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THE TERMINATION OF GRONINGEN GAS PRODUCTION—BACKGROUND AND NEXT STEPS

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JULY 2018

In March 2018, the Dutch government decided to phase out production from the Groningen natural gas field by 2030 to reduce the safety risks caused by earthquakes induced by gas production. This watershed decision marks the end of over 50 years of Groningen natural gas production that has brought the Dutch both prosperity and discord. While many countries are using natural gas as a transition fuel to move away from oil and coal toward cleaner renewable sources, the Netherlands is phasing out gas. This fast transition from Groningen gas via import gas to mainly renewable energy will be a costly affair. Dutch policy makers are mulling over a very ambitious new climate accord that aims to reduce carbon emissions by 49 percent in 2030. One of the plans under consideration is to not only ban new houses and buildings that would be connected to the natural gas grid but to also start dismantling the existing grid and encouraging consumers to switch to electricity for cooking and to heat pumps or heat networks. This will be a cumbersome and costly affair, and those who have designed the plans have so far not indicated who should pay for this transition. Meanwhile, as domestic production decreases, gas import dependence will rise, presenting a whole new geopolitical game for the Dutch, who have been self-sufficient with gas for so long.

Induced Seismicity[1]

The 3.6-magnitude Huizinge earthquake in 2012 helped change Dutch public opinion about the Groningen gas field. While the field was previously touted as a key to Dutch prosperity, the quake altered the narrative to one of safety. Earthquakes in Groningen were first officially linked to gas extraction in the late 1980s, nearly 30 years after the discovery of the gas field. Induced seismic activity has since caused widespread property damage in a province of nearly 600,000 inhabitants, resulting in calls to drastically curtail or even completely stop production. Growing worries that gas production exposed the people living on top of the Groningen field to significant safety risks coincided with the more widespread concerns about fossil fuels and global warming and the view that the Dutch have been consistently lagging within the European Union when it comes to developing low-carbon energy sources. From the perspectives of both the operator of Groningen and the government, as the co-owner and main beneficiary of the gas revenues, this combination caused a perfect storm through which the future course of Groningen must be plotted.

This paper provides a broad outline of the economic, political, and social contexts in which to consider the Groningen field. It also acts as a source of information for anyone willing to

participate in the current debate about Groningen gas production, acceptable levels of risk, Groningen's role in the European energy mix, and security of supply in the coming decades. It ends with a series of questions for policy makers to consider before making all-too-drastic decisions regarding future natural gas usage in the Netherlands.

Significant Discovery

The supergiant Groningen field (also known as the Slochteren field) was found in 1959 by the Nederlandse Aardolie Maatschappij (NAM), a 50/50 partnership between Shell and Esso. That the Slochteren-1 well found gas rather than oil was initially a disappointment since, at the time, the Dutch domestic gas market was nearly saturated with so-called town gas, which, before the development of natural gas, was manufactured from coal and used for fuel and lighting. The Dutch state directly controlled the gas distribution network in 8 of the 11 Dutch provinces through the *staatsgasbedrijf* (state gas company) and also effectively controlled the gas distribution network in the province of South Limburg through its ownership of the *staatsmijnen* (state mines or state collieries).

The earliest publicly announced reserve estimate of this gas discovery was approximately 60 billion cubic meters (bcm), but this soon proved to be a conservative figure. The Nota de Pous[2] (a policy document referring to then-minister of economic affairs Jan-Willem de Pous) mentioned proven reserves of 150 bcm with a "possible reserves" figure of 400 bcm. Current estimates of GIIP (gas initially in place) are near 2,900 bcm, of which about 2,070 bcm had been produced by 2017.[3]

Once the size of the prize had become evident to Shell, Esso, and the Dutch government, negotiations started on how best to develop this extraordinary resource. Assuming a 20-year production period, the proven reserves of 150 bcm were equivalent to a production of roughly 8 bcm per year, which in terms of energy content equal two-thirds of annual gross domestic coal production and over 25 percent of total annual energy demand of the whole country. The tremendous economic significance of these figures was not lost on the government, which insisted on substantial state control on the utilization of the giant resource.

Government Control

Thus, while the NAM was awarded the production license to operate the Groningen field, the Dutch state became the co-owner. The state's 40 percent interest in the field was to be handled by the *staatsmijnen* (referred to from 1973 onward as DSM,[4] or Dutch State Mines) acting as the state's shareholder representative. In addition to its interest, the state also received a 10 percent royalty on the NAM's profit. The produced gas was to be sold to another new company tasked with its transportation and trading to local gas distribution companies (typically municipal utilities) as well as industrial and international customers. In this new transportation and trading company (Gasunie), Shell and Esso were to each hold 25 percent, DSM 40 percent, and the state itself a direct interest of 10 percent. The stated objective of these arrangements was to ensure that the Dutch nation would be the main beneficiary of Groningen gas. Furthermore, the minister of economic affairs reserved the right of prior approval for gas transportation tariffs and sale price(s), gas utilization and/or customers, and, importantly, allocation of some of the Groningen gas to selected industrial sectors.

It is interesting to note that the Nota de Pous rejected a proposal by the province of Groningen that gas from the field should also be used to explicitly promote economic development of the northern provinces. This is especially relevant given that present-day residents of the area affected by induced earthquakes have voiced, in addition to their safety concerns, a common complaint about their situation, stating that they suffer the drawbacks of production but do not experience any direct benefits for living on top of the field and that, in fact, most benefits are passed on to others. The seeds of this complaint were thus planted by the government's policy decision back in 1962, even though it should be noted that with revenues flowing to the central government in The Hague, some of those benefits did arguably eventually flow back to the people in Groningen, albeit indirectly.

Based on the policies set out in the Nota de Pous, production facilities such as well clusters and gas treatment plants were built, as well as a major new pipeline distribution system. Moreover, as Groningen gas quality differed significantly from town-gas supplies, all domestic appliances such as kitchen stoves had to be converted throughout the Netherlands. This massive operation started in 1963. Ten years later, most Dutch households received Groningen gas through a new pipeline system. The large trunk pipelines (up to 90 centimeters in diameter) of this new network had a length of some 3,000 km, with the regional network having a length of over 6,000 km.

Closure of Coal Mines

By 1964 Groningen gas was already being supplied to a chemical plant operated by the *staatsmijnen* near the town of Geleen in South Limburg. This was but an early example of coal being displaced by Groningen gas as coal mining was becoming uneconomic due to the advent of cheap oil from the Middle East and even cheaper Groningen gas. In 1965 the government announced its decision to close down all of the state-owned and privately owned collieries in South Limburg. This meant that some 50,000 direct employees of the Dutch collieries were to lose their jobs, and on December 31, 1974, the last coal was brought to the surface. This closure of the coal mines in the South Limburg mining district was just the first phase of the demise of deep coal mining in western Europe.

Within a decade Groningen gas had not only fundamentally changed the Dutch energy supply situation, but it also quickly penetrated the energy markets of western Europe. In 1975, 10 years after the start of Groningen production, Gasunie sold 47 bcm of gas to five European countries: Belgium, France, Germany, Italy, and Switzerland. The export contract with Italy reflected high-level political rather than primarily commercial considerations as it took into account NATO's concern about increasing communist influence and the risk of consequential political destabilization of that country.

Small Fields Policy

The extremely rapid increase of gas production and sales volumes from the mid-'60s well into the '70s also reflects the wisdom of the day about the promise of nuclear energy, which was widely expected to replace fossil fuels within a few decades. Consequently, it made sense to produce Groningen gas at the highest practicable rate. Prompted by the oil price shock of 1973, the policy of very rapid depletion of the Groningen field was replaced by the small fields

policy. This means that smaller gas fields are produced preferentially, with the Groningen field having the role of "swing producer."

Gasunie combined ownership and operation of the pipeline network for gas transportation with marketing and trading of the gas. This included transportation and trading of natural gas imported from various sources, including Norway. In response to the EU directive to liberalize the European energy markets, the marketing and trading activities were split off from the transportation function. In 2005 GasTerra was formed to handle the marketing and trading of gas, whereas Gasunie, as a 100 percent state-owned transmission system operator, continues to control the transportation and distribution network and also participates in gas storage projects and LNG regasification capacity. Ownership of GasTerra is the same as for the previous Gasunie (Shell and Esso each hold 25 percent, EBN 40 percent, and the state 10 percent).

Impact of Groningen Gas on the Netherlands

The government's objective that the Dutch nation would be the main beneficiary of Groningen gas was certainly reached—at least in financial terms. In 1969 a mere 1.5 percent of government revenues was derived from Groningen gas sales, but this rapidly increased to 5.5 percent in 1974, 11.5 percent in 1979, and a peak of 19 percent in 1982. This was due to increased oil prices, to which the gas price was linked, combined with a revision of the originally agreed-upon government take of 70 percent of total gas revenues. In addition to the price bracket with a 70/30 percent revenue split, two additional price brackets with splits of 85/15 percent and 95/5 percent were established in the mid-'70s. It is worth noting that these revenue-sharing agreements were kept confidential because private companies were involved that likely had no interest in this arrangement setting a precedent for their operations elsewhere in the world, where the government takes might typically be smaller. The gas revenues made it possible to pay for the Dutch welfare state.

In the 1980s gas revenues caused the Dutch guilder to rise against other currencies. This resulted in reduced competitiveness of other economic sectors and increasing unemployment (over and above the unemployment caused directly by closing the collieries in Limburg). Combined with a, by most standards, very generous welfare state, this economic situation was widely referred to as the "Dutch disease."

Since the 1980s the government's gas revenues (proceeds from Groningen gas as well as other gas fields) have varied significantly, in line with fluctuations in oil prices and produced volumes. In 2013 the government received €15.4 billion from gas production, but in 2016 this had shrunk to €2.4 billion.[5] To date, the total government income from gas sales is approximately €300 billion. Only from 1995 to 2010 was part of the gas revenues earmarked to fund specific projects rather than treated as general revenue. In total €26 billion of gas revenues were invested in specific projects such as the *hogesnelheidslijn*[6] (high-speed rail line) and R&D programs.

The Dutch decision to treat the proceeds from gas as general revenue is very different from the one made by Norway, which opted to place part of its oil and gas revenues in a sovereign wealth fund. Had the Netherlands done the same since the mid-'60s, a very sizable nest egg (estimated at €350 billion by the end of 2013) would have been available for emergencies

such as the earthquake issue. In addition, future governments cannot count on revenues from natural gas sales and incidental financial breaks.

Decarbonization

In the context of the current public concern about CO_2 emissions and climate change, it is interesting to note that the use of natural gas in general and of Groningen gas in particular resulted in a major decarbonization of the Dutch economy in the 1970s. In 1960 50.2 percent of total Dutch energy consumption came from solid fossil fuel such as coal and lignite. Oil provided 48.4 percent and natural gas a mere 1.4 percent. By 1978 coal had shrunk to 5 percent and oil to 43 percent, with natural gas swelling to 52 percent. The magnitude of this change to a lower CO_2 intensity is even more impressive given that total energy demand had tripled in that same period. At the time, however, the most obvious environmental benefit was that smog blanketing the cities in winter became a thing of the past as households and industries switched from burning coal to clean-burning natural gas.

The switch from coal to relatively clean-burning natural gas back in the 1970s means that a further reduction in CO_2 emissions is now much harder for the Netherlands than for some other countries. In the mid-2000s the Dutch government decided to support the electricity production sector as it proposed new coal-fired power generation projects in both Rotterdam and Eemshaven. These plants, starting operation in 2014, have been subject to severe public scrutiny since the companies reached their final investment decisions, and the government is now proposing to close them down in 2030 at the latest. Meanwhile, in the last decade, the United States has cut its total CO_2 emissions by about 20 percent, or approximately a billion (10^9) tons per year, by switching from coal to natural gas for electricity generation. This was made possible by the shale gas revolution, with cheap and abundant natural gas replacing coal. The loss of market share for coal consequently caused its price to collapse, which made American coal more competitive for power generation in Japan and Europe. Following the Fukushima disaster in 2011, Japan switched on a large scale to cheap coal for power generation, and Europe also imported large quantities of American coal to generate electricity, even though the long-term outlook for coal exports from the United States, or for domestic consumption, continues to be bleak.[7]

The Significance of Groningen Gas

Though the Netherlands is still among the largest gas producers in the European Union, the days that Groningen gas was a dominant factor in the European gas market are long gone. In 2015 total EU-28[8] gas demand was ~426 bcm, of which some 30 percent was met by imports from Russia.[9] Total gas production in the Netherlands in 2015[10] was 49.7 bcm, of which 28.1 bcm came from the Groningen field. With annual domestic consumption close to 34 bcm, only some 15 bcm was therefore available for export to other EU countries—that is, no more than 3.5 percent of total EU demand. With production from small fields declining at a rate of some 7 percent per year and Groningen production capped by the minister of economic affairs at 21.6 bcm (2017–2018 planning period), the European Union will need to increase gas imports from other sources. Moreover, the minister has planned to further curtail production from the Groningen field to 12 bcm per annum in the coming years, a level that the regulator had

indicated as a "safe" level of production, and will then proceed to terminate production as soon as possible (based on current expectations, somewhere between 2028 and 2035, though it may be sooner as the ratio between costs to operate the field and revenues will change dramatically in the near future). In June of 2018, the minister announced that the Dutch state had reached an agreement with the operators of the field that they will not file claims for the natural gas that will stay in the ground (an estimated 450 bcm, worth €70 billion at current gas prices) and that the companies will guarantee compensation of damages to buildings and houses in the Groningen area that are linked to induced seismicity while at the same time continuing to operate the Groningen field and safeguard secure levels of supply for the short term.

For the medium term the minister has taken several measures to address the future shortfall of gas produced from Groningen. It should be realized that replacing Groningen gas with imported gas is technically not a straightforward process. Groningen gas, with its ~14 percent nitrogen (N_2) content, is called "low calorific" gas (L-gas), whereas imported gas is typically "high calorific" (H-gas). Replacing Groningen gas with imports therefore means that either the imported gas needs to be diluted with nitrogen or that all the end-user equipment needs to be converted to H-gas specifications. The minister has asked Gasunie to invest in additional nitrogen capacity (which, in part because of time-consuming permit efforts, will take an estimated four years to materialize) and has urged domestic industrial users to prepare to switch to different quality gas, while the previous minister had already urged off-takers in northern Germany, Belgium, and northern France to speed up their plans to adapt to a future with less natural gas from Groningen. These countries are all making progress, but changing all burners at the household level is proving to be a time-consuming affair, and advances have been modest.

Disregarding any political considerations, one should bear in mind that importing gas from Algeria or Russia, for example, also carries a significant environmental price. To transport gas via a pipeline from a field in Siberia to, say, Germany, some 10 percent of the initial gas supply will be used to power the compressors that pump the gas through the pipelines. For LNG projects for which gas is cooled to a temperature of *minus* 162° Celsius, the amount of gas used to drive that liquefaction process is a minimum of about 15 to 20 percent of the initial supply.

In other words, transporting gas over large distances adds at least 10 to 20 percent to its CO_2 footprint. Any government wishing to minimize CO_2 emissions to combat climate change should therefore give preference to maximizing local gas production over gas imports. Regrettably, the prospects for new exploration in most parts of the European Union are currently off the table, increasing the need for imports despite often polarizing and unconstructive debates that surround them.

How Did the Present Predicament about Groningen Gas Production Arise?

As stated above, public opinion about the Groningen gas field has changed in recent years from "Groningen gas: key to our prosperity" to "Groningen gas: why take any risks with our safety?" The watershed event was the 3.6-magnitude Huizinge earthquake in 2012, which caused widespread damage to property. However, this event was but the culmination of the slow erosion in the public's confidence that the NAM and the government were managing gas

production from the Groningen field in an optimum manner.

Concerns about gas production causing earth tremors were first publicly raised in the late '80s following several small earthquakes that were geographically associated with producing gas fields in the provinces of Drenthe and Groningen. Prior to the first recognized production-induced earthquake in 1986, the key environmental and safety concern was the issue of surface subsidence in response to the drop in gas pressure in the Groningen reservoir. Reservoir pressure depletion due to gas production results in reservoir compaction, and this in turn leads to surface subsidence. In the flat polder landscape that overlies the Groningen field, any change in elevation immediately affects the polder drainage system. It was this issue that, ever since the start of gas production, has received a lot of attention from the NAM, the government, and the water board(s) responsible for managing water levels in the polders. Although, by 1999, the possibility of earth tremors being caused by gas production was clearly acknowledged by the NAM,[11] this was not translated into simple and effective procedures for handling the claims for compensation for property damage caused by those tremors.

Slow and bureaucratic procedures; disputes about the cause(s) of damage, especially to older buildings (e.g., "earthquake caused" versus "differential movement of surface soils due to dewatering"); poorly understood variations in the severity of damage to buildings due to localized variations in soil properties (e.g., sand versus peat); and so on have led residents in the affected area to lose confidence in the NAM and authorities.

It is noteworthy that some 60 years earlier in a broadly similar situation in the Limburg mining district, the joint collieries (*staatsmijnen* and privately owned mines) responded very differently to claims about property damage caused by their mining operations. Surface subsidence due to coal mining was simply recognized as a common and major cause of damage to buildings. If possible, repairs were quickly done. If damage was so severe that repairs were impractical, occupants were quickly relocated and/or compensated. Quick and effective action by the mining companies kept those affected by mining subsidence reasonably satisfied. The fact that most of the directors and other senior staff of the joint collieries also lived in the areas affected by mining damage may well have been a significant factor in the way they responded to damage claims from the local residents. Another fundamental difference was that in the Limburg mining district, just about every resident was directly or indirectly economically dependent on the coal mines. In the '50s and '60s, the Limburg mines employed nearly 50,000 people directly, and the region's economy was totally dependent on the collieries.

This is very different from the situation in Groningen, where few of the affected residents benefit economically from gas production. This important difference is due to two factors. Firstly, unlike coal mining, the production of gas does not require much labor, and the NAM's main office is in Drenthe rather than Groningen, with very few NAM staff members living in the area directly affected by earthquakes. Secondly, the decision by the then-government, as outlined in the Nota de Pous, was to treat all proceeds from gas production as "general revenue" rather than allocating some of that revenue stream to the Groningen region. This decision was consistent with Napoleon's view as laid out in the Mijnwet 1810[12] that all mineral resources are the property of the state.

The frustrations about the way claims for property damage are handled, the feeling that the safety of Groningen residents has been ignored by both the NAM and the government, and the widespread feeling of being disenfranchised have polarized this situation. In the first half of 2017, the government decided to reduce the allowable annual production volume approved by its own regulatory authority[13] from 24 to 21.6 bcm. This is a very sharp reduction of the produced gas volumes, for as recently as 2013, 53.9 bcm of natural gas was extracted from the Groningen field. In 2014, to reduce the risk of earthquakes, the maximum allowable production volume of Groningen gas was set at 42.5 bcm, and this production ceiling was reduced further for the period of 2015 to 2016 to 27 bcm annually.

In a review of the Dutch gas market, Honoré[14] analyzes the implications for the European energy supply situation and concludes that the negative consequences of rapidly dwindling supplies of Groningen gas are likely underestimated. To compensate for the sharp reduction in Dutch gas production, the European Union needs to increase imports from elsewhere with potential security of supply implications (volumes, capacity, prices, and/or dependence).

Final Remarks

Recent history has made it clear that engaging in the public debate about Groningen by using only technical and commercial arguments is unlikely to convince a skeptical public. Presently, as the operator of the Groningen field, the NAM has little credibility with the public and even less so with most of the people who are directly affected by the earth tremors induced by gas production. Affected residents are frustrated with bureaucratic procedures, difficulty in selling their property even if they are prepared to move elsewhere, and so on. As a consequence, following the relatively strong earthquake (magnitude 3.4) at Zeerijp in early 2018, the Dutch government decided to reduce the production of Groningen gas as quickly as possible from 21.6 bcm per annum to zero by 2030. Taking this drastic decision as a given, there are still important questions for policy makers to grapple with. In the Netherlands, public debate sometimes equates the termination of the Groningen field with the end of natural gas usage in the country. There is an active debate whether existing natural gas infrastructure should be dismantled, even though the question of who pays for such undertakings has not been answered. Although it makes sense to find alternative solutions for heating and cooking for new buildings and homes, this is less straightforward with the existing building stock, and careful consideration seems to be in order. In addition to a hefty price tag, dismissing a role for natural gas in the short and medium terms also ignores important new developments to improve the carbon footprint of natural gas, with growing attention to the potential of biomethane and hydrogen produced out of excess renewable electricity. In addition, the current government envisages a major role for carbon capture and sequestration in the future energy mix, and both electricity generation and certain industrial processes with natural gas as a feedstock are likely candidates for CCS technologies from the 2030s onward. It is praiseworthy that the political establishment in the Netherlands is ready to move the country to a frontrunner position regarding transitioning to a low-carbon economy, though the characteristic pragmatic merchant spirit of the Dutch at times seems lost in the current debate about the future role of natural gas. For northwestern Europe, the end of Groningen production means the end of a major source of flexibility, and policy makers should contemplate how to replace that flexibility, also in light of the poor economics of natural gas

storage in the continent in recent years (as illustrated, for instance, by the closure of Rough in the United Kingdom). Finally, the Dutch will need to figure out how to meet medium- and long-term demand for natural gas. Most countries in the region do not fully rely on the spot market for their resources, something the Netherlands typically did not need to worry about. This too will require careful consideration.

The endgame for the Groningen gas field has started, with less than 12 years to go. A 450 bcm stranded gas asset worth €70 billion will be left in the ground, while the import bill will undoubtedly rise, likely intensifying discussion about security of supply.[15] However, the exact timing of production cuts will be difficult to anticipate. It will depend on how cold winters will be, how successful efforts will be in neighboring countries that depend on substantial volumes of L-gas from Groningen, and how effectively the Dutch energy transition plan will be implemented. The hope is that a pragmatic view will prevail over a utopian one.

Notes

1. "Induced Seismicity in the Groningen Gas Field, the Netherlands," *Special Issue Netherlands Journal of Geosciences*, https://www.cambridge.org/core/journals/netherlands-journal-of-geosciences/issue/5AD5EE9E8EF77A8DE50D6D60963AFFBB.
2. "Nota de Pous" is a letter from the then-minister of economic affairs to the Dutch parliament. This "*Nota inzake het aardgas*" [White Paper on Natural Gas] is dated July 11, 1962.
3. http://www.nlog.nl/en/groningen-gasfield; https://www.nam.nl/feiten-en-cijfers/gaswinning.html.
4. The state's shares in the Groningen field and Gasunie were initially held by the Dutch State Mines (DSM) through a separate legal entity called DSM Aardgas. In 1989 DSM, which had become an important chemical manufacturer, applied for a listing at the Amsterdam stock exchange, and DSM Aardgas was renamed Energie Beheer Nederland (EBN) as a fully separate entity (see https://nl.wikipedia.org/wiki/EBN).
5. https://www.cbs.nl/nl-nl/nieuws/2017/17/aardgasbaten-op-laagste-niveau-in-ruim-40-jaar.
6. https://www.rekenkamer.nl/publicaties/rapporten/2014/10/07/besteding-van-aardgasbaten-feiten-cijfers-en-scenarios.
7. http://energypolicy.columbia.edu/sites/default/files/Center%20on%20Global%20Energy%20Policy%20Can%20Coal%20Make%20a%20Comeback%20April%202017.pdf.
8. http://www.eurogas.org/statistics/.
9. http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_production_and_imports.
10. http://www.nlog.nl/en/production-and-injection-data.

11. Gussinklo et al., "Subsidence, Tremors and Society; Geologie & Mijnbouw," *Netherlands Journal of Geosciences* 80, no. 1 (1999): 121–136.

12. *Loi concernant les mines, les minières et les carrières* (*Bulletin des Lois* no. 285) is a law that came into force when the Netherlands was annexed by France in July 1810. *De Mijnwet 1810*, as the act is referred to, was written in French and remained in force until 2002.

13. https://www.sodm.nl/documenten/publicaties/2017/04/13/advies-sodm-groningen-gasveld.

14. "The Dutch Gas Market: Trials, Tribulations and Trends," *OIES NG*, May 11, 2017.

15. https://nos.nl/artikel/2238299-1-miljard-euro-voor-gaswinningsgebied-groningen.html.

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The views represented in this commentary represent those of the author(s).

This work was made possible by support from the Center on Global Energy Policy. More information is available at http://energypolicy.columbia.edu/about/mission.

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