Staatstoezicht op de Mijnen
Ministerie van Economische Zaken

Annual Report 2016

State Supervision of Mines

Contents

Preface

'Our supervisory role is a balancing act'

The Netherlands is one year further along in the energy transition. The State Supervision of Mines (SSM), too, plays a role in this transition. Our supervision contributes to the safe production of mineral resources and energy for society, employees in the energy sector and the environment. The number of calls to end the production of gas in Groningen was growing. It seemed that, in response, enthusiasm for alternative methods of energy generation, such as the production of geothermal energy, only increased. I got the impression that, at times, this enthusiasm may have been a little too simplistic. After all, just like the production of oil and gas, drilling for and producing salt and hot water are also mining activities, which means they are not without risk.

In 2017, SSM will produce the 'State of the Geothermal Energy Sector' report, containing an overview of what is going well in this young sector and what is not, along with recommendations for better ways of dealing with the risks associated with geothermal energy. It is not SSM's responsibility to decide whether drilling for hot water should take place in the Netherlands, but as the supervisory authority we do play a key role in ensuring that what happens deep below the surface of the Earth is done in a way that is safe for people and the environment. A supervisory authority cannot and will not turn a blind eye if safety is at stake, regardless of the amount of public or political support that the particular mining method has.

In 2016, SSM issued advice to the Minister of Economic Affairs on NAM's extraction plan for Groningen. This was a complicated project, which SSM had to assess in the light of the risk of earthquakes and the management of the associated risks to Groningen society. Here, too, SSM finds itself having to manage a balancing act: what to do as a supervisory authority when risk standards exist (those proposed by the Meijdam committee), but if these cannot be put to the test? In SSM's opinion, while NAM's work was of a scientific standard, it provided insufficient information to link production levels and the risk of earthquakes. It is partly for this reason that SSM did not agree with NAM's conclusion that, with a production ceiling of 33 billion Nm^3/gas year, the residents of Groningen would not be exposed to greater risks than people living in other parts of the country.

However, a lack of certainty – caused in part by the lack of fully conclusive scientific evidence – does not absolve the supervisory authority from its duty to provide an opinion. So far it seems that lowering the level of gas production, along with a levelling out of fluctuations in production, has resulted in a significant decrease in both the number of quakes and their magnitude – but SSM cannot provide certainty that it will stay that way. That's why we are keeping a close eye on day-to-day developments in Groningen.

Of course, the obvious question remains as to whether a safe level of gas production exists in Groningen, and if so, what this level would be. In SSM's opinion, however, it cannot be said that the production level of 12 billion Nm^3/gas year that is often spoken of in this context meets the Meijdam committee's risk standards. The production level that can be considered safe could be either lower or higher than 12 billion Nm^3/year.

Although safety and environmental risks in the salt industry are not comparable to those in the oil and gas industry, the safety of accessing underground salt resources also were a relevant issue in the reporting year. In 2016, this industry came under the supervisory authority's scrutiny. Violations came to light, and SSM undertook enforcement actions. The public sentiments that became apparent in this context may testify to a shift in the public's attitude to underground activities and their associated risks.

Like most supervisory authorities in the Netherlands, we employ risk-based supervision – after all, we can't monitor everything. But, partly in response to the shift in societal attitudes, we will also be publishing a 'State of the Sector' report for the salt industry, and design our supervisory regime for this industry on the basis of this. In our reflections and recommendations we will consider society's view on the risks involved. Identifying concrete risks, along with ways of addressing and managing them, is important to ensure safety – this is one of the key responsibilities that SSM shoulders as the expert in this field. But society may turn out to be a better bellwether when it comes to risk perception and perceived levels of safety – in this area, we have an important listening role to play.

In 2016, new directors and departmental heads were hired, giving concrete form to the plans to overhaul SSM. This also meant that we could start implementing changes to both the supervisory authority's modus operandi and the organisational culture. Putting our core values – 'results, quality and cooperation' – into practice was, and continues to be, the guiding principle in this. The plan is for SSM to transform from an organisation with a functional structure into a matrix organisation; from a compartmentalised working environment to a supervisory authority that works in a seamless, adaptive and transparent way, with information gathering, knowledge development and knowledge sharing – including with society at large – being the basis of its effectiveness and impact.

In 2016, SSM found there was an increase in both the number of interventions and the seriousness of the findings. This development gives rise to concern about the poorer performance of (some) companies in the area of safety culture. These types of developments have necessarily resulted in different areas of focus in SSM's supervisory role. In future, this is expected to lead to harsher interventions as well as a new balance between tolerance and enforcement. Intelligent data collection and analysis are expected to become an increasingly crucial part of SSM's risk analysis and steering of the supervision process.

Finally, the plans to overhaul SSM also led to the development of an Annual Plan for 2017 that takes an entirely new approach. It's not a five-year plan as in the past, but a plan that's firmly rooted in the present – a plan that reflects the ambition of an organisation in transition, to be finetuned and developed in greater detail during the course of 2017. This new approach will better enable us to render public account of our activities and impact in a timely manner in future annual reports – just as we should.

I hope you enjoy reading this annual report.

Harry van der Meijden
Inspector General of Mines

Management summary

Responsibilities and modus operandi

State Supervision of Mines (SSM) protects and promotes the importance of safety and the environment, both for employees and society at large, in the production, storage and transportation of mineral resources, geothermal energy and offshore wind power.

On behalf of the Minister of Economic Affairs, SSM supervises the exploration, extraction, transportation and storage of mineral resources such as oil, gas and salt, as well as geothermal energy. The supervision focuses on health and safety, the environment and optimal use of mineral resources from a technical point of view. SSM's responsibilities are set out in the Mining Act and the Gas Act. In addition, on behalf of the Minister of Social Affairs and Employment, SSM monitors compliance with legislation on working conditions and working hours at mining facilities and offshore wind farms. On behalf of the Minister of Infrastructure and the Environment, SSM monitors compliance with environmental and building legislation at mining installations. SSM also investigates criminal offences under the direction of the Public Prosecution Service.

Like many inspectorates in the Netherlands, SSM employs system supervision and risk management, with a particular focus on the risk element, especially major risks. However, the diversity of the different sectors, and the differing ways in which they are organised and have professionalised in recent years, means that there is a growing need for multiple forms of supervision. That is why SSM is working on developing 'Tailor-Made Supervision'. As of 2017, SSM will be using structured risk analyses and translating these into so-called 'State of the Sector' reports with associated, tailor-made supervision regimes. An important objective in doing this is to keep looking ahead to the uncertainties and risks of the future and how to deal with them. Important areas of focus, in the first instance, are geothermal energy and the salt industry, as well as the growing safety risks associated with continuing efforts to make natural gas production more sustainable.

SSM outsources its scientific research to leading knowledge institutions and does not conduct it itself as a matter of principle. After all, if SSM were to base its assessments on its own research this may have a negative impact on the objectivity of the supervision. In 2016, SSM and the Ministry of Economic Affairs continued work on the 'Effects of Mining' Knowledge Programme (*Kennisprogramma Effecten Mijnbouw*, KEM), which has resulted in its formal launch.

Implementation of the improvement plan

In 2016, with the implementation of its new management structure and the filling of nearly all key positions, SSM completed the important first stage of its improvement plan. SSM now consists of two technical/scientific divisions: Underground & Well Engineering and Engineering & Grid Management. In addition to these two, SSM also has an Administrative Affairs division and a Supervisory Policy division.

The 'Guidance on government inspections' and the new Mining Act that came into effect on 1 January 2017 have further shored up and safeguarded SSM's independence.

While improvements within the organisation were being implemented, SSM's supervisory activities carried on as normal and the continuity – particularly that of our most important projects – was maintained. It is expected that the full implementation and embedding of the improvement plan will take several more years.

The most socially-relevant projects

Ensuring that the level of seismic activity in Groningen remains relatively low

SSM has issued two advisory reports on Groningen to the Minister of Economic Affairs. In June, it issued advice on NAM's production plan, which was incorporated almost in its entirety into the consent decree issued by the Minister in September. In summary, SSM advised that gas production be further reduced from 27 billion Nm^3/year to 24 billion Nm^3/year, and that fluctuations be avoided. SSM found that successive interventions in production in 2014 and 2015 resulted in a significant decrease in both the number of earthquakes and their magnitude. This trend continued in 2016. Reducing production, combined with avoiding fluctuations, became the key criteria in SSM's advisory report on the production plan. As SSM was unable to say for sure that a production level of 24 billion Nm^3/year would be safe, SSM advised the Minister to continue monitoring seismic activity on a constant basis, and – for want of an approved measurement and regulatory protocol on the part of NAM – to use an emergency response protocol to this end. In December 2016, SSM found that seismic activity in the Groningen gas field had remained within the previously-set limits stipulated in the SSM emergency response protocol, and that as a result no additional control measures

were considered necessary. An increase in seismic activity in the area southeast of Loppersum in November 2016, however, resulted in SSM advising the Minister, in its December advisory report, that NAM be asked to conduct further research into seismic activity in Slochteren, Siddeburen, Wirdum and Garrelsweer.

Reducing environmental risks in the salt industry

In 2016, the salt industry came to be subject to public and political scrutiny following the discovery of spills s by AkzoNobel Salt B.V. in Hengelo that had long gone unnoticed. These were releases of diesel and possibly brine from salt wells, as well as a high number of releases of brine and brackish water from transmission pipelines since 2014. In addition, following one such spill, a transmission pipeline was put back into operation without authorisation. As a result of these incidents, SSM placed AkzoNobel Salt B.V. under intensified supervision as part of its own research plan. In addition, a criminal investigation into the various releases was initiated, led by the Public Prosecution Office.

Limiting risks in the geothermal energy sector

On the whole, this young sector with ambitious objectives is characterised by relatively poor risk awareness and unexceptional management. SSM has already reported on this in previous years. The current laws and regulations are aimed at the oil and gas sector and do not address the specific issues that arise in geothermal energy. This means that SSM has insufficient guidance to be able to effectively and efficiently undertake its supervisory responsibilities relating to safety and the environment. In addition, system supervision and risk-based supervision are barely possible in this sector, making SSM's work very labour-intensive. In 2016, SSM had to undertake a large number of interventions at geothermal wells, particularly in the drilling stage. Prompted by the poor safety culture and the increase in incidents and violations, in October 2016 the Inspector General of Mines sent a letter to all geothermal energy companies and the DAGO sector association, in which SSM announced that it would be increasing its supervision and would be quicker with enforcement if companies were in violation of the permit conditions.

Reduction in frequency of occupational accidents and number of gas releases

The frequency of occupational accidents in the E&P industry (the oil and gas sector) decreased compared to 2015, from 2.4 occupational incidents per million man-hours to 2.1. In addition, the number of serious accidents decreased compared to previous years. The same is true for the number of gas releases – the figure for 2016 was a record low since records began in 2003.

1. What is State Supervision of Mines?

Duties, role, responsibilities and organisation

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In addition to its supervisory role, SSM can advise the Minister of Economic Affairs, either upon request or on its own initiative. SSM proactively fulfils this reflective role, feeding back to policymakers and the Minister, as set out in the 'Guidance on government inspections' that came into effect on 1 January 2016.

SSM outsources its scientific research projects to leading knowledge institutions and does not conduct them itself. After all, it might have a negative impact on the objectivity of its supervision if SSM were to base its assessments on its its own research. In 2016, SSM and the Ministry of Economic Affairs continued working on developing the 'Effects of Mining' Knowledge Programme (KEM). This turned out to be a tricky challenge, as stringent requirements are placed on KEM participants, both in terms of specific expertise and in terms of the prevention of possible conflicts of interest. Verifiable expertise in the field of geology, geophysics or mining is difficult to come by – even on a global scale – especially where questions involving earthquakes are concerned, as in Groningen. Within these parameters, universities, research institutes and the industry tend to work together closely. A modus operandi has now been developed which complies with the KEM principles of expertise, scientific authority and independence as much as is possible. Although SSM already outsourced research to a number of probable future KEM participants in 2016, the formal launch of the programme took place in 2017.

In the organisational hierarchy, SSM reports to the Secretary-General of Economic Affairs. However, the Inspector General of Mines functions independently of the Ministry and the Minister. He provides the Minister with advice, both solicited and unsolicited, for example about production plans and permits. The fact that his advisory reports are publicly available contributes to his independence and that of SSM as a whole. This approach is in line with the way most inspectorates/supervisory authorities in the Netherlands operate and are structured, and is also in accordance with the recently-amended Mining Act and the 'Guidance on government inspections'. SSM feels that the organisational governance model described above functions satisfactorily and enables SSM's expertise, and its independent role as a supervisory authority, to function effectively. However, to ensure things stay this way, and to ensure the public also experiences it this way, constant viligeance and an unswerving moral compass are required. In addition to uncontested expertise, these are qualities that should be part of the DNA of every supervisory authority.

SSM has its own budget for staff, equipment and research, and renders public account in its annual report and through its advisory reports. SSM is in the process of making all its inspection reports publicly available. Communications and PR are disciplines that SSM undertakes independently.

Modus operandi: advice, supervision and reflection

Like many inspectorates in the Netherlands, SSM employs system supervision and risk management – first and foremost because this principle is clear, rational and easy to explain. After all, due to the limited resources that are available for undertaking the supervision, the focus is not on insignificant violations but on major risks. In addition, this form of supervision gives freedom and responsibility to businesses and individuals.

And yet the Groningen situation, and public concerns about the use of underground resources in general, seem to suggest different expectations from SSM. It also turns out that system supervision, in practice, ranges from politically complex (cf. the major interests at stake in the Groningen situation) to technically difficult (geothermal energy). The key principle here is trust that companies will own up to their responsibility. In practice, however, a healthy dose of distrust seems appropriate, especially when diverging vested interests are at play. These reflections are important drivers for the plans to improve SSM that were further fleshed out in 2016.

In order to prevent conflicts of interest as much as possible, and ensure that roles and responsibilities are clearly defined, SSM ensures that different employees are involved in issuing advice on, for example, environmental permits, and with checking compliance of those permits.

SSM is proactive in fulfilling its reflective role and will keep refining it over the next few years. Because of its specific role, the supervisory authority has expert 'eyes and ears' in the field. Where SSM considers it to be relevant to do so, it will – in the interests of safety and the environment – formulate points of attention and put these on the agenda, as well as advising policy departments and ministers on them. Of course, this also applies to potential issues surrounding the feasibility and enforceability of laws and regulations. SSM also feels it is its role to disseminate information to the public. This role will also be further improved upon and refined over the next few years.

Naturally, the relevant laws, regulations and associated standards form the basis for the supervision. Where safety or the environment are at stake, SSM will intervene immediately. If no clear standards exist in relation to the issue at hand, SSM will take this up with the policy department and draw attention to the fact that this may impede it in the execution of its supervisory role. If there are no norms or standards in place in certain practical situations, or if the norms are inadequate, SSM can also prescribe its own as part of its responsibility for ensuring safety. This will be done by means of written guidance. The interventions and activities undertaken by SSM described above are all aimed at increasing safety and better protecting the environment.

Tailor-made supervision

Over the past few years, there has been a strong emphasis on system supervision. The diversity of the different sectors, and the differing ways in which they are organised and have professionalised in recent years, means that there is a growing need for multiple forms of supervision. There is no single form of supervision that is appropriate for all sectors. That's why we are developing 'Tailor-Made Supervision' to help us find the right combination of supervisory approaches.

Where a safety management system has not been in place, has only barely been developed, or has been inadequately implemented, supervision will become stricter and more labour-intensive. In such cases, supervision will be characterised in particular by inspections, both announced and unannounced. The supervisory authority will be keeping a very close eye on things.

Where a safety management system has been implemented effectively, however, supervision can be more hands-off. In these cases, supervision will be verification of the implementation of systems, and checking as to whether these systems are adequate and are actually being applied.

As stated previously, like most other inspectorates in the Netherlands, SSM takes a risk-based approach. The decision to use this supervision model is, in part, an acknowledgement of the fact that inspectorates can't inspect everything and also shouldn't end up doing the operator's job for them. The implication of this is that supervisory choices have to be made based on risk analyses. It is laid down in law that this crucial task is to be undertaken by the companies that the supervisor is assessing.

SSM is investing in further professionalising these risk analyses. This will take shape in 2017 and thereafter. The new insights gained into risks will inform 'State of the Sector' reports and tailor-made supervision regimes.

Improving risk analysis will result in greater insight into the risks associated with the activities that SSM supervises. SSM will gain better insight into the need for, and outcomes of, inspections and their quality. It is expected that this will also lead to more careful consideration of the deployment of resources or of other forms of supervision. A sector with highly professional companies and a well-established safety culture will be approached differently than one in which many companies have yet to embed safety into the company culture in a structured way.

SSM is growing into a result-oriented supervisory authority which not only reports on its efforts, but also – and especially – reports on the results of the supervision. In mid-2016, the new Supervisory Policy division was established, which spearheads innovation in supervision. SSM will publish separate 'State of the Sector' reports on the geothermal energy and salt production sectors in 2017, along with new supervision regimes that have been developed with those sectors in mind.

2. The results of supervision – what have we achieved?

2.1 Reading guide

This chapter briefly sums up SSM's contributions to safety and the environment, viewed from the perspective of the public and the people working in the industry. First, the projects that SSM considers to be particularly socially relevant will be discussed, followed by a section on how SSM deals with its need for scientific research. On this issue, SSM takes the view that a supervisory authority should, as much as possible, avoid supervising research it has conducted itself. This does not apply to technical research in the field, nor to information obtained from inspections and projects. Data drawn from these sources is analysed for any trends that SSM can identify and make use of in fulfilling its supervisory and advisory role. The section discussing inspections and projects approaches the issue from a safety and environment perspective. It includes accident and environmental statistics. Where possible, conclusions will be drawn in reference to opportunities for improvement. This chapter also focuses on the safety culture – time and again people and human error turn out to play a key role in incidents and emergencies. Embedding an effective safety culture within the DNA of organisations and people alike has proven to be extremely difficult. This chapter,about the results of supervision discusses the question of what SSM's interventions and enforcement measures have yielded in 2016. Of course, this important chapter in the annual report concludes with recommendations from SSM to policymakers in those ministries on whose behalf SSM is undertaking the supervision (2.8 Reflections by the supervisory authority). SSM does this as part of its reflective role laid down for it in the relevant legislation and regulations.

2.2 Most socially relevant projects

Earthquakes in Groningen

SSM issued two advisory reports on the Groningen situation to the Minister of Economic Affairs in 2016. In June, it issued advice on NAM's production plan, which the Minister incorporated almost in its entirety in the consent decree he issued in September. In summary, SSM advised that gas production be further reduced from 27 billion Nm^3/year to 24 billion Nm^3/year, and that fluctuations be avoided. SSM found that successive interventions in production in 2014 and 2015 had resulted in a significant decrease in both the number of earthquakes and their magnitude (see Figure 1) – a trend that continued in 2016. This gave SSM greater confidence that it may be possible to regulate the system. After all, there was sufficient evidence of a strong relationship between production and earthquakes: the lower the production, the fewer quakes. But fluctuations in production were also considered increasingly important, although it was, and remains, tricky to substantiate this scientifically.

Reducing production, combined with avoiding fluctuations, became the key criteria in SSM's advisory report on the production plan. In spite of all the studies conducted over the past few years by organisations such as NAM, SSM, the Royal Netherlands Meteorological Institute, Statistics Netherlands, Delft University of Technology and the Netherlands Organisation for Applied Scientific Research's Advisory Group for Economic Affairs (TNO-AGE), as well as input from international, independent experts, it turned out that no model had been identified that could be used as an assessment tool for the safety standards developed by the Meijdam committee. Although in SSM's view, NAM's seismological model is still the best one available, SSM also feels that this model still falls short when it comes to predicting seismic activity and the seismic risks associated with different levels of production. While this does not render the model completely unusable, it unfortunately is not suitable for assessing whether the safety standards are being met. This, however, is one of the supervisory authority's key tasks. SSM therefore does not agree with NAM that a production level of 33 billion Nm^3would meet the standards of the Meijdam committee.

In its advisory report on NAM's production plan, published in June 2016, SSM stated its expectation that, if production were to be further reduced to 24 billion Nm^3/year and fluctuations were to be avoided, seismic activity may reduce even further compared to the quiet years 2015 and 2016. However, SSM was unable to say for sure that a production level of 24 billion Nm^3/year would be safe, as this could not be tested. Yet, it is possible that a further reduction in production as a result of the proposed intervention will lead to lower seismic risks.

However, SSM advised the Minister to continue monitoring seismic activity on a constant basis, and – in the absence of an approved measurement and regulatory protocol on the part of NAM – to use an emergency response protocol to this end. SSM's protocol consisted of the parameters 'earthquake density' and 'peak ground acceleration'. In its advisory report, SSM stated that if one of these limit values is exceeded, additional control measures may be required. Furthermore, it said that NAM would need to demonstrate that the number of quakes per year would further reduce compared to 2016 in the new situation (without major fluctuations).

Then, in December 2016, SSM concluded that seismic activity in the Groningen gas field had remained within the limit values set out in the SSM emergency response protocol, and therefore advised that no additional control measures were considered necessary.

This advice was issued in response to the mandatory biannual measurement and monitoring report by NAM that was published on 11 November 2016.

However, an increase in seismic activity in the area southeast of Loppersum in November 2016 resulted in SSM advising the Minister in its December advisory report that NAM should be asked to conduct further research into seismic activity in Slochteren, Siddeburen, Wirdum and Garrelsweer. SSM expressly asked NAM to investigate the relationship between seismic activity and how the gas in this specific area is produced. As a result SSM issued a new advisory report to the Minister in April 2017, in which SSM once again pushed for a further reduction in production in the event that one of the limit values stipulated in the emergency response protocol was exceeded.

Environmental risks in the salt industry

In 2016, the salt industry came to be subject to public and political scrutiny following the discovery of spills by AkzoNobel Salt B.V. in Hengelo that had long gone unnoticed. These were releases of diesel and possibly brine from salt wells, as well as a high number of leakages of brine and brackish water from transmission pipelines since 2014. In addition, following one such release, a transmission pipeline was put back into operation without authorisation.

As a result of these incidents, SSM placed AkzoNobel Salt B.V. under intensified supervision as part of its own research plan. In addition, a criminal investigation into the various releases was initiated, led by the Public Prosecution Office. On a general level, SSM's intensified supervision means, among other things, that the operator is expected to pay more attention to compliance with the applicable laws and regulations – in this case, in particular, preventing damage to the surroundings as a result of emissions. In addressing this issue, SSM is also encouraging a proactive attitude to the provision of information, as well as an appropriate sense of urgency. A specific action plan functioned as the guide in this. The intensified supervision also means that SSM inspectors will carry out inspections more frequently, both announced and unannounced. As long as the intensified supervision remains in effect, the Inspector General of Mines will personally be directly involved.

This regime will remain in place until AkzoNobel Salt B.V. has been able to convince SSM that management of the operations in general, and the integrity of all the wells and transmission lines in particular, are sufficiently safeguarded, with safety for people and the environment as the number-one priority.

There are three companies in the Netherlands that produce rock salt (sodium chloride: common salt), operating at four locations: in Twente near Hengelo (AkzoNobel), in Groningen near Zuidwending and Heiligerlee (AkzoNobel) and in Friesland near Franekeradeel (Frisia). Magnesium salt is produced near Veendam (Nedbag). Most extractions take place at depths of 200 to 1,600 metres; in Friesland, this happens at depths of 2,500 to 3,000 metres.

Salt is produced using a method called in-situ leaching or solution mining. In solution mining, one or several wells are drilled into the salt layer. Using this well, fresh unsaturated water is transported to the salt layer. The salt dissolves, turning the water into brine, which is transported by pipeline to a processing facility. There, the salt is separated from the water by evaporation. The salt produced in this way is intended partly for consumption, and partly used as water-softening salt, road salt and as a raw material for the chemical sector. Prompted in part by the releases at AzkoNobel, SSM has decided to review its risk analysis of the salt industry in the Netherlands and make any adjustments that are necessary.

It is not unreasonable to suggest that the risks associated with the salt industry in the Netherlands are on a different level to the risks associated with the oil & gas industry and with geothermal energy. It may also be that the risks in the salt industry were perceived differently by the public and the political sphere for years. However, reality suggests an increasingly low social tolerance for releases, or chance of releases, irrespective of the seriousness of the potential risks.

In addition, SSM increasingly receives questions from local governments on how to deal with depleted salt caverns; mostly these are questions about whether it is advisable to permit construction above a salt cavern. These considerations led to SSM's decision to issue a 'State of the Sector' report for the salt industry in 2017/2018.

Risks in the geothermal energy sector

So far, the production of geothermal energy (hot salt water) in the Netherlands is taking place at depths of between 2,000 and 3,000 metres below the surface. The temperature of the water varies from 60 to 100 degrees Celsius, and the energy is harnessed for heating purposes. Current geothermal energy projects are mainly restricted to the greenhouse horticulture sector. In the Netherlands, there is currently no production of very hot water (steam with a temperature of 100-250 degrees Celsius) from aquifers (underground layers of water-bearing rock) taking place at great depths of more than 4 km, which is referred to as 'ultra-deep' geothermal energy.

Since 2009, 35 geothermal wells have been drilled in the Netherlands (5 of them in 2016), accounting for 14 production systems which produce heat from water drawn from underground. In most cases, a system consists of a doublet: a well from which the hot water is pumped and a second well to recycle the water back into the aquifer. A limited amount of what are called mining additives is added to the circulating water, for example to combat corrosion. The total heat production in 2016 was 2.74 PJ, approximately 0.14% of the total amount of energy produced in the Netherlands.

Ahead of the 'State of the Geothermal Energy Sector' report, to be published by SSM in 2017, several reflections on this relatively young sector are presented below. The geothermal energy sector is a young sector with ambitious goals and the 'growing pains' to go with them. Among the permit holders and advisors there are both white sheep and black sheep. On the whole, the sector is characterised by poor risk awareness and mediocre management. The permit holder – so far in most cases this will be a horticulturist – has to hire drilling and well expertise. The disparity between the available knowledge and expertise can be vast. In many cases, integration and quality control of the preparation and implementation of plans are poorly developed. This opens the door to risks. The difference in entrepreneurial culture that exists between the oil and gas sector on the one hand and the geothermal energy sector on the other is also striking and may itself constitute a risk. Where in the oil and gas sector, drilling and extraction from wells are among the key responsibilities of the operator – who is well equipped to this end – this is not the case in the geothermal energy sector. However, there are similar risks, such as earthquakes and blowouts, releases from wells and pipelines and problems with the storage of production test water. SSM is also concerned about the occupational safety of employees in the geothermal energy sector.

A few specific observations from 2016 below

In the drilling stage of wells in particular, SSM had to undertake a lot of interventions. For example, SSM had to halt one geothermal energy project, among other things because the casing tubes in the borehole had been installed incorrectly, and because there had been no full inspection of the safety equipment (including the 'Blow Out Preventer' that is crucial for safety).

SSM concluded that insufficient efforts had been made to safeguard the integrity of the borehole. SSM also concluded that the systems, staffing and equipment of the mobile drilling rig did not always function adequately. In order to implement the necessary improvements in the interests of safety and the environment, the installation remained out of operation for a number of weeks. After a thorough review of the improvement plan that was submitted, the drilling rig was started up again. After this, intensified supervision continued right through until the drilling of the wells had been completed.

Monitoring of corrosion improves well integrity

In order to be able to detect changes in the wall thickness in geothermal wells at an early stage, in 2016 SSM asked all geothermal energy operators to conduct measurements as part of the maintenance routine. Unlike most oil and gas wells, a geothermal well has not two, but just one metal barrier between the well liquids and the surrounding environment. Corrosion could cause releases and damage to the surroundings. Periodic checks of the wall thickness reduce the risk of environmental damage. The results of the measurements of wall thickness in 2016 revealed that in two wells the wall thickness had decreased unexpectedly rapidly as a result of corrosion and erosion. In one case, this meant that repairs had to be undertaken, and in both cases the maintenance system had to be adjusted. In addition, alternative well designs are now being considered which may be more expensive in terms of the initial investment, but which make it easier to mitigate the risks to the environment, including in the longer term.

In response to the poor safety culture and the increase in incidents and violations – both in terms of number and seriousness –the Inspector General of Mines sent a letter in 2016 to all geothermal energy companies and the sector association DAGO, in which SSM announced that it would be increasing its supervision and would be swifter to move to enforcement if companies violated the permit conditions.

The stricter supervision has resulted in greater scrutiny, both on the part of policymakers and of the financiers of those companies seeking to operate in the geothermal energy sector. When preparing a geothermal project, the different parties involved are jointly exploring how risks can be better identified and mitigated.

2.3 Scientific research

One of the key recommendations in the Dutch Safety Board report 'Earthquake risks in Groningen' is that, where controversial issues are concerned, independent and external research is essential. Both the business community and the public need to be able to rely on the facts being indisputable and not up for discussion. But 'known unknowns' also need to be identified and taken into consideration in advisory reports and decision-making. It is important that, in undertaking the research, use is made of the best knowledge and expertise available worldwide.

The supervisory authority then scrutinises the facts and areas of uncertainty resulting from the research, makes an assessment and issues advice on the basis of this information. Various types of research are important for the execution of SSM's statutory responsibilities:

- Operational support: for example, supplying maps so the earthquake density in Groningen can be assessed;
- Studies in the context of SSM advisory reports, for example on exploration permits and production plans;
- Reviews and verification of calculations in reports, conducted by businesses and knowledge institutes in the Netherlands and abroad;
- Long-term knowledge development is required for more effective supervision, for example to get better insight into the long-term effects of coal, gas, oil, salt and heat production.

Professional and independent commissioning by SSM

In the past, operational support and studies relating to specific applications were mainly undertaken by TNO-AGE. SSM can also outsource reviews and the verification of calculations to the Netherlands Organisation for Applied Scientific Research (TNO). In late 2016, talks commenced between SSM and TNO to renew the partnership and set out its contractual terms in greater detail. In these new cooperation contracts, better agreements are made concerning the activities that are to be undertaken, the quality standards and capacity planning, as well as the terms and conditions. Increasingly however, SSM's scientific studies – for the short as well as the longer term – will be conducted under the auspices of the 'Effects of Mining' Knowledge Programme (KEM).

'Effects of Mining' Knowledge Programme (KEM)

In response to the Dutch Safety Board's report on Groningen (2015), the Cabinet decided to develop a knowledge programme specifically focused on mining activities. This programme, called the 'Effects of Mining' Knowledge Programme (KEM), has the following objectives:

- Accelerating and intensifying scientific research focused on the effects of mining activities and the associated risks;
- Increasing insight into, and understanding of, risks and the associated 'known unknowns';
- Increasing multidisciplinary cooperation between research centres and universities;
- Developing expert knowledge which is independently generated and fully verifiable.

So far the commissioning parties – i.e. the programme's clients – are SSM and the Ministry of Economic Affairs' policy department. A lot of hard work was done in 2016 to give shape to KEM. Due to the strict requirements that are understandably placed on KEM, this took more time than expected. In developing the programme, the following key principles were used:

- The participants (individuals and organisations) have a scientific reputation which is recognised by peers worldwide. In addition, participants have access to a network in areas of expertise relevant to KEM;
- The participant's own university or knowledge institute must consent to their taking part in the knowledge panel;
- Participants must not be involved in the mining industry or in research assignments commissioned within this sector;
- Conflicts of interest or the appearance thereof must be prevented; where this cannot be avoided due to a scarcity of experts, those involved must operate in a transparent way;
- The participants cannot themselves undertake studies that are being sponsored by KEM .

In developing various options for the organisational structure of KEM, it became apparent that the number of experts in the field of mining activities worldwide is limited, and that the total prevention of actual or perceived conflicts of interest is virtually impossible. Ultimately, a structure was decided upon in which a so-called International Expert Panel plays a crucial role. Their purpose is to safeguard the scientific quality and independence of KEM research.

To this end, this panel will evaluate research assignments from SSM and the Ministry of Economic Affairs to assess the relevance, clarity and completeness of the research question, in the context of the topic to be investigated. The panel will also advise SSM and/or the Ministry of Economic Affairs as to who is best placed worldwide to undertake this research. After the research has been conducted, the panel will also provide advice on the peer review process. The Expert Panel has been appointed by the Minister of Economic Affairs.

Based on an inventory of research questions within SSM, a first draft annual programme has been established, as well as a multi-year research programme. Within the SSM research programme, a distinction has been made between activities that fall within the statutory responsibility (outsourced to TNO-AGE) and the more general knowledge development (which tends to be long-term) that is required for more effective supervision (via KEM). In addition, a number of research questions have been included in the inventory that pertain to various projects which SSM intends to implement in 2017. The SSM/KEM programme and budget have been established on the basis of these.

The studies sought out by SSM pertain mainly to earthquakes, land subsidence and elevation, and environmental pollution resulting from releases and the like. However, SSM also seeks to commission research into topics such as the possible long-term effects of underground storage.

In addition, capacity must be available to mount a response to unforeseen issues. The overall approach is that the best experts in the world will work on providing an uncontested knowledge base which will then be used by SSM to present, interpret and assess the facts.

2.4 Technical research 'in the field', inspections and projects: what did they yield in 2016?

Accident statistics

The frequency of occupational accidents in the E&P industry (the oil and gas sector) declined somewhat compared to 2015, from 2.4 occupational accidents per million man-hours to 2.1. The number of serious accidents also decreased in comparison with previous years, and SSM was pleased to find that no fatalities have occurred in the oil, gas, salt or geothermal energy production sectors since 2013. Nevertheless, it is difficult to derive unequivocal conclusions from these figures, especially as the frequency of occupational accidents varies strongly from company to company (from 0 for the best operator to more than twice the average for some others). For this reason, SSM is careful not to become complacent with regards to the sector's safety performance.

To prevent the challenging economic and social climate from having a detrimental effect on safety in the oil and gas sector, SSM will make safety management measures in the workplace a particular area of focus over the next few years. The challenges ahead relate to further improving the safety culture, the competencies of employees with safety-critical roles, as well as ensuring sufficient maintenance of essential systems as oil and gas prices remain low.

What we are happy about, however, is that the number of gas releases further declined in 2016. The downward trend of 2015 – which first started in 2012 but was interrupted in 2013 and 2014 – continued in 2016: the number of gas releases that were classified as 'significant' or 'major' following analysis was the lowest since records began in 2003 (see Figure 3). No major gas releases occurred in the reporting year. The classification of gas releases referred to here is based on safety risk and not on the environmental impact of the gas release. After all, a relatively small emission in a confined space can still result in a serious explosion.

Safety culture

The oil and gas industry is changing. In addition to the traditional big players, more and more new smaller parties are entering the market. In addition, companies' profits are under pressure. These developments are resulting in greater diversity in companies' compliance behaviour. Analyses of the inspection results reveal that safety performance at a number of companies has become demonstrably worse. SSM has specific concerns about the declining safety culture., An inadequate safety culture is one of the determining causes of most major industrial accidents. 'Safety culture' here should be understood to mean: 'the attitude, assumptions and habits of the employees of a company with regard to safety risks'.

In 2016, SSM launched a study into the safety culture of mining companies. The objective of the project was to exert a positive influence on the safety culture of the companies involved, thereby contributing to a safe working environment. One of the developments prompting the launch of this project was the fact that cuts and reorganisations have become a regular occurrence within mining companies. The first part of the project was a study looking at the perception of the safety culture among the managers of production installations on the North Sea (which are referred to as 'Hoofd Mijnbouw Installatie', or HMIs).

The most important findings are summarised below:

- Both the HMIs involved and NOGEPA (the Netherlands Oil and Gas Exploration and Production Association) were constructively involved in the perception study. As this attests to openness and transparency, SSM considers this to have been an indication of a positive safety culture.
- Many HMIs feel there is too much safety-related paperwork – for example the extensive reporting requirements in the aftermath of minor incidents. These requirements do not only apply wrt SSM, but also within the companies' own HSE departments. This means that on-the-job training and education for employees tend to get less attention than they deserve.
- A significant number of HMIs feel they don't have sufficient people available for necessary tasks and that there isn't enough time available for training.
- The majority of the HMIs feel that recent cuts and reorganisations are not having a major impact on the safety of their installations. The HMIs indicated that the technical integrity of the equipment on their installations is closely monitored,

not least because the safety of their own employees is at stake. The importance of maintenance to safety-critical systems seems to be placed high up on HMIs' agendas.
- The employee turnover rate is relatively high, and it has turned out to be difficult to retain young people within the sector.

Lessons for SSM arising from this research:
- Random investigations into the maintenance and operation of safety-critical systems remain necessary.
- The competencies of the employees working in the mining sector are at least as important. Platforms that have high turnover rates or where significant personnel changes have taken place deserve more attention in this regard than platforms where the staffing is stable;
- Just like the mining companies, SSM itself also has a need for methods and standards to be better able to assess the HR implications arising from cuts.

These lessons will be incorporated into the continuing 'Safety Culture' project in 2017, as well as informing SSM's regular inspections.

Safety analyses from themed projects

Oil & gas

In addition to planned and unplanned inspections and studies, SSM also undertook a number of specific, themed projects in 2016. Below is a selection of the most important ones:

Closing down and removing mining installations
The integrity of decommissioned offshore mining installations must be guaranteed until the installation is fully removed. The same applies to any navigation lighting for shipping traffic. SSM monitors this, but it did not yield any significant findings for 2016.

No mining installations were removed in 2016. However, around 10 mining installations ceased the production of oil or gas. The expectation is that many more installations will cease producing over the next few years, and that the removal of offshore installations will gain momentum. In this context, SSM is following progress of the EBN initiative with great interest. Agreeing on best-practice standards for abandoning wells, installations and (on- and offshore) pipelines, in particular, is high on the SSM agenda for 2017 and 2018, along with ensuring that the relevant requirements in the laws and regulations keep pace with developments.

'Risers and Flexibles' project: integrity checks of pipelines after they have reached the end of their design life
In 2016, the 'Risers and Flexibles' project revealed that most pipelines that had reached the end of their design lives could still continue to be used safely for a longer period of time. In some cases, the checks undertaken as part of this project did result in pipelines being taken out of operation. Most of these decisions were based on cost considerations. In one case, the integrity of a flexible riser could not be demonstrated, leading the mining company to decide to no longer to use the riser and to replace it in its entirety.

Integrity of existing wells
The 'Integrity of Existing Wells' project was completed in 2016. All active mining companies that produce oil and gas have been inspected. Together, these 11 mining companies operate around 3,600 wells, of which around 2,400 are onshore and around 1,200 on the continental shelf. Based on the analyses undertaken as part of this project, SSM concludes that the quality of the well integrity in the Netherlands could not lead to major risks to people and/or the environment, nor could it have done so in the past. All points of improvement that were identified were taken in hand and incorporated into an improvement plan. However, SSM does intend to focus on the topic of well integrity in greater depth in 2017. For example, through follow-up inspections it aims to gain insight into the overall state of all onshore wells. This research will not only focus on wells for the production of oil and gas, but also on wells for the production of salt and geothermal energy.

Rig inspections
Since 2012, SSM has been undertaking the 'Rig Inspection' project. Under this project, all mobile drilling installations, both on- and offshore, are inspected annually. The project was prompted by the 2010 disaster at the 'Deepwater Horizon' oil rig in the Gulf of Mexico in the US. The focus of the inspection project is managing the risk of the uncontrolled release of underground liquids and gases. This risk, also referred to as a 'blowout', can cause significant harm, both to people and the environment, as a result of fire, explosions and releases. To manage this risk, the effectiveness, reliability and integrity of the well's safety installation, including

the Blowout Preventer (BOP), must be ensured. All this equipment must meet stringent requirements and its operation must be periodically tested. In addition, operating this type of equipment requires a high level of competency on the part of the staff responsible.

The most important findings on the period 2012 up to and including 2016 are:

- incorrect sequence of valves in the well's safety installation;
- incomplete execution of the periodic tests of the well's safety equipment;
- a lack of familiarity with several provisions from the laws and regulations and the industry standards relating to well safety equipment;
- blocked escape routes from the drilling floor;
- the presence of ignition sources in locations where an explosive mixture of gases could build up.

It is striking that these findings still occur at drilling installations in the Netherlands. This is mainly the case at new drilling installations that are being inspected for the first time. It has also become apparent that the relatively young geothermal energy sector falls short when it comes to putting safety-critical and environmentally-critical management systems in place at rigs.

Appropriate interventions on the part of SSM over the past few years have resulted in companies making clear improvements during this period. The management of the safety and environmental risks has risen to a higher level as a result. However, physical inspections of drilling installations remain necessary for SSM to ensure that the industry maintains a high standard of risk control.

Atmospheric, vertical storage of hazardous substances

During the extraction of natural gas, flammable liquids such as natural-gas condensate are released. These flammable liquids are separated from the natural gas above ground and then stored in vertical, cylindrical storage tanks. The storage of flammable liquids comes with its risks. This became apparent on 11 December 2005, when a major fire broke out at the Buncefield oil storage facility in the UK.

In the Netherlands, this led to the existing standard for the atmospheric storage of flammable liquids, PGS (Publication Series on Dangerous Substances) 29, being tightened up. In the period between April 2014 and January 2016, SSM inspected twenty mining locations to establish whether their storage tanks met the standards stipulated in the PGS 29 guideline. During the inspections, the emphasis was on the concrete, practical situations that are relevant in the risk management of these types of storage tanks. Attention was mainly directed at the technical integrity and the reliability of the safety mechanisms and regulators on tanks. The most important areas of attention were:

1. The permit status;
2. The reliability (integrity) and maintenance of storage tanks;
3. The regulators, warning alarms and automatic overfill prevention systems on the tank;
4. Cooling installations and fire extinguishing systems (including foam-based fire extinguishing systems).

The main findings emerging from the inspections are as follows:

- The Environmental Permitting (General Provisions) Act (Wabo) permits do not always include the PGS 29 guideline as the standard, or the prescribed PGS standard is outdated;
- On the whole, the tanks do not receive the same level of attention as the gas-carrying parts of the installation. In addition, various shortcomings were identified, which have since been addressed and improved by the relevant companies;
- All inspected tanks that were used for the storage of natural-gas condensate are fitted with level alarms and automatic overfill prevention systems, even if in some cases this was not mandatory for obtaining the permit.

On 2 December 2016, SSM sent out a health & safety bulletin to all companies involved summarising the key findings. This bulletin can also be found on the SSM homepage.

Offshore wind power

Supervising offshore wind farms is one of SSM's responsibilities. The offshore wind power sector in the Netherlands is still in its infancy. The first wind farm was constructed 10 years ago; in 2016, three wind farms were operational in the North Sea. The construction of two new wind farms north of the Wadden Islands commenced in 2016. Building wind farms and producing offshore wind energy is not without its risks, which is why risk management is required. Risks relate to things like working at height, entering confined spaces, electrical systems, diving, transportation by ship or helicopter to and from the offshore location, and construction risks.

SSM's supervision focuses mainly on the construction stage, where the chances of accidents are currently highest. In 2016, one inspection was undertaken during the planned maintenance of an operational wind farm, and one accident was investigated. As to the construction of the two new wind farms, the focus was on checking procedures, attendance at the meetings (including meetings on safety), and checks of equipment and ships. As far as SSM was able to establish, it seems justifiable to conclude that the current offshore wind farms perform very well when it comes to safety and risk management.

The Dutch Safety Board published the report 'Medical assistance on the North Sea'in 2016. Prompted by this, SSM evaluated the way in which processes surrounding medical assistance are designed, and provided guidance to companies in the offshore wind power sector for implementing the recommendations.

SSM is a part of the Netherlands Wind Energy Association (NWEA)'s Occupational Health and Safety Catalogue (*Arbocatalogus*) working group, which facilitates the exchange of knowledge relating to ways to improve working conditions at offshore wind farms. In addition SSM recommended in 2016 that the working hours legislation be changed to the 2 weeks on/2 weeks off system, as is already the standard for offshore mining employees. In addition, to prepare for future developments, SSM has begun updating its supervisory role and enforcement strategy for the offshore wind energy sector.

Gas distribution

Ensuring the safety of gas grids during the energy transition

In the context of the energy transition, moving away from gas for private households was placed on the political agenda in 2016, both at the national and local levels. It is important to SSM that the gas grid remains safe until the very last day that it is used. In order to ensure this, SSM conducts themed inspections of the regional gas grid operators based on risk analyses.

Direct cause	2010	2011	2012	2013	2014	2015	2016
Construction errors in the past	9	13	9	8	10	19	20
Other	67	73	55	32	35	42	15
Operation	0	0	0	1	0	2	14
Corrosion and wear and tear	9	16	20	15	16	38	16
Excavation work	133	156	164	163	173	386	105
Assembly errors (current)	5	6	2	4	4	8	3
Unknown (despite research)	12	9	2	5	0	8	1
Product faults	2	4	1	1	0	0	0
Point load	5	17	14	10	16	24	9
Vandalism/theft	25	35	46	40	64	83	27
Soil effects	41	37	29	46	36	73	27
	308	**366**	**342**	**325**	**354**	**683**	**237**

Table 1 – Causes of incidents involving gas grids

Gas grid operators can learn more from incidents

The inspections carried out in 2016 were once again focused on the operation of the safety management and safety control systems. It became apparent from these inspections that the step-by-step method of improving safety performance works. However, there is insufficient reflection on ways to learn from incidents. During the inspections SSM found that the grid operators investigate incidents on a case-by-case basis. More attention, however, needs to be paid to the link between individual cases, so that any system errors can become apparent.

Excavation damage remains an important cause of gas releases, as is evidenced by the exponential increase in 2015 (see Figure 1). For this reason, in 2016 SSM emphasised the importance of preventing excavation damage and tightened up the reporting criteria for gas incidents. This helps SSM to see the forest for the trees. As the supervisory authority, SSM encourages gas grid operators to investigate all reported incidents, with a focus on identifying parallels and drawing connections between them.

Green gas

During the themed inspections of green gas in 2014/2015, SSM found there is greater fluctuation in the quality of green gas than in the quality of natural gas. In the fourth quarter of 2016, SSM commissioned the external consultancy firm DNV GL to carry out a closer investigation of the safety margins for green gas. During this research, green gas was burned on three different gas appliances and the composition of the combustion gases was analysed. It was found that there is an absolute lower threshold to the quality of gas, below which certain appliances begin to produce too much CO and therefore can no longer be safely used. Based on this study, SSM recommended to the Ministry of Economic Affairs' policy department that the quality requirements of green gas be updated.

Safety of gas pipelines is improving thanks to replacement programme

In 2016, too, SSM monitored the progress of the replacement of brittle gas pipelines (grey cast iron and asbestos cement). The most vulnerable pipelines, those closest to the building frontage, need replacing most urgently. The lowest priority was assigned to pipelines that are out in the countryside where there is very little traffic. During the inspections it became apparent that the grid operators have complied with the agreements, and that those pipelines with the highest priority level were all replaced in 2016.

The environment

Phasing out the offshore discharge of chemicals

In order to protect the marine environment, international agreements have been made under the OSPAR Convention in relation to the use and discharge of offshore chemicals. The Netherlands has incorporated these international rules into the Mining Regulations. The stricter rules for the use of chemicals that took effect as of 1 January 2017 meant that in 2016, alternatives for around 130 products had to be introduced to enable their use and discharge to cease. The industry has switched to products that are less toxic and more biodegradable. Exemptions for the discharge of products were expiring, and the alternative products had to be assessed from scratch under a stricter regime. The replacement of products by less harmful alternatives, or ceasing their discharge, has resulted in only a small number of products (around five) having to be granted a further discharge exemption due to technical necessity. This means that overall the discharges by the offshore industry have become a lot less harmful to the marine environment.

Companies work with hazardous substances in a more professional manner

The Working Conditions Act requires a hazard identification and risk assessment (*risico-inventarisatie en –evaluatie*, RIE) to ensure healthy and safe work with hazardous substances, in which the long-term effects are as important as the immediate impact. Employers have a duty to minimise exposures to hazardous substances and to assess this using the RIE. Assessing exposure on the work floor forms part of this assessment.

SSM tests compliance with these statutory requirements through onsite inspections and verification of the RIEs. SSM initially started doing this at mining companies with production installations (both permanent and temporary ones), since this is where the largest number of employees that risk exposure are to be found – unlike mobile drilling installations, whose presence, on- or offshore, is only temporary. After SSM found, in 2014, that improvements had been made at the production installations, supervision was expanded to include the mobile drilling installations. Figure 5 shows the cumulative number of inspected RIEs with exposure assessments since 2009. It is clear from this graph that companies have made headway in this area: the inspections that were carried out reveal that the newly-completed RIEs comply with the provisions of the Working Conditions Act, and that employees' exposure to hazardous substances is currently well managed.

Further research into methane emissions in 2017

Natural gas consists predominantly of methane. Methane is a powerful greenhouse gas, and more harmful to the environment than CO_2. In 2016, SSM scrutinised the electronic annual environmental reports (*MilieuJaarVerslag*, or e-MJV) that mining companies submitted for the year 2015. Mining companies are not required to submit an e-MJV, but are required to report on their emissions under the terms of their environmental permits. The e-MJV is a handy tool for this, both for the companies themselves and for SSM.

No themed inspections of the emissions from mining facilities were conducted in 2016, although random sampling during the regular inspections was used to confirm that the permitted quantities were not being exceeded. No violations were identified in 2016. SSM also conducted research into methane emissions from abandoned wells. The conclusion was that all abandoned onshore wells were correctly sealed and no methane was being released.

In 2017, SSM will once again carry out themed inspections targeting methane emissions, using new technologies that have recently become commercially available that are capable of measuring methane emissions remotely.

Offshore discharge of produced water is well within the legal standard

Produced water from the deep subsurface is a by-product of the production of oil and gas. After it has been treated, the produced water is discharged into the sea. This is permitted, provided that the oil content in the treated produced water meets the applicable

discharge standards. SSM monitors the offshore discharge of produced water by undertaking unannounced inspection flights to the production installations. SSM uses special helicopters provided by the coast guard for these flights. During these inspections, purified produced water samples are taken . SSM then commissions an independent laboratory to analyse these samples for the oil content. The values found are then compared to the values of the analyses undertaken by the mining companies themselves.

New NO_x requirements for mining installations

SSM is responsible for ensuring that mining companies comply with the new legislation pertaining to the emission of nitrous oxide in a timely manner. In 2016 SSM worked with the Ministry of Infrastructure and the Environment, the Ministry of Economic Affairs and the Netherlands Oil and Gas Exploration and Production Association (NOGEPA) on the development of a 'NO_x compliance sheet'. This is a tool that gives the companies and the supervisory authority insight into the maximum permitted emissions for specific cases. This sheet helps companies make their investment choices, ensuring that they will be in compliance with the new NO_x standards that take effect for offshore combustion plants on 1 January 2019. The Netherlands is the only EU Member State to apply the stringent NO_x standards from the Industrial Emissions Directive to offshore installations. Installing end-of-pipe or integrated NO_x reduction technologies at existing offshore installations is not easy. In some cases, they are not even directly available as these stringent requirements have only come into effect for the installations in the Netherlands. However, it is expected that nearly all installations will be able to comply with the new legislation in a timely manner.

Injection of produced water is a suitable disposal method

As a rule, produced water that is released during the onshore production of oil and gas is re-injected into the same, or a comparable, oil or gas field. For example, since 2011 NAM has been injecting produced water released by oil production in the Drentse Schoonebeek field into empty gas fields in Twente. Local residents, as well as the local and national political sphere, have grown increasingly concerned about the potential risks of this water injection into the deep subsurface. The escaping water from the pipeline between Schoonebeek and the Hardenberg gas fields in Twente in April 2015 may have been a contributing factor in this. Approximately 100 m^3 of produced water was released. The contaminated soil was excavated and transported to an approved waste processing company. On 16 August 2016, after NAM had implemented structural improvements to this pipeline, SSM consented to the refurbished pipeline being put into operation.

The injection into the empty gas fields occurs under permit. One of the permit's provisions requires NAM to undertake an evaluation of the processing method for the produced injection water after six years. At SSM's request, this evaluation study was carried out ahead of schedule. In mid-2015, NAM commissioned Royal Haskoning DHV to complete the evaluation study. The study into water injection in Twente was completed in 2016, and revealed that the injection of the produced water that is released during oil production remains the most suitable disposal method.

2.5 Results of interventions and enforcement

Various projects and inspections were carried out under the 2016 inspection programme. As mentioned previously, there has been a falling off in compliance across all the sectors that SSM supervises. Analyses of the inspection data reveal that the number of serious violations per inspection is on the rise. This is true for all sectors, although the following must be noted:

- The geothermal energy and salt sectors are clearly lagging behind the oil and gas sector;
- Within the oil and gas sector, the drop-off in compliance is caused by a number of companies dragging down the average for the sector as a whole. The sector consists of both frontrunners and stragglers.

The increase in the number of violations per inspection resulted in an increase in repressive supervision in 2016, along with a corresponding increase in the deployment of legal resources. There are 3 gradations of repressive supervision; warnings, administrative enforcement and shutdowns.

Warnings

In the reporting year, 10 warning letters were sent in response to serious violations. These warning letters announced that structural control measures needed to be urgently implemented. The relevant companies were also informed that, if they were found to still be in violation on a further occasion, enforcement action would be taken.

Administrative enforcement

In five cases, administrative enforcement was employed, with penalty notices being sent out. Three of these cases pertained to contraventions of environmental legislation; one involved a contravention of the EC Regulation on the Classification, Labelling and Packaging of Substances and Mixtures, and one a contravention of the Dutch mining legislation.

Shutdowns

1 drilling operation was shut down because adequate management of the safety risks could not be sufficiently guaranteed.

In addition to administrative enforcement, criminal law enforcement was used as well:

Penalty reports and police reports
Based on investigations into reports of incidents and accidents, six penalty reports (administrative law) and two police reports (criminal law) were drawn up and sent to the Public Prosecution Service. The two police reports pertained to releases of natural-gas condensate and crude oil into the sea. The six penalty reports pertained to four serious accidents: one case of entrapment, one incident involving injury from a high-pressure water jet and two falls. In addition, two penalty reports were drawn up relating to serious incidents: the use of non-explosion-safe electrical equipment in a zone with a potential explosion hazard and an incident involving exposure to asbestos during operations, respectively.

2.6 Advice on environmental permits and production plans

In order to be permitted to produce mineral resources or geothermal energy, one of the requirements companies have to fulfil is to provide an approved production plan. The production plan is drawn up by the holder of the production permit, and details the method and duration of the production, the expected or actual amounts of mineral resources or geothermal energy to be produced, as well as expectations relating to soil movements and how any resulting damage will be prevented. The production plan must be approved by the Minister of Economic Affairs.

The Ministry of Economic Affairs requests advice from SSM relating to the approval of production plans and/or amendments to production plans. SSM substantiates its advice by calling on independent expertise. SSM contracts TNO-AGE to assess technical calculations and predictions in production plans. In 2016, SSM urged the Ministry of Economic Affairs to clear backlogs in the processing of production plans as soon as possible, particularly where gas production and geothermal energy are concerned. The existing situation can lead to legal uncertainty on the part of companies, an unlevel playing field, and enforcement dilemmas on the part of the supervisory authority.

The specific locations in which the production of oil, gas, salt or geothermal energy takes place must also have valid environmental permits. By way of derogation from the general rule that local authorities are the competent authority for the granting of environmental permits, the Ministry of Economic Affairs becomes the competent authority when mining locations are involved. The Inspector General of Mines is the designated legal advisor for these permits. Depending on the nature of the permit application, a regular or enhanced procedure may apply.

The enhanced procedure applies, for example, to construction on new locations, or in the event that an existing permit needs updating as a result of an environmental review. A total of 21 advisory reports on these types of permits were issued in 2016. The regular procedure applies, for example, for construction activities or alterations that do not result in a deterioration of the environmental situation. In 2016, 29 advisory reports of this sort were prepared. Outside the 12-mile zone, companies are not required to have an environmental permit for mining activities. In these cases, the environmental aspects are regulated by the terms of a mining environmental permit. SSM advises the Ministry on these as well. In 2016, it issued three advisory reports on mining environmental permits.

The Dutch mining regulations contain general rules relating to safety and the environment that apply to mining installations and mining works. Specific permissions, exemptions and approvals apply, for example, to the use and discharge of offshore chemicals, to drilling activities, and prior to a new pipeline being put into operation. An additional effort was made in this area because of the phasing-out of offshore discharges (see 2.4.4). No significant incidents occurred in this area in 2016.

2.7 Practice makes perfect – ‘Harmony’

A few years ago, SSM and the NOGEPA sector association made agreements on running safety drills for emergency scenarios and, where necessary, identifying points for improvement. Annual safety drills have been held since 2013. The lessons learned during those drills are shared with all the mining companies, and have contributed to the improvement of their emergency response plans.

On 22 September 2016, the fourth drill, called ‘Harmony’, was held at NAM’s gas treatment installation in Den Helder. In the drill scenario (a collision between a ship carrying natural-gas condensate and a ship carrying sand/gravel), cooperation between the government’s emergency response teams and the mining company’s own emergency personnel was tested. The following organisations took part in the drill: NAM, the Noord-Holland Noord Safety Region (police, fire brigade and ambulance service), the Hollands Noorderkwartier water board (the relevant water authority), the City of Den Helder, SSM, the Royal Netherlands Navy, the

Netherlands Coast Guard and the Province of North Holland. Representatives of various mining companies and services were able to observe the drill in real time from an observation room.

The most important areas for attention revealed by the safety drill were:

- Ineffective communication, as a result of which the emergency services were late to arrive onsite;
- Poor cooperation between the government teams and the mining company;
- A lack of information relating to the effects of the incident on the surroundings;
- A lack of insight into the development of the incident;
- A lack of crisis communication/a crisis communication plan that had been developed in advance;
- The lack of a strategic plan for returning to the normal situation.

Another large-scale safety drill will be held in 2017.

2.8 Reflections by the supervisory authority

Just as other supervisory authorities are the expert eyes and ears in the field that they supervise on behalf of policymakers, the political sphere and the public, the same is true for SSM. This reflective role is well laid out in the relevant legislation and regulations. As of 2017, SSM will be using structured risk analyses in carrying out its reflective role, translating these into what are called 'State of the Sector' reports with associated, tailor-made supervision regimes. An important objective in doing this is to keep looking ahead to the uncertainties and risks of the future and ways of dealing with them. Too much of the current supervision is driven by day-to-day concerns.

The importance of looking ahead can be clearly illustrated by looking at the challenges presented by the phasing-out stage that the fossil energy sector increasingly finds itself in. SSM expects that many installations are rapidly approaching the end of their life cycles, due to the anticipated depletion of oil and gas fields among other things. It may be that the existing laws and regulations are insufficient to address this upcoming decommissioning phase, which will likely bring different risks from those associated with the long-term production stage of oil and gas, now largely behind us. This not only pertains to risks to the integrity of existing platforms and pipelines, but also to the specific hazards associated with dismantling and demolition. It will also, for example, involve more clearly defining terms and conditions (including financial ones) as they apply to abandoning mining installations, and clearly setting out the responsibilities for any lagging effects. SSM also notes with some concern that the deteriorated mining climate in the Netherlands may have a demoralising effect on employees in the sector, which may, in turn, have negative implications for safety in the sector. SSM notes in this context that the government's Energy Agenda currently provides for a transitional phase in which gas, in particular, continues to be used for decades to come. If this is to happen, it's important that it happens safely. An improvement in the mining climate and the associated public sentiments could play an important role in this.

In parallel with the gradually waning role of fossil fuels, there is a growing interest in sustainable alternatives. As far as SSM is concerned, the same applies to these activities: if they are to be undertaken, it must happen in a way that is safe for the public and the environment. SSM is aware of worrying developments in the geothermal energy sector in particular. Ahead of the 'State of the Geothermal Energy Sector' report to be published in 2017, it is notable that safety awareness and compliance behaviour in this sector leave much to be desired. Geothermal energy, too, involves drilling into the deep subsurface. Risks can come into play here that are insufficiently recognised, such as the risk of earthquakes. Plans to engage in ultra-deep geothermal energy drilling operations will be assessed by SSM with the appropriate type and level of supervision.

With regards to the offshore wind energy sector – which is very much on the rise – SSM wonders to what extent the steep cost reductions that have characterised recently awarded tenders for wind farms could ultimately pose safety risks. This has implications for the choice of materials, the foundation, construction, operations and maintenance. SSM has a supervisory role in relation to offshore wind farms, and will discuss safety risks in its yet-to-be-published 'State of the Sector' report. The extent to which current supervisory duties, legislation and regulations are adequate for this rapidly growing sector will also need to be evaluated, and with the appropriate degree of urgency.

As stated in this annual report, SSM sees a number of risks in the growing efforts to make natural gas more sustainable that are capable of leading to unsafe situations. SSM urgently recommends that these risks be addressed in the regulations that are to be updated.

SSM increasingly finds itself confronted with questions about the impact of mining activities on construction above ground, especially from local governments. This is not only relevant in Limburg (possible lagging effects of coal production), but also in Groningen and Twente (possible consequences of salt production). SSM acknowledges that these questions are being asked – however, answering them is not among its statutory responsibilities, nor does SSM have the knowledge and resources to do so. SSM

recommends that these supervisory and advisory responsibilities be analysed more closely and allocated in such a way that the relevant expertise and capacity *are* available.

In 2016, SSM urged the Ministry of Economic Affairs to clear certain backlogs in the processing of production plans as soon as possible, for gas production and geothermal energy in particular. The existing situation can lead to legal uncertainty on the part of companies, an unlevel playing field and enforcement dilemmas on the part of the supervisory authority. The amended Mining Act that took effect on 1 January 2017, with an expanded list of grounds for refusal and the introduction of decentralised consultation, may complicate the backlog situation. SSM is evaluating its own expertise and the resource requirements with a view to meeting the additional requirements stipulated in the Mining Act in a satisfactory manner. It is understandable that local and provincial authorities are increasingly calling on SSM for advice in mining-related matters, but this does put pressure on SSM. This, too, is a new role for the supervisory authority, and the organisation needs to be resourced accordingly.

3. Commissioning Ministries and cooperation

3.1 National cooperation

Integrated supervision on behalf of the Ministry of Economic Affairs, the Ministry of Social Affairs and Employment and the Ministry of Infrastructure and the Environment

Because of its level of expertise and for reasons of efficiency, SSM undertakes integrated supervision of mining works. SSM does this partly on behalf of other inspectorates and their Ministers. This is set out in greater detail in cooperation agreements.

On behalf of the Minister of Economic Affairs, SSM supervises the exploration, production, transportation and storage of mineral resources such as oil, gas and salt, as well as geothermal energy. The supervision focuses on health and safety, the environment and optimal use of mineral resources from a technical point of view. SSM's responsibilities are set out in the Mining Act and the Gas Act. SSM also makes expertise available to bodies that are licenced to grant permits for the production of mineral resources.

In 2016, SSM carried out a total of 346 inspections to monitor compliance with the Dutch mining legislation, environmental permits and the General Mining Industry (Environmental Rules) Decree (*Besluit algemene regels milieu mijnbouw*, Barmm). 11 inspections pertained to compliance with the Major Accidents (Risks) Decree (*Besluit risico's zware ongevallen*, Brzo) at gas storage facilities, and six inspections concerned compliance with the 'Guideline for above ground storage of flammable liquids in vertical cylindrical tanks'. In addition, 109 inspections monitoring gas grid operators' compliance with the Gas Act were carried out.

In 2016, SSM also completed 361 inspections for the Inspectorate SZW. As part of its cooperation agreement with the Inspectorate SZW, SSM takes working conditions legislation and environmental legislation into account in its inspections. Areas of focus included exposure to hazardous substances, machine safety, work equipment, fall hazards, escape routes and safety zoning (ATEX), as well as compliance with the Working Hours Act.

SSM has cooperation agreements with the Netherlands Authority for Consumers and Markets (ACM), the Authority for Nuclear Safety and Radiation Protection (ANVS), the Directorate-General for Public Works and Water Management's Sea and Delta department ('RWS Zee en Delta'), the Human Environment and Transport Inspectorate (ILT), the Inspectorate SZW and the Dutch Emissions Authority (NEa). In 2016, work began on updating the content and legal frameworks of all existing cooperation agreements. This will be continued in 2017. SSM's approach is to review the agreements and, where necessary, make improvements in areas such as results, added value, relevance and efficiency.

SSM also investigates criminal offences under the direction of the Public Prosecution Service.

3.2 International cooperation

In order to optimise its supervisory role and responsibilities, SSM is actively represented in various international forums. The objectives of these forums tend to be the same: they focus on safety in the offshore oil and gas production sector, in particular on reducing risks and preventing disasters such as Deepwater Horizon and Piper Alpha.

Both mining companies and service providers tend to work on a global level. However, the legal frameworks and cultures differ from one continent and country to another. This, of course, also affects the supervision in different places. Nonetheless it seems that supervisory authorities exchanging information and jointly undertaking projects and audits has positive effects.

It helps to jointly explore what lessons can be learned from incidents like the Deepwater Horizon disaster. Working together at the international level also means that changes to the national and international laws and regulations aimed at making the mineral resources sector safer can be rolled out more quickly. An example of this is Directive 2013/30/EU on the safety of offshore oil and gas operations which has been incorporated in Dutch legislation and regulations, and took effect on 1 January 2017.

International cooperation is a key priority for SSM, which is why, as part of its remodelling, it has established an 'International Desk' for the above-mentioned commitments.

By way of illustration, a number of activities undertaken by these forums are described below.

North Sea Offshore Authorities Forum (NSOAF)
The joint goal of NSOAF is to encourage oil and gas companies to improve the safety, health and wellbeing of offshore employees on the North Sea on a constant basis.

European Union Offshore Oil and Gas Authorities Group (EUOAG)
EUOAG is chaired by the European Commission's Directorate General for Energy, and until mid-2016 was co-chaired by SSM on behalf of the Member States. In addition to the Netherlands, key participants include Norway and the UK. EUOAG's objectives are not fundamentally different from those of NSOAF, but they cover a large part of the European Union.

International Regulators' Forum (IRF)
Ten independent supervisory authorities from key oil and gas-producing nations, including the Netherlands, have come together in IRF (the International Regulator's Forum). The other participating countries are the UK, Norway, Denmark, the US, Canada, Brazil, Mexico, Australia and New Zealand. The three IRF working groups established in 2015 have made such progress in 2016 that they are expected to achieve their targets in 2017 on the topics 'Performance Measures', 'Asset Integrity' and 'Safety Culture'. In addition to IRF supervisors, industry and scientists are also involved in these working groups. During the IRF's annual general meeting, it was decided that SSM will be chairing the newly established Decommissioning Network.

OSPAR Convention
The Convention for the Protection of the Marine Environment of the North-East Atlantic (including the North Sea), or the OSPAR Convention, aims to protect the marine environment through international cooperation. In addition to the Netherlands, 15 Member States have signed the Convention and implemented it in their national legislation. SSM represents the Netherlands at the annual Offshore Industry Committee meeting.

European Pipeline Authorities (EPA)
The European Pipeline Authorities group was established in 1985 as a joint initiative by the Norwegian and British authorities, and is responsible for pipeline regulation and oversight in the oil and gas sectors. The group's permanent members are Denmark, Germany, Ireland, Norway, Switzerland, the Netherlands, Sweden, Belgium, France and the UK. The group's core objective is the protection of the environment.

4. Organisation

4.1 Filling of nearly all key positions: 2016 marks the start of a new SSM

With the implementation of its new management structure and the filling of nearly all of its key positions, in 2016 SSM completed the important first stage of its improvement plan. SSM now has two technical/scientific divisions: Underground & Well Engineering and Engineering & Grid Management. In addition to these two, SSM also has an Administrative Affairs division and a Supervisory Policy division.

SSM's Works Council issued a positive recommendation in favour of the improvement plan, and it has also received the support of the Minister of Economic Affairs. The 'Guidance on government inspections' and the new Mining Act that came into effect on 1 January 2017 have further bolstered and safeguarded SSM's independence.

While improvements within the organisation were being implemented, SSM's supervisory activities carried on as normal and the continuity, of our most important projects in particular, was maintained. In 2017, the planned changes to the organisation's modus operandi and working culture will be the main areas of focus. It is expected that the full implementation and embedding of the improvement plan will take several more years.

4.2 Staff

In order to achieve a gradual expansion from 69 to a maximum of 89 FTE, after the decision about the organisational structure had been made and relevant posts agreed upon, the first task was recruitment. Ten new managers and employees were hired. The broad deployment of resources turned out to be necessary in order to make the recruitment campaign a success, including the longer-term deployment of a headhunter from the upper end of the search market. In addition, the working conditions stipulated by the government for the type of expertise SSM was seeking to recruit turned out to present a considerable challenge. The recruitment of drilling specialists has not yet resulted in the desired result, in spite of a very proactive focus on this.

Twelve seconded employees worked at SSM, while two SSM employees were seconded elsewhere. No employees left. Temporary specialists were contracted for one-off tasks relating to the organisational transformation, such as reviewing the work processes, who are developing and implementing proposals in cooperation with the employees. By the end of the year, around 90% of the posts were filled by permanent or temporary employees.

Due to the many priorities SSM had to focus on, the planned expansion of the employee training programmes has not yet been able to take place. The inspectors did, however, complete all mandatory safety and technical training in 2016, including the Special Enforcement Officer (*buitengewoon opsporingsambtenaar*, BOA) training. In 2016 a total of €70,743 was spent on training, amounting to 1.3% of the total payroll.

4.3 Employee representation

The Works Council is closely involved with the conceptual development of the new organisation and the development of the improvement plan. In early 2016, the Works Council issued a positive recommendation. The huge amount of work that the Works Council has put in to fulfil its role representing employees' interests in a project that is so important for the organisation is greatly appreciated. The Works Council took a critical, but constructive approach in this process.

4.4 Finances

Overview of SSM budget for 2016 and expenditure in 2016 and 2015 budget

Budgetary expenditure		**2016**	**2015**
€ x 1,000	awarded	expenditure	expenditure
Total staff budget	€7,265	€7,389	€6,614
Total equipment budget	€2,067	€1,632	€1,197
Total	€9,332	€9,021	€7,811
Total research budget	€700	€323	€0

List of abbreviations

ACM	Netherlands Authority for Consumers and Markets
ANVS	Authority for Nuclear Safety and Radiation Protection
AT	Radiocommunications Agency Netherlands
Barmm	General Mining Industry (Environmental Rules) Decree
BGR	Federal Institute for Geosciences and Natural Resources (*Bundesanstalt für Geowissenschaften und Rohstoffe*)
BOA	Special Enforcement Officer
BOP	Blow Out Preventer
Brzo	Major Accidents (Risks) Decree
CBS	Central Commission for Statistics of the Netherlands
CODATA	Committee on Data for Science and Technology
DAGO	Dutch Association of Geothermal Operators
EBN	Energie Beheer Nederland B.V.
EPA	European Pipeline Authorities
EUOAG	European Offshore Oil and Gas Authorities Group
EZ	Ministry of Economic Affairs
HMI	*Production installation manager (Hoofd Mijnbouw Installatie)*
HPHT	High Pressure High Temperature
HSE	Health, Safety & Environment
I&M	**Ministry of Infrastructure and the Environment**
ILT	Human Environment and Transport Inspectorate
IRF	International Regulators' Forum
KCD	Quality and Capacity Document (*Kwaliteits- en Capaciteitsdocument*)
KEM	'Effects of Mining' Knowledge Programme
KNMI	Royal Netherlands Meteorological Institute (*Koninklijk Nederlands Meteorologisch Instituut*)
KNRM	Royal Netherlands Sea Rescue Institution (*Koninklijke Nederlandse Redding Maatschappij*)
KPI	Key Performance Indicator
MVJ	Annual environmental report
NAM	Nederlandse Aardolie Maatschappij
NEa	Dutch Emissions Authority
NOGEPA	Netherlands Oil and Gas Exploration and Production Association
NSOAF	North Sea Offshore Authorities Forum
NTA	National Technical Agreement
NWEA	Netherlands Wind Energy Association
OM	Public Prosecution Service
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
OVV	Dutch Safety Board
RIE	Hazard identification and risk assessment
RIVM	Netherlands National Institute for Public Health and the Environment
RWS	Directorate-General for Public Works and Water Management
SodM	State Supervision of Mines (*Staatstoezicht op de Mijnen*)
SZW	Ministry of Social Affairs and Employment
Tccb	Soil Movement Technical Committee (*Technische commissie bodembeweging*)
TNO	Netherlands Organisation for Applied Scientific Research
TUD	Delft University of Technology
vg-document	Health and safety document
Wabo	Environmental Permitting (General Provisions) Act (*Wet algemene bepalingen omgevingsrecht*)
Wbr	Public Works (Management) Act (*Wet beheer rijkswaterstaatswerken*)
WION	Underground Grids (Information Exchange) Act (*Wet informatie-uitwisseling ondergrondse netten*)
Wob	Public Access to Government Information Act (*Wet openbaarheid van bestuur*)

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