Abstract

The Ministry of Petroleum and Energy (MPE) has administrative responsibility for seabed minerals and is implementing the opening process for seabed mineral activities in relevant areas on the Norwegian Continental Shelf (NCS) in accordance with the Seabed Minerals Act. The opening process includes an environmental impact assessment process. The Norwegian Petroleum Directorate (NPD) has coordinated the technical/academic study efforts in connection with the environmental impact assessment with support from other directorates.

The present impact assessment was conducted on the basis of a stipulated environmental impact assessment programme, which takes various factors into account, including the consultation statements. The environmental impact assessment is now being put forward for public consultation. Transparency and participation are key parts of environmental impact assessment processes.

This environmental impact assessment examines the various interests that are relevant in the area in question, so this can be used as a basis for decisions as to whether, and if so on which conditions, the area can be opened for seabed mineral activities. The environmental impact assessment highlights the potential impact an opening may have on the environment, as well as presumed commercial, economic and social effects. One important question for the environmental impact assessment is whether or not it will be possible to conduct responsible seabed mineral activities while simultaneously protecting the marine environment and ensure co-existing with other users of the sea.

As regards the scope of economic and societal impacts, they will be entirely dependent on areas being opened and the proven discovery of resources where commercial extraction may be of interest. Today, there is significant uncertainty associated with both the scope of profitable seabed minerals on the continental shelf as well as the type and magnitude of economic and social effects that could result from such extraction. What seems clear is that it could potentially represent a significant value for society if areas are opened and considerable valuable mineral resources are proven and extracted. Since these are immovable and potentially scarce resources, there is a potential for economic rent. At the same time, there will be a very limited economic downside, as the exploration costs are limited, and exploration will rapidly be scaled down if no commercially interesting resources are proven. Development will not occur if extraction is not expected to be profitable at the time of development.

This environmental impact assessment process does not contain detailed assessments associated with potential future extraction projects. Pursuant to the Act, relevant studies will take place in connection with any future applications from commercial players for approval of a plan for extracting specific mineral deposits. Among other things, such applications are contingent on the deposits being located in areas that have been opened for such activities.

In parallel with the environmental impact assessment, the Norwegian Petroleum Directorate is mapping the most commercially interesting mineral deposits on the Norwegian continental shelf. A first assessment of the resource potential in the opening area will be prepared based on this mapping. The resource assessment will be a separate part of the decision-making basis for opening acreage for seabed mineral activities.

Information and a summary of key parts of the environmental impact assessment efforts follow below.

What are seabed minerals?

Two types of seabed minerals have been discovered on the Norwegian continental shelf; sulphides and manganese crusts.

Sulphide deposits are built up by elements dissolved in the water flowing from thermal vent along the spreading ridges. Sulphide deposits are formed when the heated liquid meets a physical or chemical barrier, such as cold seawater. This builds chimney-like structures that intermittently collapse to form piles of rubble. The individual hydrothermal deposits are active for more than ten thousand to a few hundred thousand years. As the continental drift continues, the inactive sulphide deposits will gradually move further and further from the volcanically active areas, and will be partially covered by sediments. Copper (Cu) and zinc (Zn) can be extracted from sulphide deposits, as well as some gold (Au) and potentially also some lead (Pb) and silver (Ag). In principle, sulphide ore can be extracted from both active and inactive deposits. However, the inactive deposits are expected to be the most interesting, since they have had the most time to accumulate minerals.

Manganese crusts are formed when dissolved metallic compounds that naturally occur in seawater build up a crust directly on underwater rock formations under certain conditions. This is a very slow, natural process, where it takes approximately one million years to form a one cm-thick layer (crust). These crusts contain various metals that can be extracted. Crust deposits on the Norwegian shelf mainly consist of aluminium (Al), manganese (Mn), iron (Fe), titanium (Ti), and there is a potential for copper (Cu), nickel (Ni), cobalt (Co) and rare earth minerals (REE), including yttrium (Y) and scandium Sc).

Why do we need seabed minerals?
The potential of economically profitable extraction of seabed minerals could be a new and important maritime industry for Norway, and simultaneously help secure the supply of crucial metals for the future. There is an increasing global need for mineral extraction in order to ensure access to necessary metals. Production and refining of several key minerals are currently concentrated in a very few countries or a small number of companies, and in areas with varying degrees of political, social and environmental risk. In addition, some of the older mines on land have been in production since the 1800s, which means that the metal content has been reduced. A circular economy will also be important to meet the demand for metals in a sustainable way, but this will not be sufficient. Seabed minerals could therefore be a new source of crucial metals the world will need moving forward.

Environmental impact and mitigating measures
During the public consultation for the proposed programme, we received comments regarding the potential environmental impact of seabed mineral activities. A lack of knowledge about both the relevant environmental conditions and impact was emphasised by multiple consultation bodies. As part of the environmental impact assessment, state agencies and research institutes have prepared baseline studies that describe natural and environmental conditions in the environmental impact assessment area based on the current knowledge base. The assessment also describes the need for knowledge. There is limited knowledge regarding fauna and natural environment in the environmental impact assessment area, which covers 592,500 square kilometres with water depths between 100 - 4000 metres, generally deeper than 1500 metres.

An opening and opportunity for commercial exploration will contribute to a clearer delineation of recoverable resources and further development of technologies that may contribute toward increased knowledge surrounding recovery concepts and potential impact.

As regards potential concrete future extraction projects, the Seabed Minerals Act has established requirements for approved plans for development. An application for such approval requires conducting an environmental impact assessment associated with the proposed, concrete activity, which includes studying local conditions and taking them into consideration. Relevant mitigating measures must be considered.

The present environmental impact assessment explains various identified impacts associated with exploration, extraction and cessation of the activities. The focus is on activities at sea. Activity associated with exploration and cessation has generally been found to result in minor environmental impact. The potential for impact from extraction activity will depend on the technical solution, including relevant mitigating measures. The impact will generally be associated with the actual geographical area where extraction takes place. This area will be very limited in relation to the overall seabed acreage. At the same time, the local impact will depend on which natural environment is affected. Each individual activity in the extraction of minerals on the seabed could lead to various types of impact on the ecosystem at the specific site. For most types of impact, current knowledge indicates that it will be possible to implement mitigating measures in the practical administration.

The most significant environmental impact is considered to be linked to local physical influence on benthic habitats/substrates with associated ecosystems from the extraction of seabed mineral deposits. This applies for active, (near) active hydrothermal vents and manganese crusts. The impact will be of a local nature, limited to the actual area being extracted (the size of an extraction site for sulphides is considered to be in the order of 0.2-0.5 square kilometres and approx. 20 square kilometres for a crust site). The possibility of re-establishing benthos is considered to be somewhat different between manganese crusts and sulphide deposits. Underlying rock provides a basis for re-establishing fauna after the crust is removed. Following the extraction of an active sulphide deposit, new chimneys will gradually build up and, over time, form a basis for establishing new benthic fauna. There is uncertainty surrounding the timing aspect for this. The environmental impact associated with the extraction of inactive sulphide deposits is nevertheless considered to be minor, as there could be a relatively rapid re-establishment of benthic fauna, and the affected area is limited as regards the dispersion of equivalent benthos.

The extraction of seabed minerals could lead to spreading particles from the actual extraction/recovery from the seabed (including potentially moving overlaying benthic sediments before extracting a sulphide deposit), as well as from potential discharges of return water (water can be used to transport mineral resources up to a surface vessel/facility). Particles from the extraction will drift along with the bottom current and be deposited across a specific area – mainly near the extraction location. Assessments carried out on the basis of international studies and models results indicate presumed influence within a radius of about one kilometre around the extraction site. The impact is thus of a local nature. Particles and dissolved metals from return water could be transported further, but will generally be diluted, and the conclusion is that this will result in minor to medium environmental impact, limited to smaller sectors of the ocean area and only small parts of populations. The study of fishery activity shows low activity little extraction of fish and other seafood in the area, and the risk of food safety consequences is considered to be low.

With current technologies, production units and the need for transport and logistics services will require energy with associated emissions to air. The actual emissions will depend on the types of vessels that will be used, the size of the vessels, the fuel that will be used, whether emission-reducing measures are installed, as well as the number of operation days. The total emissions are estimated at around 130,000 tonnes of CO2 per year per extraction project, and are based on

current energy solutions and technology. It is presumed that the activities will be subject to policy instruments aimed at reducing greenhouse gas emissions. Cross-sectoral policy instruments such as taxes on greenhouse gas emissions and emission quota trading are currently the primary instruments in climate policy to attain Norway's climate targets.

Exploration for and extraction of seabed minerals could also involve other types of environmental impact, but these are generally considered to represent a minor impact potential and can be mitigated through adequate measures. This includes:

- Noise and vibration
- Artificial light
- Risk of introducing unwanted species
- Removing organisms through water intakes near the seabed

Such factors must be specifically considered for potential extraction projects in project-specific environmental impact assessments.

Consequences for other maritime industries
There is a limited range of other commercial marine activity taking place in the environmental impact assessment area, mainly limited to some fishery activity and some passing ship traffic. The assessment has generally concluded that there will only be a minor conflict potential between seabed mineral activities and these industries, but this must be considered in project-specific environmental impact assessments.

Bioprospecting associated with thermal vents may provide a basis for new activities in the future. In general, the consensus is that there is good groundwork in place for coexistence between seabed mineral activities and potential bioprospecting.

Commercial opportunities and economic and social impact
On the global scale, there are currently no full-scale industrial projects aimed at extracting seabed minerals in deep sea areas. Seabed mineral activities have the potential to become an entirely new industry. Regulations for extracting seabed minerals in areas outside national jurisdiction are in the process of being adopted, while at the same time, the need for minerals is expected to accelerate technology development.

Challenging physical conditions far out at sea and significant water depths require specialised technological solutions and cutting-edge expertise. Some of this can be based on existing technology, but there is also a need to develop new technology. Several technology development projects are under way globally, and many Norwegian players are involved. Norwegian technology communities in both the petroleum, maritime, processing and mining sectors have opportunities to provide the required competence and expertise. A new industry involving seabed minerals is likely to emerge both across, but also as an extension of current, existing industries. A qualitative review has been conducted of such impacts as part of the environmental impact assessment.

The economic and social impacts will depend on acreage being opened and the proving of resources where recovery is interesting from a commercial perspective. Whether or not commercially interesting seabed mineral resources exist in Norway will only be clarified through the opening of areas, so that not only the state, but also commercial players can conduct exploration for such resources on the Norwegian continental shelf. There is significant uncertainty associated with the scope of resources, their profitability and potential recovery methods. This makes the assessments

of economic and social impacts highly uncertain. This is why the environmental impact assessment's reviews of potential economic and social impacts are of a qualitative nature.

Safety and emergency preparedness
It follows from the Seabed Minerals Act that mineral activities pursuant to the Act shall take place in a prudent manner and protect the safety of personnel, the environment and the economic assets represented by the facilities and vessels.

In order to ensure prudent activity, it is important that relevant operational uncertainty and risk factors are well-understood and taken into account before commencing extraction activities associated with seabed minerals. An effort to identify and study operational uncertainty and risk factors in such activities will therefore be implemented in collaboration between relevant players and authorities following a potential opening.

Much of the knowledge acquired from petroleum activities can most likely also be transferred to planning and implementation of mineral extraction. Technology development and robust HSE regulations are also key prerequisites for conducting prudent activity associated with seabed minerals. In order to address all types of challenges regardless of natural and operational circumstances, the authorities will develop functional and activity specific HSE regulations that set clear requirements for safety and management of the activities. Potential industrial standards developed by the industry could help complement the regulations.