby transforming transportation safety and efficiency.

The expansion of edge computing within Europe aligns with the EU's Digital Decade goals, which target the integration of cloud-edge technologies among European enterprises. The initiative promotes the deployment of climate-neutral and secure edge nodes, ensuring rapid data transfers and smooth integration of edge solutions within the digital sphere[45]. This integration fosters a fertile environment for innovation and collaboration, aiming to leverage the transformative power of edge computing to drive economic growth and sustainable development[46].

The essence of edge computing lies in its ability to enable real-time decision-making, independent of traditional cloud computing's latency. This shift to edge computational capacity unlocks a new sector in the digital economy, facilitating local data analysis for a wide array of devices. From autonomous vehicles and remote mining equipment to healthcare wearables, edge computing's utility is extensive and versatile[47].

Edge computing's ability to identify critical, actionable data further strengthens its value proposition. By decentralising data analysis, organisations can minimise data transmission to central systems, addressing network bandwidth limitations and reducing operational costs[48].

The synergy of edge computing and IoT is reshaping industries, offering solutions to manage the vast volumes of data produced by the increasing number of connected devices. By 2023, the surge of IoT devices is expected to revolutionise industrial operations, enhancing agility and speed[49]. This rise in IoT devices, estimated to reach $41.6 billion by 2025, underscores

[44] Ibid
[45] European Commission, "Cloud Computing," 20 June 2023. [Online]. Available: https://digital-strategy.ec.europa.eu/en/policies/cloud-computing.
[46] Ibid
[47] KPMG, "The evolving data centre landscape," March 2024. [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/ie/pdf/2022/11/ie-the-evolving-data-centre-landscape.pdf.
[48] McKinsey and Company, "New demand, new markets: What edge computing means for hardware companies," November 2018. [Online]. Available: https://www.mckinsey.com/~/media/mckinsey/industries/technology%20media%20and%20telecommunications/high%20tech/our%20insights/new%20demand%20new%20markets%20what%20edge%20computing%20means%20for%20hardware%20companies/new-demand-new-markets-what-edge-comp.
[49] KPMG, "The 5G edge computing value opportunity," June 2020. [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/pe/pdf/5g-edge-computing-value-opportunity.pdf.

the importance of effective data governance and management, which edge computing facilitates by enabling localised data handling[50].

The advent of edge computing, in tandem with the burgeoning growth of IoT devices, heralds a new industrial revolution. By processing data close to its source, edge computing is setting the stage for transformative business processes, capable of adapting rapidly to the demands of the modern digital economy[51]. The clear exploitation potential of the GLACIATION SOLUTION within the Edge computing market is highly evident.

5.5.1 Edge Computing Market in Numbers

The industrial landscape is on the cusp of a radical transformation, driven by the convergence of 5G technology and edge computing.

Telecommunications companies are poised to unlock a significant revenue stream in the industrial manufacturing sector, with projections estimating a potential opportunity worth $206 billion by 2023[52]. Comprehensive analysis by KPMG and IDC, surveying sectors such as industrial manufacturing, connected healthcare, intelligent transportation, environmental monitoring, and gaming, forecasts that the combined annual revenue catalysed by 5G and edge computing adoption could surge to US$517 billion across the entire ecosystem[53].

Specifically, the industrial manufacturing market was expected to experience a growth of 51% from 2019 to 2023, owing to the synergistic effects of 5G+Edge, offering an ecosystem opportunity of $206 billion[54]. This surge is part of a broader trend, with AI and machine learning advancements continuing to shine.

The demand for edge technologies is also expected to drive over $200 billion in hardware value within the next five to seven years, reflecting the wide-ranging impact and opportunities across various industries[55].

The edge-to-core model promises numerous benefits, including enhanced control over security, protection of business processes and intellectual property, rapid integration of IoT data, and efficient use of existing storage and analytic tools. This model also enables efficient

[50] McKinsey and Company, "New demand, new markets: What edge computing means for hardware companies," November 2018. [Online]. Available: https://www.mckinsey.com/~/media/mckinsey/industries/technology%20media%20and%20telecommunications/high%20tech/our%20insights/new%20demand%20new%20markets%20what%20edge%20computing%20means%20for%20hardware%20companies/new-demand-new-markets-what-edge-comp.

[51] KPMG, "The 5G edge computing value opportunity," June 2020. [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/pe/pdf/5g-edge-computing-value-opportunity.pdf.

[52] KPMG, "Industrial Manufacturing: The 5G + Edge opportunity. 5G and edge computing help to transform Industry 4.0." [Online]. Available: https://kpmg.com/xx/en/home/insights/2020/10/industrial-manufacturing-the-5g-edge-opportunity.html.

[53] Ibid

[54] Ibid

[55] KPMG, "The evolving data centre landscape," March 2024. [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/ie/pdf/2022/11/ie-the-evolving-data-centre-landscape.pdf.

analytics and reporting by leveraging data virtualisation strategies, maximising investments and in-house team expertise[56].

Joint analysis by KPMG and IDC articulates that, by 2023, five key sectors could generate more than $500 billion worth of market opportunity in connectivity, software, hardware, and services, spotlighting the immediate, lucrative opportunities presented by 5G+Edge[57].

By 2023, the total addressable revenue across five industry use cases—industrial manufacturing, connected healthcare, intelligent transportation, environmental monitoring, gaming—was projected to grow from $361 billion in 2019 to $517 billion. This marks an impressive ecosystem opportunity of $517 billion and potential more[58].

Furthermore, according to the IDC, European spending on edge computing will reach nearly $50 billion in 2024, representing an increase of 15% compared to last year[59].

The proliferation of IoT devices, anticipated to reach 43 billion by 2023, synergises with edge computing to process vast data quantities. This synergy is projected to trigger the next industrial revolution, transforming business processes to be quicker and nimbler. The global edge computing market was forecasted to expand at a CAGR of 19% from USD 36.5 billion in 2021 to USD 87.3 billion by 2026[60].

Edge computing elevates business operations through enhanced speed, as it diminishes the need for data to traverse to central data centres, thereby streamlining real-time decision-making[61]. It also bolsters reliability by reducing latency, ensuring that applications remain operational without interruptions due to speed constraints[62]. Furthermore, by moving computation closer to data generation points, edge computing offers superior data management, minimising the volume of data transmitted to central data centres and enhancing overall data governance[63].

5.5.2 Trends and main market characteristic global and Europe

The edge computing market continues to evolve under the influence of significant global and technological trends. The rapid increase of IoT devices, boosted by the expansion of 5G networks, is a driving force behind this growth. The integration of software engineering

[56] McKinsey and Company, "New demand, new markets: What edge computing means for hardware companies," November 2018. [Online]. Available: https://www.mckinsey.com/~/media/mckinsey/industries/technology%20media%20and%20telecommunications/high%20tech/our%20insights/new%20demand%20new%20markets%20what%20edge%20computing%20means%20for%20hardware%20companies/new-demand-new-markets-what-edge-comp.
[57] KPMG, "The 5G edge computing value opportunity," June 2020. [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/pe/pdf/5g-edge-computing-value-opportunity.pdf.
[58] KPMG, "The 5G edge computing value opportunity," June 2020. [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/pe/pdf/5g-edge-computing-value-opportunity.pdf.
[59] IDC, “Reach Nearly $50 Billion in 2024, Says IDC,” 24 March 2024. [Online]. Available: https://www.idc.com/getdoc.jsp?containerId=prEUR251963024.
[60] PWC, "What is edge computing and how does it impact businesses?" 2022. [Online]. Available: https://www.pwc.in/consulting/technology/emerging-tech/what-is-edge-computing-and-how-does-it-impact-businesses.html.
[61] Ibid
[62] Ibid
[63] Ibid

advances further propels the development of complex systems, especially those pertinent to safety-critical applications across the cloud-edge continuum[64].

The COVID-19 pandemic acted as a catalyst for the deployment of 5G and multi-access edge computing. This response to the pandemic highlights the importance of speed and low latency in services—a trend that has been particularly crucial for the telecommunications industry as it adapts to 5G infrastructure[65].

The global edge computing market's growth is primarily fuelled by rising data volumes and the pervasive integration of IoT, AI, and 5G technologies. Smart city and smart industry technologies are poised to strengthen the global market over the forecast period[66].

Increased adoption of IoT is supported by 5G operations, enabling industrial IoT service providers to expand their edge computing capabilities. This supports the management of the increasing volumes of data. The demand for real-time data processing and bandwidth optimisation continues to drive the adoption of edge computing, vital for supporting the infrastructure required for 5G, low-latency processing, and network bandwidth optimisation[67].

Furthermore, the swift adoption of AR and VR technologies, coupled with AI and IoT, is enhancing the security and problem-solving capabilities of IoT devices across various industries. This enhances analytics and decision-making processes, demonstrating the market's adaptability and innovative potential.

In conclusion, the edge computing market is experiencing transformative growth, shaped by the aftermath of the COVID-19 pandemic, the proliferation of IoT devices, the advent of 5G networks, and the increasing need for immediate data processing and optimized bandwidth. New markets and technologies, including initiatives in smart cities, further illustrate the dynamic nature of the market and edge computing's crucial role in the evolving digital landscape.

5.5.3 Main Players

The edge computing market is driven by a cohort of global corporations, each playing a significant role in advancing the industry through innovation and strategic collaborations. At the forefront are companies like Cisco, HPE, Dell, and Huawei, all of which have been instrumental in developing products that cater to the demanding conditions of industrial environments. Their offerings are designed to withstand a myriad of challenges, including electromagnetic interference, dust, explosions, vibrations, and fluctuations in current and voltage. These firms are steadfast in their pursuit to shape the future of edge computing with ongoing partnerships and frequent product developments.

[64] European Commission, "Investing in Cloud, Edge and the Internet of Things," September 2023. [Online]. Available: https://digital-strategy.ec.europa.eu/en/policies/iot-investing.
[65] KPMG, "The 5G edge computing value opportunity," June 2020. [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/pe/pdf/5g-edge-computing-value-opportunity.pdf.
[66] KPMG, "Industrial Manufacturing: The 5G + Edge opportunity. 5G and edge computing help to transform Industry 4.0." [Online]. Available: https://kpmg.com/xx/en/home/insights/2020/10/industrial-manufacturing-the-5g-edge-opportunity.html.
[67] Ibid

Leadership in edge computing is further embodied by organisations such as the OpenFog Consortium. This consortium, led by market vendors including Cisco, Intel, Microsoft, and Dell EMC, along with academic powerhouses like Princeton University and Purdue University, is dedicated to establishing reference architectures for fog and edge computing deployments. This collective endeavour underscores the collaborative nature of innovation within the edge computing sector. Market dominance is also exemplified by industry giants such as Microsoft Corporation, Google LLC, IBM Corporation, Huawei Technologies Co. Limited, and Cisco Systems Inc. These entities stand out as major operators in the edge computing market, shaping its trajectory with their comprehensive portfolios and market presence.

Moreover, an array of other pivotal players includes IBM Corporation, Intel Corporation, Amazon.com, ADLINK Technology Inc., Hewlett Packard Enterprise Development LP, and EdgeConneX Inc. These companies, with their U.S.-based operations, as well as international reach from the likes of Taiwan-based ADLINK Technology, are significantly active in enriching the edge computing market with technological advancements and global service provision.

Company Name	Type	Description
Cisco	Global	A major player in networking and communications, Cisco offers robust edge computing solutions designed to withstand industrial challenges and facilitate the rapid processing of data on the network edge.
HPE (Hewlett Packard Enterprise)	Global	HPE provides cutting-edge computing solutions that enable real-time processing and analytics at the edge, specifically engineered for challenging industrial environments.
Dell	Global	Dell's edge computing products focus on versatility and resilience, ensuring reliable performance under tough industrial conditions.
Huawei	Global	Huawei's edge computing initiatives aim to deliver high-performance computing power closer to data sources in various environments, emphasizing reliability in industrial settings.
OpenFog Consortium	Global	A collaboration of industry leaders like Cisco, Intel, and Microsoft, and academic institutions aiming to establish standardised architectures for edge and fog computing deployments.
Microsoft Corporation	Global	Microsoft is at the forefront of edge computing with services that bring cloud capabilities to the edge, facilitating local data processing and real-time insights.
Google LLC	Global	Google's edge computing services are integral to its cloud platform, offering tools for machine learning and data analytics at the edge.

IBM Corporation	Global	IBM offers comprehensive edge computing solutions that empower businesses to act on insights closer to where data is created, with a focus on security and cognitive computing.
Intel Corporation	Global	Intel provides essential hardware and software for edge computing, with a portfolio that includes CPUs, accelerators, and platforms designed for the edge.
Amazon.com	Global	Through AWS, Amazon delivers edge computing services that extend cloud capabilities to edge devices, enabling faster responses and data processing.
ADLINK Technology Inc.	Global (Taiwan-based)	ADLINK is a leader in embedded computing, offering products that support edge computing applications in various industries, with a strong presence in Asia and worldwide operations.
Hewlett Packard Enterprise Development LP	Global	As part of HPE, this company specializes in edge-to-cloud platforms that drive innovation and data-driven decisions at the edge.
EdgeConneX Inc.	Global	EdgeConneX focuses on edge data center solutions, providing the infrastructure necessary for the fast-growing demands of edge computing.
Company Name	Type	Description

5.5.4 GLACIATION Solution: Market Opportunity Analysis in Edge and IoT

The market opportunity for the GLACIATION solution within the edge and IoT sectors is considerable, as these domains are rapidly expanding with a growing need for enhanced security and the management of an increasing array of IoT devices.

With the prevalence of cybersecurity threats, there's a pronounced market demand for solutions that strengthen the security of edge computing architectures. The GLACIATION project addresses this by providing an AI-driven, metadata fabric that enhances security across the edge-core-cloud continuum. This approach ensures that data operations at the edge are safeguarded against the expanding threat landscape, positioning GLACIATION as an essential innovation for organisations looking to secure their edge computing deployments.

The IoT sector is experiencing an explosive increase in devices, which in turn multiplies the data points susceptible to cyber-attacks. GLACIATION's optimisation of data movement and operations not only enhances privacy compliance but also offers a sustainable solution to the challenge of scaling security across the myriad of IoT devices. As such, GLACIATION can capitalise on the need for robust privacy measures in a market that's becoming increasingly aware of the risks associated with IoT proliferation.

GLACIATION's commitment to minimising environmental impact through optimised data movement aligns with a growing trend in the technology sector that is sustainable innovation as well as increasing legislation in this regard. By reducing carbon emissions associated with data operations, GLACIATION aligns with the environmental goals of organisations and regulatory bodies, presenting a clear market opportunity.

GLACIATION's use of AI for optimising data movement and operations offers a unique selling point in the crowded edge computing market. As companies seek out efficient ways to handle the increasing volume of data generated by IoT devices, GLACIATION's AI-driven solutions position it as a leader in intelligent privacy aware and sustainable data management, differentiating it from competitors.

GLACIATION's solution is complementary to the offerings of current market leaders, providing additional layers of privacy and sustainability. This presents collaborative opportunities with companies like Cisco, HPE, Dell, and Huawei, which already have a strong footing in the edge computing market and could benefit from GLACIATION's specialised focus on privacy and sustainability.

In summary, the GLACIATION solution is strategically positioned to tap into the edge and IoT markets by addressing critical needs for security, privacy, and sustainability. The demand for such a solution is clear, given the exponential rise of IoT products and the increased focus on cybersecurity. GLACIATION can leverage these market trends to establish a unique value proposition, ensuring relevance and appeal to businesses investing in edge computing infrastructure and IoT device management.

6 Exploitation Plan

As the GLACIATION consortium contemplates the expansive trajectory of the project, the exploitation plan as well as the commercialisation strategy is being designed with an ecosystem-wide perspective. It is envisioned that the entire GLACIATION solution will coalesce into a unified platform, provisioned through a freemium model that maintains the foundational open-source principles of the Horizon Europe programme. This holistic approach is aimed at delivering an integrated suite of services and features that could be beneficial across a spectrum of stakeholders, from individual researchers to large public administrations.

The strategy considers establishing a non-profit organisation post-project completion to oversee the long-term management and scalability of the GLACIATION solution. This entity would be crucial for maintaining the solution's alignment with open-source principles while also steering the platform towards sustainable growth and broader impact, particularly in the realm of public administration.

The potential scale-up in public administrations, such as in Italy, is underscored by the successful implementation of Pilot 1. This serves as a prototype for how the GLACIATION solution could be integrated into governmental operations to enhance efficiency, data sovereignty, and the implementation of AI and machine learning technologies within public services.

The non-commercial exploitation of the GLACIATION solution represents a parallel path of growth, especially within academic and research institutions as well as the public administration. Project partners such as University College Cork, the Insight Centre, the University of Milan, and the University of Bergamo are poised to leverage the project's outputs to further academic research, contribute to the body of knowledge in edge computing and big data analytics, and enrich the educational experience for students.

This dual-path strategy of commercial and non-commercial exploitation acknowledges the varying needs and contributions of the diverse GLACIATION stakeholders. It ensures that the project’s legacy extends beyond commercial success to drive innovation, knowledge sharing, and policy impact within the European research community and public sector.

The creation of a non-profit organisation will facilitate the continuation of these efforts, fostering an environment where the GLACIATION solution can be further refined, expanded, and applied to new challenges and opportunities that arise in the evolving landscape of data analytics and edge computing.

6.1 Advancing the Horizon: The GLACIATION Solution's Innovative Edge

The GLACIATION solution emerges as a pivotal innovation in the technological landscape, strategically addressing the complex challenges of cloud-edge data management integral to the development of smart cities and industries of the future. As we steer towards an era that hinges on meticulous data analysis for socio-economic enhancement, GLACIATION’s commitment to minimising carbon footprint, energy demands, and privacy risks becomes

profoundly significant. This commitment is not only morally imperative but also aligns with the stringent legislative trends across the European Union, which mandate heightened responsibilities for both private and public sector entities.

At the core of GLACIATION's unique offering is its ability to defy the conventional trade-off between privacy and energy consumption. Typically, privacy enhancement is synonymous with energy-intensive encryption methods. However, GLACIATION's innovative framework ensures that privacy is fortified without an exponential increase in energy usage. This symbiotic approach to data management is particularly crucial in the current landscape where the proliferation of IoT devices and the urgency of climate change pose a dual challenge. The solution's promise to harness and process data conscientiously paves the way for European citizens and the global community to leverage this data for the greater good, without exacerbating the climate crisis or compromising personal data integrity.

Embodied within the GLACIATION project is a suite of technologies and software tools that signify a paradigm shift from traditional data operation models. Distinct from conventional methodologies that necessitate extensive data movement for processing, GLACIATION innovates by curbing superfluous data traversal, thus conserving energy and reducing latency. However, the project's ambitions transcend mere reduction in data mobility. Through intelligent redistribution of data and computational tasks across the most optimal locations—be it edge, core, or cloud—the system ensures peak performance alongside compliance with privacy standards. The project's vision is crystallised through its pioneering Distributed Knowledge Graph (DKG) and AI-based data operations, which empower privacy-preserving data handling and eco-friendly processing, placing GLACIATION at the vanguard of sustainable data operation advancements.

The trajectory of GLACIATION aligns with a profound scientific impact, potentially catalysing notable publications and software tools. Even modest progress within the project's scope is anticipated to be ground-breaking, with the potential to redefine the benchmarks of innovation. Moreover, the project's dedication to localising data harmonises with security, sustainability, and energy conservation objectives, as pre-processing at the edge drastically slashes the quantum of data necessitating transfer and storage. This strategy is set to yield substantial economic and energy-related dividends, thereby reinforcing GLACIATION's role in shaping the next generation of secure and energy-efficient data operations.

In essence, GLACIATION's development encapsulates a holistic approach to edge computing, signifying a considerable leap over traditional cloud-centric methods. This avant-garde strategy not only amplifies performance through minimised latency and bandwidth consumption but also advances the cause of data privacy. By curtailing the necessity for extensive data dissemination, GLACIATION safeguards information privacy while adhering to the strictest privacy models and technologies. These pioneering strides in edge computing poise GLACIATION as a forerunner in the domain, adeptly navigating the confluence of sustainability, efficiency, and privacy preservation.

6.2 GLACIATION Exploitation Plan for Groupings of Partners

The GLACIATION project's exploitation strategy is tailored to the nature of each partner, distinguishing between the public and private sectors. Public entities such as research

institutes, universities, and administrations follow a distinct approach focusing on policy influence and societal benefit, while private sector partners pursue commercial opportunities. Below is an outline of the initial exploitation plan for each partner category. For private sector entities, detailed business plans linked to specific innovations are presented, and for public sector partners like MEF and SOGEI, a non-commercial exploitation trajectory is elaborated, which will be expanded upon in later sections.

6.2.1 Public Administrations

For public administrations like MEF and SOGEI, the plan is to scale the GLACIATION solution's usage within the Italian Ministry of Economy and Finance and beyond. A core aspect will be to generate policy briefs from the project's findings. These briefs will provide actionable insights for policymakers across Europe, leveraging the cloud-edge continuum for the betterment of European citizens. The exploitation strategy will revolve around enhancing operational efficiency within public services and disseminating best practices learned from the project's implementation while also exploring potential for scale up across the Italian public administration and potential beyond.

6.2.2 Research Partners

Academic and research institutions involved in GLACIATION — including University College Cork, Leibniz University Hannover, University of Milan, University of Bergamo, ETH Zurich, and EURECOM — aim to leverage project outcomes to fuel further research. The knowledge and results produced will serve as a foundation for new research initiatives and innovations, with a commitment to advancing the scientific and technical understanding of the cloud-edge computing paradigm.

6.2.3 Standardisation Bodies

For standardisation bodies such as ERCIM and W3C within the consortium, the goal is to drive the creation of new industry standards informed by GLACIATION innovations. By developing standards that reflect technological advancements from the project, these bodies will play a pivotal role in ensuring sustainable and efficient technological growth, with a focus on reducing energy consumption and enhancing privacy without compromising performance.

6.2.4 Private Sector Partners

Private sector partners within the GLACIATION project will aim to incorporate research results and innovations into their respective business models and product lines. This includes DELL, EISI, ENG, HIRO, and SAP SE. While detailed exploitation plans are currently still in development, in alignment with the project reaching the demonstration stage, the foundation for these activities is laid by the SWOT analyses conducted by each private sector partners, with the SWOT analyses and corresponding business plans of certain private sector partners pending. These plans, the foundation of most of which have been detailed below, will be tailored to each company's strategic objectives and market positioning, ensuring that the project's outcomes translate into competitive advantages and new market opportunities.

6.3 Pilot Based Exploitation Potential Analysis

Below is a comprehensive evaluation of distinct pilots, grounded in the market and policy analysis previously articulated in this deliverable. This evaluation highlights demonstrable market and exploitation opportunities, garnered from insights within the pilots. Each section is meticulously designed to delineate the specific potential within both the public and private sectors, emphasising the GLACIATION solution's innovative edge and its response to the emergent needs for greater security and sustainability amidst the exponential rise of IoT products.

6.3.1 Pilot 1: Exploitation in the Public Sector

Integrating the Italian MEF use case with the GLACIATION project's exploitation strategy opens a multifaceted potential for non-commercial exploitation within the public sector. This encompasses not just the application of the NoiPA digital platform's capabilities but also the utilisation of its comprehensive data collection for policy development and public administration enhancement.

The Directorate of Information Systems and Innovation (DSII) at MEF, serving as a linchpin in IT and data management services, has established NoiPA as an instrumental platform in managing vital administrative functions for approximately 2 million Italian civil servants across over 80 public bodies. With plans to expand NoiPA's reach, the GLACIATION project identifies this scenario as an excellent opportunity for widespread public sector exploitation.

The DSII's approach, centralised yet aiming for a balance with decentralised processing, offers a blueprint for policy briefs that advocate for efficient data management, upholding data sovereignty, and optimising costs and operational timings. Such policy briefs, paired with actionable recommendations, have the potential to resonate with public administrations across the European Union Member States, shaping the future of public service IT infrastructure.

Moreover, the GLACIATION project, through NoiPA's scaling, presents a unique chance to transcend traditional service delivery, fostering user-centric public services. This serves as a foundation for a policy model that could be replicated beyond Italian borders, setting a precedent for European public sector innovation.

This non-commercial exploitation approach aligns with the broader objectives of societal improvement and political progress of the Horizon Europe Programme, ensuring that GLACIATION's impact is deep-rooted and extends beyond immediate commercial gains. The integration of policy development, public service enhancement, and potential scale-up across Italy's public service—potentially influencing other European Union Member States—epitomises the project's commitment to fostering a legacy that champions efficiency, inclusivity, and forward-thinking in public administration.

6.3.2 Pilot 2: Market Potential with Industry 4.0 and Smart Cities Integration

The exploitation plan for the second use case within the GLACIATION project must underscore the distinct commercial potential at the Dell Technologies Cork Campus as well as non-commercial exploitation for the benefits of European citizens. This site, being a pivotal hub for

Advanced Manufacturing, Engineering, Research and Development (R&D), and a suite of other critical operations, offers fertile ground for the application and development of the GLACIATION solutions at a Technology Readiness Level (TRL) of 4.

- **Further Research and Development:** With its R&D capabilities, Dell can utilise the GLACIATION solutions to enhance its research processes, particularly in manufacturing and engineering, driving innovation within its expansive product portfolio.
- **Industry 4.0 Applications:** Given the manufacturing site's sophisticated integration of cobots and Tugbots, the GLACIATION project's solutions can be further tailored to optimise robotic operations, component analysis, and package handling, thus boosting efficiency and productivity.
- **Smart Industry Solutions**: Dell's manufacturing floor and lab space, sprawling over vast square footage, are a testament to the potential scale of smart industry applications. The GLACIATION project can offer intelligent data analysis tools that could revolutionise the way robotic maintenance and energy consumption are managed.
- **Data Centres and Cloud Business:** With a focus on energy-efficient technologies, the GLACIATION solutions could be pivotal in transforming Dell's data centres. By optimising power consumption and enhancing data analysis, the solutions could provide a competitive edge in Dell's cloud services.
- **Smart Cities Integration:** The Cobots and Tugbots data, coupled with the GLACIATION project's analytical prowess, could extend to applications in smart city environments, where efficiency, energy conservation, and automation are paramount.

The deployment of GLACIATION solutions at Dell's Cork Campus represents a commercial exploitation strategy that can lead to advanced product development and a solidified presence in emerging smart industries. By addressing the current limitations in cobot fault diagnosis and excessive power consumption and corresponding environmental footprint, there is a clear pathway for Dell to refine its operations and spearhead new applications for industry 4.0, positioning itself as a leader in edge based technological transformation of industrial settings.

6.3.3 Pilot 3: Market Potential with Expected Boom in Business Analytics

For pilot 3, the SAP business analytics use case, the GLACIATION project posits a significant opportunity for commercial exploitation by enhancing big data analytics with an emphasis on sustainability and privacy. In an era where artificial intelligence and data analytics are expected to surge, the GLACIATION solution stands to offer a competitive edge by addressing the dual challenges of environmental impact and data privacy.

- **Green Big Data Analytics:** SAP's broad reach across business lines presents a unique opportunity for the GLACIATION solution to make a substantial impact on the eco-efficiency of data analytics. By optimising data processing to reduce energy consumption, the solution offers a greener alternative to current practices, aligning with European goals for sustainable development.

- **Privacy-Enhanced Technologies:** With regulatory constraints and privacy concerns at the forefront, the GLACIATION solution could provide a methodology for privacy-preserving collaborative computation. This will ensure that sensitive and confidential data is utilised for analytics without compromising individual or business privacy, adhering to stringent data sovereignty and data privacy laws.
- **Market Potential Maximisation:** By addressing these challenges, the GLACIATION solution can be leveraged to its fullest potential for the benefit of European citizens, fulfilling societal needs for privacy and sustainability while capturing market opportunities in the burgeoning field of intelligent enterprise solutions.
- **Societal and Policy Influence:** The societal implications of the GLACIATION solution extend beyond technological advancement, influencing policy-making by setting benchmarks for privacy and sustainability in big data analytics, thus driving European leadership in ethical AI application.

The GLACIATION project's solution for SAP business analytics positions itself as a market-ready technology that responds to the increasing demand for intelligent, eco-conscious, and privacy-aware data analytics. It promises not only to catalyse commercial success but also to serve European societal interests by pioneering a model for future analytics solutions that balance market demands with ethical considerations.

6.4 GLACIATION Project Innovation Trajectory: Key Exploitable Results Assessment

As part of the GLACIATION project's ongoing development, the innovation management log meticulously records advancements and assesses their potential as KERs. At this juncture, innovations are evaluated to ascertain their strategic fit within the project's broader objectives, their commercial potential, or their societal impact. Each innovation is scrutinised to determine if it merits the status of a KER—a hallmark for innovations with a high potential for commercialisation or significant societal benefits. This table provides an up-to-date snapshot of these innovations, delineating their current state of readiness and their alignment with the project's exploitation goals.

Table 5 - Innovation and Key Exploitable Result Table

#	Innovation	Partners	Description	Status	KER
1	Graph-data modeling and Distributed Knowledge Graphs	HIRO Dell, ECOM, ETH, LAKE, Sogei, W3C, ENG	The Distributed Knowledge Graph (DKG) is a novel system designed to span across edge-core-cloud architectures, aiming to minimise energy consumption in data processing. By employing AI to enforce optimal data movement and	Ready for DEMO in June	Considered a KER due to its potential for a wide range of data movement and operations, significantly in big data contexts, aiding sustainability and privacy, and aligning with emerging legislation.

			integrating analytics and control across all tiers (sensor, edge, data centre, cloud), it reduces environmental impact. This platform integrates sensor data with big data and analytics, facilitating secure, efficient deployment of analytics (AI/ML workloads) across the edge-core-cloud continuum.		
2	Workload Orchestration and Prediction Engine spanning an Edge/Core/Cloud environment	LUH, ECOM, Dell, LAKE, UCC,UNIMI, Sogei, ENG	A framework that optimises resource allocation and workload distribution across the edge-core-cloud continuum, enabling efficient data processing and energy usage.	TRL2	This is deemed a KER for its capacity to streamline operations in complex computing environments, leading to better resource utilisation and reduced carbon footprint.
3	Data Privacy and Access Control in a dynamic distributed environment	UNiBg	Enhances security protocols and access management in distributed networks, ensuring data privacy and compliance with stringent regulatory standards.	TRL2	Considered a KER, addressing critical needs for privacy and security in distributed systems, a growing concern in the IoT and edge computing markets.
4	Secure Collaborative Computation	SAP	A solution for secure data sharing and collaborative computation, enabling analytics without compromising data privacy, crucial in cross-enterprise collaborations.	TRL2-3, no demo	Acknowledged as a KER due to its facilitation of privacy-preserving data sharing, which is increasingly critical in inter-organisational operations.
5	Containerised Edge Component for integration	MEF/Sogei	Enhances NoiPA services by processing data at the edge, improving operational efficiency and reducing data	TRL1	Not identified as a KER within the broader GLACIATION context, as it serves specifically for the NoiPA application flow.

	in the NoiPA Platform		transit, aligning with energy-saving and processing time reduction goals.		
6	Swarm-based Search and Data Movement in Distributed Knowledge Graphs	LAKE, DELL, HIRO	Utilises Swarm Intelligence for distributed search within DKGs, complemented by an efficient data movement strategy that aligns data locations with request frequencies.	TRL3	Cited as a KER for its innovative approach to efficient data retrieval and energy-saving data movement within distributed systems.

6.5 Stakeholder and Innovation Match-Making

The table below serves as a strategic tool to align the GLACIATION project's innovations with the explicit needs of identified GLACIATION stakeholders, as defined in chapter 3, section 2, of this deliverable. This alignment is also informed by the creation of detailed personas, as delineated in chapter 3 section 3 of this deliverable, representing various stakeholder groups, to ensure that GLACIATION's technological advancements are attuned to the requirements, challenges, and aspirations of these stakeholders. Each entry in the table pairs a GLACIATION innovation with a target group and provides a rationale, outlining the potential benefits and relevance to the group. This exercise is not only foundational in identifying stakeholder needs but also essential in crafting a user-centric approach to innovation deployment.

Table 6 - GLACIATION Stakeholder and Innovation Match-Making Table

Innovation	Target Group	Rationale
GLACIATION Solution	**Policymakers, funding bodies, and standardization organizations:** The GLACIATION Solution can support policymakers in assessing the impact of innovative tech on societal and environmental fronts.	Policymakers can leverage insights from the GLACIATION project to guide research, innovation, and contribute to standardization processes.
Distributed Knowledge Graph (DKG)	**Industry 4.0 sectors:** DKG can offer Industry 4.0 sectors, like smart healthcare and smart cities, an advanced level of data interoperability and analysis which is crucial for their digital transformation.	These sectors rely heavily on the seamless integration of diverse data sources to improve operational efficiency and enable innovative smart applications.

Secure Collaborative Computation	Secure Collaborative Computation can be highly valuable for **researchers**, allowing them to perform joint analysis while preserving data privacy.	Research entities often require sharing insights without exposing sensitive data, which aligns with the innovation's purpose.
Container Protection	Container Protection is essential for **industry professionals** focused on containerized applications who prioritise security in their DevOps practices.	With increasing use of containers, professionals need robust access control to ensure security without compromising performance.
Swarm-based Search and Data Movement in Distributed Knowledge Graphs	**Industry 4.0 sectors** such as smart healthcare, smart cities, smart agriculture, and smart government agencies	Enhances the retrieval and management of data within large-scale distributed environments, essential for Industry 4.0 applications that require real-time data access and processing.
Data Privacy and Access Control in a dynamic distributed environment	**Industry professionals** including enterprises, entrepreneurs, and developers	Ensures the protection and sovereignty of data across distributed systems, which is a growing concern for professionals managing complex IT infrastructures.
All or Nothing Transform Algorithm	**Industry professionals** including enterprises, entrepreneurs, and developers	Provides a robust encryption mechanism that can significantly enhance the security of data storage and transmission, appealing to organisations with stringent data security requirements.
Containerised Edge Component	**Industry 4.0 sectors** such as smart healthcare, smart cities, smart agriculture, and smart government agencies	Facilitates efficient and localised data processing at the edge, reducing latency and improving the performance of IoT devices within smart environments.

6.6 Real-World Applicability of the GLACIATION Solution

The GLACIATION solution, with its innovative edge computing capabilities, holds the promise to revolutionise various sectors by enhancing operational efficiency in a green and privacy-preserving manner. Below are scenarios where its impact could be significant:

- **Smart Cities:** In smart cities, the GLACIATION solution can process data from urban IoT networks locally, optimising traffic flows and city services with minimal data movement. This local processing significantly reduces energy consumption while ensuring citizens' privacy.
- **Industrial Manufacturing:** For the manufacturing sector, the GLACIATION platform's predictive maintenance and AI-driven quality control mean less downtime and waste, translating to greener operations. It ensures that factories are not just smart, but sustainable, aligning with environmental goals while keeping data secure.
- **Connected Healthcare:** In healthcare, continuous patient monitoring with GLACIATION's edge computing allows for real-time, energy-efficient data analysis. It ensures that sensitive health data is processed securely, close to its source, safeguarding patient privacy.
- **Intelligent Transportation:** GLACIATION offers intelligent transportation systems the ability to manage traffic and public transport with reduced latency. By processing data on the edge, it saves energy and reduces the carbon footprint of data centres, all while preserving the privacy of commuters.
- **Environmental Monitoring:** Environmental agencies can leverage the GLACIATION platform to monitor ecosystems and respond to natural disasters without the need for extensive data transmission. This localised data analysis reduces energy usage and ensures sensitive environmental data remains private.
- **Gaming:** In gaming, GLACIATION can deliver high-performance, low-latency experiences for AR/VR applications with less energy consumption. It allows for the greening of the gaming industry without compromising on privacy or experience.
- **Warehouse Management:** GLACIATION can optimise warehouse operations by accurately tracking inventory through edge devices. This method ensures efficient, greener warehousing by reducing the need for centralised data processing and protecting sensitive logistical data

6.7 Overarching Business Plan for the GLACIATION Solution

In a landscape where technology and innovation are rapidly advancing, the GLACIATION project stands at the crossroads of open-source principles and commercial viability. A freemium model emerges as the cornerstone of its business strategy, marrying the Horizon Europe mandate of open access for European citizens with the pragmatism of market dynamics. This model ensures the foundational elements of the GLACIATION solution are accessible to all, fostering widespread adoption and maximising public benefit, while advanced features are monetised to sustain project developments and participant investments.

The commercialisation plan, including the freemium model, is not definitive but will evolve based on consortium deliberations, with inputs from standardisation contributions, market innovation analyses, and the policy engagement plan.

7 Business Modelling for the GLACIATION Solution

After the GLACIATION project ends, the expectation is not to unveil a fully-fledged platform with a TRL of 8 or 9. Instead, the aim is a robust proof-of-concept at a TRL of 4, laying the groundwork for further refinement and market preparation.

The envisioned freemium service model, pivotal to the commercialisation strategy, is intended to introduce the GLACIATION solution to the market. This approach will facilitate early adoption by removing financial barriers for basic service access and provide a revenue-generating mechanism through premium features.

Critical to the business plan's success is an ongoing consortium dialogue that moulds the freemium model to align with broader objectives and stakeholder needs. Contributions from standardisation efforts, market innovation, and policy engagement will shape and refine the commercialisation pathway. This approach is further detailed in the subsequent section of this chapter which will be further refined in the final

7.1 Value Proposition for the GLACIATION Solution

The GLACIATION solution promises a transformative approach to data management, privacy-awareness, and sustainability in edge-to-cloud computing. Its value lies in its adaptability to a variety of technological domains. The freemium model provides an attractive proposition for potential adopters:

- **Open-Source Access**: A foundational commitment to the Horizon Europe ethos of maximising public benefit, ensuring that the core functionalities are freely accessible to all, fostering innovation and collaboration.
- **Advanced Premium Features**: Additional, sophisticated features available for a fee, offering high value to enterprises that require more tailored solutions for complex operations.
- **Sustainable Revenue Stream**: While the open-source components drive adoption and collaborative development, the premium services generate a sustainable revenue model, ensuring the solution's ongoing evolution and support.

The value proposition is thus centred on delivering a scalable, sustainable, energy-efficient, and privacy-preserving platform that meets the dual objectives of open accessibility and commercial viability. The GLACIATION solution is positioned as an enabler of sustainable digital transformation, providing a crucial link between data-intensive applications and green computing.

7.2 GLACIATION Solution in Public Administrations

For **MEF** the GLACIATION Solution offers a progressive non-commercial exploitation plan focusing on potentially scaling up the solution and enhancing public services with advanced technological integration.

7.2.1 Value Proposition:

The GLACIATION Solution enables MEF to act as a pioneer in applying disruptive edge-to-cloud technologies within public services. Emphasising interoperability, privacy, and sustainability, this solution aligns with the Italian government's mission to optimise data operations and promote environmental sustainability. The DSII at MEF can leverage this solution to improve service delivery to a vast audience of civil servants and citizens via the NoiPA platform, thus driving transformation in public administration.

7.2.2 Non-Commercial Exploitation Plan:

This section explores MEF's role and potential non-commercial exploitation in the dissemination and potential scale-up of the GLACIATION Solution within public administrations, highlighting the potential for widespread application and the strategic approaches to enhancing public service delivery.

7.2.2.1 Facilitation and Dissemination Role:

As a public entity, MEF's role in exploiting the GLACIATION Solution is as a facilitator, leveraging the developed solutions to benefit other public administrations (PAs). By managing and providing superior public services, MEF aims to disseminate the project's outcomes, emphasizing the practical improvements evident in services used daily by millions.

7.2.2.2 Exploitation Potential:

The GLACIATION Solution's exploitation potential within MEF is substantial, considering its reach to over 80 Italian Public Administrations and approximately 2 million civil servants. This vast network presents a significant opportunity for MEF to potentially scale up the solution and expand its benefits across the Italian public administration and potentially beyond.

7.2.2.3 Strengths and Impact:

The core strengths of the GLACIATION Solution include:

- Delivering an advanced solution that combines a Distributed Knowledge Graph with AI-driven data operations.
- Preserving privacy while optimising sustainability as well as energy consumption during data operations.
- The potential to reach and positively affect a large audience of public administrations, civil servants, and citizens, contributing to the sustainably and privacy preserving delivery of public services.

7.2.2.4 Challenges in Communication and Technology Adaptation:

Communicating the complexities of the GLACIATION Solution to a general audience remains a challenge. Furthermore, as the technological solution is to be carried out by technical partners, its direct exploitation within the public administration environment may not be straightforward.

7.2.2.5 Opportunities for Public Sector Innovation:

The GLACIATION Solution provides MEF with the opportunity to:

- Raise awareness among public servants and citizens about the use of innovative technologies in public services.
- Drive high-tech initiatives that prioritise energy and environmental sustainability.
- Enhance the efficiency and effectiveness of public service delivery to citizens.

7.2.2.6 Risks and Market Dynamics:

The primary risk involves the pace of technological innovation and market changes, which may outstrip the solution's implementation within the projected timeframe.

7.2.2.7 Path to Exploitation and Maximising Impact:

To maximise the impact, MEF will focus on demonstrating the benefits and efficiency gains of the GLACIATION Solution in public service delivery. By showcasing the enhanced management capabilities of public service delivery platforms, MEF will illustrate how services can be conducted more effectively, securely, and with greater energy efficiency.

This approach aligns with MEF's strategic direction toward building a more innovative and sustainable Public Administration 4.0, providing a blueprint for other public institutions to follow suit in leveraging the GLACIATION solution for the public good.

7.3 Containerised Edge Component in Public Administrations

The exploitation of the Containerised Edge Component for integration in the NoiPA Platform by **MEF**, facilitated by its IT company **Sogei**, is centred on non-commercial benefits for the public sector. This reflects a commitment to utilising the GLACIATION Solution for the public good.

7.3.1 Value Proposition:

The Containerised Edge Component brings forth the ability to enhance NoiPA services through a balanced mix of decentralised and centralised processing, significantly reducing data movement and improving performance, energy savings, sustainability, and privacy. This technological evolution, poised under the GLACIATION umbrella, is instrumental in advancing the efficiency of public service delivery without the aim of profit generation.

7.3.1.1 Non-Commercial Exploitation Plan:

This section explores MEF's role and potential non-commercial exploitation in the dissemination and potential scale-up of the GLACIATION Solution within public administrations, highlighting the potential for widespread application and the strategic approaches to enhancing public service delivery.

7.3.1.2 Role in Exploitation:

MEF, with the operational support of Sogei, plans to use the GLACIATION Solution to serve as a template for the enhancement of various public services. By demonstrating the efficiency of the NoiPA platform's improved operations, they aim to establish a replicable model of service delivery for other public entities.

7.3.1.3 Exploitation Potential:

The Containerised Edge Component holds significant potential to be applied across various public services that could benefit from the GLACIATION Solution's capability to decentralise processing workloads, improving energy consumption and processing time, crucial for the sustainable evolution of public administration operations.

7.3.1.4 Strengths and Service Improvement:

The use case's strength lies in its potential to apply AI/ML technologies to historical data and resource usage, which is expected to yield reduced energy consumption and processing times, along with ensuring more sustainable and privacy preserving data movement and operations showcasing a substantial leap in public service operational efficiency.

7.3.1.5 Challenges in Public Administration Integration:

The challenges involve adapting the GLACIATION services to an “As a Service” delivery model that is crucial for Public Administration adoption, including the development of integration modules that align with consumer requirements for seamless service delivery.

7.3.1.6 Opportunities for Public Sector Modernisation:

For MEF and Sogei, the opportunity lies in setting the pilot as a benchmark for other digital services within MEF and promoting it as a best practice model for other public institutions, thus maximising the project's impact across the public sector.

7.3.1.7 Legal and Standardisation Risks:

The main risks are ensuring legal compliance with personal data management as per European and national law and overcoming the barriers to standardisation, which includes tailoring development efforts for each potential public service consumer.

7.3.1.8 Path to Exploitation and Maximising Impact:

While there is no commercial intent, the implementation of the pilot is followed by disseminating results to identify other MEF digital services that could benefit from the GLACIATION platform. This evaluation will consider the cost/benefit ratio, aiming to achieve energy savings and processing time reductions across public services while also ensuring greater privacy and sustainability of data movement and operations across the Italian Public Administration.

In essence, the exploitation plan for MEF and Sogei focuses on showcasing the efficacy of the GLACIATION Solution in public service delivery, with an eye toward replication and adaptation across different public entities, fostering a sustainable and efficient future for public administration services in Italy.

7.4 GLACIATION Platform in the Private Sector

The GLACIATION platform, with its innovative approach to data management, brings forth a significant value proposition to **ENG** and the wider data-centric market. Below is a tailored value proposition and business plan that integrates the insights from the SWOT analysis while acknowledging the expect TRL, which is 4.

7.4.1 GLACIATION Platform Value Proposition

GLACIATION's modular design and DKG offer ENG the flexibility to create custom solutions for diverse data management needs. Its emphasis on robust security measures and energy efficiency aligns with global trends towards sustainable operations, catering to clients who prioritise eco-friendly practices without compromising data security. The platform is poised to optimise the consumption of resources and offer comprehensive management services, providing ENG with a competitive edge in offering sustainable, efficient, and secure data management solutions.

7.4.2 Business Plan

The business plan outlined below details a commercial strategy that encompasses market entry and growth potential, alongside an exploitation plan. It identifies and addresses key challenges, proposing methods to mitigate risks. A thorough assessment of the competitive landscape is included to inform strategic decisions, all leading to a clear and executable path to market.

7.4.2.1 Commercial Strategy:

ENG's commercial strategy will hinge on leveraging the GLACIATION platform's IP to carve out a niche in the burgeoning data management market. With a TRL of 4, the immediate focus will be on product development and enhancement through research, with a view to align with real-world infrastructural needs.

7.4.2.2 Market Entry and Growth:

Validation of the platform in real-world settings will be pivotal. This will involve partnerships with IPTOs and pilot testing to refine the platform and ensure it meets the emerging needs of data producers and consumers, including public-service entities, manufacturing companies, and enterprises with significant data analytics requirements.

7.4.2.3 Exploitation Potential:

The exploitation of the GLACIATION platform will see ENG target the data management market, positioning the company as a leader in energy-efficient, secure data infrastructure solutions. The aim will be to identify and create market opportunities through the differentiated value of the platform's design and capabilities.

7.4.2.4 Product Development:

Given the platform's TRL of 4, ENG will continue to invest in R&D to evolve the platform's architecture and features. The integration of advances in AI and distributed computing will enhance the company's offerings, ensuring that the GLACIATION platform remains at the cutting edge of the data management space.

7.4.2.5 Challenges and Risk Mitigation:

Complexity in integration and privacy considerations are the primary competitive challenges. ENG will need to invest in customer support and technical training to mitigate complexity and deploy solutions that balance performance with compliance.

7.4.2.6 Competitive Landscape:

While competitive technologies and solutions exist, ENG's focus on innovative, sustainable, and secure data management solutions provides a strong footing in the market. Continuous innovation and adaptability will be crucial in maintaining an edge over competitors.

7.4.2.7 Path to Market:

Leveraging ENG's presence in international networks will raise awareness of the solutions being developed. The company's strong focus on innovation, backed by its R&D division, will facilitate the introduction of the GLACIATION platform into the market by extending the company's product portfolio or developing new products aligned with current and future market needs.

The path forward for ENG involves utilising the GLACIATION platform to address market demands for sustainable, efficient, and secure data management solutions, while remaining at the forefront of innovation in edge-to-cloud computing.

7.5 All or Nothing Transform Algorithm

Dell's integration of the "All or Nothing Transform (AONT)" algorithm, innovated by the University of Bergamo, represents a strategic advancement in data security within their storage solutions. Below is an explanation concerning the innovation alignment with Dell's business strategy, capitalising on strengths while addressing market opportunities and risks:

7.5.1 Value Proposition

Dell's implementation of the AONT algorithm strengthens their portfolio by providing ultra-secure data protection, appealing to organisations where data integrity is paramount. This security feature, combined with Dell's robust storage solutions, delivers both performance and peace of mind to customers.

7.5.2 Business Plan

The business plan for Dell's integration of the "All or Nothing Transform" algorithm outlines a licensing strategy targeting key markets that prioritise stringent data security. It capitalises on Dell's strengths in high-performance storage solutions, offering a novel security layer that

aligns with its reputation for innovation. Addressing challenges like performance impact and complex integration, the plan also identifies opportunities to lead in security for cloud and edge computing. Strategic risk management is factored in, considering the competitive landscape and regulatory compliance. The concise path to market anticipates a 1 to 3 year timeline, positioning Dell to meet emerging security demands effectively.

7.5.2.1 Commercial Strategy:

By licensing the AONT algorithm to storage hardware and software manufacturers, Dell could open a new revenue stream. The AONT is particularly suited for markets with intense data protection needs, potentially positioning Dell as a leader in secure storage solutions.

7.5.2.2 Market Application:

The target market encompasses finance institutions, healthcare organisations, government agencies, and cloud service providers, all of which demand high-level security measures for sensitive data.

7.5.2.3 Strengths and Competitive Advantage:

Dell's strengths lie in delivering high-performance, scalable, and reliable storage solutions. The AONT enhances these by adding an advanced data protection layer, optimising storage efficiency, and providing seamless management, aligning with Dell’s reputation for quality and innovation.

7.5.2.4 Challenges:

The main challenges are the potential performance overhead and the complexity of integrating the AONT into Dell's existing architecture. Dell will need to ensure compatibility with current cryptographic protocols and address the patent landscape around AONT technology.

7.5.2.5 Opportunities:

The AONT algorithm presents opportunities to attract new customers, especially security-conscious cloud and edge computing providers. In the landscape of emerging technologies, leveraging advancements in AI, distributed computing, and energy efficiency could position Dell as a provider of choice for organisations seeking to future-proof their data management systems.

7.5.2.6 Risks:

Challenges include navigating sophisticated cyber threats targeting the AONT, integration vulnerabilities, and regulatory compliance, particularly considering the European Union’s focus on data sovereignty and the push for carbon neutrality in data centres articulated early in this document.

7.5.2.7 Competitive Landscape:

While the AONT faces competition from existing technologies, Dell’s focus on integrating this innovative approach into their systems may provide a competitive edge, particularly in sectors where the demand for advanced security is growing.

By embedding the AONT into its suite of services, Dell could not only meet the current security demands but also positions itself as a visionary leader in data protection, ready to navigate the future complexities of the digital landscape.

7.5.2.8 Path to Market:

Dell's estimated 1 to 3 year timeline to market for AONT-integrated solutions allows for rigorous testing and market alignment. Leveraging their international presence, Dell can promote the AONT within its network and through the R&D division, ensuring its business units are prepared to introduce this innovation into the market.

7.6 Distributed Knowledge Graph

This section delineates **Dell's** potential strategic approach to commercialising the DKG, spotlighting the value proposition and comprehensive business plan. It encapsulates the technology's innovative data management capabilities, underpinned by a commitment to sustainability and market adaptability.

7.6.1 Value Proposition:

The DKG provides a state-of-the-art semantic linking capability, enhancing data interoperability and analysis for clients who require a sophisticated understanding of vast datasets. The DKG's modular and energy-efficient architecture could allow Dell to offer a solution that not only streamlines data management but also supports the global imperative for sustainable technological operations.

7.6.2 Business Plan:

DELL's business plan for its DKG technology revolves around a licensing model targeted at enhancing data integration platforms. The DKG, with its envisioned TRL of 4 at the end of the project, promises advanced data management capabilities and energy-efficient processing, ideal for sectors such as healthcare and government. Dell's approach addresses market needs for interoperable and scalable data solutions, with a development strategy that anticipates industry evolution and prioritises eco-conscious innovation. Acknowledging potential complexities and competition, DELL aims to solidify its market position by integrating the DKG into its AI and data architecture suite, planning for a market introduction within three years.

7.6.2.1 Commercial Strategy and Exploitation:

The DKG technology will be commercialised through a licensing model aimed at data integration platforms and software vendors. This strategy taps into the growing need for enhanced data management tools that are both powerful and environmentally conscious, potentially opening new revenue channels for Dell.

7.6.2.2 Product Development and Market Fit:

Considering the DKG's TRL of 4, Dell's product development will focus on fine-tuning this technology for integration into existing and new market offerings. The aim is to meet the

specific needs of industries like healthcare, government, and those leveraging IoT and edge computing, where secure and efficient data handling is critical.

7.6.2.3 Operational and Market Advantages:

The strengths of Dell's DKG lie in its interoperability, flexibility, and potential to significantly optimise data storage and processing energy usage. These factors position DELL as a leading provider in the data management market, addressing current business requirements and anticipating future trends.

7.6.2.4 Addressing Competitive Challenges:

The operational complexities associated with distributed data systems are acknowledged as potential weaknesses. Dell will likely focus on mitigating these through customer support, technical training, and ongoing development to ensure that the DKG remains competitive in the face of complexities and consistent data management.

7.6.2.5 Seizing Market Opportunities:

The DKG places Dell in an advantageous position to capture emerging market trends and meet the needs of new stakeholders who are seeking advanced, energy-efficient data management solutions. By leveraging developments in AI and distributed computing, DELL can offer an optimised management of energy metrics, maintaining competitiveness in an evolving technological landscape.

7.6.2.6 Risk Management:

The potential risks of data fragmentation and scalability issues inherent in DKG systems are recognised. Dell plans to address these by ensuring rigorous security analysis and robust testing to prove the DKG's resilience against cyber threats and the challenges of integration into complex IT ecosystems.

7.6.2.7 Industry Competition and Positioning:

Although DELL will face competition from other technologies, the DKG's focus on energy efficiency and advanced semantic analysis provides a unique selling point. Continuous innovation and adaptability will be key to maintaining an edge in the market.

7.6.2.8 Path to Market

DELL's strategy encompasses integrating the DKG into its AI architecture, aligning it with the market needs, and extending its product portfolio. The integration process will leverage DELL's established market presence and innovation-driven business units to ensure a successful market introduction within an estimated period of 1-3 years.

DELL's strategic plan for the DKG represents a forward-thinking approach, responding to market demands for robust data management solutions, and positions the company as an innovator poised to make the most of evolving opportunities in data-driven industries.

7.7 Container Protection Technology

For **DELL**, the development of Container Protection technology within the scope of GLACIATION represents an innovative step in enhancing the security landscape for containerised applications. This technology, with a current TRL of 1, is still in its early stages but holds promise for addressing security vulnerabilities inherent in container environments.

7.7.1 Value Proposition

The Container Protection mechanism being developed by the consortium offers a fine-grained access control solution that bolsters security for containerised applications. It is designed to streamline resource usage and facilitate secure communication between components, addressing critical security gaps and adhering to compliance requirements.

7.7.2 Business Plan

Dell's Container Protection business plan positions it at the vanguard of cloud security, offering tailored solutions to enhance its security products for containerised applications. With a focus on the burgeoning needs of IT professionals and cloud services, Dell aims to navigate implementation challenges and patent landscapes while capitalising on the shift towards containerisation. The plan outlines a clear market entry, leveraging DELL's existing relationships and reputation for secure, user-friendly products to stand out in a competitive market.

7.7.2.1 Commercial Strategy:

DELL's strategy includes developing access control solutions tailored for containerised environments, with the potential for licensing these solutions to other enterprises. The Container Protection technology will be integrated into existing security products, enhancing Dell's current offerings.

7.7.2.2 Market Application:

The targeted market comprises DevOps teams, IT security professionals, and cloud service providers that deploy containerised applications. These stakeholders require robust security frameworks to mitigate the risks associated with third-party components within containers.

7.7.2.3 Strengths and Market Differentiation:

The strengths of the Container Protection technology lie in its proactive approach to security, which allows for effective management of permissions and secures the container environment against threats. The focus on user-friendliness ensures that the technology will be accessible to software developers and IT professionals, enabling them to maintain security with ease.

7.7.2.4 Challenges and Competitive Landscape:

Implementation of the Container Protection technology may pose challenges, such as the need for significant effort and resources. Stricter access controls could potentially impact application

performance, and the technology will require rigorous validation. Additionally, there is a need to navigate the existing patent landscape carefully.

7.7.2.5 Opportunities for Innovation and Growth:

The Container Protection technology could allow Dell to innovate in the field of container security, addressing a growing market need as more organisations move towards containerisation in cloud environments. Partnerships with security experts could further enhance the solution's effectiveness.

7.7.2.6 Risks and Adaptation:

The Container Protection technology must continuously adapt to evolving threats within the container security landscape. There may be resistance to the adoption of strict access controls, and the complexity of managing access in cloud applications poses additional risks.

7.7.2.7 Competitors:

Dell will face competition from existing security solutions like Dynatrace, SNYK, GigaOm, and Calico Cloud, as well as from security organisations and open-source projects that focus on container security.

7.7.2.8 Path to Market:

DELL plans to embed this technology into its organisation by integrating it into existing security products and potentially developing new dedicated container security solutions for containerised environments. Collaboration with cloud service providers and security vendors will be pivotal in this effort.

Overall, the Container Protection technology offers a unique solution to a modern security problem, and its potential incorporation into Dell's suite of security products will enhance the company's position as a leader in providing comprehensive security solutions in the cloud computing space.

7.8 Secure Collaborative Computation Innovation

Secure Collaborative Computation innovation potentially represents a pivotal step towards redefining how businesses handle sensitive data across trust boundaries for **SAP**. This initiative aligns with the growing need for Privacy-Enhancing Technologies (PETs) in a world where data privacy is paramount.

7.8.1 Value Proposition

Secure Collaborative Computation could offer SAP's clients a means to engage in joint analytics and business intelligence without compromising sensitive information, adhering to stringent data protection regulations like GDPR. This technology enables sharing insights, not data, using methods like secure multi-party computation, ensuring data remains encrypted in use, in transit, and at rest.

7.8.2 Business Plan

The business plan outlines SAP's strategic deployment of Secure Collaborative Computation technology to enable privacy-preserving, cross-company collaborations. It charts a course for SAP to potentially deliver innovative services that harness the strengths of PETs, addressing the emergent market demand for secure data utilisation without compromising privacy.

7.8.2.1 Commercial Strategy:

The strategy involves providing secure collaboration services using PETs for cross-company collaborations. This approach allows clients to unlock new collaborative possibilities while maintaining a robust security posture. PETs also reduce liabilities associated with data breaches by ensuring continuous data encryption.

7.8.2.2 Market Application:

Target customers include asset manufacturers and users, businesses that operate with manufacturing equipment, and entities that require privacy-preserving cross-organisational collaborations, such as government agencies.

7.8.2.3 Strengths and Market Differentiation:

SAP’s core strengths are in running business applications and facilitating business networks, which provide a solid foundation for integrating the Secure Collaborative Computation technology into their service offerings. The innovation could enhance SAP’s ability to connect enterprises and provide intelligent solutions while securing sensitive data, differentiating SAP in industries where data privacy is critical.

7.8.2.4 Challenges and Competitive Edge:

The main challenge is the performance overhead and complexity inherent in some PETs. SAP’s ongoing research and development aim to abstract these complexities for end-users, maintaining competitiveness in a rapidly evolving technology landscape.

7.8.2.5 Opportunities for Innovation and Growth:

Gartner’s prediction that 60% of large organisations will use at least one PET by 2025 underscores the significant market potential[68]. PETs are recommended by BCG to mitigate risks of security policy violations and privacy law breaches, with the market for PETs expected to experience substantial growth. This trend presents SA with an opportunity to lead in this emerging field.

7.8.2.6 Risks and Adaptation:

The complex nature of PETs may require SAP to invest in stakeholder education to convey the benefits effectively. User acceptance of the potential performance overhead is vital,

[68] Gartner, "Gartner Identifies Top Five Trends in Privacy Through 2024," 31 May 2022. [Online]. Available: https://www.gartner.com/en/newsroom/press-releases/2022-05-31-gartner-identifies-top-five-trends-in-privacy-through-2024.

focusing on the use of sensitive data that would otherwise remain untapped for analytical purposes.

7.8.2.7 Competitive Landscape:

While PETs are emerging technologies and competition is still developing, SAP can leverage its position by utilising and contributing to open-source projects like Bosch Research's Carbyne Stack.

7.8.2.8 Path to Market:

SAP's multi-stage exploitation roadmap includes raising internal awareness, creating demand within its development organisation, and providing expert support to guide the transfer of research results into innovative solutions.

7.8.2.9 Time to Market and Financial Projections:

With the time to market not specified, the goal is to tap into a fraction of this burgeoning market through services for privacy-preserving cross-company collaborations. Although initial ROI estimations are unavailable, the potential addressable market is substantial.

By incorporating Secure Collaborative Computation into their product portfolio, SAP stands to extend its reach in the privacy technology sector, offering clients a unique combination of operational intelligence and data security, all while adhering to the highest standards of data privacy and regulatory compliance.

7.9 Swarm-based Search and Data Movement in DKGs

This section details **LAKE**'s strategy for its pioneering Swarm-based Search and Data Movement technology in DKGs, outlining an initial business plan to navigate the technology's journey from a valuable concept to market readiness. It encapsulates the innovation's commercial trajectory, leveraging its adaptive and energy-efficient search capabilities within the dynamic realm of cloud, and edge computing.

7.9.1 Value Proposition

LAKE's Swarm-based Search and Data Movement in DKGs stands at the vanguard of search and data optimisation for distributed systems. The innovation excels in adaptive search within dynamic environments and ensures rapid query retrieval, positioning it as an essential tool for sectors engaged in the cloud, and edge computing.

7.9.2 Business Plan

Lakeside Labs envisages a business plan pivoting on indirect commercialisation through strategic licensing, targeting the burgeoning demand for sophisticated data handling in the cloud market and Industry 4.0 applications. With no immediate conflicting IP concerns and a TRL ranging from 4 to 5, the plan underlines the potential for customised solutions that optimise the use of network resources and seamlessly integrate with the cloud-edge continuum.

7.9.2.1 Commercial Strategy:

The commercialisation strategy hinges on leveraging the technology's adaptability and reduced network resource usage to offer bespoke solutions, potentially expanding Lakeside Labs' influence across diverse technology sectors through partnerships and licensing agreements.

7.9.2.2 Market Application:

The primary market for this innovation includes Industry 4.0 sectors and Public Administrations seeking efficient data processing capabilities to bolster their digital infrastructure and support smart city initiatives.

7.9.2.3 Strengths and Competitive Advantage:

Lakeside Labs' competitive edge lies in its agile and energy-efficient search capabilities, which are particularly suited for rapidly changing network architectures and the vast data landscapes characteristic of modern cloud-edge systems.

7.9.2.4 Challenges and Adaptation:

Challenges include demonstrating the full efficiency of the system and ensuring compatibility with various network architectures. Privacy considerations within distributed systems also require further exploration.

7.9.2.5 Opportunities for Innovation and Growth:

Opportunities abound in the cloud and big data analytics markets, with the potential to cater to organisations requiring advanced data processing and management solutions.

7.9.2.6 Risks and Mitigation:

Potential risks involve the emergence of similar projects within the cloud-edge continuum. Remaining abreast of market developments and continuing to innovate will be essential for risk mitigation.

7.9.2.7 Competitive Landscape:

Currently, no direct competitors have been identified, but the technology space is fluid, and vigilance for emerging competitive technologies will be crucial.

7.9.2.8 Path to Exploitation

LAKE aims to capitalise on this innovation by enhancing its research portfolio, facilitating a larger network for future collaborations, and anchoring itself as a centre for advanced computer science research.

With no specific time to market currently established, LAKE will focus on R&D, aiming to position itself as a thought leader in swarm optimisation for data systems.

8 Open Source and IPR Management in the GLACIATION Project:

Building on the foundation laid by the project's grant agreement, the GLACIATION project embodies the ethos of Horizon Europe, which emphasises an open source spirit as a catalyst for further innovation and advancement. This approach aligns with Deliverables 8.6 and 8.7, the initial and intermediate data management plans, which outline the ethical research principles integral to the project. These documents articulate the commitment to an open innovation environment while meticulously addressing IPR and open source guidelines, ensuring that the project not only advances technological frontiers but also contributes to the collective growth and ethical application of knowledge within the European research area and beyond.

8.1 Open Source: Pioneering for Public Good

The GLACIATION project, deeply rooted in the ethos of Horizon Europe, prioritises societal benefit and open innovation. The consortium champions Open-source Software (OSS), propelling contributions to and collaborations with OSS communities. This strategy hinges on releasing community code, supporting commercial licensing models to bolster OSS business strategies, and maintaining the GLACIATION platform for post-project community enhancement.

Code from GLACIATION, subject to partners' IP protocols, will largely be open-source, adopting a freemium model that reserves sophisticated features for proprietary commercial products. This approach preserves the ecosystem's functionality while encouraging community and commercial development. Architectural patterns and other emerging components will be openly released under Creative Commons, furthering good practice standards.

In advancing policy management technologies and promoting adaptation beyond initial use cases, the project leans on tools like OpenPolicyAgent. These efforts are augmented by the potential demand in the global market, evidenced by rising open-source architectures.

8.2 IPR Management: Fostering Innovation and Facilitating Exploitation

Conversely, the project's IPR management underscores a structured approach to innovation valorisation, ensuring partners' rights while amplifying European citizens' socioeconomic benefits. The project's life cycle encompasses a diligent IPR registry, maintaining an active record of ownership and facilitating exploitation post-project completion.

As detailed above, the project's blueprint includes a detailed business plan per private sector partner, market and competitor analysis, and a comprehensive exploitation plan. As GLACIATION confronts environmental, climatic, and societal challenges, a NPO may emerge as the custodian of project outcomes, potentially offering services to public administrations.

The IPR table registry within the innovation management log ensures each innovation is considered for its IP impact, aligning with Horizon Europe's mandates on exploitation and potential exploitation, both commercial as well as non-commercial.

Both sections, 'Open Source' and 'IPR Management', embody the project's dual commitment to open innovation and the protection of intellectual assets. The OSS strategy aims to deliver community-driven advancements while the IPR management ensures responsible stewardship of intellectual property, combining to drive the project toward meaningful societal contributions and potential commercial success of the innovations for all private sector partners.

9 Upcoming Activities

The GLACIATION project's exploitation plan is a dynamic framework designed to refine business modelling and plans for both commercial and non-commercial exploitation. It also aims to envisage these plans, paving the way for sustainable utilisation of project outcomes. Below is an outline of each of the upcoming activities:

9.1 Industry and Policy Community Building

The GLACIATION project prioritises establishing key industry and policy contacts to form a comprehensive community of stakeholders for exploitation. Leveraging deliverables D8.1 and D8.2, the project aims to map out stakeholders based on thorough market analyses. This will include a list of organisations and the utilisation of various dissemination events to forge new contacts both third party as well as GLACIATION dissemination events. The GLACIATION project will seek to leverage the Harmonisation series of events delineated in D8.1 and D8.2 in particular, as an important avenue to foster industry and policy contacts.

Targeted social media strategies and conversations will be anchored by personas representative of specific stakeholders, as the diverse applications of GLACIATION solution span a multitude of industries. Engaging with these sectors will be achieved by creating a sense of community and inviting pivotal players to participate in project activities, thereby fostering a network that is integral to the project's success.

9.2 Validation of Innovations in Operating Conditions

Validating the GLACIATION solution's efficacy in actual operating conditions is essential. A rigorous regimen for measurement, testing, and reporting will be linked to live demonstrations, while a thorough analysis of the pilots will assess the solution's performance. This evaluation will extend to various real-world applicability scenarios to ascertain the adaptability and effectiveness of the GLACIATION solution across different environments and contexts.

9.3 Upcoming Activity: Market Analysis News Aggregate

To ensure the GLACIATION consortium partners have access to the most current and relevant market intelligence, an upcoming activity involves the establishment of a news aggregate function. This will be directly linked to the market watch initiative, deriving from the market analysis conducted within this document. The news aggregate will systematically collect and distribute the latest relevant news articles, research findings, and market trends related to the sectors pertinent to the GLACIATION project. By providing a real-time feed of industry insights, partners can be assured of receiving information that is not only current but also directly applicable to guiding the nuanced exploitation plans outlined in this document.

The intent is to enrich the consortium's collective understanding of the evolving market dynamics, thereby enabling more informed decision-making processes. This dynamic tool will

serve as a living repository of market knowledge, crucial for the continuous updating of the exploitation strategy, ensuring alignment with market shifts and emerging opportunities. This will involve an agile and responsive framework for information dissemination, ensuring that partners are poised to respond to the latest developments, further underpinning the project's aim of maximising value creation and societal impact.

9.4 Innovation Management Log Refinement

A key upcoming activity detailed in this deliverable involves the meticulous enhancement of the IML. The focus will be on identifying and examining the KERs linked to specific innovations within the GLACIATION project. This systematic logging will provide a granular view of each innovation's progress, marketability, and potential for commercialisation or societal impact.

The refinement process will delve into the applicability of KERs in various contexts, informed by ongoing research and market feedback. This will help in tailoring the exploitation plans, business modelling, and business plans to be as precise and strategic as possible. The iterative process of logging will also serve as a critical tool for tracking innovation development over time, assessing risks and barriers to market entry, and identifying new avenues for exploitation.

By continuously capturing the nuances of each innovation, the consortium can adjust strategies in real-time, aligning with evolving technological advancements and market needs. This forward-looking approach ensures that the GLACIATION project remains at the forefront of innovation, with a clear view of how to navigate the complexities of commercialisation and societal implementation.

9.5 Policy Brief for Project Legacy

Recognising the paramount importance for the project's legacy, the Work Package 8 Leader has prioritised the creation of a comprehensive policy brief. This brief is also deemed crucial for the Market, Innovation, and Applicability analysis, supporting the commercialisation of the GLACIATION solution. It is designed to furnish policymakers with comprehensive, evidence-based information on the project's outcomes, encountered challenges, and the valuable lessons learned, which are integral to making informed decisions for future initiatives.

The groundwork for this policy brief has been laid through extensive research tailored to the project's objectives. A policy landscape document has been compiled, giving all partners insight into the legislative framework surrounding the GLACIATION solution. This document will be updated regularly with new findings from ongoing research. A reading list has been assembled, featuring essential research papers, articles, and market reports to ensure a well-rounded understanding of the current situation, and it will be refreshed continually for relevance and precision. Furthermore, a stakeholder map at the organisational level has been drafted to pinpoint key players in policy and market sectors, which will be refined to enhance engagement and strategic communication.

This policy brief is slated for development in the project's concluding phases, specifically between months 30 to 33, and is strategically aligned with a corresponding webinar. This event

will aim to succinctly convey the project's insights and offer pragmatic guidance to policymakers. These efforts underscore the GLACIATION project's commitment to leaving a lasting imprint on policy and aiding the commercial trajectory of its innovative solutions.

9.6 Scaling Up Strategy and Business Plan Refinement

For the expansion within the public sector, the GLACIATION project envisions a strategic scaling-up, especially leveraging the results of Pilot 1. This move aligns with both compliance needs and the urgent imperative to address climate concerns of data movement and operations. The extensive reach of NoiPA, a critical administrative platform for numerous Italian civil servants, demonstrates the vast potential for deploying GLACIATION's solutions more broadly.

The MEF approach could potentially translate to a paradigm shift in public administration data management and coupled with policy briefs advocating sustainable data management, cost optimisation, and data sovereignty leveraging the GLACIATION project innovations. These briefs could influence public administrations throughout Italy and potentially across Europe, to promote sustainable and privacy preserving data management across the public sector. This approach emphasises societal and political advancements over immediate financial benefits, embedding GLACIATION's impact in the fabric of public administration by championing efficiency, inclusivity, and progressive thinking.

9.7 Strategic Roadmap for Long-term Sustainability

The project's outcomes will be guided by a strategic roadmap, detailing the steps for exploitation and sustainable long-term application of the GLACIATION solution. This roadmap will articulate the trajectory of the project’s innovations, ensuring they continue to benefit stakeholders and adapt to evolving market as well as societal needs.

9.8 Creation of a Non-Profit Organisation

In alignment with the overarching goal of maximising socioeconomic benefits for European citizens, a NPO will be established. This NPO will act as the custodian of the project’s results, ensuring they are leveraged effectively for societal good. It will explore the possibility of providing services to public administrations, alongside securing funds from donors and funding bodies to further its objectives.

The GLACIATION exploitation plan encapsulates a commitment to ensuring that the innovative technologies and methodologies developed throughout the project catalyse significant and enduring socio-economic benefits for European citizens and contribute meaningfully to global sustainability and privacy-preserving practices.

9.9 Third Party Events

Table 7 provides a curated list of events targeted for potential third-party attendance by the GLACIATION consortium in 2024, spanning diverse fields from digital policy to Industry 4.0 were developing industry and policy contacts is seen as instrumental to the aims delineated in this deliverable.

Table 7 - List of Potential Third Part Events for GLACIATION Dissemination and Networking

Event name	Event type	Dates
SEMANTiCs 2024	Conference	Abstracts March 2024
Enlit Europe	Conference	24-25 October 2024
DG Society	Conference	11 -24 June 2024
International Data Spaces Symposium	Scientific Conference	12-14 March 2024
Horizont NRW	Scientific Conference	15-16 February 2024
Long Night of Research (AUT)	Scientific Conference	2024
Research Days	Public event	2024
European Big Data Value Forum	Conference	2-4 October 2024
EGI2024	Conference	20-24 September
DATAWEEK Leipzig	Scientific Conference	15-19 April 2024
the European Sustainable Energy Week (EUSEW)	Conference	11-14 June 2024
European Research Days	Workshop	21 March 2024
International Conference on Machine Learning	Scientific Conference	21 to 27 July 2024
AI and Big Data EXPO	Scientific Conference	1-2 October 2024
Smart City EXPO World Congress	Scientific Conference	5-7 November 2024

10 Conclusion

In line with the objectives articulated in the opening of this seminal document, this conclusion emphasises that the approaches and blueprints presented in "GLACIATION IPR Management, Business Models, and Business Plan – Intermediate Deliverable (D8.4)" are both fundamental and adaptable. They serve as a critical foundation for extending and enhancing the outcomes of the GLACIATION project exploitation and commercialisation strategies. Acknowledging the crucial early phase of the project, the consortium recognises that although it is ready to unveil the first GLACIATION demonstration, this marks merely the beginning of a broader journey.

The strategies currently outlined, while in their formative stages, are designed with foresight for incremental refinement, drawing on a dynamic comprehension of both stakeholder requirements and market forces. These activities, moving forward, will be executed with a commitment to precision and adaptability, meticulously sculpting the business modelling and exploitation plans—both commercial and non-commercial—as detailed in this document. This focused and responsive approach is vital, for enhancing the overarching benefits for European citizens and beyond, securing a durable legacy for the innovations, project outcomes, and insights generated by the project.

As the GLACIATION consortium anticipates the project's final stages in September 2025, a concluding iteration, "The GLACIATION IPR Management, Business Models, and Business Plan – Final Deliverable (D8.5)," will be crafted at Month 36. This definitive document will integrate the full spectrum of IPR management, business modelling, business plans, and exploitation strategies that will be employed throughout the project’s duration and beyond. It will chronicle the journey, articulate the impact, and share the knowledge gained, ensuring that the influence of GLACIATION endures and continues to drive innovation within its domain long after its formal conclusion.

In the meantime, the GLACIATION consortium will remain committed to enhancing these exploitation strategies and establishing pivotal connections with relevant industry and policy stakeholders. Ultimately, this document is evolutionary, destined for ongoing enhancement and refinement.

Reading List

- BIS Research, "Europe Space-Based Edge Computing Market," 2024. [Online]. Available: https://bisresearch.com/industry-report/europe-space-based-edge-computing-market.html.
- Business Wire, "Europe Data Center Market Insights Report 2023-2028: Market is Ripe with Opportunities Driven by Technological Advancements and Evolving Customer Needs - ResearchAndMarkets.com," 10 November 2023. [Online]. Available: https://www.businesswire.com/news/home/20231110885821/en/Europe-Data-Center-Market-Insights-Report-2023-2028-Market-is-Ripe-with-Opportunities-Driven-by-Technological-Advancements-and-Evolving-Customer-Needs---ResearchAndMarkets.com.
- Coursera, "Market Analysis: What It Is and How to Conduct One," 30 January 2024. [Online]. Available: https://www.coursera.org/articles/market-analysis.
- Council of the European Union, "General Data Protection Regulation (GDPR)," [Online]. Available: https://www.consilium.europa.eu/en/policies/data-protection/data-protection-regulation/#:~:text=The%20GDPR%20lists%20the%20rights,his%20or%20her%20personal%20data
- Dell, "Edge to Core and the Internet of Things," 2020. [Online]. Available: https://infohub.delltechnologies.com/en-US/l/edge-to-core-and-the-internet-of-things-2/sap-edge-services/.
- Deloitte Insights, "Battle for the Enterprise Edge: Providers prepare to pounce on the emerging enterprise edge computing market," 30 November 2022. [Online]. Available: https://www2.deloitte.com/xe/en/insights/industry/technology/technology-media-and-telecom-predictions/2023/edge-computing-battle-for-the-enterprise-edge.html.
- European Commission, "Big data." [Online]. Available: https://digital-strategy.ec.europa.eu/en/policies/big-data.
- European Commission, "Cloud Computing," 20 June 2023. [Online]. Available: https://digital-strategy.ec.europa.eu/en/policies/cloud-computing.
- European Commission, "Cloud and Edge Computing." [Online]. Available: https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/cloud-and-edge-computing-0.
- European Commission, "Green Cloud," [Online]. Available: https://digital-strategy.ec.europa.eu/en/policies/green-cloud.
- European Commission, "Investing in Cloud, Edge and the Internet of Things," September 2023. [Online]. Available: https://digital-strategy.ec.europa.eu/en/policies/iot-investing.

- European Commission, "IoT and the Future of Edge Computing in Europe," 2022. [Online]. Available: https://digital-strategy.ec.europa.eu/en/news/iot-and-future-edge-computing-europe.
- European Commission, "Public procurement - Accessing markets," [Online]. Available: https://policy.trade.ec.europa.eu/help-exporters-and-importers/accessing-markets/public-procurement_en#:~:text=In%20the%20EU%2C%20in%202017,market%20within%20Europe%20in%202016.
- European Union, "Commission Regulation (EU) 2019/424 laying down ecodesign requirements for servers and data storage products pursuant to Directive 2009/125/EC of the European Parliament and of the Council and amending Commission Regulation (EU) No 617/2013," Official Journal of the European Union, [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32019R0424.
- European Economic and Social Committee, "Driving Prosperity for All A Competitiveness Agenda for the EU EESC EMPLOYERS' GROUP PRIORITIES," 2023. [Online]. Available: https://www.eesc.europa.eu/sites/default/files/files/qe-09-23-031-en-n.pdf.
- Gartner, "Gartner Identifies Top Five Trends in Privacy Through 2024," 31 May 2022. [Online]. Available: https://www.gartner.com/en/newsroom/press-releases/2022-05-31-gartner-identifies-top-five-trends-in-privacy-through-2024.
- Global Market Insights, "Europe Cloud Computing Market Size By Service (Software-as-a-Service, Infrastructure-as-a-Service, Platform-as-a-Service), By Organization (Large Enterprises, SMEs), By Deployment Model (Public Cloud, Private Cloud, Hybrid Cloud), Application, 2023-2032," December 2022. [Online]. Available: https://www.gminsights.com/industry-analysis/europe-cloud-computing-market.
- Heidebrecht, Sebastian, "From Market Liberalism to Public Intervention: Digital Sovereignty and Changing European Union Digital Single Market Governance," 05 April 2023. [Online]. Available: https://onlinelibrary.wiley.com/doi/full/10.1111/jcms.13488.
- IDC, "Reach Nearly $50 Billion in 2024, Says IDC," 24 March 2024. [Online]. Available: https://www.idc.com/getdoc.jsp?containerId=prEUR251963024.
- Kanellos, M., "152,000 Smart Devices Every Minute In 2025: IDC Outlines The Future of Smart Things," Forbes, 2016. [Online]. Available: https://www.forbes.com/sites/michaelkanellos/2016/03/03/152000-smart-devices-every-minute-in-2025-idc-outlines-the-future-of-smart-things/?sh=715c48f4b63e.
- KPMG, "The 5G edge computing value opportunity," June 2020. [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/pe/pdf/5g-edge-computing-value-opportunity.pdf.
- KPMG, "The evolving data centre landscape," March 2024. [Online]. Available: https://assets.kpmg.com/content/dam/kpmg/ie/pdf/2022/11/ie-the-evolving-data-centre-landscape.pdf.

- McKinsey & Company, "Accelerating data and analytics maturity in the US public sector," [Online]. Available: https://www.mckinsey.com/industries/public-sector/our-insights/accelerating-data-and-analytics-maturity-in-the-us-public-sector.
- McKinsey and Company, "New demand, new markets: What edge computing means for hardware companies," November 2018. [Online]. Available: https://www.mckinsey.com/~/media/mckinsey/industries/technology%20media%20and%20telecommunications/high%20tech/our%20insights/new%20demand%20new%20markets%20what%20edge%20computing%20means%20for%20hardware%20companies/new-demand-new-markets-what-edge-comp.
- The Organisation for Economic Co-operation and Development, “Measuring the Environmental Impacts of Artificial Intelligence Compute and Applications, The AI Foot Print,” OECD Publishing, November 2022.
- Peter Gailhoffer et al, “The Role of Artificial Intelligence in the European Green Deal,” European Union, May 2021. Available online: https://www.europarl.europa.eu/RegData/etudes/STUD/2021/662906/IPOL_STU(2021)662906_EN.pdf
- PWC, "What is edge computing and how does it impact businesses?" 2022. [Online]. Available: https://www.pwc.in/consulting/technology/emerging-tech/what-is-edge-computing-and-how-does-it-impact-businesses.html.
- Research and Markets, "Europe Data Centre Market Overview and Forecast 2023-2029: Top Five Companies Hold 25.33% Share, Led by CyrusOne, Equinix, Global Switch Holdings, NTT, and Vantage Data Centres," 21 February 2024. [Online]. Available: https://www.globenewswire.com/newsrelease/2024/02/21/2832512/28124/en/Europe-Data-Center-Market-Overview-and-Forecast-2023-2029-Top-Five-Companies-Hold-25.33-Share-Led-by-CyrusOne-Equinix-Global-Switch-Holdings-NTT-and-Vantage-Data-Centers.html.
- StandICT.eu 2023, "Report of TWG IIoT & Edge: Landscape of Edge Computing Standards," 13 December 2022. [Online]. Available: https://zenodo.org/records/7432520#.Y6H843bMI2x.
- Steve McDowell, "Nvidia And Dell Build An AI Factory Together," 21 March 2024. [Online]. Available: https://www.forbes.com/sites/stevemcdowell/2024/03/21/nvidia--dell-build-an-ai-factory-together/.
- Venture Insights, "European GovTech," [Online]. Available: https://www.venture-insights.de/european-govtech-publication.
- World Economic Forum, "What is ‘dark data’ and how is it adding to all of our carbon footprints?" 5 October 2022. [Online]. Available: https://www.weforum.org/agenda/2022/10/dark-data-is-killing-the-planet-we-need-digital-decarbonisation/?utm_campaign=social_video_2022&utm_content=27617_dark_data&utm_medium=social_video&utm_source=linkedin&utm_term=1_1.

- Yahoo Finance, "Europe Edge Computing Market Analysis and Forecasts Report 2024-2030 Featuring ATOS, Capgemini, Deutsche Telekom, Ericson, Nokia, Advantech, ARM, Intel, NXP, Qualcomm, Microsoft, and Vmware," 2024. [Online]. Available: https://finance.yahoo.com/news/europe-edge-computing-market-analysis-174500433.html.

Annex A - Stakeholders

Table 8 provides a stakeholders list. It includes the name of the stakeholders (first column) and the type, according to the target groups (second column).

Table 8 - GLACIATION Stakeholder Table

Stakeholder	Type
CLEVER	E - Initiatives
MobiSpaces	A – Industry
Smart Manufacturing Industry	A - Industry
Smart Governance and Smart Cities	A - Industry
Gaia-X	E - Initiatives
Digital Europe	A - Industry
EHTEL	C - Industry
MarineTraffic	C - Industry
NTT Data	C - Industry
Ericsson	C - Industry
Epsilon Italia	C - Industry
APCO Worldwide	C - Industry
Open Geospatial Consortium	C - Industry
ETAPAS	E - Initiatives
MOSAICrOWN	E - Initiatives
TRUSTS	E - Initiatives
SERENA	E - Initiatives
BRAINE	E - Initiatives
DECIDO	E - Initiatives
ACROSS	E - Initiatives
CPSwarm	E - Initiatives
BugWright2	E - Initiatives
SWILT	E - Initiatives
MESON	E - Initiatives
C3ISP	E - Initiatives

InSecTT	E - Initiatives
4DOmics	E - Initiatives
OligoArchive	E - Initiatives
BIGFOOT	E - Initiatives
MARSAL	E - Initiatives
HOPE	E - Initiatives
MUSKETEER	E - Initiatives
TOREADOR	E - Initiatives
BD4NRG	E - Initiatives

Annex B

Table 9 provides a list of key publications and conferences where GLACIATION may engage with the scientific and industry communities to share its research and insights.

Table 9 - Key Publications and Conferences to Submit GLACIATION Papers

Name	Type	Audience
IEEE Access	Academic Journal	Scientific community
IEEE Explore	Academic Journal	Scientific community
Swarm Intelligence	Academic Journal	Scientific community
IEEE International Conference on Autonomic Computing and Self-Organizing Systems ACSOS	Conference Proceedings	Scientific community
International Conference on Swarm Intelligence ANTS	Conference Proceedings	Scientific community
BDVA	Industry publication	Industry
ERCIM	Online and offline magasine	Industry
EGOV-CeDEM-ePart	Conference Proceedings	Scientific community
IEEE Euro S&P	Conference Proceedings	Scientific community
ESORCIS	Conference Proceedings	Scientific community
ICIS	Conference Proceedings	Scientific community
NATURE	Academic Journal	Scientific community
IEEE Transactions on Cloud and Computing	Academic Journal	Scientific community
ACM	Academic Journal	Scientific community
Springer	Academic Journal	Scientific community
Elsevier	Academic Journal	Scientific community
arXiv	Academic Journal	Scientific community
MIS Quarterly	Academic Journal	Scientific community