OG21 Strategy - A New Chapter

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Enablers for innovation and broad implementation

A need for technology leadership

The value of new technology and knowledge is realized when it is applied. A study by OG21 showed that technology adoption takes too long time (OG21, 2018).

The study concluded that there is a tendency of over-emphasizing technology risks over the opportunities the technology offers. The tendency is exacerbated by risk-averse decision makers in oil companies and production licenses that add their perceived risks to technology investment decisions. The final decision makers in a production license tend to have a narrow objective of optimizing the value for the license, rather than for a portfolio of production licenses at company or national level.

OG21 believes the combination of risk management tools that fail to consider value creation opportunities, technology risk aversion among decision makers and a lack of portfolio thinking, lead to over-cautious technology decisions unless enterprise culture, leadership, objectives, and incentives drive a different behavior. (OG21, 2018).

Recommendation: Industry enterprises should have visible "technology champions" at the executive level. Technology responsibility should start at the executive level and be distributed throughout the organization. Executive level technology managers should make sure that technology opportunities are identified and communicated to potential technology providers in a timely fashion.

An efficient innovation system with public stimulation of R&D&I

5.2.1 A sectoral approach to innovation in Norway

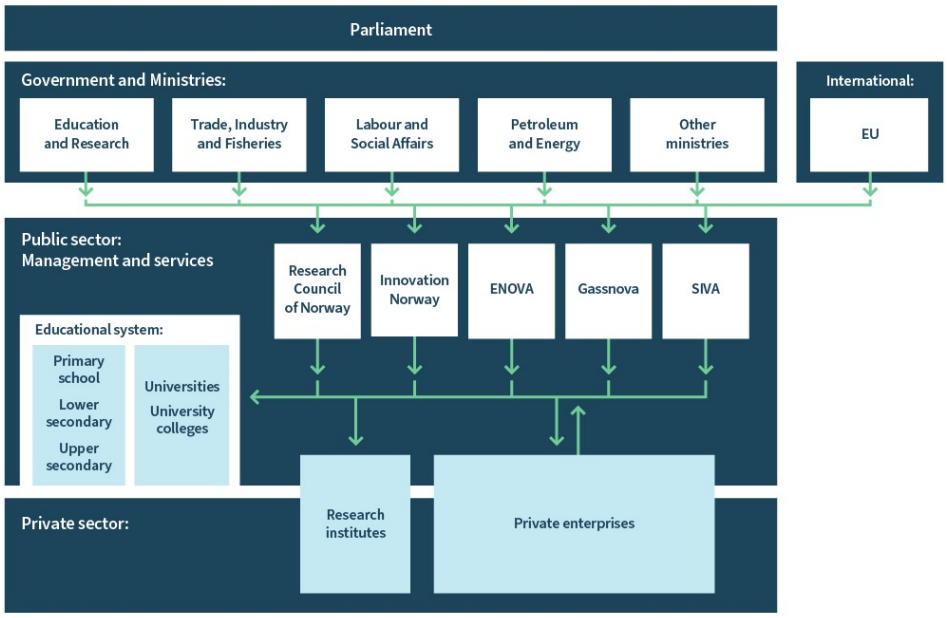
The innovation system in Norway follows a sectoral principle where individual ministries govern and coordinate R&D&I investments within their responsibilities, see Figure 44. The "21-processes", such as OG21, support this structure by providing guidance on R&D&I priorities within the sector, often based on a bottom-up approach.

The approach has some obvious benefits, e.g. that R&D&I investments target specific challenges within an industry, and that it is easy to obtain alignment between industry, academia and the ministry on objectives and priorities. The approach has proven efficient to produce results with significant impact as a study commissioned by the RCN on effects of petroleum R&D, clearly indicates (Rystad Energy, 2020).

The sectoral principle also has some weaknesses, as alluded to by OECD in a recent report (OECD, 2021): lack of a high-level agenda setting mechanism; weak holistic coordination; and a fragmented policy landscape. OECD proposes that a mission-oriented innovation policy (MOIP) could address the short-comings and be a supplement to the current system and practices.

Recommendation: OG21 supports the idea of supplementing the well-established and efficient sectoral approach to R&D&I, with cross-sectoral "missions" to guide R&D&I efforts on societal challenges reaching across sectors.

Figure 44. The R&D and innovation system in Norway (Adapted from Indikatorrapporten, 2018)

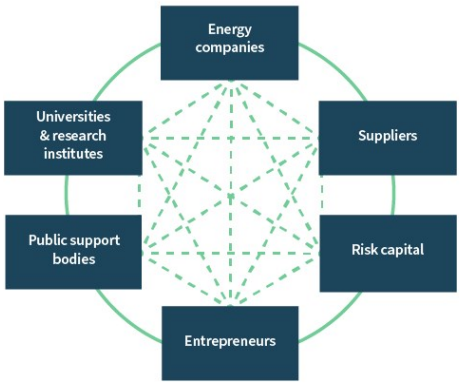


5.2.2 A shared responsibility for R&D&I

The industry, academia and governmental bodies have a shared responsibility for R&D&I. OG21 encourage all R&D stakeholders including industry enterprises, universities, research institutes and public funding bodies, to reflect the OG21 priorities in their R&D&I plans and programs.

OG21 is of the opinion that efficient innovation occurs through collaboration and close connections between many competent stakeholders as depicted in Figure 45. In this picture, public R&D&I bodies play an important role both for bringing stakeholders together and for providing economic risk relief.

Figure 45. Stakeholders necessary for efficient innovation



5.2.3 Governmental R&D&I support instruments relevant for the petroleum sector

Even though the responsibility for R&D&I is shared between private enterprises, academia and the society, governmental R&D&I incentives and funding are important to adjust for externalities and market failures such as:

- New knowledge and technology resulting from R&D becomes available in the market, which makes it more attractive to be an

adopter of new solutions rather than the developer.

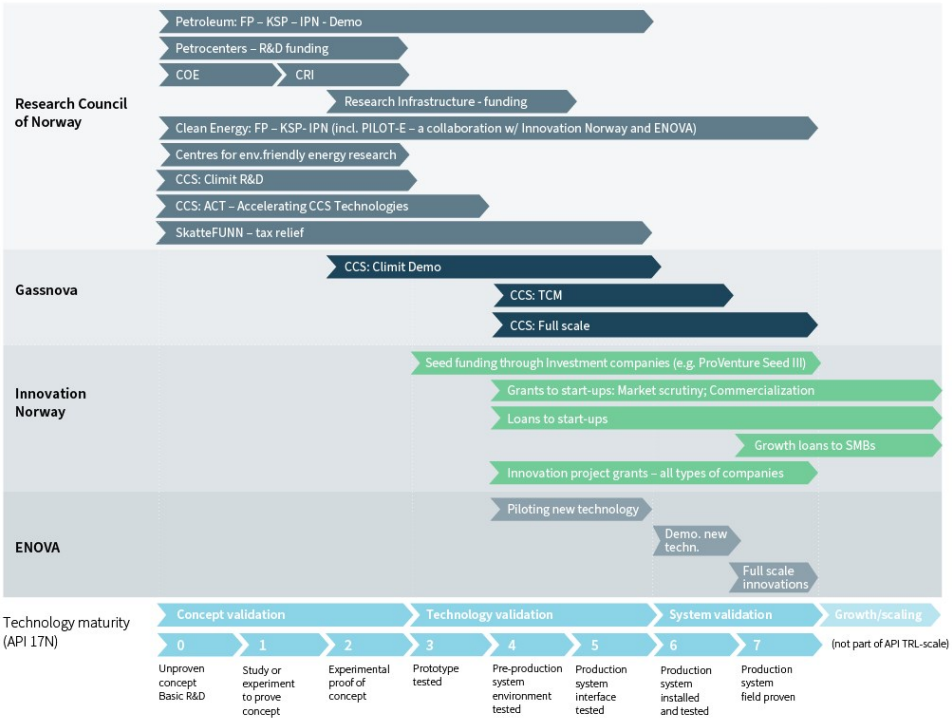
- Some technologies may offer high rewards, but struggle to attract R&D investments due to high development costs, high economic risks, or too small application scope within single enterprises' project portfolios.
- Some R&D offer high societal rewards, but do not provide sufficient return to private enterprises.
- System critical research could struggle to attract funding from private enterprises within the industry sector.

A recent study on drivers of transformation in the Norwegian oil and gas industry, focusing on climate-related research, confirms several of the R&D challenges listed above. Based on a survey among participants in the OG21 network, it finds that low profitability and long payback times are among the most important hurdles preventing companies from conducting more climate-related research. Other important hurdles mentioned in the study include lack of regulatory requirements and lack of competence (Karlstad, 2021).

Governmental R&D&I funding is also a possible and important counter-cyclical measure. This was demonstrated in 2016 and 2020 when increased R&D funding contributed to offset parts of the R&D investment decline that followed activity reductions in the Norwegian petroleum sector.

The most important R&D&I instruments managed by governmental R&D&I bodies in Norway, relevant for enterprises and organizations within the petroleum sector, are shown in Figure 46.

Figure 46. R&D&I financing instruments relevant for petroleum managed by RCN, Innovation Norway, Gassnova and ENOVA.



FP: Research project **KSP:** Collaberative and knowledge building project **IPN:** Innovation project for the industrial sector
Demo: Demonstration project for the industrial sector **COE:** Center pf Excellence **CRI:** Center for Research Based Innovation

OG21 is of the opinion that the Governmental R&D&I financing instruments serve the petroleum industry well, and that they have contributed to creating world leading petroleum clusters. The instruments include:

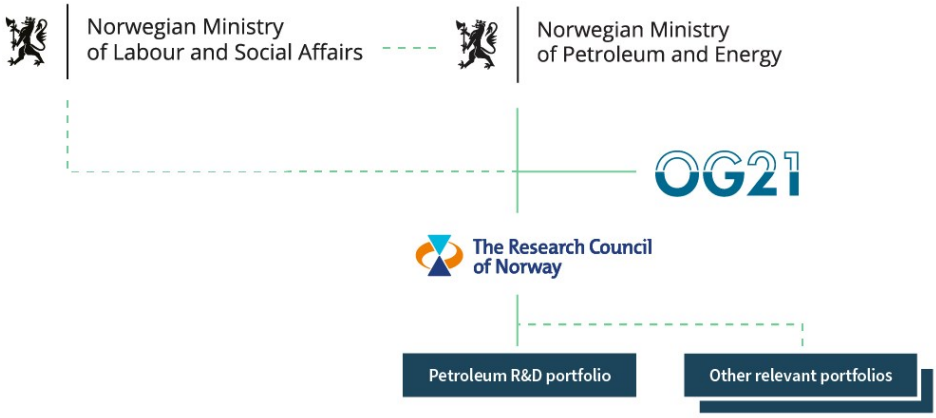
- The sector specific petroleum R&D program, including FP, KSP, IPN and Demo projects (also known as Petromaks2 and Demo2000).
- Petrocenters, multiple-year funding of research partnerships, which address topics of particular importance for the petroleum industry sector.
- Open R&D arenas where petroleum sector enterprises compete with other industries, e.g. Centers of Excellence, Centers for research based innovations, and Infrastructure.
- SkatteFUNN, an R&D tax deduction program.
- Industry Innovation Norway supported projects, seed funding as well as industry cluster programs.

- ENOVA funding of energy efficiency and climate technology projects.

CCS is a key technology for Norway to reduce CO_2-emissions, secure future petroleum markets, and develop new industry. To make CCS attractive, costs need to be reduced and well-functioning value chains need to be established. Climit is an R&D program managed by Gassnova and the Research Council of Norway. It supports technology development within CO_2 capture, transport, injection, and storage. Gassnova manages the CO_2 capture demonstration project at Technology Center Mongstad (TCM), as well as the full scale "Longship" project with the aim of demonstrating the full CCS value chain from capture to storage.

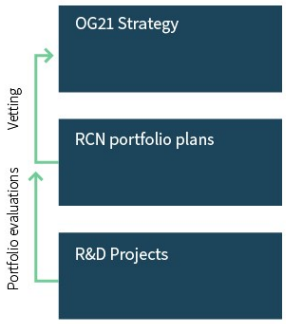
OG21's technology priorities are operationalized, among others, through research projects administered by the RCN, see Figure 47. The OG21 strategy provides recommendations and suggested technology priorities to the Ministry of Petroleum and Energy (MPE), which is then reflected in the annual allocation letter from the MPE to the RCN. In 2021, the OG21 scope was extended to also include safety and working environment, which is the responsibility of the Ministry of Labour and Social Affairs. The petroleum portfolio of research projects is the main vehicle in the RCN for operationalization of the OG21 strategy but depending on the type of technologies and knowledge recommended by OG21, the RCN may choose to implement parts of the strategy also in other relevant project portfolios.

Figure 47. OG21 influences public R&D funding and priorities



The implementation of the OG21 strategy in the RCN project portfolios is monitored through two steps as shown in Figure 48: OG21 reviews relevant portfolio plans, and RCN monitors that the project portfolios reflect the portfolio plans through regular portfolio evaluations.

Figure 48. Implementation of the OG21 strategy through RCN R&D portfolios



OG21 believes that the established R&D structure and organization support the close collaboration philosophy. For instance, the RCN petroleum portfolio board has a broad industry representation, and the project evaluation processes and criteria reflect industry needs. The competition for funding and the project selection process results in high quality R&D projects providing high returns for the Norwegian society (Rystad Energy, 2020).

R&D funding from the RCN is allocated through competition. The traditional and well-recognized approach is to issue calls for proposals with set deadlines, evaluate proposals and allocate funding within the budget available to the projects that receive the highest score on evaluation criteria. This linear approach works well for many types of R&D projects where time to impact is not critical. For other projects where time to impact is a determining factor for competitiveness and/or relevance of the results, e.g. digitalization projects within areas with a high transition pace, other approaches that could speed up the innovation cycle should be evaluated. The identification and evaluation of new approaches could be informed by practices used in the industry as well as approaches evaluated or used earlier in the RCN.

Recommendation: The RCN should evaluate new and more agile approaches to R&D funding to complement the established approach and identify for what types of projects and calls such new approaches could be applied. New approaches could for instance be open-ended calls (no proposal deadlines) or parallel funding of competing projects/concepts up to a selection gate after which only the better project(s) receive funding.

Recommendation: To better understand the value of new technologies and how technologies depend on system integration, petroleum research programs should encourage holistic R&D approaches, including system perspectives.

Recommendation: Collaboration across disciplines such as engineering, physics, and social science spur innovation. OG21 encourages cross-discipline R&D collaboration when relevant.

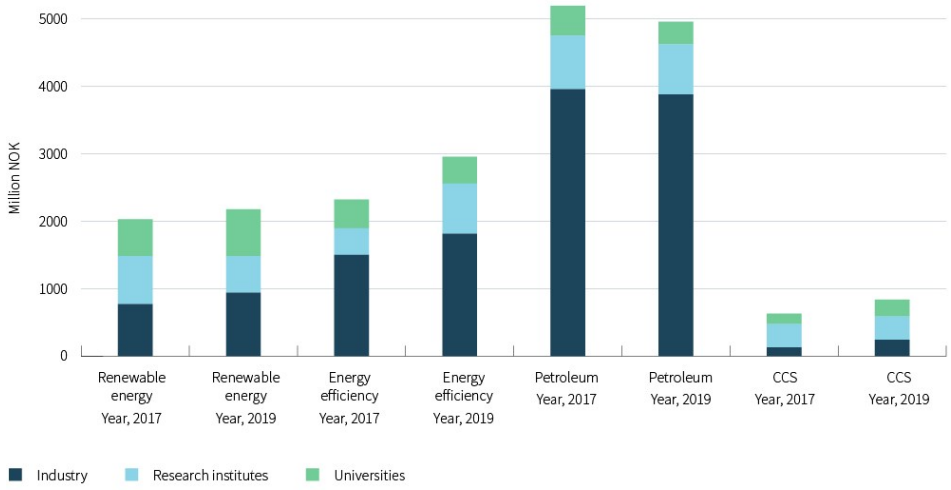
5.2.4 Significant investments in energy R&D

NIFU biannually collects and publish data on R&D investments in Norway split on sectors and types of enterprises, see Figure 49. Petroleum R&D investments are the largest followed by energy efficiency, renewable energy, and CCS. Petroleum R&D has seen a small decline from 2017 to 2019, whereas R&D investments in the other sectors have increased. (NIFU, 2021).

A much larger portion of the total R&D is funded by the industry in the petroleum sector as compared to the renewable energy sector and within the CCS theme. An important driver for the industry to invest in petroleum R&D is the FOT agreement, a mechanism that allows the operating oil companies to charge their partners in production licenses for R&D expenses, given that the R&D is relevant for the NCS, see details in section 5.2.5.

As discussed in Section 3, the future competitiveness of the NCS is dependent upon the ability to reduce GHG emissions from the production, as well as through the value chain for natural gas. In such a context, integration of the petroleum systems with renewables to provide green power to the production, and applying CCS to de-carbonize natural gas, are both highly relevant for the NCS.

Figure 49. Energy R&D investments in Norway (NIFU, 2021)



5.2.5 Petroleum R&D funding and prioritizations

The Research and Technology arrangement ("FOT-ordningen") is possibly the most important national mechanism for stimulating petroleum R&D. It allows production license operators to charge the production licenses, and thus their license partners, a certain %-age of the licenses' revenue for R&D. The R&D needs to be relevant for the NCS, but there is no requirement of relevance to the specific licenses that are being charged and there is no requirement for disclosure to the license partners of what the R&D funding has been invested in.

NCS operating companies reported nearly 4 billion NOK R&D investments in 2019, see Figure 50. It decreased to 3.4 billion NOK in 2020, probably due to R&D investment cuts resulting from the Covid-19 pandemic. 77% of R&D investments, or 2.6 billion NOK, reported to the RCN in 2020 was charged to the licenses. 23%, or 0.7 billion NOK, was not charged to the licenses, which indicate that some NCS operating companies invest significantly more in R&D than the limits for what the companies can charge their partners. On the other hand, the potential limit for what operators could have charged their partners, aggregated over all licenses, amounts to 3.5 billion NOK in 2020 as compared to the 2.6 billion NOK that was charged. This indicates that some operating companies do not leverage the full R&D potential that the license arrangement offers. The gap could be explained by a lack of organizational capability to initiate, conduct, and follow up R&D projects. It does, nevertheless, represent a lost innovation opportunity for operating companies and the society.

60% of the operating companies R&D investments reported through the FOT-reporting, are done externally in the R&D market. The external investments in Norway, corresponding to 1,5 billion NOK in 2020, are very important for activities and competence development in research organizations such as research institutes.

Figure 50. R&D investments through the FOT arrangement (RCN data)

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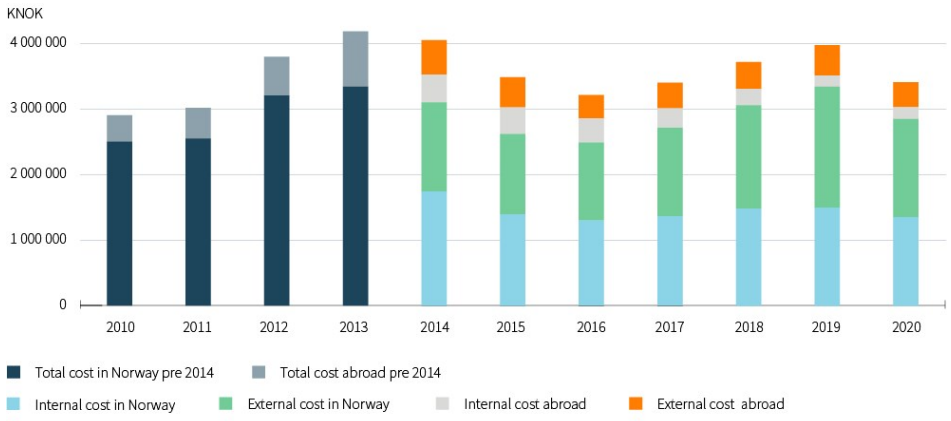
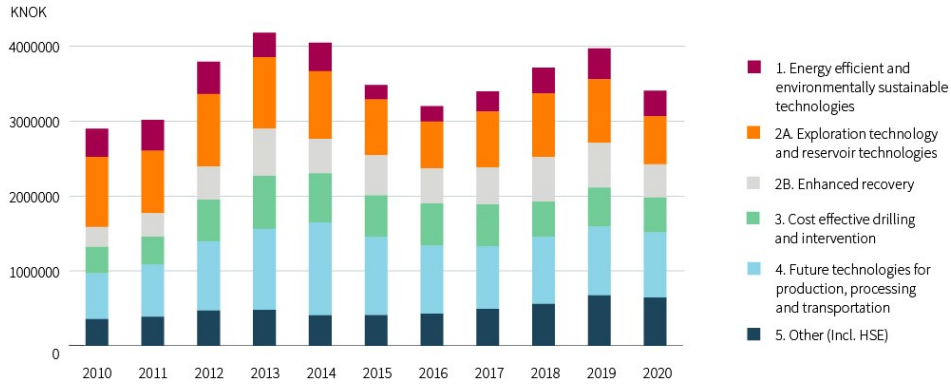


The R&D investments are well spread on themes aligned with the scope of the various OG21 technology groups. Subsurface, including exploration, reservoir, and enhanced recovery, is the larger one, but all themes see significant investments.

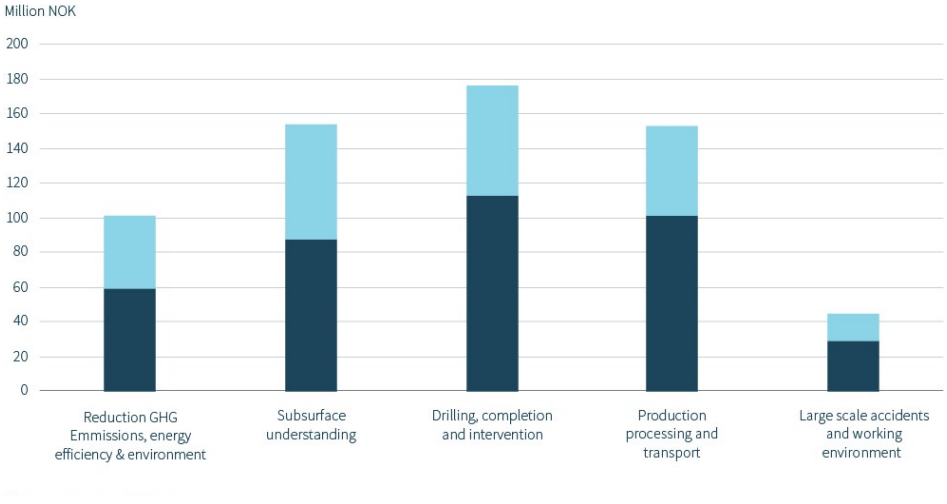
Figure 51. FOT-investments distributed on disciplines (RCN data)



The public R&D investments through the Research Council of Norway (RCN) totaled 630 million NOK in 2020, distributed on disciplines as shown in Figure 52. Investments earmarked for petroleum contributed with 62% of the total. It included investments through petroleum programs such as Petromaks2, Demo2000 and the Petrocenters. "Other" are the open investment programs and schemes where applicants from all sectors compete for funding, e.g. through calls for new research centers and calls for research infrastructure projects. The large portion of "other" shows that petroleum related organizations are relatively successful in the competition for funding through the open arenas, which suggests that they deliver high quality and convincing project applications.

The petroleum R&D funding through the RCN is targeted at suppliers, research institutes and universities. Oil companies are encouraged to participate as research project partners, but they cannot apply for research funding themselves in the petroleum R&D project calls.

Figure 52. Direct public petroleum R&D investments through the RCN in 2020 (RCN data)



Moving forward, public R&D inc
entives and funding in Norway are as important as ever to adjust for externalities and market failures discussed in Section 5.2.3.

- Reducing GHG emissions will be crucial to attract project investments, maintain society acceptance and curb global warming. Even with increasing CO_2-costs as described in the Government white paper on climate strategies (Meld.St.13 (2020-2021)), technology for reducing GHG emissions offers low economical returns, at least on the enterprise level.
- The NCS is maturing, and the average field size is decreasing. This reduces the financial capability of individual licenses to carry R&D investments.
- Improved oil recovery is important for a maturing NCS, but often such projects are marginal and new IOR/EOR technologies could struggle in the competition for funding internally in oil companies.
- The NCS attracts new types of oil companies, often smaller with a strategy of applying market proven, low risk technologies, and with little appetite for developing and applying new technologies.
- Petroleum from the NCS is competing with supplies from other regions in the world. Staying competitive requires improved productivity and lower cost solutions.
- The global competition for attracting technology clusters is increasing.

A report commissioned by the RCN, shows that petroleum research creates high value for the society, and that research can also contribute to solutions that help Norway achieve its climate commitments. The report estimates that for every NOK the Norwegian society invests in petroleum R&D, it gets a 30-fold payback, (Rystad Energy, 2020).

Public petroleum R&D funding contributes to realize value through development of competence and solutions in academia and research institutes and by stimulating industry R&D and innovation. Figure 53 and Figure 54 illustrate that many more high-quality R&D projects could have been conducted if more public funding had been available. The graphs show the accumulated Petromaks2 and Demo2000 awards split on the project evaluation scores where 7 is the highest. If all high-quality projects (grade 5 or higher) should have received funding, the allocations would have had to almost double for Demo2000 and increase three-fold for Petromaks2.

Recommendation: OG21 recommends that public funding through Petromaks2 and Demo2000 is increased. Historic data suggest that there is sufficient research capacity and high-quality R&D project ideas to accommodate a significant increase of the annual budgets.

Figure 53. Petromaks2 awards 2016–2020 split on evaluation grade (RCN data)

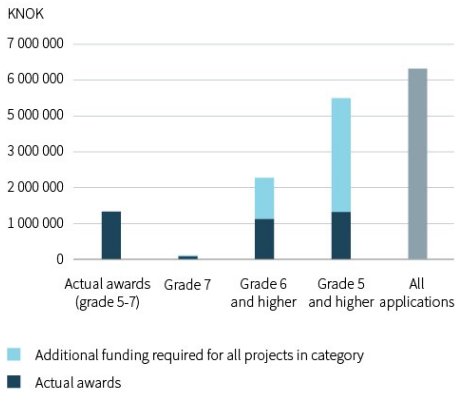
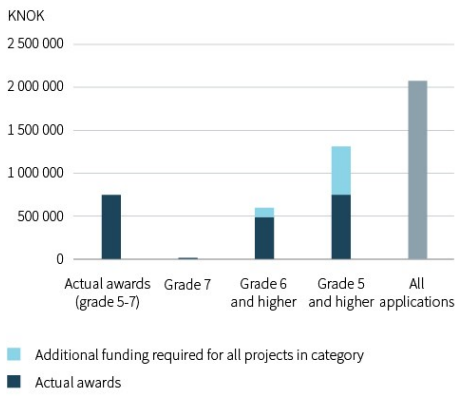


Figure 54. Demo2000 awards 2016–2020 split on evaluation grade (RCN data)



5.2.6 Opportunities within the EU research and innovation system

EU will over the years 2021-2027 invest a total of 95 billion € in R&I through the Horizon Europe program. It is organized into three pillars as shown in Figure 55. The "Excellent Science" pillar covers basic research, whereas Pillar II on "Global Challenges and European Industrial Competitiveness" is centered around applied research with the potential for fast adoption of results. "Climate, Energy and Mobility" is one out of 6 clusters organized under Pillar II of the program. Approximately 28% of the pillar's budget, or more than 15 billion €, is allocated to this cluster.

Figure 55. The organization of the Horizon Europe R&I program

The energy scope of Horizon Europe is aimed at de-carbonizing the energy system to meet EU's target of climate neutrality by year 2050. It includes energy topics such as renewable energy, CCUS and energy systems, power grids and energy storage. Petroleum is not included – nevertheless Horizon Europe provides enterprises and institutions that historically have operated within the petroleum industry and that now want to make the transfer into low-carbon energy industries, opportunities for R&I support.

Successful applicants for EU R&I funding are characterized by:

1. Project proposals that demonstrate R&I excellence and solutions with high impact and job creation in Europe.
2. This must be achieved through strong partnerships that combined can muster the competence and skills to cover the complex challenges of the calls.
3. A strong understanding of EU's R&I objectives, and a convincing demonstration of the partnership's capability of contributing with tangible results and impacts.

There are several R&I priorities specifically mentioned within the cluster "Climate, Energy and Mobility", that align well with the competencies and capabilities of many Norway based enterprises and institutions that historically have worked for the petroleum industry, e.g.:

- Earth system science.
- Global leadership in renewable energy, e.g. geothermal and offshore energy production.
- Energy systems, power grids and energy storage.
- Carbon capture, utilization and storage.

There could also be many opportunities within other clusters, e.g. in Cluster 4, "Digital, industry and space", where for instance advanced materials, AI and other data analytics, and robotics are included.

In addition to Horizon Europe, other EU initiatives where Norway participates, also provide R&I opportunities:

The *EU Important projects of common European interest* (IPCEI) address specific strategic topics such as batteries and hydrogen. Norway is co-funding the hydrogen IPCEI and Enova manages the Norwegian participation. The selection of Norwegian projects for further matchmaking with projects from other countries was done in March 2021. Innovation Norway has the responsibility for coordinating future IPCEIs.

An EU *Clean energy transition partnership* (CETP) is being developed. Norway will be participating through the RCN, and calls

are likely to include topics such as CCUS, renewable energy and energy systems.

EU is setting up 10 new *European partnerships* where industry clusters and the EU collaborate for a green and digital transition. Relevant partnerships for Norwegian industry include "Key digital technologies" and "Clean hydrogen".

The *EU Innovation fund* is funded with revenue from the European Trading System (ETS). It funds the commercial demonstration of new low-carbon technologies such as CCUS, renewable energy and energy storage solutions. Innovation Norway manages the Norwegian participation.

Norway also participates in the *Digital Europe Programme*. The program will provide strategic funding to projects in five key areas: in supercomputing, artificial intelligence, cybersecurity, advanced digital skills, and ensuring a wide use of digital technologies across the economy and society, including through Digital Innovation Hubs.

Further information on the Horizon Europe and other opportunities for Norwegian organizations in the EU R&I system, can be obtained from National Contact Persons in the Research Council of Norway and Innovation Norway: https://www.forskningsradet.no/eus-rammeprogram/horisont-europa/ncp/and https://www.innovasjonnorge.no/no/tjenester/snakk-med-en-radgiver/eu-finansiering/ .

5.2.7 International collaboration on R&D

Since petroleum R&D is not part of the Horizon Europe scope, the Norwegian national petroleum research programs as well as research collaboration efforts between Norway and other countries with petroleum production, become particularly important for the petroleum industry.

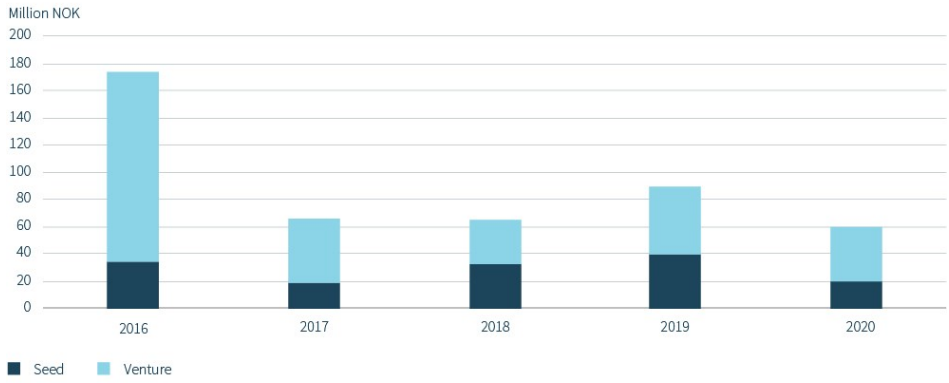
Norway currently has bilateral agreements on petroleum research, technology development and higher education with among others the USA and Brazil. Further collaboration agreements should be evaluated based on the strategic R&D priorities for the Norwegian petroleum industry described in this OG21 strategy.

Private equity investments in technology development

Enterprises in the petroleum sector in Norway in 2020 attracted 2 790 million NOK in private equity investments (NVCA, 2021). The majority of this, 2 730 million NOK, was invested in enterprises in the "buy-out" phase, a phase relatively late in the technology development when the technology is available in the market. In the earlier "seed" and "venture" phases when the technology is still being developed and little revenue is made, private equity investments are modest. In 2020 seed investments amounted to 20 million NOK whereas venture investments were 40 million NOK, see Figure 56.

The seed investments level in petroleum related enterprises in Norway of 20-40 million NOK per year is much less than the public funding through the Research Council of Norway and Innovation Norway. This underpins the importance of RCN and IN in the development of new entrepreneurial enterprises.

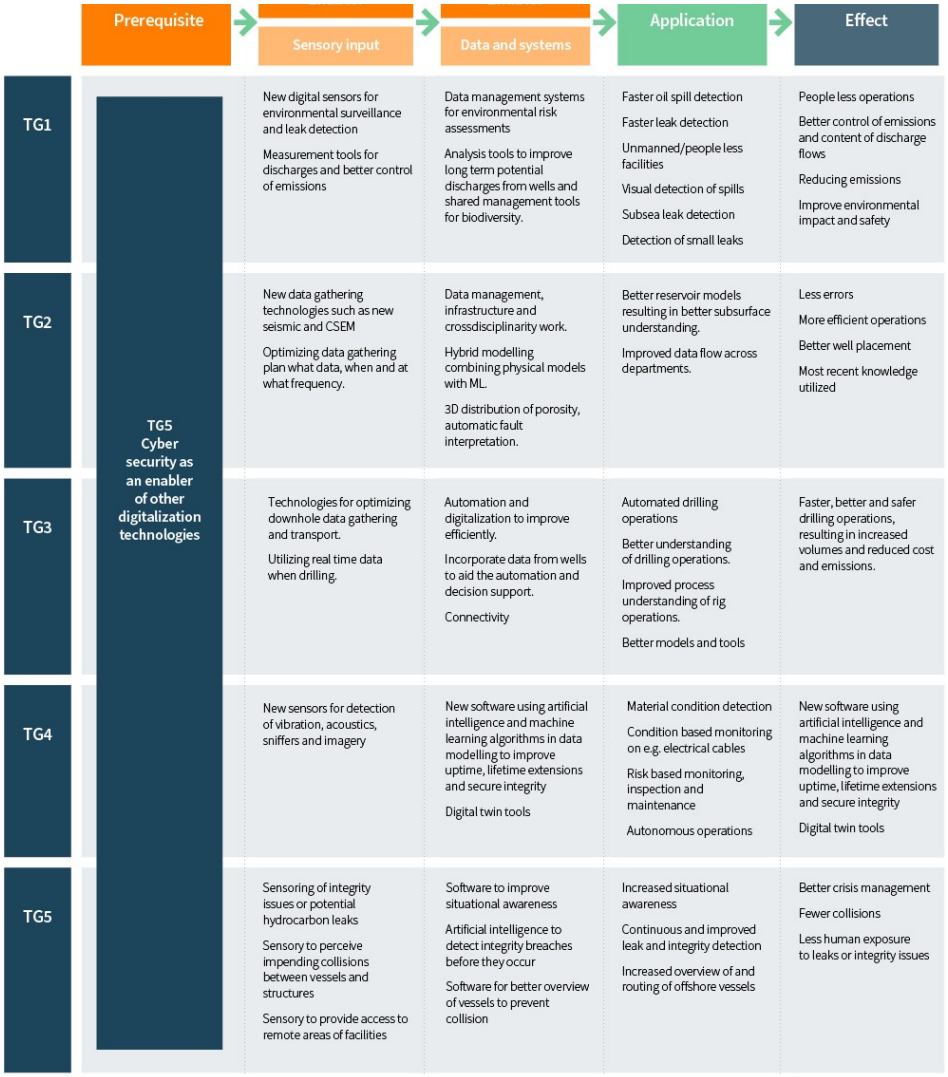
Figure 56. Norwegian private equity investments in petroleum for the early development phases of enterprises
(Seed typically TRL4-6, venture typically TRL7 on the API-scale) (NVCA, 2021)



Digitalization and efficient data utilization

Most of the technology areas prioritized by the TGs and discussed in Section 4, include some elements of digitalization. Some examples from the TG priority tables are presented in Figure 57, categorized into a model where cyber security is a prerequisite, data collection and data management systems are considered enablers, and the specific physical or data analytics tools are called applications (Rystad Energy, 2021).

Figure 57. Prioritized technologies mapped into a digitalization value chain model (Rystad Energy, 2021)

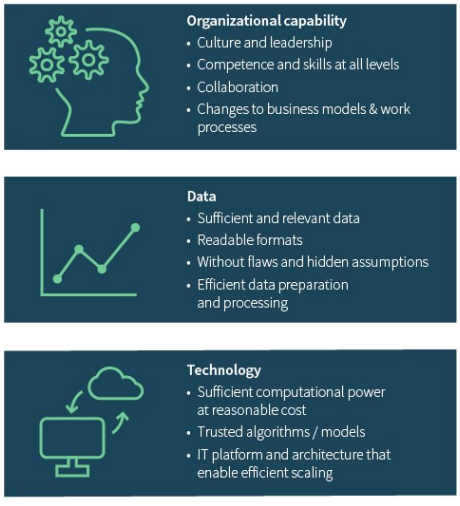


Source: Rystad Energy research and analysis

The digital transformation that the NCS needs to take part in, include tools and solutions such as AI in combination with physical models, robotics, drones and automation, remote operations, unmanned installations, and advanced digital twins. The transformation is enabled by technological advancements such as computational power and improved algorithms and models. But improved technology that can efficiently process data and provide quality decision support is not enough. Successful digitalization delivering added value, also require organizational capability, access to quality data, systems for efficient data management, and new technology.

Challenges and opportunities with digitalization identified in this OG21 strategy revision align well with the challenges and opportunities discussed by OG21 in recent study on machine learning (OG21, 2020).

Figure 58. Digitalization success require maturity in organizational capability, data collection and management, and technology (OG21, 2020)



Gathering and processing the right data is often a cumbersome and time-consuming task. Data might not be on the right format, it may be locked into applications, it might not be known to the user because it sits in other departments, or it may need to be manually checked for flaws. High data quality is fundamental for creating trust in data and therefore for realizing full digitalization and autonomous systems. Systems and sensors that can correct for data errors is an important part of providing high quality data, but high-quality data is also dependent upon safe and efficient data transfer. The full data value chain must be considered to build trust, starting from sensors, through data transfer, communication and storage, all the way to and including the use of data in applications.

In an industry where the amounts of data are growing exponentially, it will be important to develop technology, systems and work processes that enable efficient data gathering and processing as well as efficient data sharing between parties.

There are many examples of good collaboration on data gathering and exchange in the petroleum industry. The "Subsea Wireless Group" (SWiG) is an example of an international industry collaboration on data gathering and transfer, where one of the objectives is to promote interoperability for subsea wireless communications.

Another example is "DISKOS", an industry database for the NCS with seismic data, well data and production data. "Digitalt grunnfjell" is a third example where information on drill cuttings from 1500 NCS wells is digitized and made available for analyses. With the many collaboration initiatives going on and the considerable opportunity for more collaboration going forward, the oil companies on the NCS have come together in a digital collaboration initiative, managed by the Norwegian oil and gas association, with the purpose of coordinating such initiatives to the best for the whole industry.

Recommendation: The industry should collaborate on developing procedures and standards that enable data interoperability and efficient data sharing.

The importance of collaboration

The petroleum industry in Norway must be prepared for tightened competition in the future, where the producers with low costs and low CO_2-emissions are likely to be the winners. OG21 believes more collaboration between players in the Norwegian petroleum industry will be essential to succeed.

We have a long tradition for collaboration on petroleum R&D in Norway. The industry organizes its own Joint Industry Projects, and many of the projects that get public funding are required to engage co-funding partners in the industry. This practice has several advantages: It secures dissemination of knowledge in the industry cluster; it makes the R&D in the research organizations relevant for the industry, which is motivating for the researchers; and it provides the industry access to state-of-the-art research.

The average field size on the NCS is decreasing and the average production license has less economic incentive and time window for technology development than some of the large discoveries developed earlier. Many licenses do however share the same challenges which new technology could solve. It is therefore imperative that the industry succeeds in viewing technology implementation at scale and across portfolios of projects.

Recommendation: The larger oil companies need to have a portfolio rather than a project approach to new technology, Petoro should advocate for technology collaboration across the wide range of licenses they are involved in, and the NPD and the PSA should leverage their influence on technology development and adoption in licenses.

Competence – attracting talent could become a challenge

The application statistics to higher education in Norway show that M.Sc.-studies are popular and that they even experience an increased interest in 2021 from the year before (KD – Samordna opptak, 2021). Oil companies, oil service companies and other suppliers to the petroleum industry recruit from a broad range of technology studies, and the recruitment basis appears solid provided that the jobs offered are attractive. The statistics do however also show that the petroleum specific studies are becoming less popular: To the petroleum M.Sc. study at NTNU with a capacity to enroll 20 students, only 26 people applied for the study as their first choice in 2021. An even lower interest was shown for the petroleum M.Sc. studies at the UiS where 21 people had the study as their first choice as compared to a maximum enrollment capacity of 20.

Whether the low interest in petroleum specific studies reflect a reduced support for the petroleum industry among young people, is uncertain. A poll in December 2019, conducted for Klassekampen, revealed that 49% of the people interviewed supported the opening of new areas, whereas 28% were against. 23% had not decided. Among the 18-22 year age group, 58% supported the opening up of new areas. A study from Cicero (2019) suggests that 30% of Norway's population wants to reduce the oil production, whereas 40% are against reducing the production. The low application numbers to petroleum studies could therefore have other explanations, e.g. a perception of insecure jobs after several hiring and firing cycles over the last two decades.Some universities find innovative ways to attract people to petroleum studies. The BRU21 initiative at the NTNU is a telling example of how new approaches can boost the interest in petroleum relevant studies (see case description).

CASE - BRU21

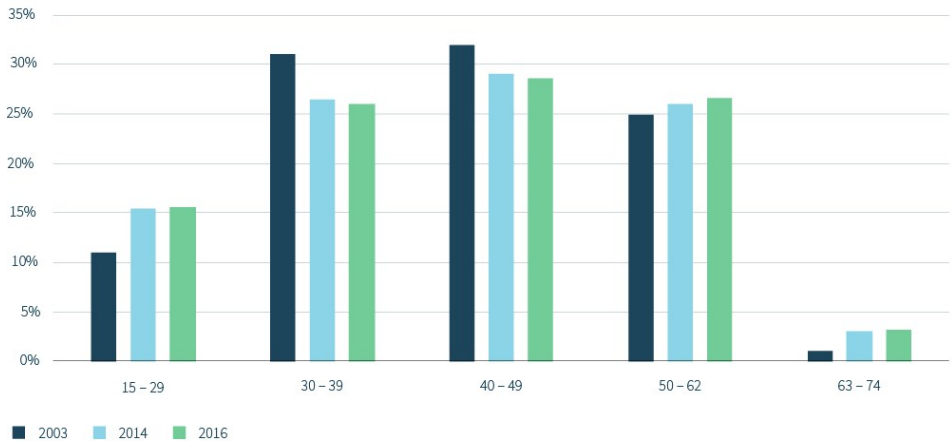
The BRU21 initiative

The BRU21 case example from NTNU illustrates a general observation related to Ph.D. studies in technology disciplines. In 2020, 64% of technology Ph.D students in Norway were non-Norwegians (RCN, 2021). This provides unique opportunities for establishing international networks and for cultural exchange and awareness. The risk is that highly skilled people leave Norway to return to their home country or other countries. Numbers from NIFU (2013) suggest that around 50% of foreign Ph.D. students remain in Norway after finalized studies. Foreigners with a technology Ph.D. from a Norwegian university are less inclined to leave Norway after finalized Ph.D. studies as compared to the average for all disciplines (37% as compared to 50%) (NIFU, 2013).

The petroleum R&D project portfolio at the RCN is very important for educating people to high competence positions in academia and the industry. Combined the Petromaks2 projects and the Petrocenters have had around 80 full-time Ph.D positions annually over the last three years, engaging more than 100 people annually with Ph.D. studies.

The workforce in the Norwegian petroleum industry is aging as Figure 59 shows. Around 30% are expected to retire over the next decade. With the "great crew change" looming in the petroleum industry, it is important that the industry can offer stable, meaningful, and attractive jobs to young talents. If not, lack of competence and skills could become a bottleneck in the further development of the NCS in the years to come.

Figure 59. Age distribution of workforce in oil companies, pipe transport, oil service, petroleum onshore bases and yards. Year 2003, 2014 and 2016. (SSB, 2017)



The digital transformation that the Norwegian petroleum industry is going through, requires new competencies and skills within areas such as artificial intelligence, robotics, cyber security, and more. The availability of people with such skills could become scarce, e.g. a study by Mark (2019) indicated a potential undersupply of 4100 cyber security experts in Norway by 2030. Going forward, we could therefore expect a competition for professionals with computer science backgrounds. To secure sufficient competence, the industry not only needs to become more attractive to young professionals, it also needs to educate its existing workforce in digital technologies. Some universities have started to offer continued education courses within data science, like for instance the "From data to insight" program at the University in Oslo (see textbox).

Recommendation: The industry needs to improve its attractiveness to young professionals. They need to be offered exciting and meaningful jobs, and be convinced through tangible results that the industry takes climate change seriously.

Recommendation: To harvest the value of digitalization the work force must understand the technology, its opportunities, and its limitations. Such competence development is a life-long endeavor, and the industry therefore needs to educate and train its employees to master and adopt new digital technologies. Industry enterprises should as part of this look for ways to collaborate with universities to develop their staff.

From data to insight

"From data to insight" is an educational program offered by the University of Oslo to professionals working in various industries. It provides the students with relevant state-of-the-art knowledge within data science, machine learning and computation. The program provides a broad introduction, with some deep dives, of the process from data collection and representation, to knowledge extraction and the use of new technologies based on data.

Meldinger ved utskriftstidspunkt 13. mars 2025, kl. 01.50 CET

Det ble ikke vist noen globale meldinger eller andre viktige meldinger da dette dokumentet ble skrevet ut.