Groningen gas: the loss of a social license to operate

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Abstract

In March 2018, the Dutch government decided to stop natural gas production from the Groningen field as soon as the demand for Groningen gas allows. This implies that gas production will stop in 2030 at the latest and that about 500 BcM of gas will be left in the ground.

Since the first registered induced earthquake in the Groningen field in 1991 the amount of seismic energy released per unit of produced gas has gradually increased. Up until 2012 this did not receive the attention it should have received from the operator (NAM) and from the Dutch state.

In the years following the 2012 Huizinge earthquake (the largest earthquake so far) a number of legal and regulatory measures were taken that made a long-term continuation of gas production increasingly difficult. From late 2015 onwards, production has been set at the minimum level that meets domestic demand and existing export contracts for Groningen gas.

A reversal of the burden of proof for damage to houses, in combination with a large rise in the number of associated damage claims, has greatly increased the non-
technical cost of gas production. Many of the more recent claims, especially those on the outer fringes of the field, were not, or were only to a very small extent, related to damage caused by earthquakes but this could usually not be proven. The application of a relatively strict norm for safety related to earthquakes implied that a long-term continuation of significant gas production would require a major house strengthening program. Home owners are currently entitled to compensation for any related reduction in the value of their houses. People have the right to claim compensation for psychological duress.

As a result of the rapid increase in non-technical costs, of which a relatively large share had to be paid by the operator, the Groningen gas field had by 2017 become a major liability to Shell and ExxonMobil (the NAM shareholders). For a long-term continuation of gas production these costs would have been of the order of several tens of billion euros. The measures taken in 2018, apart from leading to a planned cessation of gas production also included a more equitable division of costs between NAM and the Dutch state and implied a large reduction in the house-strengthening program.

These measures were taken against a setting in which the social license to operate for Groningen gas production was gradually lost. Earthquakes played a major role; those with damaged houses that had trouble receiving compensation received widespread sympathy in the Netherlands. Concerns about climate change and a desire among the population in Groningen (who did not financially benefit from gas production) to have a greater say in what was happening in their region also played an important role. Amongst decision makers there was a greater emphasis on environmental and safety concerns at the expense of financial and economic considerations. Electorally, it had become very difficult to defend a long-term continuation of Groningen gas production.

It is the loss of the social license to operate that we see as the core reason for the termination of Groningen gas production.

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1. Introduction

The risk that hydrocarbon assets become stranded has emerged as a significant threat to the oil and gas industry. So far, stranded oil and gas assets have primarily comprised undeveloped reserves that are not sufficiently commercially attractive to be developed. In the future, developed reserves in countries like Saudi Arabia may become stranded due to a lack of demand related to falling costs of renewables and rising costs of CO₂ emissions.

The giant Groningen natural gas field falls in neither of these categories. Nevertheless, the bulk of its remaining reserves will become stranded. The Dutch government has forced the operator to reduce yearly production from over 50 BcM (billion norm cubic meters) in 2013 to about 20 BcM in 2018 and is now aiming to phase out production as quickly as security of supply permits. Groningen gas production is expected to cease by 2030 at the latest. As a result, about 500 BcM of gas that could be produced at a relatively small technical cost will be left in the ground. Dutch gas demand is currently stable and will, even if ambitious reduction plans are realised, decline much more slowly than the expected Dutch gas production capacity.

Earthquakes induced by gas production have played a key role in the decision-making process. In addition, a strong desire to move away from fossil fuels in order to limit global warming and an effective campaign by politicians and non-governmental organisations (NGO’s) highlighting the damage caused by induced earthquakes, as well as a sustained absence of constructive debate in the national parliament, have gradually resulted in the loss of the social license to operate¹ the Groningen field. The local population in this north-eastern corner of the country, traditionally feeling neglected by the central government and receiving no financial benefits from the gas production, saw this as an opportunity to take back control of what was happening in their region.

The loss of a license to operate was the background against which several political, regulatory and legal measures were taken that greatly increased the non-technical cost of gas production, making a long-term continuation of Groningen gas production very difficult, if not impossible. Shale gas never obtained a social license to operate in the Netherlands, even though various companies have shown an interest to explore for it, foremost in the south of the country. The Groningen gas field has lost this license and it is possible that gas production from other, smaller, onshore fields will lose it as well. Resistance from local communities has effectively brought exploration for new onshore fields to a halt.

On the gas demand side, it is now forbidden to install natural gas heating systems in

¹ Social license to operate: the acceptance of a company or industry’s products, business practices and operating procedures by society.
newly built houses unless a specific exemption is granted. For existing houses natural gas heating is to be phased out gradually. No other country is anywhere near imposing such restrictions on the use of natural gas (both on the production and on the demand side). If anything, the development the most reminiscent of this has been the German “Atomausstieg”, where long-term resistance from a large part of the German population eventually resulted in a phasing out of nuclear energy. It is as yet unclear whether the Dutch measures on gas will be a forerunner of a more widespread development in Europe or whether this will remain an isolated event. It is also worth noting that it is currently unclear how some of the more drastic proposals, e.g. to dismantle existing heating systems, will be financed, and so we cannot rule out that over time the sharp edges of some of the current proposals are softened, despite that being difficult to envision in the current political climate.

The aim of this paper is to give a concise overview of what has happened around Groningen gas, from a geological, financial, political and societal point of view, focusing mostly on developments since 2012. We will not be describing the potential consequences of the planned Dutch gas phase out or presenting any opinion on the wisdom of this policy. Let history judge.
2. Gas production and earthquakes up to 2012

Overview

Initial recoverable reserves for the giant Groningen field have been estimated to be about 2800 - 2900 BcM; the exact number depending on the abandonment pressures and a late stage compression project (which has now been cancelled). By late 2018, some 2220 BcM has been produced. As per current plan production is now expected to cease by 2030 at the latest, and at a time that about 2300 BcM will have been produced.

The field was discovered in 1959 and started producing in 1963. A national gas transport and distribution grid was built in the 1960’s and Dutch households and industries quickly made the transition from coal to gas. In addition, a number of gas export contracts were signed and international transport infrastructure was built, encompassing most western European countries. Production rapidly ramped up to about 80 BcM per year in the 1970’s, in anticipation that nuclear energy would take over from fossil fuels at some time in the future. Once it was realized that nuclear energy was not unstoppable, and with a greater focus on security of supply of fossil fuels after the 1973 oil crisis, production was cut back. A successful small gas fields policy was implemented which resulted in a substantial exploration and development phase that brought smaller fields onto production throughout the 1980’s and 1990’s. The onset of a gradual decline in production from these smaller fields was compensated by a gradual increase of Groningen production from 2000 onwards. An extensive overview of the Dutch gas industry during these years can be found in the reference book: Natural Gas in the Netherlands.

Groningen gas has a relatively high nitrogen content of about 14% (and is referred to as low-calorific or L-gas), which sets it apart from most other sources of gas. As a result, the Netherlands has two gas systems: one for Groningen gas (L-gas) and another for high-calorific gas (H-gas) with a low nitrogen content, which is produced from small Dutch fields or is imported. Heating or industrial equipment tends to be constructed specifically for one of the two gas types and switching usually requires a costly adaptation of equipment. Gas conversion plants allow for the conversion of a significant volume of H-gas to L-gas by adding nitrogen. Heating systems in houses use L-gas, complicating a rapid phase out of Groningen gas.

The Groningen field is operated by the Nederlandse Aardolie Maatschappij (NAM), a joint venture between Royal Dutch Shell and ExxonMobil with each company owning a 50% share, on behalf of the “Maatschap Groningen”. The latter is a partnership of NAM (60 %) and Energie Beheer Nederland (EBN) (40 %) whereby both partners have an equal say in decision making. EBN is wholly owned by the Dutch state. NAM management and senior technical staff are provided by Shell.
Initial financial arrangements were re-negotiated after the first oil crisis and from 1974 onwards, including the effect of taxes, NAM received about 10% of the gas revenues (the exact percentage was dependent on the gas price) and paid 36% of the costs. Effectively this implied that NAM received about 10% of the profits from Groningen gas as long as the costs were relatively small. With very small technical costs (due to the large volume and high well production rates) it was envisioned that the costs related to the production of Groningen gas would always be a tiny fraction of the revenues. That earthquakes could one day result in substantial additional costs was not foreseen.

Throughout the 1970 - 2015 period, state revenues from gas production (which was for about 80% coming from the Groningen field) accounted for about 3-10% of state income (Fig. 1). In total, the income for the state reached some 300 billion euro (without any correction for inflation).

Figure 1. a) Gas production in the Netherlands from the Groningen field and from the numerous small fields. b) Total gas revenues for the Dutch state and its share in the total government revenues. From Mulder and Perey (2018).

Groningen seismicity characteristics

The Groningen gas is produced from the Rotliegend Sandstone reservoir (from pores in between the sandstone grains). As a result of production, the pressure in the gas has decreased from about 350 bar to about 60 - 80 bar and, due to the weight of the overburden (there is about 3 km of rock above the gas bearing sandstone) the sandstone has compacted. The total amount of reservoir compaction due to gas production at the centre of the field is expected to reach about 40 - 50 cm.

Compaction of the gas-bearing reservoir results in subsidence at the surface, but on its own does not result in seismicity. It is a combination of faulting and reservoir compaction that does. The Groningen field is cut by numerous faults and these faults, apart from being zones of weakness, are associated with vertical offsets of the gas
reservoir across faults, pressure differences across faults and low compaction damage zones which all play a role in generating differential compaction and shear stresses along the fault planes.

It has been found that most earthquakes occur in areas where reservoir compaction is relatively large and faulting relatively intense. A high compaction and highly faulted area near the centre of the field, approximately coinciding with the municipality of Loppersum, has experienced the highest seismic intensity (Fig. 2).

![Map of the Groningen field in the NE part of the Netherlands.](image)

Figure 2. Outline of the Groningen field in the NE part of the Netherlands. Figure on the right side: colours denote magnitude of compaction (colour scale ranging from 0 to 0.4 m). Black lines denote faults. Red line gives the approximate outline of the field. Seismicity is shown by symbols (size of the symbol indicates event magnitude). Highest seismic activity takes place in a region near Loppersum (“Loppersum area”) of high compaction and high fault intensity. Source: TNO (2015)

For given locations, seismicity has increased over time with total accumulated reservoir compaction. A threshold exists of about 10 - 15 cm of reservoir compaction before the onset of seismicity. Initially, stresses on faults in the gas-bearing Rotliegend level were not anywhere near the level required for seismic slip but beyond this threshold earthquakes have (so far) increased both in number and in magnitude with reservoir compaction.

Since the early 1990’s the amount of seismicity per unit of produced gas has gradually increased with increasing total production and reservoir compaction. In simple words: for a constant production rate the problem gradually gets worse (see also Fig. 3). It is simply not known to what level of reservoir pressure this relation will continue. It is not certain but the simplest and most straightforward assumption (and also the assumption commonly made in models of future Groningen seismicity) is
that this relation will continue all the way down to the abandonment pressure. This is the reason why models of future seismic intensity, with a constant future field production, exhibit a gradually increasing yearly number of earthquakes above a certain magnitude (and a gradually increasing chance of a relatively large earthquake).  

![Graph showing history and forecast of induced seismicity and gas production in Groningen](image)

Figure 3. History and forecast of induced seismicity (annual number of M ≥ 1.5 earthquakes) as well as annual gas production (BcM/yr) in Groningen. Stars indicate M ≥ 3.0 earthquakes. From Sintubin (2018).

The earthquakes occur within, or in the immediate vicinity of, the reservoir at close to 3000 m depth. The shallow depth of these earthquakes, in combination with the near surface soil conditions (often clay or peat with very low seismic velocities), implies that earthquake intensity and damage to houses is relatively large compared to the seismic magnitude. Natural earthquakes usually occur at much greater depths. Older houses and farms, built with a single layer of bricks on a relatively poor foundation, which form a relatively large proportion of houses in rural Groningen, are the most vulnerable.

**Groningen earthquakes through time**

The first registered earthquake in the Northern Netherlands related to gas production was registered near a small gas field close to Assen to the south of Groningen in 1986. These early earthquakes took place at small fields, which depleted much more quickly than the Groningen field. The first registered earthquake in the Groningen field occurred in 1991. In 1993, a joint NAM, KNMI (Royal Dutch Meteorological Institute – which also has a section monitoring seismicity in the Netherlands) and SoDM (the “State Supervision of Mines”, the Dutch Regulatory Authority supervising the oil and gas industry) study confirmed the relation between gas production and earthquakes.

What has not helped the public image of the NAM in the long term is that from 1986 to 1993 NAM spokespeople denied that there was a relation between gas production
and earthquakes. Admitting that when earthquakes start to appear at producing gas fields, in a tectonically quiet area without any historical seismicity, should have been relatively straightforward (even though in the vast majority of worldwide gas fields, including most of the Dutch small fields, production does not cause induced earthquakes).

For a long time NAM and various stakeholders, such as the NAM shareholders, EBN, the Dutch government (in particular the ministry of Economic Affairs) and organizations such as KNMI and SodM, did not realise the potential consequences of this issue. The 1993 joint report contained a section in which an estimate was made of the expected maximum magnitude of a Groningen earthquake. This method (using a Gutenberg Richter relation between earthquake magnitude and frequency) played a key role in KNMI reports, providing estimates of maximum magnitudes for years to come. Deriving an expected maximum magnitude from historically observed seismicity, using the Gutenberg Richter relation, is something that can be done for stationary situations (as is usually the case for natural earthquakes). A depleting gas field, however, is not a stationary situation. If anything, it gave an estimate for the maximum magnitude at the time - a lower bound for the expected maximum magnitude of a future Groningen earthquake. For Groningen, as depletion progressed, the KNMI gradually revised its estimates from an initial 3.3 (1993) to a possible 3.9 (2006), at which time it eventually became clear to them that this method was not applicable.

Neither NAM nor SodM was pro-active in starting further research (for instance to determine uncertainty estimates on KNMI’s results or to invite alternative views from other institutes). The focus was very much on subsidence rather than on seismicity. There was a genuine expectation that earthquakes could only result in limited material damage. This was not backed up by solid research, however, and in hindsight uncertainties were severely underestimated.
3. The first turning point: the Huizinge 2012 quake

Over the six year period from 2012 to 2018, the outlook for the Groningen field radically changed. In 2012, the field was still expected to be the backbone of Dutch gas production for many years to come. Damage from earthquakes was seen as a serious but manageable problem. In 2018, the decision was taken to shut down the field as soon as demand for Groningen gas would allow this.

The period started with the 3.6 magnitude Huizinge quake in August 2012. In the following months about 2000 damage claims were received. A large proportion of these claims (about 80%) was evaluated to be related to damage caused by this earthquake.

The Huizinge earthquake stirred SodM, the state regulator, into action. They realized that the estimate of the maximum potential magnitude of 3.9 for a Groningen earthquake, as assumed so far, was likely to be too low (and subject to considerable uncertainty) and that seismicity could not only result in material damage but potentially also in loss of life if production would remain unchanged and if the trend of increasing seismic intensity with increasing cumulative production would continue.

The Huizinge earthquake followed years in which the confidence of the local population that the Dutch state and NAM (the operator) took their interests into account in a serious manner had gradually declined. A strong desire to take back control of what was happening in their region began. Discontent on how the field was managed had grown both within the established population living in the area (with a left leaning political tradition among poorly paid farm and industry workers) and in the recent import population (frequently employed by the Groningen University and medical centre). The Huizinge earthquake was a catalyst that now stirred many people into action and local NGO’s (in which the import population played a dominant role) saw their membership increase many times over.

The following year (2013) saw the highest production from the field since the 1970’s of about 54 BcM. The 10 year cap of 425 BcM for the 2006-2015 period, put in place to give preference to the production of small fields and to preserve the swing capacity of the Groningen field as long as possible, combined with underproduction over the preceding years due to relatively soft winters, provided room for NAM to do so. The minister of Economic Affairs started a number of investigations which he felt would be necessary prior to taking any step towards curtailing production. However, both he and the NAM had underestimated the extent to which societal support in the Netherlands for unabated continuation of Groningen gas production was eroding.
4. 2012-2018 developments

Gradually lower production caps

From 2012 onwards increasing pressure was exerted by Dutch politicians and society on Henk Kamp, the minister of Economic Affairs (from 2012 until October 2017), to curtail Groningen production.

A report by the Dutch Safety Board concluded in a [damning review](#) that NAM and the Ministry of Economic Affairs had underestimated (and had disregarded uncertainties of) risks related to Groningen gas production, and so had failed to act with due care for citizen safety in Groningen. SodM advised the minister to reduce production on a number of occasions. This was against a background in which there was a long-term shift amongst decision makers and institutions from an emphasis on economic and financial considerations towards highlighting safety and environmental considerations. The new 'Meijdam' norm (named after the committee advising the government) implied that the safety risk for Groningen citizens should be the same as that for other Dutch citizens, regardless of the revenue from the field and the large dependence of the Dutch energy system on Groningen gas.

Over the years, the Dutch government introduced gradually lower production caps for the field. The 2015-2016 cap was the result of the Raad van State (the Council of state; the Dutch supreme administrative court) [overruling the minister of Economic Affairs](#) (arguing that people in Groningen should not be subjected to risks greater than those deemed acceptable for e.g., people living in flood-prone areas).

<table>
<thead>
<tr>
<th>Year</th>
<th>Production Cap (BcM)</th>
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<tbody>
<tr>
<td>2014</td>
<td>42.5</td>
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<tr>
<td>2015</td>
<td>39.4</td>
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<tr>
<td>2015-2016</td>
<td>27 (Oct 1 2015 – Sept 30 2016)</td>
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(a Dutch gas year runs from Oct 1 to Sept 30)

From 2015-2016 onwards the cap was set at the minimum level deemed needed to secure the supply of gas to Dutch households and industry as well as to honour the existing export contracts.
A greatly diminished acceptance of fossil fuels in general and Groningen gas production in particular

In the years following the Huizinge earthquake a number of local NGO’s saw their membership rapidly increasing. They were at the centre of increasingly frequent and vocal protests. Many politicians chose their side and took up their cause, arguing that Groningen gas production had to be stopped as quickly as possible. They were unwilling to engage in a constructive debate to explore options for the long-term continuation of Groningen gas production. For many of them Shell (by far the largest company on the Dutch stock market for decades) had always been a very unpopular company. ExxonMobil, having a much smaller presence in the Netherlands, stayed out of the limelight.

People with damaged houses became regular guests on national TV talk shows. Up against a sympathetic person with a damaged home who had encountered trouble getting compensated - the large number of claims and the time needed to properly evaluate whether damage was related to earthquakes implied that people with justifiable claims often had to await compensation or repairs for a long time - a technically-based reasoning did not stand a chance. NAM shareholders and the ministry of Economic Affairs limited their participation in the public debate on TV and social media. Their strategy came down to keeping a low profile and hoping the storm would eventually blow over. It did not.

NAM’s strategy according to the principles of outrage management (“apologize for your mistakes, give others the credit for your improvements and acknowledge their grievances and concerns”) was perceived by the people in Groningen as insincere and turned out be singularly unsuccessful.

What enhanced the local protests was a long-standing feeling in Groningen that they had always been badly treated and neglected by the central government. All revenues of the Groningen gas went to the central government, in spite of behind the curtain pleas from the operator to channel more money from gas revenues to the Groningen province. When investments from the FES (the Dutch infrastructure fund which received 40% of Groningen gas income for the 1995-2009 period) were analyzed it was found that close to 90% went to the Randstad area (Amsterdam – The Hague – Rotterdam) while only about 1% of the investments went to the three northern provinces combined (of which Groningen was part). Gas production from such a giant conventional field is not labour-intensive, so that relatively few people in the Groningen were employed in the industry. In addition, the NAM head office was not located in Groningen but in the neighbouring province of Drenthe to the south, and its management, provided by Shell, were often seconded for a limited period of about 4 years only, thus not establishing local roots.
The debate grew so fierce that scientists and technical experts became very reluctant to participate. They feared the consequences of speaking out freely. The house-strengthening program being based on an outdated and far too conservative risk analysis was well known among technical experts but remained hidden to members of parliament. In a briefing to members of parliament, Ira Helsloot (a Nijmegen University professor whose research focuses on risk analysis) stated that “in this remarkably polarised environment scientists did not feel they could speak freely. They feared the public debate”.

Reports and scientific studies on Groningen were published on a number of websites (such as those of the NAM, SodM and KNMI). This was not followed up, however, by an effort to make the results of these studies understandable to the general public. In the words of Manuel Sintubin (a Belgian geology professor from Leuven University and one of the few technical experts who felt free to comment on Groningen): scientific reports “fell victim to cherry picking by non-experts who lacked knowledge of basic concepts of earthquake science. An alternative public science was created that eventually took on a life of its own, completely disconnected from the true science.”

At the same time, climate change and global warming became one of the most prominent - if not the most prominent - public issue in the Netherlands. The Paris 2015 agreement was broadly supported by all mainstream political parties. Among many people and organisations in the Netherlands a strong desire developed to take climate change more seriously and to undertake preventative measures. National NGO’s frequently drew the connection between combating climate change and resisting Groningen gas production. This struck a chord with many Dutch citizens. The extent to which public opinion has turned against fossil fuels in countries like the Netherlands and Germany is difficult to fathom outside these countries. Gas is often seen as a fossil fuel contributing to climate change; not as a (temporarily acceptable) bridge fuel.

**A rapid increase in the number of damage claims**

Between 2012 and 2015 the number of damage claims rapidly increased from about 2000 in 2012 (the year of the 3.6 magnitude Huizinge earthquake) to over 20,000 in 2015. Since then it has stayed at a relatively constant but high level.

This explosion of the number of damage claims was not caused by an increase in seismicity. In 2015, the total amount of seismic energy released was about 25% of that in 2012. The number of damage claims in 2015, on the other hand, was over 10 times the 2012 number. Either actual damage in 2012 did often not result in a damage claim or many of the 2015 claims were not related to damage caused by earthquakes.
The latter explanation is by far the most likely. Houses close to the epicentre and subjected to a higher PGA or PGV (peak ground acceleration or velocity) have a greater chance of being damaged. The largest earthquake in 2012 was the 3.6 magnitude Huizinge earthquake; the largest 2015 earthquake was a much smaller 3.1 magnitude event near Hellum. For the Huizinge earthquake there was indeed a strong correlation between PGA (which in turn has a strong relation to distance to epicentre) and the percentage of buildings with damage claims. For the Hellum earthquake, on the other hand, no such correlation was observed and the vast majority of claims came from areas at a large distance from the epicentre, and associated with minimal PGA’s. In general, the 2015 PGA’s and PGV’s related to earthquakes were smaller than those due to other causes, such as traffic or building activities (Fig. 4).

![Graphs showing number of damage claims per week vs seismic energy released, and PGV vs PGF.](image)

**Fig. 4.** Weekly number of damage claims vs. seismic energy released, from 2012 to 2015 (left figure). Maximum velocity registered by the TNO network. Red dots indicate velocity measurements associated with earthquakes. Blue dots could not be associated with an earthquake (right figure). Both figures are from the [technical addendum to the 2016 Groningen field development plan](https://example.com).

Damage to houses built on clay or peat in low-lying parts of the Netherlands (usually comprising cracks in masonry) is common. Irregular subsidence in the shallow subsurface and soil settling as well as the high cost of constructing foundations that limit such damage play a role here. A recent, [detailed study from Delft Technical University](https://example.com) concluded that for those cases studied outside the central area of the Groningen field the technical contribution from earthquakes to the observed damage was virtually none or very small (<1% or 1-10%). Within the core area, the technical contribution from earthquakes was, on average, evaluated to be small or medium, of the order of 33% (often being expressed as an increase in the size of cracks of which the primary cause was still not earthquake related).
Outside the central area, a relation between damage and gas production may be more likely to be caused by rapid changes in ground water levels (something to which gas production, and many other factors, contribute) than by earthquakes.

Between 2012 (the year of the Huizinge earthquake) and December 2015, the fraction of claims evaluated to be related to damage not caused by earthquakes gradually increased from 20 to 80%. Although this conclusion is likely to be justified from a technical point of view (something that technical experts from all stakeholders were reluctant to point out, however, given the fierce reaction that this message encounters in such a polarised environment), the large fraction of rejected claims as well as the increasing time that it took to process claims resulted in major discontent among the local population.

The large increase in claims in recent years is, in fact, a reflection of the intense publicity and the calls from NGO’s and local politicians to put in claims, rather than a reflection of an increase in seismicity and actual earthquake-related damage. The duress of the local population is real, however, and should not be ignored. People are confronted with an avalanche of (often conflicting and poor quality) information as well as bureaucratic procedures. Uncertainty often exists whether their houses will qualify to be strengthened (a significant operation meaning that inhabitants have to move out of their houses for weeks if not months). Uncertainties and the perception of safety (some people do live in fear of a major earthquake with numerous fatalities) are by now a much greater risk for the wellbeing of people than the actual safety risk that they run.

**A series of legal and political developments that greatly increased current and future costs**

In 2016, the Dutch mining law was changed to incorporate a reversal of the burden of proof for damage claims to houses in the Groningen area. This had major implications for future production cost estimates. It is relatively easy to build a convincing case that, except for the core area around Loppersum, most of the claimed damage is not primarily related to earthquakes. It is very difficult, if not impossible, to actually prove, for an individual case, that earthquakes have not contributed to at least some of the damage.

Since then, NAM has lost virtually all cases that ended up in a final arbitrage procedure. This meant that it was often forced to pay major amounts for damages that were not, or only to a very limited amount (e.g., a minor extension of an existing crack in masonry), related to earthquakes. The only counter measure left to the company was to often insist that cases went through a lengthy procedure (which
again did not improve their reputation) and to ask for a more equitable sharing of costs between NAM and the state.

By end 2017, the effect of the new law on total historic costs was still limited, and the total cost related to evaluating claims and repairing damages stood at about € 1.2 billion. However, should production continue at a yearly level of 20 BcM, the total future cost was calculated to be at least an order of € 10 billion.

In December 2015, the Dutch government confirmed that the Meijdam norm should apply to Groningen. This norm states that the maximum acceptable individual risk should not exceed 1E-5 (that is the chance per year for someone living in the area of dying as the result of an earthquake should be less than 1 in 100000). For people living in high risk houses (with an individual risk higher than 1E-5 but lower than 1E-4) a period of 5 years became the maximum time to strengthen these houses. The same norm applies to the large number of people in the Netherlands that live in areas below sea-level with a risk of flooding (with a transition period of 20 years instead of 5 years). The large revenues generated by gas production and the vital role of Groningen gas in the Dutch energy system were considered irrelevant in this matter.

In 2016 and 2017, the estimates of the number of houses that needed reinforcement (due to the application of the Meijdam norm) reached tens of thousands. Cost estimates were highly uncertain but were of the order of € 10 billion. For the local population the constantly shifting estimates of the number of houses (and their location) that would need to be strengthened has been maddening. These shifts are caused by varying future production forecasts, more sophisticated models for the risk analysis and changing views on the exact application of the Meijdam norm (e.g., should it be based on a worst case or a mid-case risk analysis?). By the end of 2017, the 600 houses that had been reinforced represented only a small fraction of the number of houses that needed reinforcement to comply with the Meijdam norm.

Damage, safety risks and the publicity surrounding this have had a negative influence on property values in the region. The operator is obliged to compensate for lower house prices and, as confirmed in a court case in early 2018, is required to do so at a time of the house owner’s choice (who thus does not need to wait for the sale of a property). The negative impact on the value of houses is typically 5-10%. This affects over 100,000 houses so total cost could easily exceed € 1 billion.

By the end of 2017, some € 1.5 billion had been spent on non-technical costs, mostly on evaluating damage claims and subsequent repairs. The total bill, taking into account the increase of seismic energy released per unit of produced gas, a steady stream of new damage claims, a large backlog of existing claims, increasing costs due to the reversal of the burden of proof and an extensive reinforcement program, was
still highly uncertain but likely to amount to several tens of billions of Euros if long term production would remain anywhere near 20 BcM per year.

**NAM’s financial situation rapidly deteriorates**

Over this period, the rapidly escalating non-technical costs resulted in a major deterioration of the financial situation and outlook for the operator. In 2017, NAM stopped paying dividend to its shareholders Shell and ExxonMobil. A simple back-of-the-envelope calculation illustrates the bleakness of NAM’s financial outlook. Assuming a remaining total Groningen production of 500 BcM and total revenues of €75 bn (assuming an average sale price of €0.15 per m3 of gas) total NAM revenues would be about €7.5 bn. With NAM paying a relatively high share (36%) of the costs this implies that Groningen becomes an asset with a negative value once total costs exceed €20 bn (approximately in the middle of the range of future total cost estimates made in 2016 and 2017). With the rapid development in legal, regulatory and political measures a much higher future cost could not be excluded (e.g., due to compensation for psychological duress).

Whereas NAM does not publish detailed figures on reserves and related future cash flow (until 2017 NAM did not publish a financial report at all), Shell SEC 20-f reports (which split out NAM results under European joint ventures) give a detailed picture (albeit for the NAM as a whole, which includes NAM’s small fields).

Based on Shell’s 20-f reports (such as the [current latest 2017 report](#)) we estimate that the future discounted net cash flow from proved Groningen reserves decreased from approximately $5-6 bn in 2012 to a level close to zero by the end of 2017 (Fig. 5). Shell’s Q1 2018 results included a short statement that with a write-down of $224 mln Shell’s investment in NAM has now been completely written off. For Shell (and presumably also for ExxonMobil) Groningen had ceased to be a valuable asset. Instead, it had become a major potential liability. Any remaining value of NAM now resides in its small fields. This is the logical consequence of the combination of major cost increases (of which NAM paid a relatively high share) and rapidly falling production. After limited reserves de-bookings in 2016 and 2017, the Shell 2018 SEC 20-f will include a major reserve write off for Groningen.
Fig. 5: NAM proved reserves and future net cash flow (Shell share; from various Shell SEC 20-f submissions) as well as an estimated Groningen field future net cash flow.

A perfect storm for Groningen gas

By the end of 2017 Groningen gas production found itself in a perfect storm:
- Legal changes had made the field no longer profitable for the operator. Continuation of production required a revision of the way costs and revenues were divided amongst the state and the operator.
- The government found itself virtually without any room to manoeuvre between the minimum amount of gas needed for security of supply and the maximum amount of gas permitted from a safety and regulation point of view.
- The strongly diminished support for Groningen gas production, essentially meaning that it had lost its social license to operate, made it from an electoral point of view very difficult to continue in the long term.

Although 2016 and 2017 saw relatively little seismicity, the risk of a larger earthquake occurring remained. In the NAM risk analysis (ironically considerably more pessimistic than the risk analysis from the regulator SodM), the yearly chance of an earthquake with similar or greater magnitude than Huizinge was about 20% (in spite of the much reduced level of gas production). A Huizinge-like earthquake was due to happen at some time.

Over most of 2017, the outgoing government did not want to take a major decision on Groningen and left this to the new government – which came into function in October 2017. Minister Henk Kamp (Economic Affairs) was replaced by Eric Wiebes (also belonging to the liberal VVD party, the largest political party in the Netherlands in the last decade).
5. The second turning point: Zeerijp 2018

The next significant earthquake took place near the village of Zeerijp on January 8th, 2018. With a 3.4 magnitude it caused substantial damage. Within weeks, the Dutch regulator advised the minister to reduce Groningen gas production, as quickly as possible, to 12 BcM/year.

The minister subsequently decided (announcement made on March 29, 2018) to firstly reduce production to 12 BcM as soon as security of supply permits (by October 2022 at the latest), and secondly to stop Groningen gas production altogether (again as quickly as possible, envisioned by 2030, potentially as early as 2025; Fig. 6).

![Graph showing future Groningen gas production](image)

**Fig. 6: Future Groningen gas production, as per March 2018 plan.**

The motivation was based on safety related issues only, and thus reduced the chance of a claim by the operator. Any such claim, which according to a leaked internal note of the Ministry of Economic Affairs looked at some stage possible, if not likely, might have had a chance of success if the cessation of Groningen gas production had been related to a different view on the production of gas in general rather than on safety. Although acceptance by society was mentioned, this referred to the reduced acceptance of safety risk or damage to houses only.

The reason for deciding to stop Groningen gas production altogether (rather than reducing gas production to e.g., 12 BcM/year and taking things from there) was that this was seen as a requirement for a significant reduction in the house-strengthening program (see appendix 4 in a series of released government documents on the decision taking process).
In order to be able to rapidly reduce the demand for Groningen gas a number of additional measures were announced:
- An increase in the capacity to convert imported gas and gas from small Dutch fields to Groningen specification L-gas with a high nitrogen content
- Large industrial users have been given four years to switch from L-gas to normal H-gas
- A reduction of the export of Groningen L-gas as quickly as possible
- A long term reduction of heating by gas (invariably Groningen spec L-gas) in Dutch houses

In addition, a draft of a new mining law was published in which the Groningen gas field is treated in a different way than other gas fields in the Netherlands. When the new law comes into effect, the Dutch state will have full control of the Groningen gas field production and will set the level of production equal to the minimum amount needed to ensure security of supply.

Finally, in June 2018 the minister announced that he had reached an agreement with the NAM shareholders in which Shell and ExxonMobil agreed to accept that the Dutch state would take full control of the level of production for the Groningen gas field and that they would not at some stage file a claim for the value of Groningen gas remaining in the ground.

In return, the minister agreed to a new arrangement for costs and revenues from the Groningen gas production. Effective January 1, 2018 the NAM would be entitled to 27% of the revenue of Groningen gas and pay 27% of all costs related to Groningen gas production. Under the pre-existing agreement these percentages were approximately 10% (depending on gas price) and 36%. This new division of costs and revenues was necessary in order to ensure that NAM would continue with the production of Groningen gas. Ironically, the cessation of Groningen gas production was the one and only remaining trump card left for the NAM shareholders. Even under the new law it would be difficult to ensure that NAM would continue with a loss making activity and at the same time remain accountable for damages related to production.
6. Concluding remarks

Prior to 2012, decision-making was primarily based on economic considerations. After 2012 the pendulum swung the other way and safety (including the perception of safety) took a much greater role in decision-making.

From a financial point of view, political and legal measures (the Meijdam safety norm for house strengthening and the reversal of the burden of proof for damages) resulted in greatly increased costs for the operator (who had to pay for a relatively large fraction of these costs). The reversal of the burden of proof went together with a large increase in the number of claims (and also a large increase in the proportion of claims for damage likely to be not - or only to a very small extent - caused by earthquakes). By the end of 2017 the Groningen gas field had become a significant potential liability for Shell and ExxonMobil (the NAM shareholders).

From a political and societal perspective, the loss of the social license to operate (the background for the political and legal measures taken in between 2012 and 2018) was the most striking development. Supporting a continuation of Groningen gas production had increasing electoral repercussions for the major political parties. Apart from the earthquakes a strong desire to combat climate change has also played a role here. In our view the decision in March 2018 to stop Groningen production as soon as possible was the logical outcome of the loss of a social license to operate and the resulting political and legal measures.

For fossil fuel companies in other parts of the world, the fact that the Groningen gas field has become a 500 BcM stranded asset provides some interesting learning points. Once a social license to operate is lost, a rational cost-benefit analysis, including in this case the significant financial consequences for the Netherlands of the loss of Groningen gas production, no longer plays an important role in decision making (nitrogen injection, the only technical way to maintain pressures and reduce seismic intensity for a given production level, has not been taken seriously as an option). That all of this may have severe repercussions from a financial, security of supply and environmental point of view (in practice Groningen gas is being replaced by Russian import gas with a significantly larger footprint due to methane leakage) gives cause for reflection, but falls outside the scope of this paper.

It is not peak fossil demand (and stranded assets due to lack of demand) that may turn out to be the biggest future risk for oil and gas companies but the loss of the social license to operate, which can result in legal measures that can turn out to be extremely costly. In the developed world assets becoming stranded because of the loss of the social license to operate may turn out to be more common than assets becoming stranded due to a lack of demand.