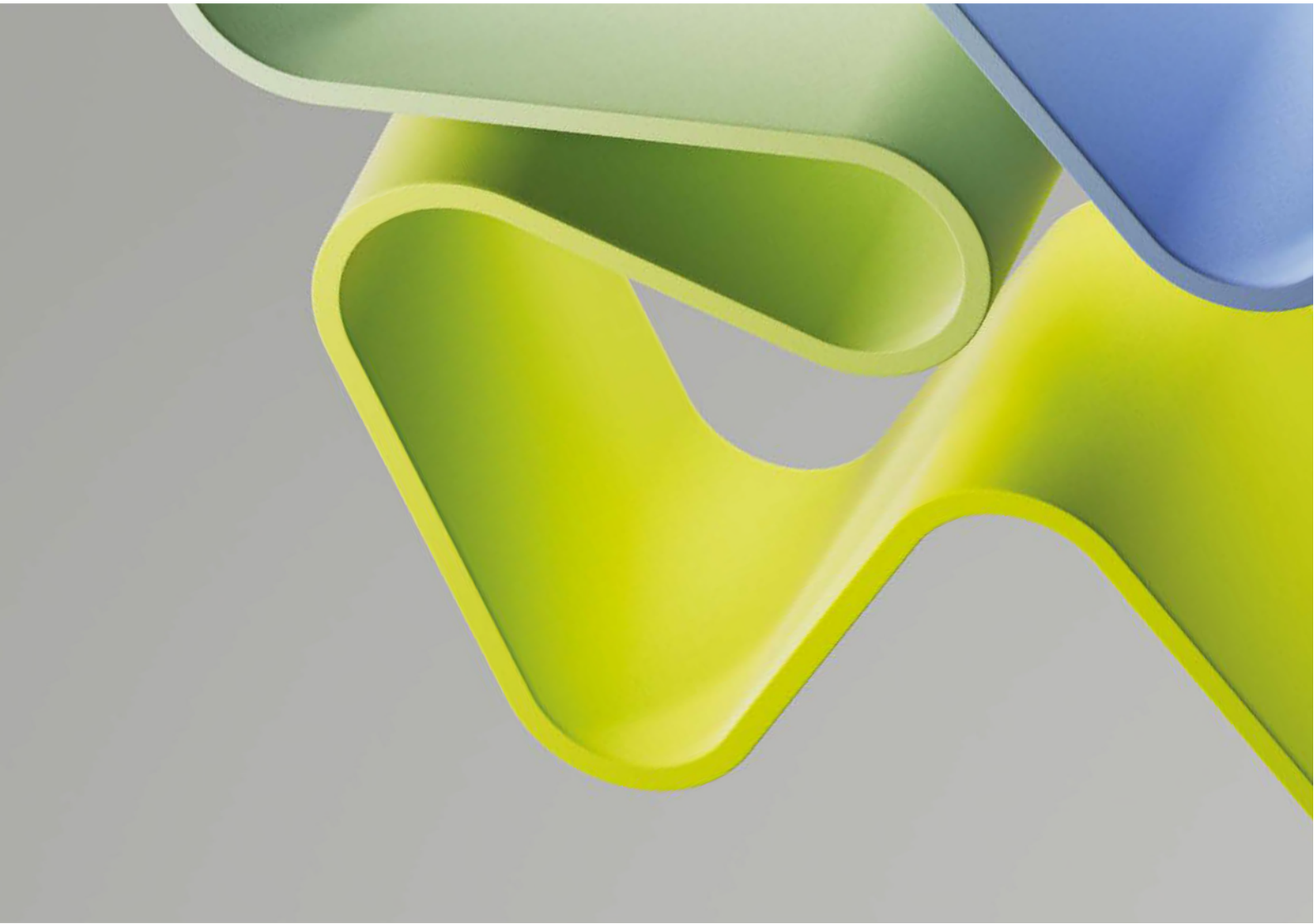
The Research Council of Norway

Norwegian roadmap for Research infrastructure 2025



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Preface

This document has been automatically translated. Please note that the original version may differ, and any discrepancies should be verified against the source language.

The official content can be found in the Norwegian version of the roadmap.

About the 2025 Roadmap

The Ministry of Education and Research has given the Research Council responsibility for preparing a Norwegian roadmap for investments in research infrastructure. The roadmap is updated in advance of each call through the National Financing Initiative for Research Infrastructure (INFRASTRUCTURE), and will, among other things, highlight the need for research infrastructures in the future. Norwegian researchers collaborate extensively with international actors and participate in a number of European research infrastructures. The roadmap therefore makes visible both national infrastructures and international research infrastructures with Norwegian participation.

Function of the roadmap

The roadmap shall:

- communicate the Research Council's strategic decision-making basis for future allocations of funding from the INFRASTRUCTURE scheme
- highlight nationally important research infrastructures that are crucial for achieving research policy goals
- clarify Norwegian participation in international research infrastructures and show the balance and relationship between such participation and national investments
- guide applicants to see future needs in relation to the opportunities provided by already established infrastructures

The roadmap's structure

The roadmap has three main parts:

Part 1: The Research Council's funding of research infrastructure

This section presents the guidelines for how the Research Council finances research infrastructure, and recommendations are made to the ministries and R&D institutions. This is mainly a continuation of previously defined priorities and principles for the division of labour between the actors and allocations from the Research Council.

Part 2: Strategic basis

This part focuses on future needs for research infrastructure within different thematic areas, and the strategic basis for these priorities. To ensure a good coherence between investments in infrastructure and research needs, we have used the priorities in the portfolio plans as a basis for the preparation of the roadmap. The portfolio plans are based on the Research Council's strategy and the Long-term plan for research and higher education 2023-2032. In the work on the roadmap, we

have also used the Government's white paper about the research system which was published in March 2025, in addition to a number of more topic-specific strategies and documents.

Part 3: Funded research infrastructures

This section presents most of the research infrastructures that are under funding from the INFRASTRUCTURE scheme, as well as some international infrastructures with funding through a political decision outside the open competition arena. Research infrastructures that have previously received funding from the INFRASTRUCTURE scheme are listed in table form.

The process for a new roadmap 2025

The institutions that receive infrastructure funding from the Research Council assume considerable responsibility for operating and making national research infrastructures available. It is therefore important for the Research Council to involve the institutions in our thinking about national and international research infrastructure.

When preparing the previous roadmap, a broad round of input was conducted, with both written input and input in workshops. In addition, a committee was appointed to assist the Research Council in the preparation of the roadmap. As a result, there is a lot of material, which has also been useful in this year's update of the roadmap.

To ensure good coherence with research needs, the Research Council's portfolio boards have provided their input. The Research Council has also arranged open digital meetings where the institutions and other stakeholders could provide input on part 2 of the roadmap in particular. The input has been incorporated where appropriate.

Part 1: The Research Council's funding of research infrastructure

The Research Council's strategy describes advanced research infrastructure as a driving force in a well-functioning research system, a prerequisite for research of the highest quality, and provides opportunities for strengthened collaboration between research actors, industry and society. The Research Council will therefore work to prioritise research infrastructure, sharing and making data available, by investing in national research infrastructure and Norwegian participation in international infrastructure cooperation that supports Norwegian priorities.

What do we mean by research infrastructure of national importance?

National investment in research infrastructure only funds infrastructures of national importance. We have therefore developed the following criteria that determine whether an infrastructure is of national importance:

- **The infrastructure must be of broad national importance**
  It should be of great interest to Norway as a nation to establish the infrastructure. The Research Council will take national priorities into account.
- **As a general rule, the infrastructure must be complementary to other existing infrastructure**
  The Research Council encourages research institutions with similar interests to establish an appropriate division of labour and to cooperate on the applications.
- **The infrastructure will lay the foundation for internationally leading research**
  Grants will support activity in environments that are already at the forefront of international research, or that have good, realistic opportunities to get into such a position.
- **The infrastructure must be made available to relevant research groups and industries**
  If there are groups outside the applicant consortium that will need to use the infrastructure, they must be granted access, and a plan for such user access must be described in the application.

The value of national cooperation

Research infrastructure such as expensive scientific equipment, databases and high-performance computing resources are often too expensive for one institution alone. Therefore, collaboration between several research institutions is necessary to build, develop and use such resources effectively. The Research Council can play an important role in coordinating and supporting these collaborations to ensure national utilisation and coordination of investments. By analysing applications, the Research Council gains an overview of needs for research infrastructure and can prioritise large, important investments. We also require cooperation between institutions and other actors in order to receive funding, which promotes accessibility and efficient use of the infrastructure.

The Research Council will:

- **Develop mechanisms for a holistic landscape of research infrastructures**
  To ensure a comprehensive landscape of research infrastructures, subject-specific needs must be linked to national and international investments. Part 2 of the roadmap describes the need for research infrastructures in different thematic areas, where the needs are rooted in different national strategies and seen in relation to ESFRI's landscape analysis. Furthermore, strategic coordination across disciplines is required, where existing research infrastructures are assessed before new ones are established. Good interaction between the ministries, the Research Council and the institutions is important to ensure efficient use of resources and long-term sustainability.
- **Use the opportunities offered by international cooperation on research infrastructures and see national and international priorities in context**
  To meet global challenges and strengthen Norwegian research, Norway will participate actively in international cooperation on research infrastructure. International cooperation provides access to research infrastructure that Norway cannot build alone. At the same time, international cooperation will contribute to increased use of our national research infrastructures and to avoid the development of parallel research infrastructures where this is not appropriate. Decisions on the establishment or further development of international collaboration on research infrastructure will be based on the priorities set out in the Long-term plan for research and higher education 2023-2032.
- **Encourage the national research infrastructures to be proactive towards the private and public sectors**
  National research infrastructures should actively develop partnerships with the private and the public sectors to strengthen research, innovation and societal development. This requires that the research infrastructures establish clear strategies for collaboration both nationally and internationally, make services and data widely available, and offer user support to external actors. Joint research projects and exchange of expertise should be facilitated.
- **See prioritisation and financing of the infrastructures in a life cycle perspective**
  Research infrastructure must be planned and financed on the basis of the entire life cycle – from idea and establishment to operation, upgrading and possible decommissioning. We must take into account that needs change over time and that the landscape is dynamic. Long-term commitment is required from host institutions and users to ensure sustainability and efficient use of resources. Costs must be made visible and distributed across projects and users, and models for co-financing and institutional collaboration must be established.
- **Contribute to good accessibility and utilisation of research infrastructures**
  To ensure good utilisation of research infrastructure, broad access, both physical and digital, must be facilitated for researchers across disciplines and institutions. The infrastructure must follow the principles of open science and ensure that data is retrievable, accessible, interoperable and reusable (FAIR). This requires advanced user support, clear access policies and incentives for researchers to contribute to development and operations. Infrastructures should also include training and career paths for technical and scientific staff and develop

services that respond to users' needs. Cooperation between institutions and sectors is crucial to ensure sustainable operations and high utility value.

- **Strengthen research security through awareness of sensitive knowledge and technology, as well as stricter requirements for data management and other operations**
  A secure research system requires secure access control, especially when handling sensitive data and technologies with dual-use potential. We must have a good overview of which technology areas are considered to be particularly sensitive to national security at any given time, and infrastructure must be established for secure data sharing and classified communication. Data sharing must take place according to the principle of "as open as possible, as closed as necessary", and the operation of research infrastructure must ensure robustness, traceability and controlled access across sectors.

International cooperation on research infrastructures

Participation in international research organisations gives Norwegian researchers access to research infrastructures and the opportunity to participate in innovative and resource-intensive research that would be impossible to achieve with national funding alone. This may be important for safeguarding and developing national expertise in subject and technology areas where Norway may not naturally be expected to take a leading role in establishing research infrastructure. Participation also provides significant potential for networking, technology transfer, data sharing and development of Norwegian business and industry. In future EU framework programmes, greater emphasis will be placed on the role of the business sector, particularly with regard to competitiveness and innovation. A strategy for research and technology infrastructures has just been published, which allows for closer cooperation between businesses and research infrastructures. This will be central in the development of the infrastructure landscape in the future.

At the same time, a cost-benefit assessment must be made of membership in new, large international infrastructures, as well as in connection with decisions on the continuation of existing membership. Such memberships usually entail long-term institutional commitments – both strategic and financial – from all participating partners in the consortia.

Principles for Norwegian participation in international research infrastructure

The Ministry of Education and Research has asked the Research Council to follow up Norway's participation in international research infrastructures. This includes preparing a basis for decision-making and making recommendations for Norwegian membership in relevant infrastructures. This means that Norwegian research groups that plan to participate in international collaboration on research infrastructures must, as a general rule, apply for INFRASTRUCTURE in the same way as national applications for research infrastructures. This is to ensure that the projects of the highest

quality and relevance to Norwegian research are granted. The Research Council prepares its recommendations on Norwegian participation to the relevant ministries that make the final decision on Norway's membership after each application processing in INFRASTRUCTURE.

In collaboration with the Ministry of Education and Research, the Research Council has also established principles for the establishment, continuation and eventual termination of membership in international research infrastructures, how the institutions and the Research Council are to relate to the funding of membership, and to Norwegian representation in the infrastructures' governing bodies.

ESFRI

The European Strategy Forum on Research Infrastructures (ESFRI) together with the European Research Infrastructure Consortium (see below) have become important parts of the international research infrastructure landscape.

ESFRI was established in 2002 by the EU research ministers as an advisory forum for research infrastructure. ESFRI develops strategic roadmaps that identify the need for new or upgraded research infrastructure in Europe. This includes landscape analyses that describe both national and international research infrastructures that are open to European researchers and business actors (ESFRI Landscape Analysis 2024). ESFRI's roadmaps and landscape analyses constitute an important knowledge base for international cooperation and technology transfer.

Many initiatives on participation in international research infrastructures concern infra structures on ESFRI's roadmap. ESFRI's function as coordinator and quality assurer is of great importance for European and other international cooperation on research infrastructure, and for Norway's participation in this cooperation.

National applications for ESFRI roadmap

A national consortium can participate in an application for the planning of a European infrastructure to be included on ESFRI's roadmap, either as leader of the consortium or as a partner. It is necessary that applicants inform the Norwegian ESFRI delegate well in advance of the application deadline.

Both a strategic assessment and a quality assessment are made by ESFRI working groups before the ESFRI forum decides whether the infrastructure should be included in ESFRI's roadmap. Once the infrastructure is on ESFRI's roadmap, it can apply for funding from the Research Infrastructure programme in the EU to prepare for the establishment of an infrastructure. If Norwegian research groups receive funding and work as a result of funding under this call, they can apply for funding from the Research Council of Norway's call for support for Norwegian participation in the planning of research infrastructure under the ESFRI Roadmap.

When the planning is close to complete, the Norwegian communities can apply for funding from INFRASTRUCTURE to create a Norwegian node. Similarly, the groups from the other countries apply for funding from their respective funding agencies. The European Commission only contributes in the planning phase. In the event of Norwegian participation in an ESFRI infrastructure, it is the relevant ministry who sign a binding agreement for Norway. The Research Council makes its recommendation based on the application to INFRASTRUCTURE. For the vast majority of ESFRI nodes, the obligations entail a membership fee in the international infrastructure. The institutions can apply for this membership fee to be covered by the Research Council through the application to INFRA-STRUCTURE. Note that this is only relevant in the construction phase of an infrastructure and that the institutions themselves later must take the full responsibility for this fee.

The timelines for applications to the ESFRI roadmap and the national call for proposals in INFRASTRUCTURE often do not match. A national consortium of institutions can participate in an application to the ESFRI roadmap, but the consortium cannot obtain political support from the Ministry or financial support from the Research Council until it has successfully applied for funding from INFRASTRUCTURE. The institutions themselves can sign a "Memorandum of Understanding" to ensure the institution's participation in the planning phase of the research infrastructure.

Organisation of research infrastructures and the ERIC Regulation

While a national research infrastructure can in many cases be operated within the framework of an existing organisation, an international research infrastructure will typically entail the establishment of a separate organisation for the purpose.

International research infrastructures are different, also in terms of organisational form. For a long time, it was mainly a matter of examples of associations, limited liability companies, international organizations, etc. All these forms of organisation had their weaknesses, and in 2009 the EU adopted a regulation on the European Research Infrastructure Consortium (ERIC).

The ERIC Regulation provides a legal framework for countries that are to cooperate on the establishment and operation of research infrastructures in Europe. ERIC entities have a legal status that allows them to operate across member states' borders with harmonized rules and procedures. This makes it easier to collaborate internationally and ensures a common understanding of roles and responsibilities. An ERIC is also exempt from VAT and customs duties.

The legal framework for ERIC units has facilitated cross-border collaboration and has facilitated a more efficient utilisation of research resources. It ensures long-term institutional commitment from all participants in the consortium, which is critical for stability and continuity in large international research projects. As of January 2025, 30 ERIC units have been established.

European Open Science Cloud and Norwegian participation

The European Open Science Cloud (EOSC) is an initiative launched by the European Commission to promote and strengthen open science in the European Research Area. The vision for EOSC is a common research infrastructure for data and services that cuts across disciplines and national borders.

In order for the vision of EOSC to be fulfilled, it is important that the infrastructure is perceived as useful, relevant and user-friendly by researchers. Involvement is therefore being worked hard to ensure that their interests are represented in the development, organisation and implementation of EOSC.

In addition to the European Commission and country representatives, both research-performing and research-funding organisations, as well as research infrastructures and service providers, are represented on the governing body of the EOSC (Tripartite governance). On the Norwegian side, the Research Council of Norway, CESSDA, NORCE, NTNU, Sikt, UiT, UiO and UiB are members of the EOSC association, while the Ministry of Education and Research and the Research Council of Norway are members of the EOSC board. The Research Council has a statutory role in the association as a 'mandated organisation', given by the Ministry of Education and Research, as a representative of the interests of the Norwegian research system.

ESFRI infrastructures have had and continue to play a particularly important role in the implementation of the EOSC, and cooperation with ESFRI has been ensured at several levels of the organisation.

The Research Council finances membership fees in the EOSC Association for Norwegian institutions and is based on annual applications to the scheme Support for membership of the European Open Science Cloud Association.

EuroHPC Joint Undertaking and Norwegian participation

Norway is a member state of the European High-Performance Computing Joint Undertaking (EuroHPC). EuroHPC acquires, operates and makes available European supercomputers, artificial intelligence adapted supercomputers, quantum computers and data infrastructures for use in research and innovation. Norway is a co-owner of the LUMI supercomputer, which is located in Finland.

Norwegian researchers and companies can apply for LUMI computational resources through Sigma2 and both computational resources and projects through the calls on EuroHPC's website. A prerequisite for Norwegian actors to be awarded funding through EuroHPC's project calls is that Norway is associated with the EU framework programmes that contribute funding to the call. EuroHPC administers funds from Horizon Europe, Digital Europe and the Connecting Europe Facility, while Norway is only associated with the first two.

The Research Council represents Norway in the EuroHPC steering group, with one delegate. In addition, several Norwegian experts from relevant actors in Norway provide advice when deciding on matters of special interest.

Different roles when deciding on the establishment of research infrastructure

In line with the white paper Climate for Research, there is a defined division of responsibilities between the R&D institutions, the Research Council and the ministries when it comes to decisions on the establishment of research infrastructure.

R&D institutions

Basic infrastructure at the R&D institutions includes scientific equipment that is required to ensure academic activities at a prudent level. Investment in and establishment of such infrastructure should be made by the institutions themselves, and financed from the institutions' basic allocations. The R&D institutions are considered to be in the best position to assess the need for this type of equipment and to ensure simple and good allocation procedures. The Research Council will contribute to the institutions' own investments by ensuring that all grants for R&D projects from the Research Council that involve the use of "procured" infrastructure can cover a proportionate share of the depreciation on these infrastructures. In addition, the grants can cover the operating costs for the project's use of infrastructure. "Project-specific equipment" can also be funded through the Research Council's grants. This is equipment that is necessary for the implementation of the research project, but which has no application beyond the current project.

Ministries

Decisions on international cooperation on research infrastructures that entail significant and permanent commitments related to investments and membership fees are made at the ministry level. National research facilities that involve investments exceeding NOK 200 million will also be handled at ministry or government level, preferably on the advice of the Research Council. Preferably, these are funds that must come in addition to the permanent item for research infrastructure in the national budget.

The Research Council of Norway

The Research Council shall make decisions on investments in infrastructure of national importance. Allocations from the Research Council's budget are intended to support the development of nationally prioritised research areas and nationally important industries with a major need for research infrastructure. The division of responsibilities means that the Research Council shall contribute to the

coordination of the institutions when several research groups need research infrastructure, but the costs are so high that it is most appropriate to collaborate. The Research Council assesses infrastructure applications from NOK 2 million and upwards and, may contribute up to NOK 200 million to individual projects.

The establishment of research infrastructure that needs external funding in excess of NOK 200 million is decided at ministry or government level. However, the Research Council may assess applications for amounts greater than NOK 200 million in order to then be able to make recommendations to relevant ministries. Institutions or consortia that wish to establish research infrastructures that involve such high investments are therefore encouraged to contact the Research Council so that any application can be submitted and assessed together with other applications. Any positive recommendation from the Research Council will be based on the infrastructure having received a very positive assessment in accordance with the Research Council's criteria. In exceptional cases, the Research Council may, following dialogue with the Ministry of Education and Research, support a design phase.

Since INFRASTRUCTURE is primarily intended to renew Norwegian research infrastructure, the Research Council is restrictive in allowing this scheme to contribute to funding the operation of research infrastructure. Expenses for the operation of research infrastructure shall instead, and as far as possible, be covered by the projects that use the infrastructure. The Research Council therefore requires applicants for funding for the establishment of research infrastructure to also submit plans for how sustainable operation of the infrastructures can be achieved. User fees from the R&D projects that use the infrastructure should preferably be an important part of the operational funding. Expenses for the use of research infrastructure are therefore legitimate costs in any application for research funding from the Research Council's various funding schemes.

In exceptional cases, however, it may be considered whether operating costs for new or existing infrastructure of national importance should be supported through INFRASTRUCTURE. Infrastructures with very high operating costs that there are good reasons why ongoing projects, the host institutions or other financiers are unable to fully cover, may receive long-term support for operations after special assessment. Similar exceptions may be made in other circumstances where funding from the user projects or the infrastructures' owner institution(s) is clearly inappropriate.

Research data

Data has always been one of the key building blocks of research, and in line with newer digital information technology, it is taking an increasingly larger role in the development of knowledge, not only in research, but also in administration and industry. This makes data an important resource that must be managed properly to fully exploit the value of the data.

Awareness of the value of high-quality research data has laid the foundation for policy development both nationally and internationally over the past two decades. Much of the development has taken place within

the EU's European Research Area (ERA) policy, the associated European Cloud for Open Science (EOSC) initiative and the European Strategy Forum on Research Infrastructure (ESFRI).The EU has set a goal that all publicly funded research data should be as retrievable, accessible, interoperable and reusable (FAIR) as possible.

Norway has largely taken the same line. The Long-term plan for research and higher education 2023-2032 assumes that Norway will participate in the EOSC and strive for FAIR research data. In the report from the Data Infrastructure Committee, which forms the basis for the Long-term plan for research and higher education 2023-2032 and the Government's white paper about the research system, it is emphasized that high-quality research data is dependent on both physical and human components: technology and expertise.

Research data of high quality and value depend on high-quality generation, processing, access and analysis in line with international best standards. Data of particularly large volume or with special protection needs will often be difficult to handle for data producers alone and need specialised infrastructures for storage. With a desire for the entire research system, from the largest universities to the smallest departments, to maximize the potential of their research data, the system white paper emphasizes the need for an "increased emphasis on data infrastructure". Because we want all parts of the research system—from big universities to small departments—to make the most of their research data, the Government's white paper about the research system says we need to focus more on data infrastructure. As a national infrastructure, Sigma2 is a provider of storage of large and sensitive data, respectively, through NIRD and Services for Sensitive Data. This is discussed in more detail in the section Generic data infrastructures.

Recommendations to the ministries

The large number of applications for INFRASTRUCTURE, and the very good assessments that many of these applications have received, show that there is a great need and potential for national research infrastructure in Norway. In some areas, there is a need to establish new infrastructure, and there will be a continuous need to upgrade existing infrastructure to ensure that Norwegian research communities have the equipment required to achieve sufficient quality and efficiency. It is important that Norway maintains the volume of investment in national research infrastructure in the coming years. Part of the investments are expected to go to cover operations. A long-term approach to funding is crucial for maintaining strategic room for manoeuvre in the best interests of Norwegian research over time.

Recommendations for R&D institutions

The Project Owner and the project partners must enter into a binding collaboration in which they have clear, long-term plans for how they will manage, operate and make available the infrastructure they establish. The institutions must ensure that there are qualified personnel with special responsibility for day-to-day operations. The establishment and operation of national research infrastructures entails a

responsibility for making research data available and secure, and an obligation to develop and facilitate the infrastructure for all relevant user groups. Good management of a national research infrastructure includes user dialogue and mobilisation of users.

The establishment of a national research infrastructure entails a great deal of responsibility. It is essential that the research infrastructure is anchored in the senior management of the host institution and the partners. The institutions must make a financial commitment. It is recommended to establish business models for long-term and sustainable operations where relevant user groups and/or user institutions contribute to the financing.

Research institutions are encouraged to have financial systems that highlight all costs associated with research infrastructure, including operating costs and depreciation on infrastructure acquired by themselves. These costs should, as far as possible, be distributed among the R&D projects that use the infrastructure and be made visible in the project budget. This means that research funders, including the Research Council, can cover infrastructure costs incurred in the projects. Research institutions are encouraged to make use of this opportunity.

Duplication of research infrastructures at national and European level should be avoided as far as possible. Research infrastructures that are established or further developed should therefore strive to build on existing solutions, technology and networks whenever possible.

Part 2: Strategic basis

This part of the roadmap focuses on future needs for research infrastructure in various thematic areas, and the strategic basis for these priorities. These descriptions are an important part of the decision-making basis for allocations to research infrastructure from the Research Council's budget and the planning of future calls for proposals for research infrastructure.

Parts 2 and 3 will provide an overview of current research infrastructures and future needs. This will help coordinate infrastructures across disciplines and technology. When considering establishing new research infrastructures, one must also look at what the existing infrastructures already offer.

Thematic areas

Investment in research infrastructure must take place within topics and disciplines where research is funded. In the division into thematic areas, we have therefore taken the Research Councils' portfolios as our starting point, with some adjustments to ensure a holistic approach. The structure is as follows:

- Generic data infrastructures
- Enabling and industrial technologies
- Energy and transport
- Climate and environment
- Food and bioresources
- Health
- Humanities and social sciences
- Other natural sciences

Because the infrastructure needs in different areas vary greatly in terms of types/categories of infrastructure, investment and operating costs, and the number and types of users, the descriptions will vary somewhat in length and level of detail. There will be some overlap between some of the sub-areas, and the division should not represent obstacles to collaboration on research infrastructure across the areas. An interdisciplinary approach is a prerequisite for solving many of society's challenges and for succeeding in the development and utilisation of new technology and industries.

Long-term plan for research and higher education 2023-2032

The long-term plan has been, and will continue to be, an important part of the decision-making basis for the Research Council's allocations to research infrastructure. The Long-term Plan puts forward three overarching goals that apply to all disciplines, including six thematic priorities. The six thematic priorities are selected areas where the Government believes it is particularly important for Norway to invest strategically in research and higher education in the years to come.

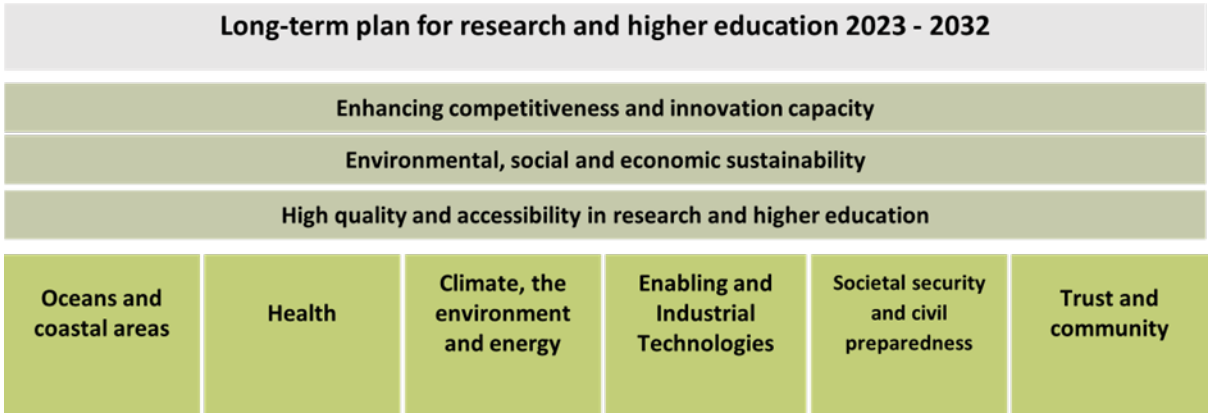

Figure 1. Overview of the overall objectives and Thematic priorities of the Long-Term Plan

The long-term plan encompasses a wide range of topics, disciplines and technology areas, and at the same time provides some guidelines for areas that should be given special attention. The need for investments in research infrastructure within all the priority areas has been clearly addressed, and in particular the need for infrastructure for data management.

Secure knowledge in an uncertain world

The research policy objectives and thematic priorities that were determined in the Long-term plan for research and higher education 2023-2032 are fixed in the work on the research system (Meld. St. 14 (2024-2025)).

In today's society, major political tensions and new threats mean that the research system must be equipped to deal with increasingly complex ethical and security challenges. At the same time, the Government will safeguard important principles such as transparency and verifiability. We therefore need infrastructures and regulations that ensure transparency and accessibility where possible, but also security and protection where necessary.

In the white paper on the research system, the Government focuses on the need for an updated digital research infrastructure and to ensure sufficient computing power. The Government has also prepared an overview of measures of relevance to research in artificial intelligence and future data processing. The overview provides a picture of the ministries' total efforts in this area and will be updated annually. They are also concerned with collaboration between sectors and describe that parts of the digital research infrastructure must be further developed to serve broader societal purposes than research.

The Research Council's portfolio plans

In 2024, the Research Council organised its investment work into 11 new portfolios. A 12th portfolio will be established in 2026 with a focus on defence, national security and emergency preparedness.

Through portfolio management, the Research Council will develop a strategic and comprehensive portfolio. The portfolio plan is the overarching steering document for each portfolio and is intended to facilitate management of the portfolio in which objectives, priorities, investments and results are viewed in context, and form the basis for annual measures and investments. To ensure that there is a good correlation between investments in infrastructure and the needs of research, it is therefore important to use the priorities in the portfolio plans as a basis for the preparation of the roadmap.

Generic data infrastructures

The sciences as a whole are becoming increasingly data-intensive. Disciplines that are traditionally data-intensive have long increased both the production and use of data with the help of advances in measurement instruments, analysis methods and computational technology. At the same time, disciplines with traditionally lower data intensities are adopting new methods that allow them to collect and make use of ever-increasing amounts of data. Although increased data intensity and digitalization open up new opportunities, it also poses new professional, legal, ethical, as well as security challenges. This places higher demands on data management infrastructures, and capacity is needed for storage, high-performance computing, data transport and curation.

The infrastructure landscape ahead

The Government's white paper on the research system assumes that Norway has experienced and will experience an increased emphasis on data infrastructure in the years ahead. Most of these will be discipline-specific data infrastructures. Generic data infrastructures will in many cases not be used directly by the researchers, but will support the more discipline-specific infrastructures. In this respect, they constitute an important foundation on which other infrastructures and services can be built. Increased needs in specific areas of research may therefore lead to a direct increase in the need for generic data infrastructures.

A key generic data infrastructure is Sigma2, which offers capacity and expertise for high-performance computing and large-scale data storage. Sigma2's high-performance computing capabilities include national calculators and European calculators through the EuroHPC collaboration. Sigma2 offers its resources directly or in collaboration with other national infrastructures. They coordinate National Competence Centre for High-Performance Computing (NCC) in collaboration with SINTEF and NORCE, and offer services and guidance for high-performance computing users through the Norwegian Research Infrastructure Services (NRIS) in collaboration with UiO, UiB, NTNU and UiT.

Sigma2 also has significant storage capacity for research data, also for sensitive data in the NORTRE collaboration. Although sensitive data are primarily associated with social science research and health research, infrastructures for sensitive data may be relevant in fields outside of these. Infrastructures must prepare to meet the demands placed on the handling of sensitive data when they are analysed to an extended extent in virtual spaces, on high-performance computing infrastructures and across national borders, for example through the European Health Data Space. Future developments in the generation and use of sensitive data will place special demands on both technical solutions, legal expertise and other processing in the infrastructure.

Currently, Sigma2 is funded by competitive funds through the Research Council's INFRASTRUCTURE scheme. In 2024, the Research Council submitted a report on high-performance computing to the Ministry of Education and Research in which they recommended that Sigma2 be removed from the INFRASTRUCTURE scheme and financed through a more stable and predictable

basic allocation. This is in line with the previous recommendations in the evaluation of the infrastructure initiative as a funding indstrument and the report from the Data Infrastructure Committee. A rapidly increasing need for computing capacity is expected in the future, and an upgrade is necessary in the years to come.

At the same time, the Norwegian research communities are experiencing challenges in realising the national strategy on access to and sharing of research data, particularly with regard to making research data retrievable, accessible, interoperable and reusable in accordance with the FAIR principles. The reports from the Data Infrastructure Committee and the FAIR report refer to a lack of knowledge and services for data sharing as a key barrier.

On this basis, the Storting has based its decision on the Long-term plan for research and higher education 2023-2032 that efforts will be made to ensure that all disciplines in Norwegian research are offered expertise, guidance and curation of research data by 2030, also with a view to using data across research and public administration. Much of this expertise already exists in domain-specific environments and infrastructures, and should be better utilised to scale and expand to generic services, in interaction with the research communities and more generic data infrastructures. Such a development is in line with the Research Council's strategy and portfolio plan for the research system.

In the European context, initiatives are underway to establish centres for curating and fumigating data through the European Cloud for Open Science (EOSC). Norwegian communities participate in several of these.

Enabling and industrial technologies

Infrastructures within enabling technologies will help to drive radical innovations, new groundbreaking technologies, major societal changes and international competitiveness. Enabling technologies refer to broad technology areas with a wide range of known and unknown areas of application. In the Long-term plan for research and higher education 2023-2032, enabling technologies are referred to as the following thematic areas:

1. Biotechnology encompasses biological systems, living organisms, or parts thereof, and is a generic technology that helps modernize several sectors, including industry, agriculture, aquaculture, and health.
2. Nanotechnology and advanced materials include the use of nano-, micro- and materials technologies to develop and manufacture advanced materials and systems with specific and controllable properties.
3. Information and communication technology (ICT) includes technologies that enable collection, storage, processing, sharing, communication, visualisation, use and collaboration of data and information in electronic form.

In the Long-term plan for research and higher education 2023-2032's discussion of enabling technologies, the importance of artificial intelligence, quantum technology and neurotechnology is highlighted as particularly priority areas.

Industrial technologies are referred to as generic, advanced technology platforms that utilise and build on the enabling technologies. Reference is made to vulnerable value chains that highlight the need for advanced production processes that can also contribute to reduced emissions, standardisation and increased reuse. Industrial technologies can be split-up thematically, sorted by value chains; raw materials, process and metal industry, goods production.

The Portfolio Plan for Enabling Technologies from 2025 points out that it is important that research has access to national and international advanced laboratories as well as other physical and digital infrastructure. As research becomes increasingly data-driven, this requires data with quality and transparency, computational capacity, storage capacity and advanced tools for data analysis.

The infrastructure landscape ahead

Radical innovation and cooperation with the private sector must be facilitated, and barriers to cross-sectoral use of infrastructures should be lowered. Here, good and coordinated development of technologically relevant research infrastructures nationally and the EU's new work on technology infrastructures will be central and provide important opportunities for further development and cooperation.

In the future, more money should be set aside for research infrastructures in advanced materials, bio-, nano- and quantum technology. Generic infrastructures that support research across the relevant disciplines, and that have many users, should be prioritised. It is important to upgrade and further develop existing, well-functioning infrastructures to support long-term and basic research and ensure good utilisation of them. At the same time, it must be opened up for financing of new infrastructures of high strategic importance.

Biomaterials and sensors play a key role in the development of medical products and sustainable solutions. The Safe and Sustainable by Design (SSbD) methodology with assistance from artificial intelligence has become important for nanotechnology, advanced materials, health, safety, the environment and sustainability. In general, there is a growing need for data-driven methods, machine learning and artificial intelligence in technological research, and there is a need for capacity to handle large amounts of data.

The defence sector's long-term plan for 2025–2036 emphasises that a technological lead in big data, artificial intelligence, autonomous systems, space technology and quantum technology is crucial for Norwegian and allied security and defence capability. It is therefore important that we have updated research infrastructure that covers these areas. In the future, we should invest in research infrastructures that strengthen Norway's preparedness and sovereignty, and further develop our strength in semiconductor and sensor technology, including quantum sensors. Efforts should be made to develop infrastructures for quantum technology and digital infrastructure that use artificial intelligence.

International analyses underline the importance of investing in research infrastructure in enabling and industrial technologies. ESFRI's landscape analysis points out that in order to be technologically leading, such infrastructures must be continuously developed, including in photonics, advanced materials, nanotechnology, and micro- and nanoelectronics. According to the World Economic Forum's report on technology convergence, the most important future technologies are artificial intelligence, omni computing, synthetic biology, robotics, advanced materials, spatial intelligence, quantum technology, and next-generation energies. In its report on technology trends in the period 2025-2045, the NATO Science & Technology Organization highlights, among other things, the race for AI and quantum technology as well as the biotechnological revolution as key trends, while the EU's overview includes advanced semiconductors, AI, quantum technologies, biotechnology, digital technology, sensors, space technology and recycling.

Biotechnology

Research infrastructures in biotechnology are essential for the green transition and are highlighted in the Long-term plan for research and higher education 2023-2032 as particularly important in the areas of food, health, aquaculture, agriculture and the environment. They are also central to security and preparedness, including food security, medicine and vaccine development. We currently have important infrastructures in bioinformatics, gene sequencing, protein analyses, structural biology, and imaging technologies. Some of these are part of European cooperation projects under ESFRI.

The World Economic Forum highlights synthetic biology as a key technology, particularly the interaction between biotechnology and artificial intelligence in health, food, and industry. Examples are AI-based drug development and biofabricated materials. NATO points out that advances in synthetic biology and gene editing offer great opportunities, but also challenges with health security and ethics.

Biotechnology is important for all parts of medicine and health research - from preventive medicine, to the development of new treatments and drug production (biopharma). Methods in bioscience, molecular biology, cell technology and biomedicine are crucial for innovation in biotechnology. We need infrastructures that support these disciplines, and special attention should be paid to personalised medicine and the health industry. There is a growing need for better integration of medical, digital and eHealth technologies. Research infrastructure for medical and health research is also discussed in the section Health.

Biotechnological research infrastructure is important for food production and bioresources. Biotechnology contributes to efficiency and ensures healthy food with a low climate and nature impact. In the marine industries, agriculture and the process industry, we need better utilisation of biomass and the development of new feedstuffs. In the years to come, we should focus in particular on scale-up and piloting facilities for fermentation processes and bioproduction, among other things. Biotechnology is also crucial for research on breeding, plant health, animal health and soil health. In order to succeed with the Social Mission of Sustainable Feed, and to solve challenges in eHealth, biotechnological research infrastructure is central.

Nanotechnology and advanced materials

Nanotechnology and advanced materials are increasingly important for innovation and national security. Half of the EU's 10 critical technologies for economic security require infrastructure that falls under nanotechnology and advanced materials. The Long-Term Plan for the Defence Sector 2025-2036 also prioritises these areas for the Norwegian defence industry.

Norway already has good generic cleanroom facilities for nano, quantum and materials technology. It is important to upgrade these with cutting-edge equipment so that they can be at the forefront of research, while the use of the new equipment requires pre-processes and analyses that require well-maintained existing laboratories. There are also good laboratories for general and specialized materials characterization. In order to utilise Norway's membership of the European Synchotron Radiation Facility (ESRF) and the European Spallation Source (ESS), there is a need for relevant national expertise and infrastructure.

Modern, advanced equipment for materials characterization will be important for resource utilization, sustainability and safety, and is relevant for many disciplines and technology areas. Public R&D environments often collaborate closely with companies, and advanced materials are

important for membranes/separation technology, chips, sensors, solar technology, and batteries. Many research results are taken forward in start-ups and established industry, and can contribute to Norwegian competitiveness.

In Europe and in Norway, experimental pilot lines for research and development in semiconductor technology (part of the Chips Act) are being built up and these are available to Norwegian companies and research communities, possibly with the assistance of the "Chips Competence Centre".

ICT

In the future, we will need more specialised infrastructure, especially for artificial intelligence, quantum technology and test facilities for advanced ICT equipment, as a platform for both experimental ICT/HPC research and production-oriented high-performance computing in other disciplines. At the same time, we must safeguard sustainability by facilitating energy-efficient data processing and communication.

Global partnerships, cooperation and links to international infrastructures, such as current and future infrastructures established under EuroHPC, EuroQCI and ESFRI, within the priority technology areas will be crucial for accelerating Norwegian ICT research and ensuring access to critical infrastructure.

We need a national research infrastructure for research and innovation that addresses "the compute continuum" by tying high-performance computing together with future internet technologies, smart networks and services. The infrastructure must be flexible and support research into networking, computing, and storage – especially with cloud and edge technology. Among other things, it will make it possible to solve new challenges and conduct innovative research in the areas of the Internet of Things, low-latency communication and distributed systems. Cybersecurity is becoming increasingly important in the face of advanced threats, including AI-powered attacks. It is necessary to establish realistic test arenas where we can develop, simulate, validate and verify secure solutions.

Artificial intelligence is changing the ICT field rapidly, and is becoming increasingly important for society. In order to safeguard national interests, privacy and security, we must ensure robust storage and access to good, standardised and representative data, robust national high-performance computing capacity adapted to artificial intelligence and be able to operate large language models and other new models in Norway - while maintaining access to international solutions. The research infrastructure must cover the entire value chain – from collection and management of data to the development, testing, training and operation of artificial intelligence models – and also be able to be seen in the context of capacity in the business sector. Intelligent autonomous systems will have more tasks in society in the future, and it will be critical for safety that this technology is under Norwegian control and works in harsh Norwegian conditions. We should therefore have up-to-date development and testing facilities available to Norwegian academic communities.

Norway has internationally strong environments in neuroscience and microchips, and good traditions for interdisciplinary collaboration, which gives us particularly good conditions for asserting ourselves in

neurotechnology – technology that makes it possible to measure and manipulate activity in the nervous system. We must therefore ensure that infrastructure for research and development of neurotechnology is available and up-to-date.

Quantum technology

Quantum technology is a new, strategic focus area for the Government. It will be important to think holistically and take into account the entire value chain and ecosystem around quantum technology. We must ensure that we have infrastructure that facilitates research and development of quantum sensors, components and systems and interaction with other technologies, both at room temperature and cryogenically. In quantum computing, Norwegian communities are strong in quantum software, middleware and algorithms. International, and especially Nordic cooperation on access to quantum computers, is very important since these are too expensive to develop and operate for Norway alone. At the same time, we must build up national infrastructure for quantum communication – with nodes, fibre networks and secure transmission capacity to build the necessary expertise, and to facilitate Norway's active participation in Nordic and European cooperation.

Industrial technologies - raw materials, process and production technology

Defence security is closely linked to security of supply, and in the current geopolitical situation, this is more important than it has been for a long time. Access to critical raw materials and the ability to further refine these through a robust process and manufacturing industry is crucial. The Government has proposed measures through the Norway mineral strategy, Prosess21, Green industrial initiative 2.0 and the Governments white paper on competitiveness of Norwegian industry to strengthen Norwegian industry and contribute to the EU's green transition. To support this development, it is important to have good research infrastructure along the entire value chain, from the extraction of raw materials to products in use.

Norway has good opportunities to develop industry based on land-based critical minerals. There is a need for research in geology, mineral extraction, processing technology and metal production to ensure growth in the Norwegian mineral industry and create new value chains. Existing research infrastructures should be updated, and there is a need for new research infrastructure to support research into advanced exploration technology, analytical opportunities and recovery technologies. Seabed minerals are discussed under the section Energy and transport.

According to Green industrial initiative 2.0, Norway will have the world's cleanest and most energy-efficient process industry, based on high-tech solutions. Research infrastructure is important for developing technology that reduces emissions and increases value creation. The process industry cooperates closely with Norwegian research communities, and as emphasised in the Government's white papers on the research system and competitiveness for the industry, this cooperation should be strengthened.

Research infrastructure for process technology and materials characterisation should be placed in connection with strong research environments, which can ensure optimal utilisation of the equipment. Digitalization, including the development of digital twins and simulation tools, is important to make the industry greener and more efficient.

In the autumn of 2024, SIVA, Innovation Norway and the Research Council of Norway submitted a report to the Ministry of Trade, Industry and Fisheries that analyses the challenges in the Norwegian manufacturing industry. The conclusion is clear: Norwegian material and goods production has major challenges in using digital technology, especially artificial intelligence and data analysis to optimize production. Norwegian research infrastructure for production technology should support research on small, advanced and automated productions. It should also facilitate research into material use, recycling and modern production methods such as additive manufacturing.

Energy and transport

Infrastructure in energy and transport shall contribute to research for a sustainable and future-oriented low-emission society with enough renewable energy in the right place at the right time, safe and robust land- and ocean-based transport solutions, a sustainable use of natural resources and a competitive business sector, and includes the following thematic areas:

1. Energy and low emissions include the production, distribution and use of renewable energy, as well as low-emission solutions and the decarbonisation of industrial processes.
2. Petroleum includes oil and gas activities in open areas on the Norwegian shelf.
3. Maritime includes all types of ships and vessels, including vessels and maritime technology related to other ocean industries.
4. Transport includes the development, testing or piloting of new, smart mobility solutions, and can include freight and passenger transport within all four modes of transport (road, rail, sea and air).
5. Seabed minerals include a possible future extraction of minerals on the seabed.

According to the portfolio plan for energy and transport, access to world-class research infrastructure and data through national and international collaboration is a crucial tool for research quality.

The infrastructure landscape ahead

Investments have been made in a number of national infrastructures within the above-mentioned research fields. Initiated research centres help to ensure good coordination and utilisation of research infrastructure and to ensure good links with the business sector and the basic research relevant to the portfolio. It is important to look at the development of infrastructures in Norway in the context of what is happening in terms of the establishment of research infrastructure in the EU and internationally. The EU's new work on technology infrastructures can also provide important opportunities for further development and cooperation.

The energy and transportation sectors are evolving rapidly with increasing use of artificial intelligence, electrification, and autonomous systems. This increases the need for high-performance computing, data storage and sharing, data security, and digital technologies. Information and communication technology will be important for sustainable energy production, distribution and energy efficiency.

The use of artificial intelligence and machine learning in research in the field requires large amounts of data. To train for critical situations that haven’t happened yet and where there’s no data, we need infrastructure that can create realistic data and allow testing of solutions at the system level Digital twins provide better models and support real-time decisions.

Increased digitalization makes systems more vulnerable to cyber attacks, and it is important to secure the energy and transport sectors against such threats. A growing international threat situation underlines the need to focus on security.

Energy and low emissions

Infrastructures in this area will contribute to research and innovation for a future sustainable energy system, renewable energy production, efficient energy use and reduced CO2 emissions in industry. The area also includes the transition of the transport sector to future zero- or low-emission solutions and includes both maritime, land- and air-based transport.

National infrastructures have been funded in wind power, battery, hydrogen and solar cell technology, bioenergy, energy systems, energy use in buildings and industry, and CO2 management. There is a need for both upgrades and new infrastructure in several of these areas.

When it comes to infrastructures for research on power grids and electricity transmission, new investments and upgrading of existing infrastructures are necessary. Digitalisation, electrification and safety are becoming increasingly important. To ensure flexibility in the integration of intermittent energy sources into the power system, there is a need for further research into hydropower and variable operation of hydropower plants.

The sustainable energy systems of the future require the development of new technologies, for both production, storage and use of energy. There is a need for research infrastructures that include test facilities and facilitate research on the reuse and recycling of materials. Circularity and recycling are crucial for the development of new energy technologies.

Hydrogen is an energy carrier and has the potential for energy storage. To realise the value chains for hydrogen and related energy carriers, there is a need for both upgrading and new research infrastructure to ensure that there are gradually research infrastructures along the entire value chain with safety as an integral part of this.

In offshore power generation, there is a need for the development of marine, electrotechnical and materials engineering laboratories and test centres. In addition, there is a need for equipment, sensors and more measurement data to be able to design even better models that are used, among other things, to optimize wind and solar power facilities.

There are relevant ESFRI Landmarks for parts of the Norwegian energy sector, and the most important are in solar energy, offshore wind and CO2 management. Research infrastructure for CO2 capture and storage is largely integrated into the ESFRI project The European Research Infrastructure for CO2 capture, utilisation, transport and storage (ECCSEL ERIC), where Norway is the host nation. ECCSEL ERIC has received funding from the Research Council of Norway on several occasions.

Nano and materials technology is used in large parts of energy research, for example in solar energy research and research on battery and fuel cells. There may be a need for updating and testing facilities for these areas. Bioresources infrastructures are used in bioenergy research, biofuels and other bio-based products. Climate and environmental infrastructures are important for the breadth of the energy field.

Petroleum

It is still important to continue the ongoing large research infrastructures/test centres in well, drilling and multiphase, both for the research communities and the business community. These are used for world-leading research and to pilot and verify new technology. At the same time, there is a need for strengthened research infrastructure in subsea technology, for example related to long subsea tiebacks. Deeper understanding of fluid chemistry, multiphase flow, and interactions with production chemicals are essential to optimize energy efficiency.

Many petroleum fields on the Norwegian shelf are in a mature phase. Therefore, there is still a need for methods that are cost- and energy-efficient for recovery and production, as well as for safe and efficient permanent plugging and abandonment of wells (P&A). There is also a need for research and technology development to increase safety, including physical and cyber security, major accidents and oil spill preparedness, which will also be valuable for the maritime sector.

There is a need for infrastructure that can contribute to technological improvement and innovation for accurate imaging of subsurfaces, and better understanding of fluid systems in porous media. The infrastructures should be a platform for research on multiphase flows in the subsurface and energy-reducing solutions. The need includes both experimental equipment and ICT-related infrastructure.

Fatigue and fracture are a major challenge for structures made of metallic materials. All offshore energy production is exposed to this phenomenon due to the combination of large forces and aggressive chemical conditions in salt water. There is therefore a need for a research infrastructure that provides a better understanding of material challenges and corrosion in connection with the transport of fluids.

Energy efficiency and emission reductions on the Norwegian continental shelf are a high priority. Technologies such as autonomy, automation, robotics, drones (both above and below water), subsea technology and communication, and artificial intelligence can be important. It is important to have a good workflow and collaboration between different disciplines, as well as more efficient processes and energy recovery. It is often useful to develop physical and digital infrastructure in close integration. For example, a portal for making process data, both field data and simulated data, available could be useful for research, education and innovation.

Maritime and transport

It is a goal for Norway to continue to be a world-leading ocean nation, and for Norwegian ocean industries to deliver the most innovative, sustainable and environmentally friendly solutions for the future. If Norway is to continue to be a leader in the oceans, it is important that we have laboratories that ensure that the industries involved can develop further. The construction of the new ocean technology laboratory, the Ocean Space Centre, is being funded directly by the Storting and includes a number of laboratories and pools.

Maritime technology is important for safe and sustainable value creation in all ocean industries. The Long-term plan for research and higher education 2023-2032 aims to promote climate- and environment-friendly maritime transport, based on the recommendations of Maritim21. To lead the way in the green shift, the maritime industry and research communities must invest early in research, development, demonstration and commercialisation of new technologies and sustainable solutions. In line with Maritim21, the infrastructure should support research in the digitalisation of the maritime industry, green shipping and safety at sea.

Transport21 has three main focus areas for transport research: the zero vision, freedom of movement and value creation and competitiveness. Vision Zero is about achieving zero emissions, zero deaths and zero injuries, noise and particulate matter from the transport sector. Freedom of movement means giving everyone access to sustainable and efficient transport, both in cities and in rural areas, for both people and goods. Value creation and competitiveness focus on strengthening the competitiveness of the business sector with innovative transport solutions. In line with Transport21, the infrastructure should support research in the areas of freedom of movement, climate and the environment, transport safety and a robust transport system, as well as value creation and competitiveness.

Seabed minerals

Infrastructures in this area should be aimed at research on resources on the Norwegian shelf that are relevant for possible future extraction of seabed minerals, both from a resource and an environmental perspective. This includes in situ infrastructures that can map and investigate conditions in the sea and laboratories on land. We need tools that help study how seabed mineral extraction affects the environment. These tools also help develop better ways to map resources and extract them with less damage. In addition, it may be useful to look at how existing infrastructures, in areas such as marine research and geosciences, can also be used for research that is relevant to seabed minerals.

Climate and environment

The area of climate and environment includes research infrastructure and observation systems that are important for research and management of Norwegian nature, the environment, climate and resources on land, in the sea, along the coast and in polar areas. The goal is to support research and technology development that contributes to sustainable solutions, circular economy, adaptation to climate change, reduced loss of nature and cultural environments, increased knowledge about biodiversity, and improved societal security and emergency preparedness.

Climate and environmental research includes studies of the state, links and changes in the terrestrial and marine environment, all components of the coupled climate system, social sciences and humanities related to environmental and climate challenges, as well as geopolitical changes in polar regions. In addition to being system-oriented and fundamental, the research will deliver knowledge for a green transition and strengthen society's resilience to unforeseen changes by linking interdisciplinary and cross-sectoral perspectives.

The portfolio plan for climate and the environment emphasises the importance of up-to-date and modern research infrastructure. Norway has a particular responsibility for managing long time series that are relevant to the climate and environment in Norwegian land, freshwater, marine and coastal areas, as well as in polar regions. Norway must also contribute to international observation systems and ensure access to critical datasets and databases, both for national and international users. In order to achieve a comprehensive understanding of nature and climate change, national and international research infrastructure must be used effectively. This requires good coordination and coordination of technology, data collection and sharing between research communities, the business sector and different countries.

The infrastructure landscape ahead

Considerable resources have been invested in research infrastructure in the field of climate and the environment, both nationally and internationally. A key priority is given to research infrastructure that is connected to major international systems of strategic importance to Norway, as well as national research infrastructure with large international user communities and that supports research with a high societal benefit. Norway has well-developed land-based research platforms, various marine observation systems, a national Earth system model, and participates in international collaborations that make important contributions to the IPCC's main reports. Norway also has research infrastructure at the Troll station in Antarctica and Svalbard, as well as good logistics for collecting data on the environment, climate and nature.

Norway and Europe must now take greater responsibility for the global infrastructure and knowledge development in the area of climate and nature. There is a need for storage systems and databases operated by Norwegian or Nordic/European institutions to ensure access to data in uncertain times. In line with the Government's white paper on the research system , we must also look at how artificial intelligence, big data, machine learning, Earth observation and digital twins can be used in new ways. This can contribute to the

development and application of various model systems and services that benefit society. The need for computing power and storage capacity is increasing, and access to a modern high-performance computing facility is important.

National research infrastructure must support both long-term basic research and research that is useful for public administration, politics and economics. The understanding of the Earth's climate and environment is the basis for all other climate and environmental research, and requires investments over time. This includes long time series that show changes in the Earth system over decades to millennia, and advanced laboratories that can analyze climate archives from seafloor sediments and lakes. Major changes, tipping points and feedbacks in the Earth system are of considerable importance and will make it more difficult to achieve national and international goals related to climate, biodiversity and social security. Increased understanding of expected upheavals in nature will require biological laboratories and data infrastructures, and the development of good tools for monitoring biodiversity. This is important in order to contribute to global knowledge summaries, such as in the The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES Home page | IPBES secretariat).

In the future, it will be particularly important to strengthen research infrastructure that supports research on land use, natural resources, oceans and coasts, as well as societal security and emergency preparedness. We need modern platforms and systems for observing biodiversity, and access to advanced laboratories, field stations, data and expertise that can strengthen research on bioresources, ecosystems, environmental monitoring and the effects of new activities in Norwegian sea areas. Interdisciplinary collaboration and coordination of infrastructures from other knowledge disciplines will be particularly important to meet the challenges related to societal security, the green transition and a new geopolitical reality. To understand the role of soil in the climate system and the importance of agriculture for food security and preparedness, research infrastructure is needed that provides insight into what good soil health is, and how we can maintain or improve it while reducing greenhouse gas emissions.

Research and public administration increasingly have common needs, and in line with the Government's white paper on the research system, they should work together to share and use each other's infrastructures. A good example is water treatment and management, where research infrastructure for water management, stormwater, water purification, circular wastewater technology and resource recovery is important for a more circular and environmentally friendly society. To achieve this, it must be possible to connect computer systems in different sectors such as health, the environment, agriculture and public administration.

In line with the evaluation of Natural Sciences in Norway 2022-2024 and the evaluation of Norwegian polar research, close coordination of research infrastructures between the research communities – and with the business community – is crucial to strengthen the quality, efficiency and relevance of research. This applies, for example, to the construction industry, where there is a need for research infrastructure that supports the development of sustainable building materials, as well as circular and sustainable value chains. The collection and sharing of data across disciplines and sectors must be

strengthened, and databases with a societal perspective should be developed, for example on climate policy, restructuring and cultural understanding of climate and nature.

The Government's white paper on climate transition emphasises that infrastructure is particularly important with regard to the need for large computing capacity, the development of artificial intelligence, international cooperation and the sustainable operation of research infrastructure. The Government's white paper on floods and landslides also emphasises the importance of new infrastructure to reduce risk and to strengthen coordination.

This is especially true when natural hazards, extreme events or abrupt changes occur. Climate-related risk encompasses many different challenges, and it requires efforts and coordination between different areas such as climate change adaptation, natural hazards and societal security and emergency preparedness. The Ministry of Climate and Environment's Knowledge Strategy 2025 - 2030 points to the importance of environmental data for monitoring developments and assessing the effect of measures. The Governments white paper on use and preservation of nature emphasises that research infrastructure is particularly important for green and blue-green management, where areas and landscapes are important for biodiversity.

The polar regions are changing rapidly and are important for climate, environment and security globally. To keep up with the changes, well-developed and integrated observation systems are needed in the Arctic and Antarctic. This is in line with Norway's obligations in the Antarctic Treaty and the work of the Arctic Council. The Governments white paper on Svalbard emphasises that advanced research infrastructure is important for Norwegian and international research, and that more binding cooperation with sharing and mutual access is needed. In Svalbard, it is important to have research infrastructure related to the monitoring of coastal and land areas, and that contributes to understanding system changes of importance for the entire Arctic. It is also important to continue observations of the upper polar atmosphere and near space, as well as in a rapidly changing Arctic Ocean. By using Earth observation and new autonomous technology, we can collect data more efficiently and with less impact on the environment. This provides a unique data basis for research in the Arctic Ocean and strengthens Norway's contribution to the next International Polar Year in 2032-2033.

Clean and rich coastal and ocean areas are important for sustainable use of marine resources, particularly for fisheries and food production. At the same time, we are facing challenges such as nature loss, ocean acidification, environmental toxins and plastics. Norway is investing in knowledge-based management, with mapping, research and environmental monitoring. In order to understand and manage changes in ecosystems, better methods and cooperation across sectors and countries are needed. The Government's business plan for Norwegian sea areas opens up new opportunities for public-private cooperation, where industry actors who gain access to sea areas will contribute to the collection and sharing of relevant data. The development of models used in warning and monitoring is important for understanding the oceans and coasts, and requires collaboration between research communities and public administration. This is also important for contributing to European initiatives such as Copernicus.

To ensure good analyses of samples, there are several laboratories for environmental chemical, biological and physical/chemical analyses. There will be a need to renew analytical tools, laboratories, and measurement technology in order to be able to detect new environmental toxins and pollutants and understand how they affect nature.

Climate and environment are interconnected with all the other areas in the roadmap.

Food and bioresources

The area of food and bioresources includes research infrastructure and observation systems in agriculture, fisheries, aquaculture, forestry and other bio-based industries. The aim is to support research and technology development with access to national and international research infrastructure that promotes high-quality research, and that contributes to sustainable restructuring in the business and public sectors, increased competitiveness and innovation capacity, and increased food security and food safety. The Long-term plan for research and higher education 2023-2032 has three overarching goals and six thematic priorities, all of which are relevant to the area of food and bioresources. The long-term plan also emphasises the importance of circular solutions, as well as the safe use of bioresources across industries, sectors and disciplines.

There is a need to increase national self-sufficiency in food, and sustainable and circular utilisation of Norwegian bioresources considering the environment, society and industry. The current new geopolitical situation increases the need for research on Norwegian food production and the utilisation of Norwegian bioresources, and the research must contribute to strengthened management of our natural resources for the sake of climate, nature and national preparedness.

Research on food and bioresources includes sustainable safe and healthy food, food production, bio-based products such as animal and fish feed, forestry, biochemicals and biomaterials. Research within and across agronomy, veterinary medicine, agriculture and marine subjects is important for achieving the goals for food production and the development of the bioeconomy. Technology and digitalisation play a major role in understanding biological relationships, making better use of raw materials and safeguarding biodiversity. The Government has launched a national social mission with the goal that all feed for farmed fish and livestock must come from sustainable sources and contribute to reducing greenhouse gas emissions in food systems. At the same time, it is crucial that the food chains and end products safeguard food safety, healthy eating experiences and contribute to increasing food safety.

Knowledge about consumer behaviour for better health and a more sustainable diet is central to the production and use of new raw materials in food production. The same applies to new treatment methods, optimisation of production processes and the use of existing food raw materials.

The area involves extensive international research collaboration and is a prerequisite for finding good solutions to food and bioresource challenges. The portfolio plan for food and bioresources points to the importance of international cooperation also in connection with research infrastructures. This can give Norwegian researchers access to infrastructures they would not otherwise have had access to, and is positive in terms of resource utilisation, collaboration and networking.

Within the topic of food and bioresources, there is a need for research infrastructures that focus on basic research and long-term observations, as well as infrastructures aimed at applied research and the needs of the business community. It is also important that research within the blue and green food systems is seen to a greater extent in context.

The infrastructure landscape ahead

In line with the Government's white paper on competitiveness for industry, Norway can achieve increased competitiveness, innovation capacity and sustainability by strengthening the link between business and research. The importance of seeing research and innovation in context is also highlighted by the Research Council of Norway, Innovation Norway and Siva in their joint action plan for research and innovation in the field of bioeconomy, which is based on the Government's bioeconomy strategy. Important basis for priorities is also the white paper on animal welfare and the National One Health Strategy Against Antimicrobial Resistance 2024-2033.

Strengthening the link between research and business involves investing in research infrastructures that utilise food waste, marine raw materials, and harvesting, cultivation and processing of organisms from lower trophic levels in the sea, as well as the development of feed ingredients and documentation of their health effects. At the same time, it is important that infrastructures support basic research in order to provide knowledge for increased food safety and food security. Research infrastructures that make use of modern technology, including increased use of digitalisation and artificial intelligence, and effectively share new knowledge are important for future-oriented climate- and environment-friendly agriculture, fisheries and aquaculture, and for the sustainable management of our marine resources. These measures are important for promoting a blue-green bioeconomy based on Norwegian bioresources. In the field of food and bioresources, there are several research infrastructures that play an important role in the transition to a green bioeconomy, based on Norwegian bioresources.

The "one health" strategy in food production requires that the environmental perspective is seen in an interdisciplinary context. There is a need for interdisciplinary research in toxicology, nutrition, health, agriculture, fisheries and aquaculture to ensure the necessary food safety.

In a world of environmental and climate change, migration waves and rapid technological shifts, a high degree of interdisciplinary collaboration is required, where all thematic areas and disciplines can contribute in collaboration with the business community. There is a need to upgrade existing research infrastructures and link existing platforms for better resource utilisation. Norway participates in European Infrastructure Cooperation (ESFRI) for research on marine organisms, infrastructure for advanced phenotyping (phenomics) and coordination of data resources for the life sciences. We should increase our involvement in international investments in research infrastructure for food and bioresources and further develop Nordic cooperation.

The development of research infrastructure within tomorrow's sustainable food systems must be seen in the context of basic biology knowledge, biotechnology, nanotechnology, energy, materials technology, building construction, health and medicine, climate and environment, and e-infrastructure. The infrastructures will contribute to increased food security and food safety, and sustainable and circular use of resources and food. Stable access to clean water (water quality) is essential to ensure safe food production, reduce environmental impacts and efficient use of resources. The development of water

treatment technologies is important in the transition to a more sustainable food and bioresource sector. Priorities include infrastructures that strengthen research on monitoring and management of natural resources, water and soil health, sustainable capture, processing of natural resources, sustainable feed and feed sources, new production and cultivation systems, plant breeding, aquaculture, and the development of new products based on bioraw materials. It is also important that research within the blue and green food systems is seen to a greater extent in context.

Advanced technology such as sensors, automation, digitalization and robotization can help develop food production, fisheries, aquaculture, agriculture and forestry in a more sustainable direction. With an ever-increasing amount of data, it is becoming important to develop systems and use modern technology so that data from different sources can be made available, compared and analyzed.

The area of Food and Bioresources should be seen in the context of the areas of innovation, enabling technologies, climate and environment, and transport and logistics. This requires the development of an interdisciplinary approach with contributions from several areas including energy, health and nutrition, climate and environment, social sciences and humanities, biotechnology, nanotechnology and other enabling technologies.

Effective coordination and coordination of existing and new research infrastructures within and across the research communities, and with the business community, is crucial for future development. This is consistent with the conclusion of the Evaluation of Life Sciences 2022-2024 which highlights access to advanced and varied research infrastructures as a strength.

Health

The area of health includes biomedicine, medicine, and health sciences. Interdisciplinary sciences such as life sciences are an important part of medical research, but subjects and disciplines under other disciplines are also relevant in the field of health. This applies to the disciplines of technology, natural sciences and mathematics, social sciences and humanities.

There is a need for research that contributes to new knowledge across the entire breadth from basic research to clinical and epidemiological research. The research will provide increased knowledge about causal factors, health-promoting measures and prevention. It will also cover diagnostics, treatment of and rehabilitation after illness, as well as the organisation and restructuring of health and care services, including health monitoring and emergency preparedness. Outstanding research and research results from the area are central to the development of the health industry.

The need for knowledge in the field of health is clearly described in the Long-Term Plan for Research and Higher Education 2023-2032, where health is one of the main priorities. Knowledge needs that are highlighted are related to public health challenges, the One Health perspective, the sustainability of services, clinical research and integration into the service provision, better use of health data, and life science and value creation of health research.

The portfolio plan for health emphasizes that health data in the form of health registries, health surveys, biobanks, etc., are valuable and constitute a unique information and knowledge base for the health sector. This is also supported by the Government's white paper on the research system which emphasizes thathe amount and quality of the data combined provide a great potential for value creation, both in the form of research, business development and the development of services.

The infrastructure landscape ahead

It is important that actors in the health sector have access to national and international infrastructure that promotes research of high quality and relevance, contributes to innovation and business development, and strengthens international collaboration (Portfolio plan for health 2025). Coordination of establishment and use of research infrastructures in the research communities and across the higher education sector, the institute sector, the business sector, the health trusts, the primary health services and the local government sector is of great importance. This is consistent with the results of the Evaluation of Medicine and Health in Norway 2023-2024, which recommends better access to and use of national research infrastructure.

Considerable resources have been invested in health research infrastructures through various sources and programmes. This includes infrastructures for clinical trials in the primary and specialist health services, health registries and biobanks, and secure analysis rooms for processing and storing health data. There has also been a lot of investment in technology platforms for bioinformatics, systems and structural biology, as well as gene sequencing and various 'omics' techniques, precision medicine, MRI

analyses and other imaging technologies. These are technologies that, in combination with artificial intelligence has great potential for the development of new diagnostics, personalized treatment and innovation in drug development. Further investments and continuous development will be necessary. The data source may include human biological material, such as molecules, cells, cell fractions, tissues and individuals or similar model organisms.

In order to solve the R&D challenges in health and medicine, there is a need for infrastructure that covers the entire spectrum from basic to clinical research. At the same time, health research is dependent on interdisciplinarity and access to research infrastructures in other disciplines such as materials science, nanotechnology and radiation physics. For Norwegian research to contribute to the development of more sustainable health services, it is essential that Norway invests in infrastructure that enables research and innovation in the operating methods of the health services and how a more data-driven operation can support new and efficient forms of organisation that reduce the need for health personnel.

In the future, medical and health research will be shaped by the growing amount of data being collected, including health records and surveys of the population. There is a need for simpler and more efficient access to national health registries, including the possibility of linking these in different parts of the services. Patient data from municipal health and care services are very useful for research, for an overview of patient populations and for recruitment to clinical trials. This means that there is a great need for data infrastructures and advanced data processing in both the specialist and primary health services. Such infrastructures will be of great importance for research related to demographic changes and exclusion, and for research in municipal health and care services, including the GP service.

In order to achieve the goals set by the Government in the strategy Digital Norway of the Future, it is necessary to have sufficient research funding, infrastructure, data and expertise in advanced data processing that safeguards health data's strict requirements for privacy. Advanced computing refers to high-performance computing, high-capacity data analysis, machine learning, artificial intelligence and quantum technology. There is a need for better access to computing power and opportunities for high-capacity data analysis, artificial intelligence and machine learning. This is very important for infra structures for health data analysis. It is also important that both existing and new infrastructure for sensitive personal data have privacy by design and that trust and ethical aspects are handled according to the highest standards. Specifically, it is also important to have national coordination of consent management and dialogue with participants in surveys and studies. There is a need to further redevelop digital treatment services, and their implementation. In addition, the development of new infrastructure for secure storage, sharing and analysis of sensitive health data will be crucial for how Norwegian research can participate in the European and international research arena in the years ahead. The of the Evaluation of Medicine and Health in Norway 2023-2024 also points out that better national coordination of e.g. health registries and near-real-time health data will be unique seen from an international perspective.

In line with the Government's white paper on research systems, the use of supercomputers can help solve complex problems and develop services that benefit society, such as developing new diagnostics and treatments for personalised medicine or to conduct efficient and good management for emergency preparedness. For research on antimicrobial resistance (AMR) and infection biology, there is a need for infrastructures dedicated to experimental work with microorganisms in different hazard classes (1, 2 or 3). There is a need for infrastructures for data on disease-causing microorganisms' genomes, routes of infection and spread for research on antibiotic resistance in a one-health perspective, as well as exposome research. Here, it is important to share data across sectors, which can provide valuable knowledge related to e.g. consumption habits, exposure to chemicals, environmental pollution and climate change, and there will be a need for secure handling of sensitive data. This is also important from a social security perspective, where an interdisciplinary approach to social science and humanistic perspectives is required. Preparedness for and management of crises is discussed in the priority 'societal security and preparedness' (Long-term plan for research and higher education 2023-2032), and is related to e.g. the management of pandemics and AMR. For preparedness purposes, it is important that Norway establishes well-functioning infrastructures that can contribute to the rapid development of new vaccines and therapies and to the establishment of production processes for these.

The national infrastructures are important for competence building nationally and for positioning for and contributing to international cooperation. Interaction with European research infrastructures is absolutely necessary, and national infrastructures must be adapted to international standards and facilitate international cooperation both in connection with the development of the European Research Council. new purchases and upgrading of national infrastructure. In the European healthcare infrastructure landscape, there is a focus on standardization, integration with national infrastructures, implementation of GDPR, and cloud services to handle data storage and analytics (ESFRI landscape analysis 2024). From an international perspective, the European Health Data Space and 1+Million Genomes entail a need for data management and standardization of secure analysis rooms also at the national level, both for primary health data and secondary use for research. Norway must ensure that it is equipped with the necessary infrastructures that enable us to participate in the many comprehensive European and international health and population studies.

Humanities and Social Sciences

The area includes both the social sciences and the humanities, and includes research infrastructures that provide resources, tools and services necessary to understand and analyse human societies, human psychological characteristics, art, culture, religion, language, history, democracy and governance.

The aim of research in the social sciences and humanities is to understand and analyse human societies, culture and cultural heritage, creative and performing subjects, language, ideas, history, democracy and governance. This involves examining how people interact, how societies are structured, and how cultural and historical factors influence today's society. The research contributes to the development of knowledge that can be used to promote the desired development of society, and greater cultural understanding. This includes relevant knowledge for the Government's social mission for children and young people, which aims to include more young people in education, working life and society. The Long-term plan for research and higher education 2023-2032 highlights the important role of the humanities and social sciences in addressing societal challenges. This area is relevant to all of the Research Council's portfolios, and perhaps especially to ground-breaking research, welfare and education, Sami society and culture, and democracy and global development.

The infrastructure landscape ahead

In a time characterized by increasing complexity, technology and global challenges, it is crucial to strengthen the humanities, social sciences and artistic development work. The Long-term plan for research and higher education 2023-2032 emphasises the need for insight into cultural and historical contexts, particularly with regard to security and conflict in Europe. It is also essential to understand how the rapid technological development affects culture and society. Research on democracy, trust, societal security and emergency preparedness requires research infrastructure that facilitates longitudinal studies and coordinated data collection nationally and internationally. This requires solutions that support linking data from different sectors, providing secure handling of sensitive information, and support for advanced analytics. In addition, there is a need for infrastructure that safeguards the special ethical considerations of research on and accessibility of cultural heritage material from indigenous peoples and minorities (Truth and Reconciliation Commission, 2023). The CARE principles (collective benefit, right to control, responsibility and ethics) also apply to this material, in addition to the FAIR principles

The digitalisation of research processes involves a comprehensive transformation of the social sciences and humanities. Follow-up of the evaluation of humanities research in Norway recommends increased investment in digitalisation and research infrastructure for the humanities. Existing research infrastructures must be further developed for standardisation, increased access and reuse. This ambition raises issues related to privacy, data quality and ethical and legal issues (including copyright). These issues are exacerbated by the emergence of artificial intelligence, which is a key part of the digital shift and opens up to explore more complex issues by connecting and utilizing large amounts

of data across sectors and disciplines. There is also an increasing need for facilitation of training data, long-term storage of large amounts of data and high-performance computing facilities.

Interdisciplinary collaboration is necessary to meet societal challenges. It is necessary to strengthen infrastructures that make it possible to work across disciplines and data types and sources. This includes the coordination of infrastructures in the social sciences and humanities with other scientific areas such as health, life sciences, technology, climate and the environment, in addition to sources from public administration and the courts. In crises, quick access to data across sectors is crucial, but raises legal and ethical challenges. Access to commercial data requires further development of ICT solutions such as encryption and anonymisation. The use of international standards is important for the interaction and reuse of data.

Norway has extensive administrative data for research and research data on the entire population. In line with the Government's white paper on research systems, it is appropriate for infrastructures developed for administrative or research purposes, respectively, to be able to benefit from each other. This requires flexible data infrastructures that support different data types, documentation standards, and analytics tools. Research that provides knowledge about issues related to social participation, democracy, the welfare and labour market model, inequality, migration, public innovation, education and emergency preparedness is crucial for insight into societal development and for developing knowledge-based policies. When data infrastructures facilitate sharing, researchers can use them to develop new services and solutions for the benefit of society.

In order to strengthen social science and humanities research and knowledge sharing, access to structured and reusable data is needed in the areas of language, art, cultural heritage, media and history. With high precision and common standards, Norway can become a pioneer in European data infrastructure. This will promote data-driven research in the social sciences and humanities, strengthen collaboration between knowledge institutions and make Norwegian resources more accessible internationally. Artistic development work and research often involve large-scale audiovisual data, necessitating tailored infrastructure for secure handling, long-term preservation, and public presentation, as well as compliance with copyright frameworks. This is especially true for audio, image and video material, which requires solutions adapted to both quantitative and qualitative data. There is an increasing need for access to and analysis of fresh data sources such as language data, websites, online newspapers and content from social media that can be harvested on an ongoing basis. User-generated content from teaching materials and learning platforms also represents an important source of insight. At the same time, there is a need for better accessibility and interdisciplinary use of existing registry data. These types of data raise new ethical issues related to privacy and responsible use, which the research infrastructure must safeguard.

We currently have research infrastructures that support citizen science and user involvement as a way to strengthen the relevance of research and its anchoring in society. By opening up for contributions from citizens and user groups – for example in the form of data collection, annotation or sharing local knowledge – research can be both enriched and made more accessible to the general public.

In order to conduct high-quality research in certain areas, access to advanced and expensive equipment is also required. There is an increasing use of experimental methods in parts of the humanities and social research, and the need for laboratories and infrastructure for collecting and processing experimental data is expected to grow. Examples of this are archaeology and conservation, where analysis of finds requires advanced instruments, or linguistics, music and psychology, where laboratories make it possible to study and manipulate behaviour, cognition and brain function under controlled conditions.

European cooperation on high-tech research equipment is important to strengthen research capacity and ensure access to the best resources. Norway should also participate in international research projects and initiatives that compare data across countries. ESFRI's roadmap contains prioritised research infrastructures that are important for strengthening Europe's research capacity. By participating in these initiatives, Norwegian researchers can gain access to valuable data, expensive equipment and important collaboration.

Other natural sciences

Access to advanced research infrastructure is a prerequisite for many research fields, and the need is great in the basic natural sciences. Both the scope and costs of the research infrastructures make international cooperation essential. This research, and especially the infrastructures, is often very long-term. This places great demands on both applicants and funding authorities. Research in these disciplines, and also the work on the development of relevant research infrastructure, contributes to the development of new advanced technology, which in turn lays the foundation for new applications and new production methods. It is therefore also important to be concerned with the link to more applied research and industry.

When working on the roadmap, the Research Council has organized according to the portfolios. This helps make sure that applications for new or upgraded research infrastructure are viewed in the context of related research and with relevant priorities and plans. The disadvantage is that we do not get an overall picture of the research infrastructures in the natural sciences.

In this chapter, we will therefore discuss infrastructure needs in the following disciplines:

- Earth science
- Astrophysics, Space Physics and Earth Observation
- Particle Physics, Nuclear Physics and Nuclear Chemistry

According to the evaluations for natural sciences, life sciences and mathematics, ICT and technology, the Norwegian research communities have good access to national and international research infrastructure. The importance for the research communities of maintaining the investment in research infrastructure is emphasised, and they point out that utilisation can be even better with better coordination between the infrastructures. The good access makes the research communities more productive and more attractive as partners in EU projects, since Norway is in a unique position when it comes to access to state-of-the-art research equipment.

Within several of the relevant disciplines, and especially with the use of advanced research infrastructure, significant amounts of data are generated. This places great and different demands on computational and storage capacity, and it means a digitalisation of research that entails increasingly stronger demands on the design of the experiments and on the researchers' ability to use the digital opportunities that open up.

The infrastructure landscape ahead

Earth science

Earth science is the science of the various Earth systems: the geosphere, the atmosphere, the hydrosphere and cryosphere and encompasses a number of different disciplines. The disciplines of meteorology and oceanography is largely covered in the description of the portfolio 'Climate and Environment'. We have therefore chosen not to discuss these specifically here. The focus here is on the disciplines of geology, solid earth geophysics, and physical geography. These disciplines have a very strong position in Norway and have a clear international profile with several world-leading academic communities and cover both studies of the earth's crust, processes on or near the earth's surface, and the earth's internal structure. Recently, there has also been an increased focus on different planetary systems. Earth sciences play a crucial role in increasing the understanding of phenomena such as earthquakes, landslides, volcanic eruptions, erosion, sedimentation, and the movements of the earth's crust. Satellite-based Earth observation is useful for the study of several of these phenomena.

There is considerable activity in applied geosciences, which includes petroleum geology, hydrogeology, geohazards and environmental geology. The need for knowledge and expertise in these areas is described, among other things, in the Governments white paper on floods and avalanches and OG21. Geosciences play a key role in the management of the earth's resources, and after Norway has been a significant oil and gas industry, it is now important to build and further develop expertise in sustainable resource management and environmental protection.

Earth sciences play an increasingly important role in sustainable resource management and environmental protection, and are important for climate research by securing archives for sediment cores and access to relevant laboratories. In addition, changes in the geopolitical picture will with a high probability indicate that Norwegian geoscience will be able to play a key role in the exploration and extraction of critical minerals and metals. The infrastructure needs related to this are discussed under the sections Enabling and Industrial Technologies and Energy and Transport, and are closely linked to basic research in the earth sciences.

Astrophysics, Space Physics and Earth Observation

Astronomy and astrophysics encompass the study of the sun and the physics of the sun, the bodies of the solar system, and the study of stars, galaxies, and the universe (cosmology). The field is strong in Norway. Space physics includes the study of the Earth's ionosphere and magnetosphere, as well as the plasma between the planets in the solar system. In this field, Norway, with its position far north, has strong traditions when it comes to Northern Lights and space weather, for example through the use of EISCAT's radars in Sweden, Finland and Norway.

Space technology has evolved and provides many services that benefit society. Norway's participation in ESA and the EU Space Programme strengthens academic communities and international cooperation

within the breadth of space-related research and technology development. ESA also offers research infrastructure of importance for space research.

Space also provides new opportunities for research on the Earth, again ESA is an important provider. Earth observation has developed rapidly and provides valuable insights into climate, ocean currents, and crustal movements. The European countries cooperate on Earth observation, climate research and societal security in the Copernicus programme. According to the Ministry of Climate and Environment's knowledge strategy, satellites will in the future become an increasingly important and cost-effective source of environmental information. Maintaining long time series is important, among other things, for studying climate change and slow changes in the space environment.

Particle Physics, Nuclear Physics and Nuclear Chemistry

Basic research in particle physics, nuclear physics and nuclear chemistry helps to increase the understanding of phenomena, forces and constituents in the universe.

Norwegian particle physics is closely linked to CERN, where nature's smallest building blocks are studied in large accelerators with particle collisions at extremely high energies. The research is both in theoretical and experimental physics as well as in technologies relevant to particle physics, including the development of advanced particle and radiation detectors. Norwegian participation in CERN provides good opportunities for technology development in Norway and technology transfer from CERN. The data are largely analysed in the individual countries and necessitate local capacity for heavy monitoring and storage of large amounts of data. The emergence of particle accelerators has, among other things, contributed to the development of proton therapy for cancer treatment.

The Long-term plan for research and higher education 2023-2032 highlights the need for competence in nuclear physics and nuclear chemistry to ensure Norwegian expertise in radiation protection and nuclear safety. The subject area is also relevant to health and materials science. A national nuclear research centre, supported by the Research Council of Norway, brings together the most important research communities and is linked to national and international infrastructure.

Norway has no nuclear power plants, but is surrounded by countries with existing and planned facilities. Norwegian research communities participate in initiatives for the establishment of nuclear power based on small modular reactors (SMRs) and for reactor operation of civilian ships. The reactors are mainly developed abroad, and it is not relevant to build experimental plants in Norway. The need for research infrastructure applies in particular to safety and waste management.

Part 3: Funded research infrastructures

Research infrastructures per thematic area

Table 1. Generic datainfrastructures

Short name	Project	Webpage
E-INRA/ Sigma2	A national e-infrastrucutre for Science	https://www.sigma2.no/

Table 2. Enabling and industrial technologies

Short name	Project	Webpage
eX3	Experimental Infrastructure for Exploration of Exascale Computing	https://www.ex3.simula.no/
NAIC	Norwegian Ai Cloud	https://www.naic.no/
NNP	The Norwegian NMR Platform	https://www.uib.no/en/rg/nmrspectro/94669/norwegian-nmr-platform
NORCRYST	Norwegian Macromolecular Crystallography Consortium	http://en.uit.no/prosjekter/prosjekt?p_document_id=451221
Nor-Openscreen	Nor-Openscreen	https://www.openscreen.uio.no/english/index.html
NALMIN	Norwegian Advanced Light Microscopy Imaging Network	http://nalmin.no
ELIXIR Norway	ELIXIR Norway	http://elixir.no
NAPI	National network of Advanced Proteomics Infrastructure	http://www.napi.uio.no
NorFab	Norwegian Infrastructure for Micro- og Nanofabrication	http://norfab.no
NORTEM	The Norwegian Centre for Transmission Electron Microscopy	http://nortem.no
NcNeutron	Norwegian Centre for Neutron Research	https://ife.no/en/project/ncneutron-norwegian-center-for-neutron-research/
ESS	European Spallation Source	http://ess.eu
SNBL	Swiss-Norwegian Beamlines at ESRF	http://www.snbl.eu http://www.esrf.fr
HUNT	Competence hub for Neutron Technology	
MiMaC	Norwegian Laboratory for Mineral and Materials Characterisation	http://www.ntnu.edu/mimac
NorHTE	Norwegian open infrastructure for highthroughput experimentation and scale-up	http://norhte.w.uib.no

MANULAB	Norwegian Manufacturing Research Laboratory	http://manulab.org
TEMP	Transition to Sustainable Resource Efficiency in Metal Production and Recycling	http://www.sintef.no/projectweb/temp
SMART-H	Infrastructure for materials research for transporting hydrogen	http://www.smarth-ntnu.com

Table 3. Energy and transport

Short name	Project	Webpage
HighEFFLab	National Laboratories for an Energy Efficient Industry	https://www.sintef.no/en/all-laboratories/highefflab/
SBHub	Smart Building Hub - Norwegian e-Infrastructure for energy-flexible and healthy buildings	https://smartbuildinghub.no/en/
ElpowerLab	Future distribution and transmission electrical grid components lab	https://www.sintef.no/en/all-laboratories/elpowerlab/
NABLA	Norwegian Advanced Battery Laboratory	https://www.nablalab.no/
HydroCen Labs	HydroCen Labs	https://www.ntnu.edu/hydrocen
ProWind	Norwegian Infrastructure Platform for Foundation Technology Research in Offshore Wind	https://www.ngi.no/en/projects/prowind/
IMF	Norwegian Infrastructure for Multiphase Flows	https://www.sintef.no/en/all-laboratories/multiphase-flow-laboratory/ https://flowda.net/
ECCSEL	European Carbon Dioxide Capture and Storage Laboratory - Enhancing Norwegian Capabilities	https://eccsel.eu/navroot/about/eccsel-eric-members/current-member-countries/norway
NorPALabs	Norwegian P&A Laboratories	https://norpalabs.no/
SINTEF Ocean Labs	SINTEF Ocean Labs	https://www.sintef.no/en/ocean/laboratories2/
OceanLab	Ocean Space Field Laboratory Trondheimsfjorden	https://www.ntnu.edu/oceanlab
The Digital Ocean Space	The Digital Ocean Space	

Table 4. Climate and environment

Short name	Project	Webpage
NorArgo	A Norwegian Argo Infrastructure – a contribution to the European and global Argo infrastructure	https://norargo.no/ https://www.euro-argo.eu/

NorEMSO	The Norwegian node for the European Multidisciplinary Seafloor and water column Observatory	https://www4.uib.no/en/research/research-projects/noremso
LoVe Ocean	Lofoten-Vesterålen cabled observatory	https://loveocean.no/
NorSOOP	Norwegian Ships Of Opportunity Program for marine and atmospheric research	https://www.niva.no/en/projects/norsoop
NORMAR	NORMAR-II, Upgrade of the ROV Ægir 6000 - a remotely operated underwater vehicle for deep-sea research	https://www.normardeepsea.com/
SeaBee	Norwegian Infrastructure for drone-based research, mapping and monitoring in the coastal zone	https://seabee.no/
Arctic ABC	Arctic ABC Development	
SIOS	Svalbard Integrated Arctic Earth Observing System	https://sios-svalbard.org/
TONe	Troll Observing Network	https://npolar.no/tone/
INES	Infrastructure for Norwegian Earth System modelling	https://www.ines.noresm.org/
ICOS Norway	Integrated Carbon Observation System Norway	https://no.icos-cp.eu/
ACTRIS	Aerosol, Clouds, and Trace gases Research InfraStructure in Norway	https://actris.no/index_en.html
COAT	Climate-Ecological Observatory for Arctic Tundra	https://www.coat.no/en/
EMBRC Norway	The Norwegian Node of the European Marine Biological Resource Centre	https://www4.uib.no/forskning/forskningsprosjekter/embrc-norge

Tabell 5. Food and bioresources

Short name	Project	Webpage
RI Seaweed	Norwegian Test Center for Seaweed Cultivation and Utilization Technologies	https://norwegianseaweedcentre.com/
PLANKTON LAB	Norwegian Center for Plankton Technology	https://www.planktonsenteret.no/
NBioC	Norwegian Bioprocessing and Fermentation Centre	https://nbioc.no/home
FoodPilotPlant Norway	Pilot Plant Facilities for Food Processing at Campus Ås	https://www.nmbu.no/en/research/groups/food-pilot-plant-norway
NORCELlab	The Norwegian Cellulose laboratory	https://norcellab.no/

SUPRANO	Sustainable Processes Advancement from Norwegian Research: an integral Bio-, Thermo-, Electrochemical effort	
PheNo	Norwegian Plant Phenotyping Infrastructure	https://www.nmbu.no/en/research/projects/pheno https://emphasis.plant-phenotyping.eu/

Tabell 6. Health

Short name	Project	Webpage
Biobank Norway	A national biobank infrastructure for global research collaboration	https://bbmri.no/ https://www.bbmri-eric.eu/
PraksisNett	The Norwegian Primary Care Research Network	https://www.uib.no/en/praksisnett
NorCRIN	Norwegian Clinical Research Infrastructure Network	https://www.norcrin.no/en/ https://ecrin.org/
ATMP Norway	A multi-nodal infrastructure for Advanced Therapy Medicinal Products in Norway	
NORMOLIM	Norwegian Molecular Imaging Infrastructure	https://normolim.w.uib.no/ https://www.eurobioimaging.eu/
NorMIT	Norwegian centre for Minimally invasive Image guided Therapy and medical technologies	https://normit.no/
NORBRAIN	Norwegian Brain Initiative: a large-scale infrastructure for 21st century neuroscience	https://norbrain.no/

Tabell 7. Humanities and social sciences

Short name	Project	Webpage
ACCESS	Life Course Database: Upgrade and Expansion	https://www.oslomet.no/en/about/nova/norlag
CESSDA ERIC	Consortium of European Social Science Data Archives	https://www.cessda.eu/
ESS	The European Social Survey	https://www4.uib.no/en/research/research-projects/european-social-survey-ess-eric https://www.europeansocialsurvey.org/
KODEM	Coordinated Online Panels for Research on Democracy and Governance in Norway	https://www4.uib.no/en/research/research-projects/kodem
PSI	Peace Science Infrastructure	https://www.prio.org/projects/1998

Microdata.no	Microdata.no	https://www.microdata.no/en/
Histreg	Historical Registers	https://home.nr.no/~holden/HBR-english.pdf
SAMLA	National Infrastructure for Cultural History and Tradition Archives	https://samla.no/viewer/index/
ADED	Archaeological Digital Excavation Documentation	https://aded.unimus.no/om
Norchron	Norwegian Diachronic Corpus 200-1814	
CLARINO	Common Language Resources and Technology Infrastructure Norway	https://clarin.w.uib.no/ https://www.clarin.eu/
WebData	Norwegian research infrastructure for web data	https://www.nb.no/dh-lab/forskningsprosjekter/webdata/
fourMs Lab	Music, Mind, Motion, Machines	https://www.uio.no/ritmo/english/research/labs/fourms/

Tabell 8. Other natural sciences

Short name	Project	Webpage
NorLHC	Enabling LHC Physics at Extreme Collision Rates	https://norway.cern/en https://home.cern/
EISCAT	European Incoherent SCATter	https://en.uit.no/prosjekter/prosjekt?p_document_id=487937 https://eiscat.se/
EPOS-NG	The European Plate Observing System – Norway	http://www.epos-no.org/ https://www.epos-eu.org/
Goldschmidt Laboratotiet	Goldschmidt Laboratoriet	https://www.mn.uio.no/geo/english/research/goldschmidt/

Research infrastructures in Europe

Table 9. Norwegian participation in international research organisations funded by the ministries.

Short name	Project	Status
CERN	www.home.cern	Member from 1954
EMBL/EMBC	European Molecular Biology Laboratory The European Molecular Biology Conference	Member from 1985
ESA	The European Space Agency	Member from 1987
ESRF	The European Synchotron Radiation Facility	Member from 1989
IARC	International Agency for Research on Cancer	Member from 1987

Table 10. Norwegian membership of pan-European research infrastructures. Membership in EATRIS and EMSO ends in 2025.

Short name	Project	Host country	Ministry
ACTRIS ERIC	Aerosol, Clouds and Trace Gases Research Infrastructure	FI	KLD
BBMRI-ERIC	Biobanking and BioMolecular Resources Research Infrastructure	AU	HOD
CESSDA-ERIC	The Consortium of European Social Science Data Archives	NO	KD
CLARIN ERIC	Common Language Resources and Technology Infrastructure	NL	KD
ECCSEL ERIC	European Carbon Dioxide Capture and Storage Laboratory	NO	ED
ECRIN-ERIC	European Clinical Research Infrastructure Network	FR	HOD
EISCAT	European Incoherent SCATter	SE	KD
ELIXIR Europe	A distributed infrastructure for life-science data	UK	KD
EMBRC	European Marine Biological Resource Centre	FR	NFD
EPOS	European Plate Observing System	IT	KD
ESRF	The European Synchrotron Radiation Facility	FR	KD
ESS ERIC	European Spallation Source ERIC	SE og DK	KD
ESS ERIC	European Social Survey	UK	KD
EU-Openscreen ERIC	European Infrastructure of Open Screening Platforms for Chemical Biology	DE	KD
Euro-Argo ERIC	European contribution to the Argo programme	FR	NFD
Euro-BioImaging ERIC	European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences	FI	KD
ICOS ERIC	Integrated Carbon Observation System	FI	KLD
SIOS	Svalbard Integrated Arctic Earth Observing System	NO	KD

Previously funded research infrastructures

Table 11. Previously funded research infrastructures – Enabling and industrial technologies.

Short name	Project	Project start	Webpage
NICE	National Surface and Interface Characterisation Laboratory	2009	www.nicesurface.no
RECX	Norwegian Centre for X-ray Diffraction, Scattering and Imaging Resource Centre X-rays	2011	www.recx.no
ReRaNP	Reconfigurable Radio Network Platform	2015	https://wisenet.uia.no/projects/reconfigurable-radio-network-platform-reranp/

Table 12. Previously funded research infrastructure - Energy and Transport.

Short name	Project	Project start	Webpage
BIGCCS	BIGCCS Laboratory	2010	www.sintef.no/en/projects/2009/bigccs-international-ccs-research-centre
SAFFT	SAFFT - Shearing, fracturing and flow in geomaterials related to petroleum reservoirs, CO2 storage and geothermal energy production	2009	
ULLRIGG	Laboratory upgrade of Ullrigg Drilling and Well Centre	2012	ullrigg.norceresearch.no
	Research infrastructure for environmental design of renewable energy reseacrh in CEDREN	2014	www.cedren.no/english/About-CEDREN
SmartGrid	National Smart Grid Laboratory & Demonstration Platform	2014	www.ntnu.edu/smartgrid
OBLO	Norwegian Offshore Wind Energy Research Infrastructure - Offshore Boundary Layer Observatory	2013	oblo.w.uib.no
Motion Laboratory	Motion Laboratory	2015	www.uia.no/english/about-uia/centres-and-networks/motionlab
Zeb Lab	Norwegian Zero Emission Building Laboratory	2015	zeblab.no
	Norwegian Fuel Cell and Hydrogen Centre	2016	www.sintef.no/projectweb/nfch
NSST	Norwegian laboratory for Si solar cell technology	2015	www.sintef.no/projectweb/solarlab
OpenLab Drilling	OpenLab Drilling	2015	openlab.app

Table 13. Previously funded research infrastructure - Climate and environment.

Short name	Project	Project start	Webpage
NORMAP	Norwegian Satellite Earth Observation Database for Marine and Polar Research	2010	normap.nersc.no
AVIT	AVIT - updgrading and development of the NTNU membrane laboratory for enviornmental applications	2009	www.ntnu.edu/chemeng/research/environmental-engineering-and-reactor-technology/membrane-research
	Norwegian Atlantic Current Observatory	2010	www.uib.no/en/rg/fysos/525118/norwegian-atlantic-current-observatory
NMDC	Norwegian Marine Data Centre	2012	www.hi.no/hi/forskning/forskningsgrupper/norsk-marint-datasenter-nmd
NorBol	Norwegian barcode of life network	2014	https://www.norbol.org/
NorDataNet	Norwegian Scientific Data Network	2015	www.nordatanet.no

Table 14. Previously funded research infrastructure - Food and bioresources.

Short name	Project	Project start	Webpage
	Aquafeed Technology Centre	2016	aquafeed.science

Table 15. Previously funded research infrastructure - Humanities and social sciences.

Short name	Project	Project start	Webpage
ACDC	Advanced Conflict Data Catalogue: Defining an Industry-Standard for Data on Armed Conflict	2010	https://www.prio.org/projects/1522
	Digital corpus and dictionary of Norwegian Medieval Latin - Prosjektbanken	2016	www.nb.no/forskning/medieval-latin

eVIR	eInfrastructure for Video Research	2016	www.uv.uio.no/ils/forskning/prosjekter/evir
NORDi	Norwegian Open Research Data Infrastructure	2016	

Table 16. Previously funded research infrastructure - Other natural sciences.

Short name	Project	Project start	Webpage
G3	Geosystem 3-D Seismic Imaging	2010	
EARTHLAB	Earth Surface sediment Laboratory	2014	www4.uib.no/en/research/research-centers/centre-for-deep-sea-research/earthlab
	The Oslo Geomagnetic Laboratory	2014	www.iggl.no
FARLAB	Facility for advanced isotopic research and monitoring of weather, climate, and biogeochemical cycling	2015	www.uib.no/en/FARLAB
NGTS	Norwegian geotest sites	2016	www.ngi.no/en/projects/ngts
OSCAR	New generation scintillator detectors for nuclear research in Norway	2015	www.mn.uio.no/fysikk/english/research/projects/oscar

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