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Abstract

This deliverable represents the first release of the H-CLOUD European Cloud Computing Portfolio. It explores the European cloud landscape with the objectives of mapping it in all its dimensions, identifying the positive outcomes of work undertaken by the European cloud community and spotting potential gaps, and creating a viable knowledge resource for use by the community.

Keywords:

Cloud computing, the cloud computing landscape, cloud federation, edge computing, green IT

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EXECUTIVE SUMMARY

This deliverable represents the first release of the H-CLOUD European Cloud Computing Portfolio. It explores the European cloud landscape with the objectives of mapping it in all its dimensions, identifying the positive outcomes of the work undertaken by the European cloud community and spotting potential gaps, and creating a viable knowledge resource for the community. It will be the basis for the development of an easily searchable online catalogue of relevant cloud-related initiatives.

The deliverable has been completed within the H-CLOUD project. H-CLOUD leads coordination and support activities for the consolidation and growth of the cloud computing research and innovation community in Europe, bringing together innovators, policy makers, cloud computing researchers, industry stakeholders, and users into a participatory and sustainable open forum. To address the challenges and opportunities arising at the research, technology, policy, standardisation, and organisation levels, H-CLOUD provides the community with a rich set of collaborative content, tools, and actions to overcome fragmentation and increase collaboration in Europe and beyond, while aligning on a common direction to help create a strategic research, innovation, and deployment agenda for cloud computing in Europe.

Through desk research, in this deliverable, the EU cloud computing landscape has been analysed from two perspectives: research & innovation (European-funded projects in the field of cloud computing) and deployment (private, public, and private-public initiatives making cloud computing services available for use). The initiatives covered have been drawn from different sources, such as the Cordis database, IDC's Industry Cloud tracker, and IDC Government Insights research.

The initiatives have been categorised via many different dimensions to make the upcoming online catalogue as complete as possible for all relevant stakeholders willing to obtain deeper knowledge of what is considered state of the art in the European cloud computing arena. Priority has been given to initiatives that address topics of relevance for the H-CLOUD project – namely, cloud computing, cloud federation, edge computing, and green IT.

For this first release of the European Cloud Portfolio, we have analysed 111 initiatives relating to cloud computing, federated clouds, edge computing, and green computing. In the research and innovation (R&I) context, 67 H2020-funded projects were identified; 44 initiatives have resulted from desk research in the deployment area, of which 28 relate to the public sector, 6 come from the private sector (industry collaborative clouds), and 10 concern public-private partnerships.

In the current European cloud landscape, this first round of desk research has identified:

- 56 federated cloud initiatives – 16 from R&I projects and 40 from deployment
- 20 edge initiatives – 18 from R&I projects and 2 from deployment
- 9 green IT initiatives – 5 from R&I projects and 4 from deployment

Although the data collected did not enable us to draw definitive conclusions and more research needs to be performed, the analysis has highlighted some interesting elements for further research. Following are the main findings of the analysis concerning key H-CLOUD topics (cloud federation, edge computing, and green computing):

- **Cloud federation:** The level of cloud federation projects is relatively high from an operating/governance model perspective. But there are technical complexities, particularly for cloud initiatives that involve a broad private-and-public-sector ecosystem. Identifying and sharing governance best practices, conducting more research on the technical-architecture aspects of distributed computing, and stimulating innovation in this area are all necessary. A good example is SUNFISH, which is designed for secure data processing in a distributed environment.

From the operating model perspective, the questions of "How can we create awareness and demand from European users?", "How can collaboration between the private and public sector be extended beyond R&I projects to scale deployment initiatives?", and "How do the participants of the cloud federation earn money?" are not very well understood and are not covered in the initiatives, which focus more on technical capabilities.

So far, the cloud federation initiatives covered in this European Cloud Portfolio are very siloed, and cross-country initiatives are few. If cloud federation is to span cloud providers (both private and public) from all European countries, the right capabilities and organisational structures need to be in place. These must include: the technology architecture to integrate all the services; the operating model to govern federation; the business model to ensure economic advantages for all participants; technology open standards; the marketing to ensure the awareness and adoption of federated services; and the security, compliance standards, auditing, and certification to inspire trust within the potential customer base. These components do not seem to be in place at this stage. Most importantly, a clear purpose of the federation should be identified.

- **Edge:** A healthy number of R&D projects cover edge, but only two deployment initiatives originate from the public sector, and none from the private sector. At the moment, usage is broad of terms like edge computing and fog networks, which are similar but different, indicating the need for more research and innovation into architectural capabilities, which would lead to a more common standardised language to describe the edge computing market and its components. The research should start from good coverage of networking elements (e.g., low latency capabilities) and expand into security, big data processing, and edge application management capabilities, which are key components of the edge ecosystem.

  The analysis has highlighted a lack of vertical use cases, with just a few examples in the smart city and manufacturing domains. To increase the adoption of edge use cases, it makes sense to look for more industry-specific use cases within particular sectors – those that solve individual business problems – to increase relevance and adoption.

- **Green IT:** The number of green IT initiatives is generally low, both at the research & innovation stage and the deployment stage and across both the private and public sectors.

  In the green IT space, it is crucial to understand how to measure the impact of certain technologies on sustainability, carbon footprint reduction, energy efficiency, etcetera. The success of green IT initiatives will depend on clear KPIs, on understanding how they can be achieved and how they will be measured, and on an independent governance body to audit and certify energy efficiency so that providers can use the certificate in their marketing communications.

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1 INTRODUCTION

This section outlines the background, methodological approach, and structure of this document.

1.1 Background

H-CLOUD leads coordination and support activities for the consolidation and growth of the cloud computing research and innovation community in Europe, bringing together innovators, policy makers, cloud computing research, industry stakeholders, and users into a participatory and sustainable open forum. To address the challenges and opportunities arising at the research, technological, policy, standardisation, and organisational levels, H-CLOUD provides the community with a rich set of collaborative content, tools, and actions to overcome fragmentation and increase collaboration in Europe and beyond, while aligning on a common direction to help create a strategic research, innovation, and deployment agenda for cloud computing in Europe.

Cloud computing is a key enabler of the European Commission's digital agenda "Shaping Europe's Digital Future". In fact, cloud can deliver business and technical benefits to both public institutions and private enterprises in Europe. It is also at the nexus of other technology trends, such as edge computing and green IT, which are expected to positively impact the European Data Strategy, the European Industrial Strategy, and the European Green Deal (see Figure 1).

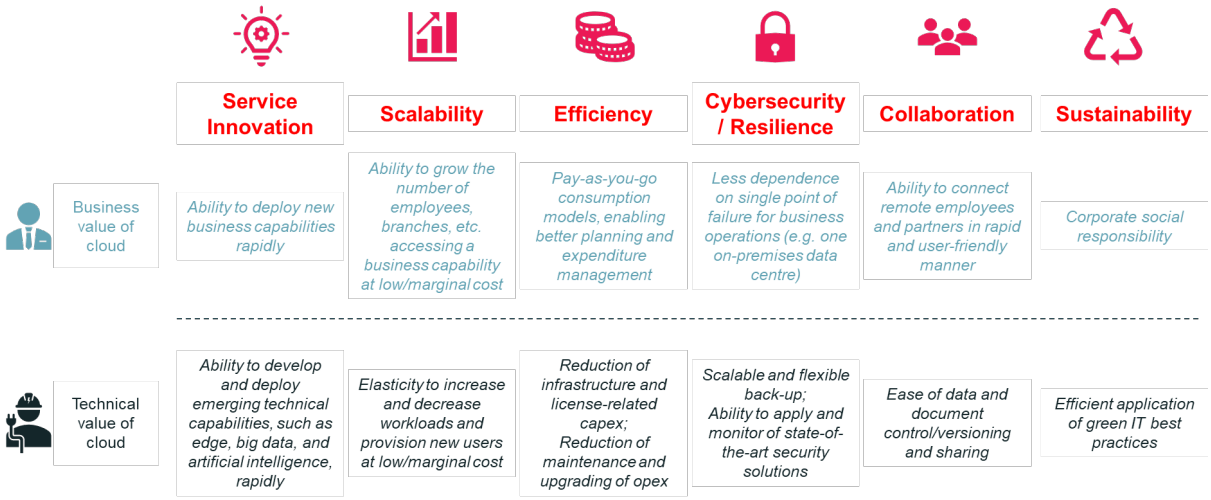

Figure 1: The Potential Business and Technical Value of Cloud Computing

However, to realise the potential value of cloud as an enabler of digital public services, next-generation industries, the data economy, and clean and sustainable energy usage, regulatory, organisational, architectural, and data sharing concerns must be investigated to provide evidence to support the creation of enabling policies.

This deliverable has the objective of collecting the foundational evidence for analysis and policy recommendations that the H-CLOUD project aims to provide. The deliverable will explore the European Cloud landscape from two perspectives: research & innovation (European-funded projects in the field of cloud computing) and deployment (private and public initiatives making cloud computing services available for use). A portfolio of past and current European cloud initiatives has been collated and profiled.

Essentially, the goal of this deliverable is:

- To map out the European cloud landscape in all its dimensions
- To identify the positive outcomes of the work undertaken by the European cloud community and to spot potential gaps
- To create a viable knowledge resource for use by the European cloud community

In particular, this deliverable will represent the basis for the development of D1.3, Best Practices Guide, and D1.5, Online Catalogue and Knowledge Transfer.

The Best Practices Guide (D1.3) will identify and describe initiatives providing added value to what is currently considered state of the art and will present a model for the implementation of future actions in the cloud computing field.

The online catalogue (D1.5) will store the data collected within this deliverable and use it to deliver an easily searchable collection of relevant cloud-related activities that will be integrated into the H-CLOUD portal. This catalogue will be continuously updated as more information is made available through the Cloud Computing Portfolio. Users will be able to filter their search results based on the categories, classifiers, and metadata defined within the portfolio, and their results will be displayed in an intuitive and user-friendly fashion. These search results will provide best-practice indicators that link back directly to their sources and will provide insightful information to the user.

1.2 Methodological Approach

The mapping of European cloud computing initiatives in this deliverable is based on desk research. This qualitative research encompasses European initiatives that have taken place or are being developed on a local, national, European, or global level and have been collected from different sources.

To create the first version of the Cloud Computing Portfolio, with specific reference to R&I EU-funded projects, we have analysed several H2020 calls-for-proposal topics and related funded projects, including:

- **The Industrial Leadership Pillar**
  - Cloud Computing (ICT-15-2019 and ICT-06-2016)
  - Future Internet (ICT-07-2014, "Advanced Cloud Infrastructures and Services"; and ICT-09-2014, "Tools and Methods for Software Development")
  - SME Instrument
  - Factories of the Future (FOF-11-2016, “Digital Automation”; and FOF-12-2017, “ICT Innovation for Manufacturing SMEs”)
  - EU-Brazil, EU-Japan, and EU-Korea – joint calls
- **Societal Challenges Pillar**
  - Smart, green, and integrated transport
  - Health, demographic change, and wellbeing
  - Food security; sustainable agriculture and forestry; marine, maritime, and inland water research; and the bio economy

For this first round of research, the identification of relevant initiatives within the private and public sectors has been performed using IDC's Industry Cloud tracker[1] as a base for private and public-private collaborative cloud initiatives, as well as select cloud initiatives from the public sector based on IDC Government Insights research[2].

The methodology used in this report is based on the following steps, implemented between February 2020 and June 2020:

a) The creation of a portfolio structure to profile relevant initiatives on the European cloud computing scene

b) Desk research of the main public sources (mainly Cordis database and project websites) to select the most relevant EU-funded projects in the field of cloud computing

c) The extraction of relevant data from IDC databases and ongoing research on industry clouds and public sector initiatives

d) A list of initiatives and initiative profiles frozen as of April 2020 to allow for analysis

e) The elaboration of desk research results

f) The production of this deliverable (D1.1), presenting the main results of the analysis

1.3 Structure

This deliverable is structured as follows:

- **Section 1** outlines the background, the methodology, and the structure of the deliverable.
- **Section 2** provides an overview of the Cloud Computing Portfolio's structure
- **Section 3** presents the Cloud Computing Portfolio
- **Section 4** provides an analysis of the profiles identified, focusing on the three pillars (Federation, Edge, and Green IT) and identifying gaps
- **Section 5** concludes the deliverable with main takeaways and next steps

[1] IDC's Industry Cloud Directory is a semi-annual research effort that tracks and monitors the development of industry cloud platforms by vertical, across healthcare, life sciences, financial services, manufacturing, retail, government, oil and gas, utilities, media and entertainment, agriculture, transportation, automotive, and other industries. Research is captured through a combination of primary and secondary research (subscription service) https://www.idc.com/getdoc.jsp?containerId=US45246420. While writing this report, the directory numbers grew, with the collection of around 173 initiatives. In the second round of research, a deeper look at the directory and at other relevant sources will be performed.

[2] https://www.idc.com/getdoc.jsp?containerId=IDC_P38165

2 CLOUD COMPUTING PORTFOLIO STRUCTURE

This chapter describes the Cloud Computing Portfolio structure and the rationale behind it. It explains the main categories used for the profiling of the identified initiatives. The definitions used in this section are further explained in Appendix A – Glossary.

2.1 Portfolio Priority Areas

To map out the European Cloud landscape in all its dimensions, we have selected initiatives across two main contexts:

- **Research & Innovation:** Collaborative R&I projects funded by the European Commission under the H2020 research programme
- **Deployment:** Private or public initiatives that make cloud computing services available for use; in particular:
    - Public initiatives (cloud initiatives managed and funded by governments, local or regional administrations, or other public sector organisations)
    - Private initiatives (collaborative industry clouds intended as cloud-based platforms through which multiple companies in an industry collaborate in some fashion towards a common goal, such as improving industry insight and/or capability, achieved by aggregating cost reductions, operational benefits, risk mitigation, and/or insight creation from pooled data/information; excludes single vendor commercial offerings)
    - Public-private initiatives (initiatives resulting from partnerships between public and private sector entities aiming to establish a dynamic ecosystem in the field of cloud computing)

Initiatives were selected if they included keywords on which the H-CLOUD project focuses – namely, cloud, federation, green, or edge.

- **Cloud:** As per NIST's definition, we consider cloud as having five essential characteristics – namely, on-demand self-service, broad network access, resource pooling, rapid elasticity or expansion, and measured service. (Appendix A describes this further.)
- **Federation[3]:** For this analysis, the concept of cloud federation is considered from both an architectural perspective and an operational viewpoint:
    - From the architectural point of view, cloud federation is intended as distributed technical resources (computing, storage, data, application services, identity management services, etc.) scattered across a network and logically pooled together for consumption by a broad set of users.
    - From the operating model standpoint, cloud federation is intended as the mechanism that regulates how the participating entities collaborate to pool resources for broader consumption.
- **Green IT:** This relates to sustainable energy and materials to build and use computing resources.

[3] This definition has to be considered as a 'work-in-progress'; H-CLOUD consortium is currently working on it.

- **Edge:** We consider edge computing not just as the pure functionality of supporting computation at the network edge, but through the full cloud-edge continuum – i.e., from cloud data centres, via intermediary edge devices and capabilities, to devices at the network edge.

2.2 Template Structure

Once the main contexts of the research and priority keywords had been identified, we proceeded with the development of a profiling template to include all the relevant information needed for consequent mapping and analysis.

We have built up a structure composed of four macro-areas, described as follows.

Macro-area 1: Identification. This includes an initiative name, acronym, accessible link, and contact person (useful for the further collection of information via interview).

Macro-area 2: Description. Besides including an initiative description, duration, geographical scope, specific domain, and technology, this macro-area includes specific details on:

- **Initiative lifecycle stage:**
  - *Research and innovation projects* aimed at designing, engineering, prototyping, piloting, and demonstrating.
  - *Deployment initiatives* aimed at making services available for consumption on the market. For this stage, initiatives have been differentiated at an even more granular level between experimentation and deployment in controlled operational environments and deployment, operations, and support in operational/industrial environments.
- **Cloud delivery model:**
  - *Infrastructure as a Service (IaaS):* IaaS refers to services closely tied to the physical technologies themselves – notably, various types of compute, storage, and file system and networking and typically exposed as virtual machines ("instances") and managed with virtualisation tools such as OpenStack.
  - *Platform as a Service (PaaS):* In PaaS, cloud-based business functions are developed in the selected PaaS environment and resources can be configured to scale up or down automatically; the client is charged for this but does not have to track utilisation or adjust configurations directly.
  - *Software as a Service (SaaS):* SaaS involves fully integrated software suites centred on specific activities. Major examples include customer relationship management (CRM), enterprise resource planning (ERP), and financial accounting, as well as office productivity tools like Google Office and DropBox. Microsoft's Azure offerings are largely SaaS, supported by flexible IaaS capabilities that are also sold to clients.
- **Cloud deployment model:**
  - *Public:* Public cloud services are open to a largely unrestricted universe of potential users and designed for a market, not a single enterprise.
  - *Local:* This refers to on-premises private cloud.
  - *Hosted Private:* In the private cloud scenario, third-party commercial cloud service providers offer customers access to private services that the service providers have built and they own and operate.
  - *Enterprise Private:* In the private cloud scenario, an enterprise typically either acquires a pre-integrated cloud services system or integrates component software and hardware elements and operates the cloud service for its own use.

- *Hybrid:* This is a solution that includes two of more of the above deployment types.

Initiatives have also been categorised by the industries they serve. The main industries covered are:

- Manufacturing
- Utilities
- Public administration
- Education and skills
- Finance
- Healthcare
- Information and communication industry
- Construction
- Retail
- Transport
- Professional services

Macro-area 3: Organisation. This macro-area includes details on the governance model, operating model, ownership, and control and on the main stakeholders.

Macro-area 4: Impact. This macro-area will capture good practices and aims at collecting information on uptake, customer satisfaction, socioeconomic impacts, and lessons learned.

A full representation of all the dimensions included in the H-CLOUD portfolio can be found in Appendix B. These dimensions will be searchable in an online catalogue by European organisations, policy makers, end users, and other interested parties.

3 THE EUROPEAN CLOUD COMPUTING PORTFOLIO IN NUMBERS

3.1 Description of European Cloud Portfolio

For this first release of the European Cloud Portfolio, we have analysed 111 initiatives relating to cloud computing, federated cloud, edge computing, and green computing. In the R&I context, 67 H2020-funded projects were identified; 44 initiatives have resulted from desk research in the deployment area, of which 28 relate to the public sector, 6 come from the private sector (industry collaborative clouds), and 10 are from public-private partnerships.

In the current European cloud landscape, this first round of desk research has identified:

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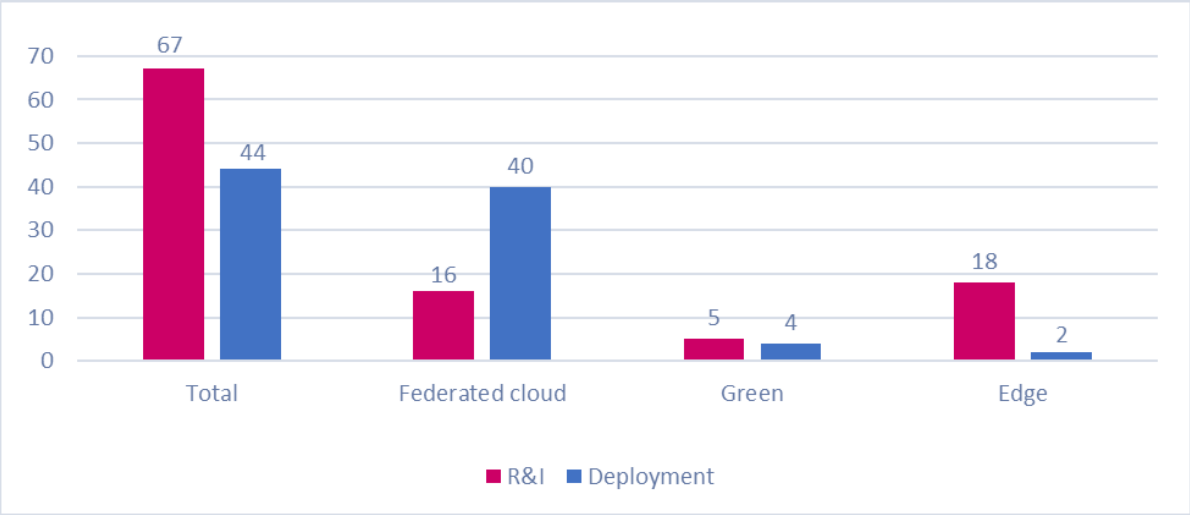

Figure 2: R&I and Deployment Initiatives by H-Cloud Relevant Keywords

Note: The sum of federated cloud, edge, and green IT initiatives is not 111 because some initiatives entailed more than one topic of interest for this analysis and some other initiatives referred generically to cloud.

Referring to Figure 2, the level of cloud federation is relatively high in terms of operating/governance models that enable public administrations or private companies to collaborate, with one R&I project and 40 deployment initiatives that leverage some form of collaboration among participants. Examples are public sector shared services, and private sector marketplaces and pre-competitive data exchanges. However, few federations adopt technical solutions at an architectural level to pool capabilities from a distributed set of resources. Most notably, the majority of these technically federated capabilities have been, or are being, tested in R&I projects (16) and put in place in public-private deployment initiatives (8).

A healthy number (18) of R&I projects cover edge, but only two deployment initiatives originate from the public sector and none from the private sector, which clearly indicates that the edge computing market is at an early/discovery stage.

The number of green IT initiatives is low. They only exist in R&I and the private sector; none originates from the public sector.

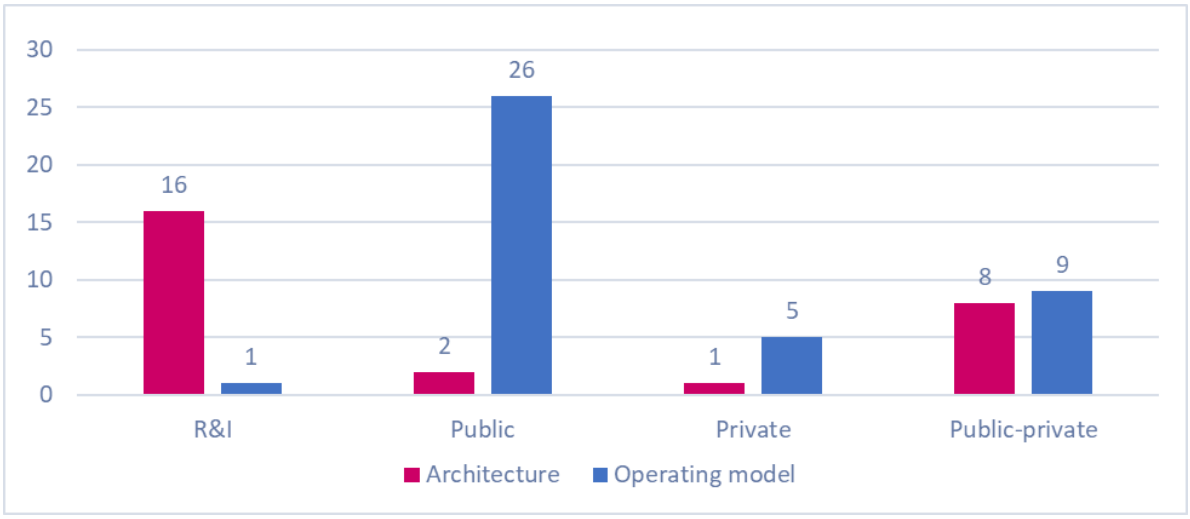

Figure 3: R&I and Deployment Initiatives on Cloud Federation

Figure 3 indicates that technical research and development still need to be conducted on the theme of technical federation[4]. This also indicates that the more complex federations from an operating model perspective – namely, those that involve both the private and public sectors – correlate with technical federation solutions. However, it is difficult to tell whether it is the ecosystem and use case complexity of public-private collaboration that motivates the search for more sophisticated technical federation solutions, or whether it is the complexity of technical solutions that requires the involvement of a broader set of participants.

Cloud federation, edge computing, and green IT can all be developed and deployed horizontally, as a technology layer. Alternatively, they can be implemented differently across different sectors to solve a specific industry problem. Figure 4 shows the number of R&I projects funded by the EC, revealing:

- A strong focus on horizontal ICT projects (37)
- Attention towards key industries, such as healthcare, manufacturing, and professional services
- A relatively large number (10) of R&I projects that are focused on cloud for the public sector, which is in line with the delayed adoption of cloud in the public sector compared with other industries

[4] From a market perspective, it is very likely that edge computing will also drive further demand for these technical developments.

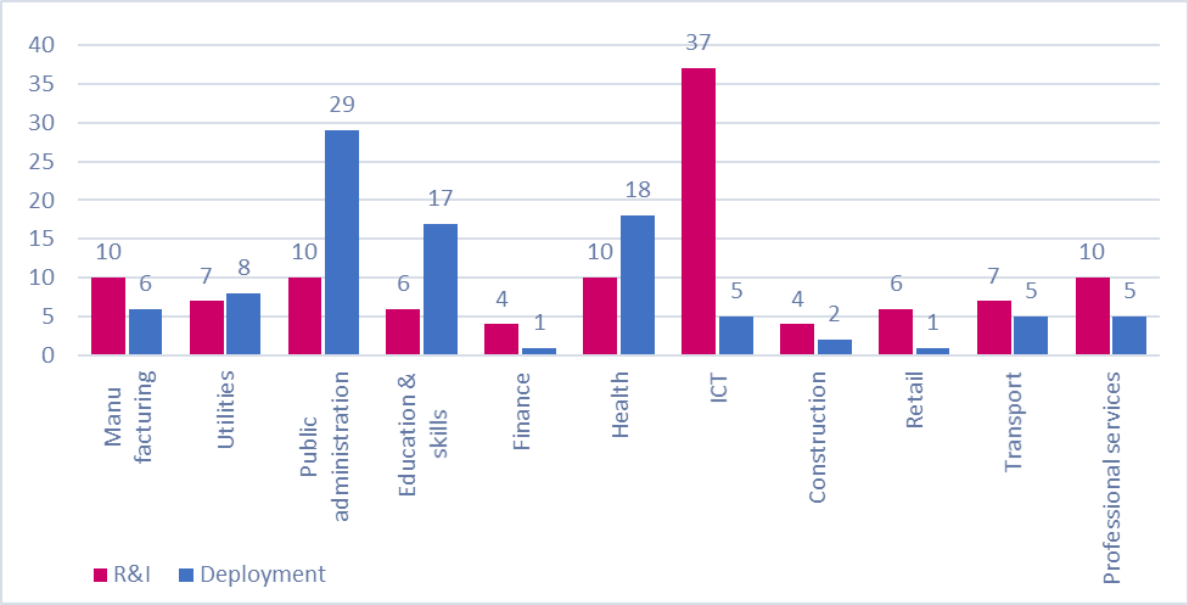

Figure 4: R&I and Deployment Initiatives by Sector

Note: some initiatives involved more than one industry

When looking at the European cloud landscape, it is important to look at the cloud delivery model. IaaS is commoditising rapidly, while innovation is happening at the PaaS layer. SaaS provides an opportunity for European independent software vendors (ISVs) to become cloud players[5]. Table 1 shows the distribution of the profiled R&I and deployment initiatives by cloud delivery model.

Cloud Delivery Model	Number of Initiatives	%
IaaS	25	23%
PaaS	30	27%
SaaS	19	17%
Iaas + PaaS	14	13%
PaaS + SaaS	9	8%
IaaS + SaaS	3	3%
IaaS + PaaS + SaaS	11	10%
Total	111	100%

Table 1: R&I and Deployment Initiatives by Cloud Delivery Model

When analysing the prevalence of delivery models by industry (see Figure 5), the difference is interesting between public administrations, which tend to have cloud initiatives that provide

[5] For more information on market dynamics, see H-CLOUD Appendix 10 of the Green Paper on Cloud Services Supply Landscape.

relatively numerous IaaS services, and organisations from industries such as manufacturing, utilities, and transport, which are more focused on PaaS and SaaS. The information collected in this first round of research does not allow us to draw specific conclusions. This is possibly a result of demands to support use cases like smart manufacturing, smart grid management (in utilities), and fleet management and intelligent traffic management (in transport), all of which require solutions that combine big data analytics, IoT device and data ingestion, and application integration capabilities leveraging PaaS services. By contrast, in the public sector, IaaS services are often used to enable migration from legacy on-premises data centres or from managed services contracts that have reached the end of their lifecycles. In the next round of research, detailed analysis of use cases will be conducted.

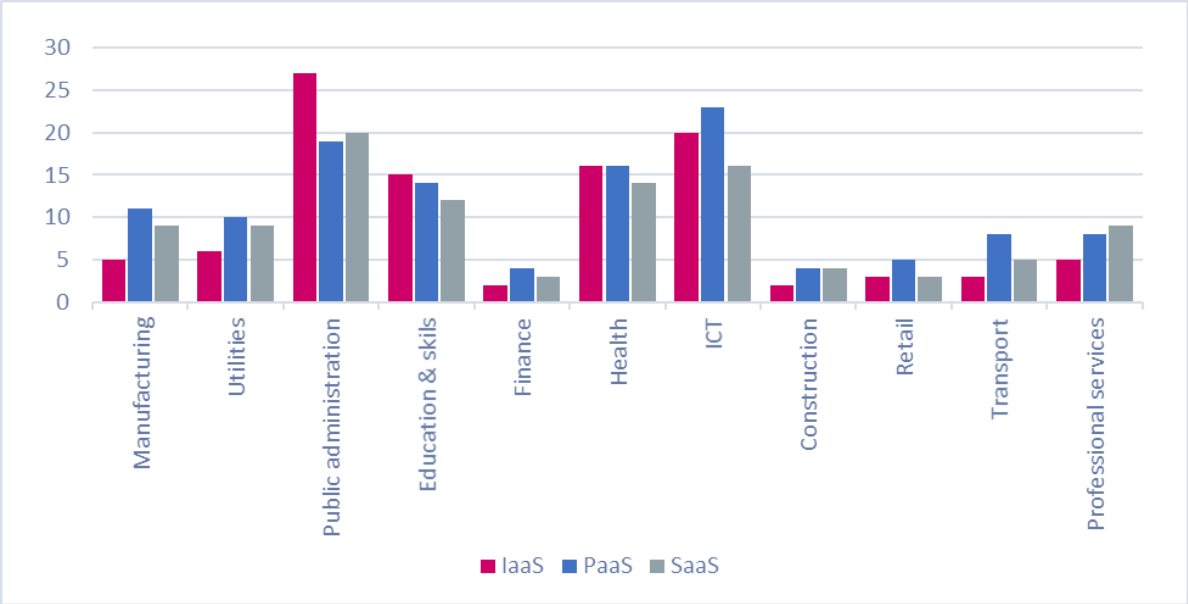

Figure 5: R&I and Deployment Initiatives by Sector

The cloud deployment model depends heavily on regulatory requirements, which often mandate where data can be stored; industry best practices, which are enforced by industry governing bodies; and performance requirements. Consequently, private cloud deployments are popular in Europe, as they ensure control over data and its location. Hybrid cloud models are also popular, as the data storage location can be ensured, while compute can take place in the public cloud, which is more scalable.

Public clouds – and private clouds to some extent – can be accessed by users through self-service portals and are shared by all users. Public clouds have several advantages, such as innovative and collaborative ecosystems forming around them, scalable and flexible infrastructure, innovative features and services, and high-level security. Table 2 shows the number of initiatives classified by the cloud deployment model used.

Cloud Deployment Model	Number of Initiatives	%
Public	10	13%
Local	0	0%
Hosted private	3	4%
Enterprise private	26	35%
Hybrid	36	48%
Total	75	100%

Table 2: R&I and Deployment Initiatives by Cloud Delivery Model

Note: The total number of initiatives in the table is 75 rather than 111, since our desk research could not assess the deployment model used in 36 projects. This gap will be addressed in the second round of research.

As shown in Figure 6, the share of public cloud initiatives is higher in PaaS and SaaS. This appears to be driven by two factors:

- On the supply side of the cloud market, the variety of PaaS and SaaS public cloud providers is much wider, while the IaaS market is increasingly concentrated, resulting in hesitation to relinquish control to a dominant hyperscaler.
- On the demand side, enterprises have IT resources and competencies that are more focused on infrastructure and operations – as opposed to platforms, analytics, AI, and end-user applications – resulting in organisational resistance to relinquishing control. Public cloud services thus offer a faster route to deploying more advanced capabilities.

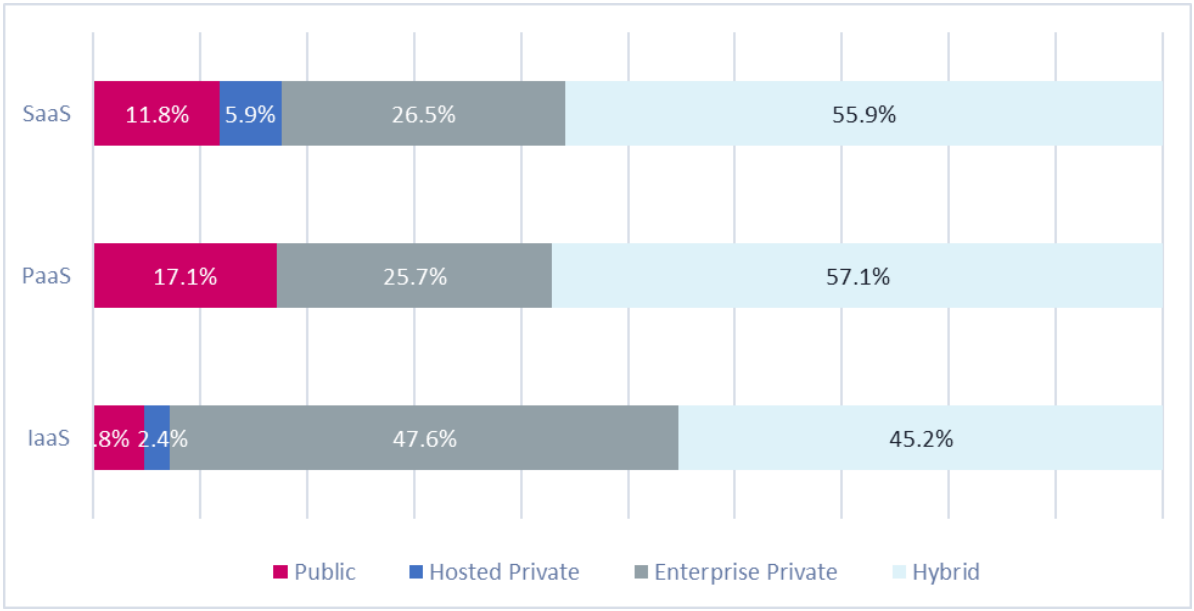

Figure 6: Distribution of R&I and Deployment Initiatives by Cloud Delivery and Deployment Model

3.2 Key Takeaways

The majority of cloud initiatives (67) identified in this first round of research originate from EC funded R&D projects, followed by public sector deployment initiatives (44), with relatively few deployment initiatives originating from private-sector (6) or public-private initiatives (10).

These initiatives are broadly distributed across the various industry sectors, with modest concentrations in finance, construction, and retail.

The level of cloud federation projects is relatively high from an operating/governance model perspective. But there are technical complexities, particularly for cloud initiatives that involve a broad private-and-public-sector ecosystem. Identifying and sharing governance best practices, conducting more research on the technical-architecture aspects of distributed computing, and stimulating innovation in this area are all necessary. A good example is SUNFISH, which is designed for secure data processing in a distributed environment.

The number of R&D initiatives covering edge is healthy, but only two deployment initiatives originate from the public sector, and none originates from the private sector. This clearly shows the early stage of maturity of edge computing, from both a technical architecture perspective and an operating model perspective, thus suggesting the need for more research investment.

The number of green IT projects is generally low. They only exist in R&D and the private sector; none originates from the public sector. To date, more data needs to be collected to develop a more comprehensive view of the market.

4 ANALYSIS OF THE EUROPEAN CLOUD LANDSCAPE

4.1 Cloud Federation

The analysis has highlighted the need for a clear definition of what a cloud federation is, what its constituents are, and how it is going to work. Some projects classified as cloud federation are actually shared services, while others represent knowledge platforms, which are not federated cloud services in the sense of different players coming together and connecting their infrastructures, applications, and/or data to create a larger service. It would be useful to clearly define what the different layers of cloud federation are (network, infrastructure, applications, data, services, etc.) and how cloud federation works in each layer.

Networking will play a key role to enable cloud federation at each level and to ensure the right performance and user experience, despite IT resources, applications, and data residing in different locations. However, only a few initiatives are looking at the networking component. The second round of research will look more deeply in this area.

Security is another critical component of cloud federation, and a fair number of initiatives address the security issue. But the security aspect is also multifaceted and needs to be understood not only from a technical perspective, but also from governance, auditing, and certification perspectives.

The business model component also represents an issue. The questions of "How can we create awareness and demand from European users?" and "How do the participants of the cloud federation earn money?" are not very well understood and are not covered in the initiatives, as they tend to focus on technical capabilities.

The cloud federation initiatives covered in this European Cloud Portfolio are very siloed, and few are cross-country and cross-industry initiatives. If cloud federation is to span cloud providers (both private and public) from all European countries, the following elements need to be put in place:

- The right incentives
- The technology architecture to federate all the providers
- The operating model to govern the federation
- The business model to ensure economic advantages for all participants
- Technology open standards
- The marketing to ensure the awareness and adoption of the federated services
- The security, compliance standards, auditing, and certification to inspire trust within the potential customer base

These components do not seem to be well understood at this stage.

4.2 Edge Computing

The analysis has identified a lack of vertical use cases of edge computing, with only two examples of smart city use cases and one for factory automation in manufacturing. To increase the adoption of edge use cases, it makes sense to look for more industry-specific use cases within specific sectors that solve specific problems. That would increase relevance and adoption.

A "federation of edge resources" would be helpful because it would allow multiple owners of edge devices to pool those devices to achieve wider and/or denser coverage of a service area. For example, a power distribution company can federate its edge infrastructure with public safety applications to provide better "visibility" of, and lower latency to/from, a geographic

area[6]. As mentioned in the previous section, for edge computing, it is also important to define the federation and its constituent parts, the level at which resources from various providers should be federated, and the desired governance, operating, and business models to be employed. In the next iteration of the landscape report, we will analyse more edge-related use cases and will answer these questions.

4.3 Green IT

In the green IT space, we need to understand how we want to measure the impacts of certain technologies on sustainability, carbon footprint reduction, energy efficiency, etcetera.

The success of green IT initiatives will depend on clear KPIs, understanding how they can be achieved and how they will be measured, and an independent governance body to audit and certify energy efficiency so that providers can use the certificate in their marketing communications.

In general, centralised computing in large data centres is more energy efficient than decentralised computing in smaller data centres or at the edge, so the next generation of IT infrastructure should be designed with energy efficiency and circular economy principles in mind.

4.4 Parameters for Success

To understand the potential and challenges of cloud federation, edge computing, and green IT for European organisations, understanding some relevant parameters for success is crucial.

Relevant questions related to the three key areas on which H-CLOUD focuses include:

Topic	Questions
Cloud federation	At which level(s) does the federation happen – infrastructure, application layer, data layer, and/or service catalogue layer?
	Who is going to lead/govern the federation?
	Who is going to ensure the security and compliance of all the members of the federation and their services?
	Who is going to invest in the marketing of the federation to make the federation known and to attract enough users?
Edge computing	Who is going to provide which elements of the infrastructure – endpoints, edge, cloud, and data centre?
	What should a federation include? At what level does it make sense to federate resources from different providers? What governance, operating, and business models should be employed?
	What needs to be considered in terms of interoperability and capacity to scale?
Green IT	What is your energy consumption?

[6] Appendix 11 'From core clouds to edge clouds', H-CLOUD Green Paper

Topic	Questions
	How do you measure the contribution to sustainability and the reduction of carbon emissions?

Table 3: Ideas for the Further Exploration of Key H-CLOUD Areas

These and several more questions will be answered via in-depth interviews for the Best Practices deliverable (D1.3), as the landscape does not provide enough evidence to answer them.

5 CONCLUSIONS

5.1 The Current European Cloud Landscape

In this first round of analysis, an introductory overview of the European cloud landscape has been developed. Although the data collected does not enable definitive conclusions, from a first look, it is plausible to say that cloud federation, edge computing, and green IT are still some way off mainstream adoption. More research is needed in different aspects of cloud federation, edge computing, and green IT before a larger number of European organisations will adopt these technologies and services.

Successful federated cloud services with large-scale adoption are still a long way from reality. Several challenges need to be overcome, and considerable work must be done before they become mainstream. At the current stage of maturity, public sector organisations have a better chance of developing and adopting federated cloud services within a region or country because of a long tradition of building shared services. As for the private sector, a strong champion must take the lead in its industry, and more industry-specific federated clouds must be scaled at the deployment stage.

The edge computing ecosystem is still emerging in Europe and will depend a lot on the timeframe of the roll-out of 5G technologies. The edge ecosystem has many different layers, and a better understanding of the interrelation between cloud and edge is required. In addition, the layer at which federation makes sense in the edge ecosystem needs to be understood.

With European organisations now including requirements for the sustainability of IT equipment into their supplier requirements, green IT and energy efficiency have become design criteria for next-generation IT infrastructure. When building out edge infrastructure, thinking about the lifecycle of the equipment and defining standards and guidelines for lifecycle management are important.

The three dimensions of federation, edge computing, and green IT are interlinked and should be considered conjointly.

5.2 Next Steps for the European Cloud Portfolio

The next version of the European Cloud Portfolio will focus on:

- Completing the landscape, covering other relevant H2020 ICT topics on the research side and other relevant deployment initiatives, and enriching in particular the profiles list of private-sector cloud-, edge-, and green-related initiatives.
- Understanding the operating, governance, and business models for the three areas on which the H-CLOUD project focuses, as they are as critical for success as the technical components.

A second round of desk research, using an enlarged set of sources, as well as direct interviews with relevant stakeholders, will increase the number of profiles and enrich the knowledge base presented in this first release of the Portfolio. This will enable the creation of an enhanced overall view of the European cloud landscape.

APPENDIX A – GLOSSARY

Cloud Computing

The original meaning of cloud computing related to having characteristics such as elasticity of resource supply and the automated provision of services, rather than any specific IT technologies. NIST's definition[7] of the five essential characteristics of the "cloud" is widely accepted:

- On-demand self-service
- Broad network access
- Resource pooling
- Rapid elasticity or expansion
- Measured service

In this definition, ICT services can be provided in a "cloud-like" way, without specifying the technology or business model to be used.

Cloud Federation

Federated cloud allows cloud-based services to be delivered to clients using a federated organisational structure. "Federation" more generally allows various services and/or assets provided by individual federation partners to be planned, deployed, and delivered seamlessly to clients in an integrated manner. Federation is one kind of coordinated organisational structure.

Federated data clouds are receiving extra attention in the current environment. On the supply side, GAIA-X is a federated cloud initiative that was announced by the governments of Germany and France in October 2019. It has a strong focus on creating a federated data capability, enabling it to address issues around various challenges.

For the purposes of this analysis, the concept of cloud federation is considered from both an architectural perspective and an operational viewpoint:

- From the **architectural** point of view, cloud federation is intended as **distributed** technical resources (computing, storage, data, application services, identity management services, etc.) that are scattered across a network and **pooled** for consumption by a broad set of users.
- From the **operating model** standpoint, cloud federation is intended as the mechanism that regulates how the participating entities collaborate to pool resources for broad consumption.

Edge Computing

Edge computing is a distributed computing paradigm that brings computation and data storage closer to the location in which it is needed to improve response times and save bandwidth. It refers to the "edge" of the network, where a network connects with specific devices, such as smartphones, wearable devices, and Internet-of-Things (IoT) devices.

[7] https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf

Green IT

Green cloud refers to the adoption of green principles across the cloud computing ecosystem and throughout all related equipment lifecycles.

APPENDIX B – PORTFOLIO STRUCTURE

Macro-area 1: Identification	
Project Acronym	This database column should report the project's acronym.
Full name	This database column should report the project's full name.
URL link	This database column should include a URL link to an active webpage.
Contact	This database column should name the individual responsible for project leadership, including the organisations to which s/he belongs and his/her phone number and email address.

Macro-area 2: Description		
Project description	*This database column should include a short paragraph or a maximum of three bullets describing the strategic goals (WHY) of the project and the solutions developed/used (WHAT).*	**WHY**
		WHAT
Project type – actual cloud services	*Research & innovation collaborative projects (European, national, ...)*	**Research & innovation**
	Public initiatives (cloud providers funded by governments)	**Public initiative**
	Private initiatives for profit/ not for profit (industry cloud; no single-vendor commercial offering)	**Private initiative**
	Public-private initiative (i.e. Helix Nebula)	**Public-private initiative**
Duration	*This database column should indicate start and end dates – or no end date if the duration is indefinite.*	**Start date**
		End date
Object	*This database column should explain the focus of the project in terms of the deliverable(s).*	**Enabler** This includes the design and development of a technology that enables the operation of a cloud solution, such as a piece of hardware or software.

Macro-area 2: Description		
		Operator This includes the design, development, prototyping, and production of cloud solutions.
		Broker This entails the orchestration of third-party solutions through a marketplace, a catalogue, framework procurement agreements, an identity and access management portal, etc.
		Regulator This entails the definition, dissemination, and auditing of standards, certifications, and toolkits that help with the procurement, development, deployment, and management of cloud solutions.
Geographic scope	*Local, regional, national, multinational: within the EU, the whole of the EU, other world regions, or global*	**Local/Regional**
		National
		European
		Global
		Named area
Cloud delivery model	*This database column should outline whether this relates to:* • *Infrastructure as a service* • *Platform as a service* • *Software as a service* *as per NIST definitions.*	**IaaS**
		PaaS
		SaaS
Cloud deployment model	*This database column should outline whether this relates to:* • *Public cloud* • *Local cloud as a service* • *Hosted private cloud* • *Enterprise private cloud* • *Hybrid cloud* *as per IDC definitions.*	**Public**
		Local
		Hosted private
		Enterprise private
		Hybrid

Macro-area 2: Description		
Project lifecycle stage	*This database column should explain the stage of cloud solution development and delivery on which the project focuses:* • ***Research and development, including design and engineering**, prototyping, and pilot demonstration* • ***Experimentation and deployment** in a controlled but operational environment* • ***Deployment, operations, and support** in an operational/industrial environment*	**Research & development** **Small-scale deployment** **Operational deployment**
Industry	*This database column should reflect the industry as per IDC classification:* • *Construction* • *Education* • *Finance* • *Health* • *Information & communication* • *Manufacturing* • *Professional services* • *Public administration* • *Retail and wholesale* • *Transport* • *Utilities*	**Manufacturing** **Utilities** **Public administration** **Education & skills** **Finance** **Health** **Information & communication** **Construction** **Retail** **Transport** **Professional services**
Specific domains targeted	*This database column should indicate the specific domains that the project targets:* • *Green deal* • *Science and research* • *Mobility*	**Green deal** **Science & research** **Mobility** **Smart cities**

Macro-area 2: Description		
	• *Smart cities* • *Small and medium-size enterprises (SMEs)*	**Small & medium-size enterprises**
Technology	*This database column should provide a qualitative description of the innovative technologies on which the project focuses beyond cloud. These could include, but are not be limited to:* • *Big data and analytics (BDA)* • *Social media* • *Internet of Things (IoT)* • *Artificial intelligence/ Machine learning (AI/ML)* • *Augmented reality/ Virtual reality* • *Blockchain* • *Edge computing* • *Next-gen connectivity: 5G/6G/wi-fi 6* • *Quantum computing*	**Big data** **Social media** **Internet of Things** **Artificial intelligence/Machine learning** **Augment reality** **Blockchain** **Edge** **Next generation connectivity** **Quantum**

Macro-area 3: Organisation		
Governance model	*This database column should describe the governance model of the initiative*	
Operating model	*This database column should explain how resources are organised to develop/ deliver cloud service:* • ***Centralised**: One legal entity is entirely accountable for organising resources to develop/deliver the service.* • ***Federated**: Service development/delivery responsibilities are distributed across a network but coordinated by an orchestration entity.* • ***Consortium**: Temporary collaboration is set up for the time of the project.*	**Centralised** **Federated** **Consortium**
Ownership and control		**Centralised** **Collaborative**
Business model	*Only for R&D projects, this database column should report the amount of investment in the project. It should also, where relevant, report the share of investment funded by the EU.* *For initiatives other than R&D, this database column should describe the models used to exploit the solutions designed and developed in the project:* • *Typology (licensing, subscription, corporate funding, support services, and government grant)* • *Distribution of annual revenues by category (% share)*	**Funding** **Typology** **Distribution revenues by category**

Macro-area 3: Organisation		
Stakeholders	*This database column should describe the mix of contributors to the project:* 1. *Public sector* 2. *Academia/Research organisation* 3. *Industry – to include R&D units of commercial enterprises* 4. *Community organisations (associations, PPPs, etc.)* *For each four categories, the names, roles, and countries of origin of the participants should be reported.* *R&D projects – a list of coordinators and partners – names and categories* *All other projects – the leader (name and type) and other participants (overall number + % distribution by category)*	**Public sector** **Academia/Research organisations** **Industry** **Community organisations** **Other participants (nr and %)**

Macro-area 4: Impact		
Uptake	*Target users (government, academia, industry, associations, and individual consumers)* *Number of users (most recent data)* *Growth rate (% increase from previous year)* *Revenues (previous year)* *Revenue increase (% from previous year)*	**Target users** **Number of users** **Growth rate** **Revenues** **Revenues increase**
Customer satisfaction	*Improvement of experience, quality of services, no lock in*	
Socioeconomic impact	*Impact on SMEs' industry competitiveness (not a target, low, medium, high)*	**Not a target** **Low** **Medium** **High**
Socioeconomic impact	This database column should describe the socioeconomic impacts of the project.	
Lessons learned	This database column should analyse what went well in the project and what could have been done differently with the benefit of hindsight.	

APPENDIX C – LIST OF INITIATIVES PROFILED IN THE EUROPEAN CLOUD COMPUTING PORTFOLIO

Appendix C shows the initiatives that have been included in the Portfolio and address federation, edge, and green IT.

The initiatives listed below will be consultable in the H-CLOUD online catalogue, which will include detailed descriptions, information on related stakeholders, and links to official websites.

R&I Initiatives Related to Cloud Federation

Name	Short Description
ACTiCLOUD	Novel cloud computing architecture for the drastically improved management of cloud resources
BEACON	An effective, agile, and secure federation of cloud networking resources
MUSA	A security framework to support the security-intelligent lifecycle management of distributed applications over heterogeneous cloud resources
CYCLONE	The management of multi-cloud application deployment, software defined networks, and federated entities
ENTICE	Enables the integration, interoperability, and federation of storage providers
M-Sec	A collaborative project between the EU and Japan, strengthening connections in the technological spheres of big data, IoT, blockchain, and cloud computing
SSICLOPS	Focuses on techniques for the management of federated private cloud infrastructures – in particular, cloud networking techniques
CHOReVOLUTION	Provides an environment to enable interactions between various services currently provided by local authorities and to deliver advanced applications based on, for example, traffic conditions and local weather information
ACCORDION	Opportunistically brings together edge resources/infrastructures (public clouds, on-premises infrastructures, telecom resources, and even end devices) in pools, defined in terms of latency, that can support next-gen application requirements
ATMOSPERE	Considers a broad spectrum of properties and their measures, and supports the building, deployment, measurement, and evolution of trustworthy cloud resources, data networks, and data services

Name	Short Description
PRISMACLOUD	Enables secure and trustworthy cloud-based services by improving and adopting novel tools from cryptographic research
MELODIC	Enables data-intensive applications to run seamlessly within defined security, cost, and performance boundaries on geographically distributed and federated cloud infrastructures
RESTASSURED	Provides solutions to specific technical concerns around data protection in the cloud (such as geo-location restrictions on personal data), which are imposed by the multi-stakeholder and decentralised dynamic nature of federated cloud systems
SESAME	Supports the Cloud-Enabled Small Cell (CESC) concept, a new multi-operator-enabled small cell that integrates a virtualised execution platform (i.e., the Light Data Center) for deploying Virtual Network Functions (NVFs), supporting powerful self-x management, and executing novel applications and services inside the access network infrastructure
SUNFISH	Provides infrastructure and technology to enable public sector players to integrate their computing clouds
FNS-Cloud	A cloud solution that aims to increase the exploitation of food and nutrition security (FNS) knowledge by federating FNS data on diet, health, and consumer behaviour, and aims to promote the exploitation of sustainable agriculture and organic farming

R&I Initiatives Related to Edge Computing

Name	Focus
Pledger	A new architectural paradigm and a toolset that will pave the way for next-generation edge computing infrastructures
DECENTER	Delivers a robust fog computing platform covering the whole cloud-to-things continuum to provide the AI application-aware orchestration and provisioning of resources
ACCORDION	Opportunistically brings together edge resources/infrastructures in pools, defined in terms of latency, that can support next-gen application requirements
SELFNET	Designed and implemented an autonomic network management framework to achieve self-organising capabilities in managing network infrastructures by automatically detecting and mitigating a range of common network problems currently still being manually addressed by network operators
RAPID	A secure unified model whereby almost any device or infrastructure – ranging from smartphone, notebook, laptop, and desktop to private and public cloud – can operate as an accelerated entity and/or as an accelerator serving other, less-powerful, devices in a secure way
CLARUS	Enhances trust in cloud computing services by developing a secure framework for the storage and processing of data outsourced to the cloud, allowing end users to monitor, audit, and retain control of the stored data without impairing the functionality or cost-saving benefits of cloud services
CLASS	Aims to develop a novel software architecture to help big data developers combine data-in-motion and data-at-rest analysis by efficiently distributing data and process mining along the compute continuum (from edge to cloud) in a complete and transparent way, while providing sound real-time guarantees
DITAS	Provides a framework, composed of an SDK and an execution environment, that aims to overcome barriers now hampering the adoption of cloud computing and aims to increase the adoption of fog computing by exploiting the full potential of these two paradigms in a synergic way
FogProtect	Delivers new and advanced architectures, technologies, and methodologies to ensure end-to-end data protection across the computing continuum, from cloud data centres through fog nodes to end devices
LightKone	Provides a scientifically sound and industrially validated model for doing general-purpose computation in edge networks

Name	Focus
mF2C	Designing an open, secure, and decentralised multi-stakeholder management framework, including novel programming models, privacy and security, data storage techniques, service creation, brokerage solutions, SLA policies, and resource orchestration methods
NECOS	Addresses the limitations of current cloud computing infrastructures to respond to the demands of new services, as presented in two use cases that will drive the whole execution of the project
PrEstoCloud	Makes substantial research contributions in the cloud computing and real-time data intensive applications domains to provide a dynamic, distributed, self-adaptive, and proactively configurable architecture for processing big data streams
RECAP	Developing the next generation of cloud/edge/fog computing capacity provisioning via targeted research advances in cloud infrastructure optimisation, simulation, and automation
SESAME	Targets innovations around three central elements in 5G: the placement of network intelligence and applications at the network edge through network functions virtualisation (NFV) and edge cloud computing; the substantial evolution of the small cell concept, already mainstream in 4G but expected to deliver its full potential in challenging high-density 5G scenarios; and the consolidation of multi-tenancy in communications infrastructures, enabling several service providers to engage in new access-capacity and edge-computing sharing models
RAINBOW	Designing and developing an open and trusted fog computing platform that facilitates the deployment and management of scalable, heterogeneous, and secure IoT services and cross-cloud applications (i.e. microservices)
FITOPTIVIS	Developing an integral approach to the smart integration of image- and video-processing pipelines for CPS, covering a reference architecture supported by low-power, high-performance smart devices and by methods and tools for combined design-time and run-time multi-objective optimisation within system and environment constraints
FAR-EDGE	A joint effort to lead experts towards the smooth and broad adoption of virtualised factory automation solutions based on Future Internet technologies

R&I Initiatives Related to Green IT

Name	Focus
COMMUNITY CLOUD	Developing a cloud service to replace centralised server farms with a distributed data centre based on a peer-to-peer network free of infrastructural costs
CLOUDWATCH2	Supporting EU R&D on cloud computing, software, and services across the full innovation lifecycle and move to market, promoting technology advancements and supporting OS software reusability
AFarCloud	Providing a distributed platform for autonomous farming to enable the integration and cooperation of agriculture cyber-physical systems in real-time to increase efficiency, productivity, animal health, and food quality and to reduce farm labour costs
FNS-Cloud	Aiming to overcome fragmentation problems by integrating existing FNS data – which is essential for high-end pan-European FNS research – and by addressing FNS, diet, health, and consumer behaviours, as well as by promoting the exploitation of sustainable agriculture and organic farming
Blue Cloud	Aiming to federate leading European marine data management infrastructures and horizontal e-infrastructures – data resources, computing resources, and analytical service resources – to capitalise on what already exists and to develop and deploy a Blue Cloud framework as a thematic EOSC cloud

Deployment initiatives related to cloud federation

Name	Sector	Focus
CINECA	Public sector	High performance computing, focusing on IT solutions and services for universities and for the Italian Ministry of Education and Research
GDS	Public sector	Centre of excellence in digital, technology, and data, supporting the UK central government
PagoPA	Public sector	Increasing the uptake of trusted digital payments in the public sector
SPOTES	Public sector	Enhancing the IT services experience for French civil servants
BUILD TO SHARE	Public sector	Accelerating the digital transformation of the Irish government and providing common capabilities across departments of different size
BMI	Public sector	Sharing secure data-centre infrastructure across the German federal government
STATENS IT	Public sector	Managing IT operations to improve capacity utilisation and asset maintenance
LOGIUS	Public sector	Offering lower expenditure, improved efficiency, and better services for citizens and businesses through smart ICT solutions
VALTORI	Public sector	Providing high-quality, reliable, and harmonised basic IT services
CSI Piemonte	Public sector	Delivering shared IT infrastructure, applications, and end-user support services
Trentino Digitale	Public sector	Delivering shared IT infrastructure, applications, and end-user support services
SIAG	Public sector	Delivering shared IT infrastructure, applications, and end-user support services
Arsenàl.IT	Public sector	Delivering a shared platform and application services
ARIA	Public sector	Delivering shared IT infrastructure, applications, and end-user support services
Lepida	Public sector	Delivering shared IT infrastructure, applications, and end-user support services

Name	Sector	Focus
Insiel	Public sector	Delivering shared IT infrastructure, applications, and end-user support services
Dataport	Public sector	Delivering a shared platform and application services
AGID Cloud Marketplace	Public sector	A catalogue of AGID-certified cloud service providers
BRZ	Public sector	Delivering shared IT infrastructure, applications, and end-user support services
NICS-ESS	Public sector	Delivering efficient and effective customer-focused services, combining HR, IT, finance, digital services, and property management
G-Cloud	Public sector	A catalogue of cloud services certified by the UK government and included in framework procurement agreements
P-Direkt	Public sector	HR application and business processing services
NoiPA	Public sector	HR application and business processing services
LGMA	Public sector	HR application and business processing services
SPCSS	Public sector	Delivering IaaS, PaaS, and SaaS services in the public sector
DCOM	Public sector	SaaS solutions developed for local administration
Veeva OpenData	Private sector	A science-focused subscription service for HCP, HCO, affiliation, email, and compliance data
SAP ICH	Private sector	A cloud-based solution that enables pharmaceutical partners to exchange serialisation information in a secure and easy manner
CODE	Private sector	Driving innovation and supporting improvements in cancer care, addressing information gaps by providing timely information on anti-cancer medicine use via healthcare systems
Polymore	Private sector	A digital B2B market for the sustainable plastics industry (compounds, recyclates, and post-industrial waste) in Europe
Schneider Electric Exchange	Private sector	A digital platform for energy solution collaboration and a marketplace – an open ecosystem for IoT energy management and automation solutions

Name	Sector	Focus
Helix Nebula Science Cloud	Public-private	A hybrid cloud platform linking commercial cloud service providers and publicly funded research organisations' in-house IT resources, via the GEANT network, to provide innovative solutions in support of data-intensive science
CREODIAS	Public-private	Cloud infrastructure adapted to process large amounts of Earth observation (EO) data, including an EO data storage cluster and dedicated IaaS cloud infrastructure for the platform's users
WEkEO	Public-private	The EU's Copernicus DIAS reference service for environmental data, virtual environments for data processing, and skilled user support
CODE-DE	Public-private	Offering high-performance access to all Copernicus data throughout Germany
GAIA-X	Public-private	Aiming to connect decentralised infrastructure services, such cloud and edge, via a user-friendly homogeneous system
SENSORIS	Public-private	A data standard and exchange for the automotive industry that defines consistency for gathering in-vehicle data
IDS	Public-private	Aiming to create a secure data space that supports enterprises in different industries and of different sizes in the autonomous management of data
Estfeed (E-elering)	Public-private	Energetics-centric IT infrastructure developed in cooperation with partners to offer all interested parties the chance to develop, market, and use smart solutions
Entso-e	Public-private	Providing continuous and free access to key information on the European grid for all market participants and other stakeholders

Deployment Initiatives Related to Edge Computing

Name	Sector	Focus
GAIA-X	Public-private	Aiming to connect decentralised infrastructure services, such cloud and edge, via a user-friendly homogeneous system
FIWARE	Public-private	A framework of open-source platform components to accelerate the development of smart solutions

Deployment Initiatives Related to Green IT

Name	Sector	Focus
Polymore	Private sector	A digital B2B-market for the sustainable plastics industry (compounds, recyclates, and post-industrial waste) in Europe
Estfeed (E-elering)	Public-private	E-elering – a portal to give customers access to data and services Estfeed data platform – an energy data exchange for accessing, sharing, and managing meter data across data suppliers (data hubs), data users, applications (via the E-elering app store and data access management), and customers
Entso-e	Public-private	A transparency platform to provide continuous and free access to key information on the European grid for all market participants and other stakeholders
CODE-DE	Public-private	Offering high-performance access to all Copernicus data throughout Germany