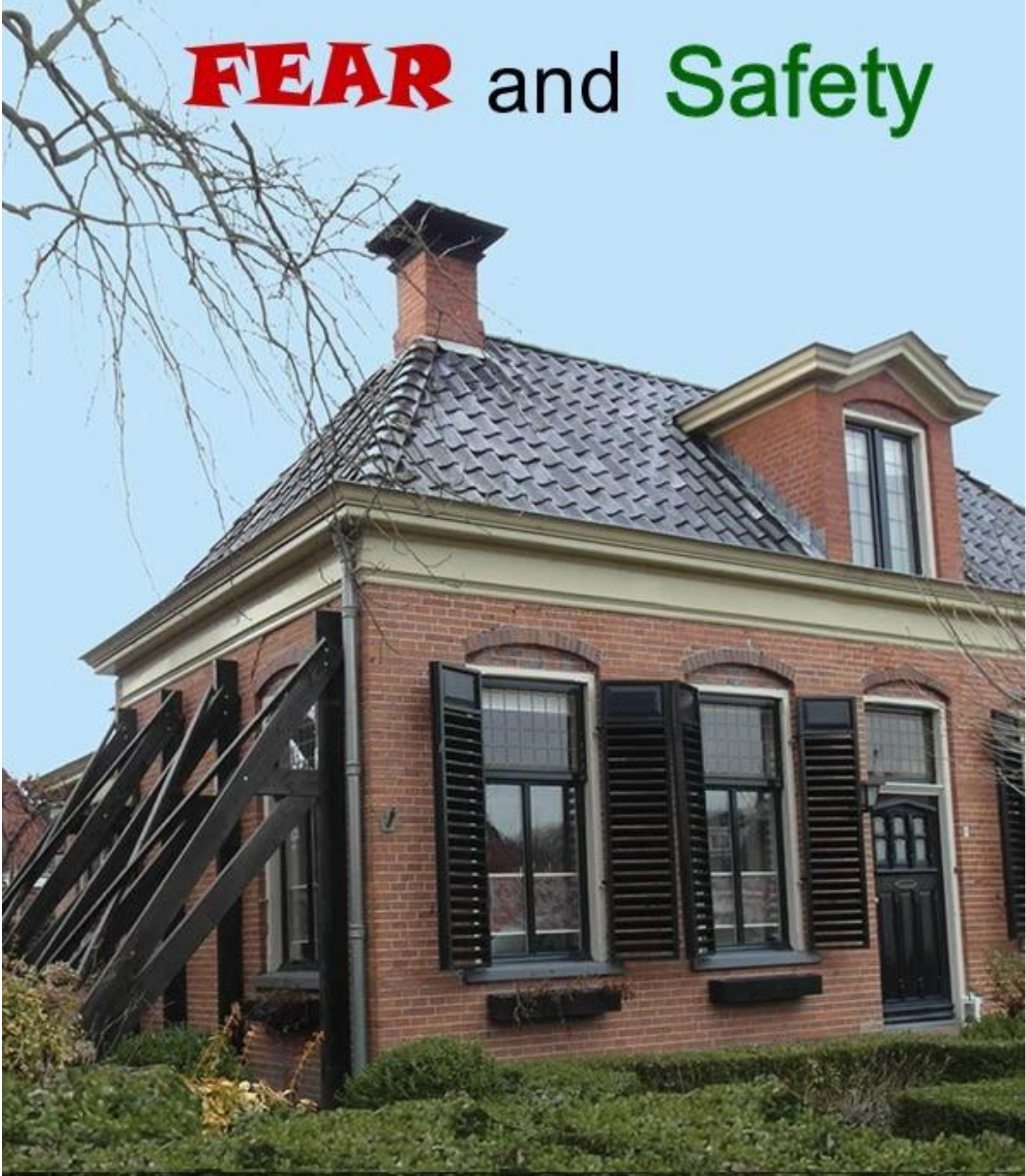
FEAR and Safety



In relation to the 2006 - 2023 induced earthquakes in Groningen

by seismic structural eng. Sjoerd Nienhuys

Colofon

FEAR and SAFETY

Related to the 2006-2023 induced earthquakes in Groningen

The far too high Mmax projections and the consequences for the Groningen population

Website: www.nienhuys.info

http://510790959.swh.strato-hosting.eu

The document about the options for seismic strengthening of masonry houses “DUURZAAM HERSTEL en VERSTERKEN van Woningen in Groningen’ is posted on my website, 2de page, Completely and in 13 separate chapters.
It can be downloaded for free.
ISBN-number 1st draft May 2021: 9789 0820 4081
1500 illustrations, sketches, photos and graphs, >500 pages.
Drawings by Sjoerd Nienhuys.
Photo frontpage by Hanneke Andringa,
https://hannekeandringa.wixsite.com/portfolio/afstudeerproject

FEAR and SAFETY

Fear and Safety, about the 2006-2023 induced earthquakes in Groningen, is a short, illustrated summary about the alleged unsafe situation due to the extremely high earthquake forecast (Mmax) that was distributed by the NAM in early 2014, after the Huizinge earthquake of August 16, 2012. This Mmax (PGAg 0.42) suggested that in the future more than 100,000 homes in the province of Groningen were at risk of collapse, possibly resulting in thousands of deaths. This Mmax (from the KNMI) was also expressed in the Richter scale (Mw = 6 to 7), while the population only had the reference of tectonic earthquakes in the same Richter scale, which differed a lot.

Although the KNMI earthquake forecast was adjusted slightly downwards towards 2015, it remained extremely high (PGAg 0.36) and led to widespread concern and fear among the population. This was because the media and all authorities adopted this Mmax forecast as an established fact. Only after 2018 was the Mmax estimate slightly adjusted downwards again.

This illustrated explanation is part of the technical documents by seismic, structural engineer Sjoerd Nienhuys, who was encouraged by Em. Prof. Dr. Ir. Mick Eekhout to develop his previous architectural book "**DUURZAAM HERSTEL en VERSTERKEN van WONINGEN in GRONINGEN**" ("SUSTAINABLE RECOVERY and REINFORCEMENT of HOMES in GRONINGEN"), which is a summary of the training material that was compiled in response to the Huizinge earthquake between the end of 2013 and the end of 2015.[1]

This paper presents a brief and illustrated story of the negative impact among the population of Groningen by the extreme high forecast of Mmax (PGAg 0.42 Richter >6) that was calculated by the KNMI in 2013 (5x the 2012 Huizinge earthquake with PGAg 0.085 and Mw 3.6).

Abbreviations.

PGAg. The Peak Ground Acceleration that determines the maximum building load. This PGA value is stated in the National Practice Regulation (NPR9998), but the Richter value is not.

Mmax. The maximum earthquake. The chance that an earthquake with the calculated maximum magnitude will occur is very small (<< 1% after >> 50 years). It is the theoretical, increased with various safety margins, calculated, largest, but impossible earthquake. So, this will never happen.

NAM. 50% Shell and 50% ExxonMobil (managed by Shell). The Ministry of Economic Affairs (EZ) and Climate (EZK) had indicated in the 'Groningen Field Determination Decree 2023 - 2024' that NAM must be able to restart production from the Groningen gas field. In 2020, gas production from the Groningen field was first put on a 'pilot light' and a hundred wells were closed.

Richter. This is an earthquake scale in the hypocentre that is measured by the KNMI. There are about 30 differences between tectonic earthquakes and induced earthquakes. Comparing the two is like comparing a lion and a cat. That is possible, but with many differences. One full point higher on the Richter scale (from 3.5 to 4.5) is a 10X stronger earthquake with an approximately 2X higher PGAg (ground acceleration).

[1] For download see: www.nienhuys.info 2de webpage (>500 pages). Also available in 13 separate chapters.

Introduction.

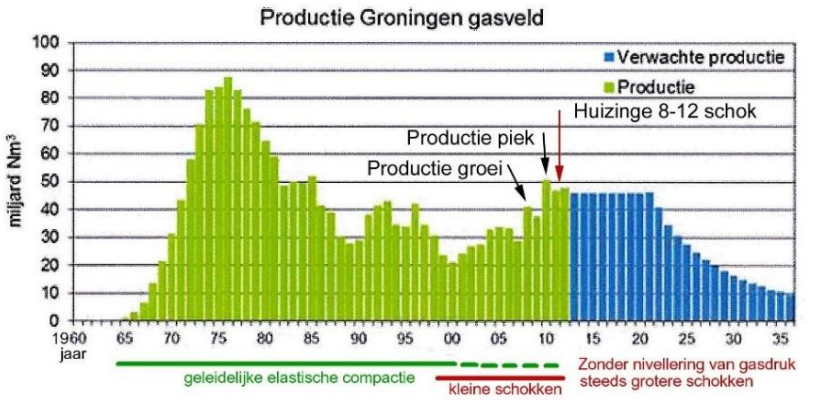
2006. The Groningen natural gas exists under high pressure in a ≈200 m thick sandstone layer at a depth of 3 km and is covered by a gastight, tough salt rock layer (Zechstein) which is approximately 1 km thick. In some places the salt rock is much thicker and comes close to the Earth's surface. Salt extraction has taken place here and large cavities have been created. These cavities are used to store gas under pressure during the summer, so that peak demand can be met in the winter. This is important to manage the speed of gas extraction and supply during the winter.

With gradual gas extraction, the sandstone will first be elastically compressed, which results in compaction and thus surface soil subsidence. If more/faster gas is extracted locally, the gas pressure in the sandstone decreases further and a small local collapse/crushing will occur. This then produces a shock/tremor in the hypocentre. The collapses remain small (a few cm) and localized (<1 km^2) because the thick an tough salt rock hardly yields and deforms only slowly.

Natural gas was created 350-280 million years ago by the accumulation of hundreds of meters thick layer of rotting plant remains from former tropical swamps. The digesting plants, which were deprived of oxygen, produced methane gas (CH_4) by bacteria. This is a >21x stronger greenhouse gas than CO_2. That large amount of methane caused very strong global warming, further desertification and sand drifts for millions of years. The rotting plant mass was first covered by a 200 m thick sand layer, which meant that there was a lot of methane gas captured in that sand layer, but the methane gas also escaped at the top. Due to global warming, the ice caps melted, and a shallow sea formed over that sand layer. Due to salt deposition in the increasingly warmer and drying sea (Zechstein Sea), the sand layer was covered by a one km thick salt layer. To date, two km thick other rock and sediment layers such as lime, marine clay, sand and peat have been added, causing the top pressure on the sandstone to rise to 670 bar or 683 kg/cm^2. The gas spewed out in 1965 under high pressure (347 bar).

Burning natural gas (CH_4) leaves CO_2, which is now once again leading to very rapid global warming. To prevent this very rapid climate warming, this CO_2 should be compensated immediately during the extraction of natural gas and permanently stored with gas combustion.

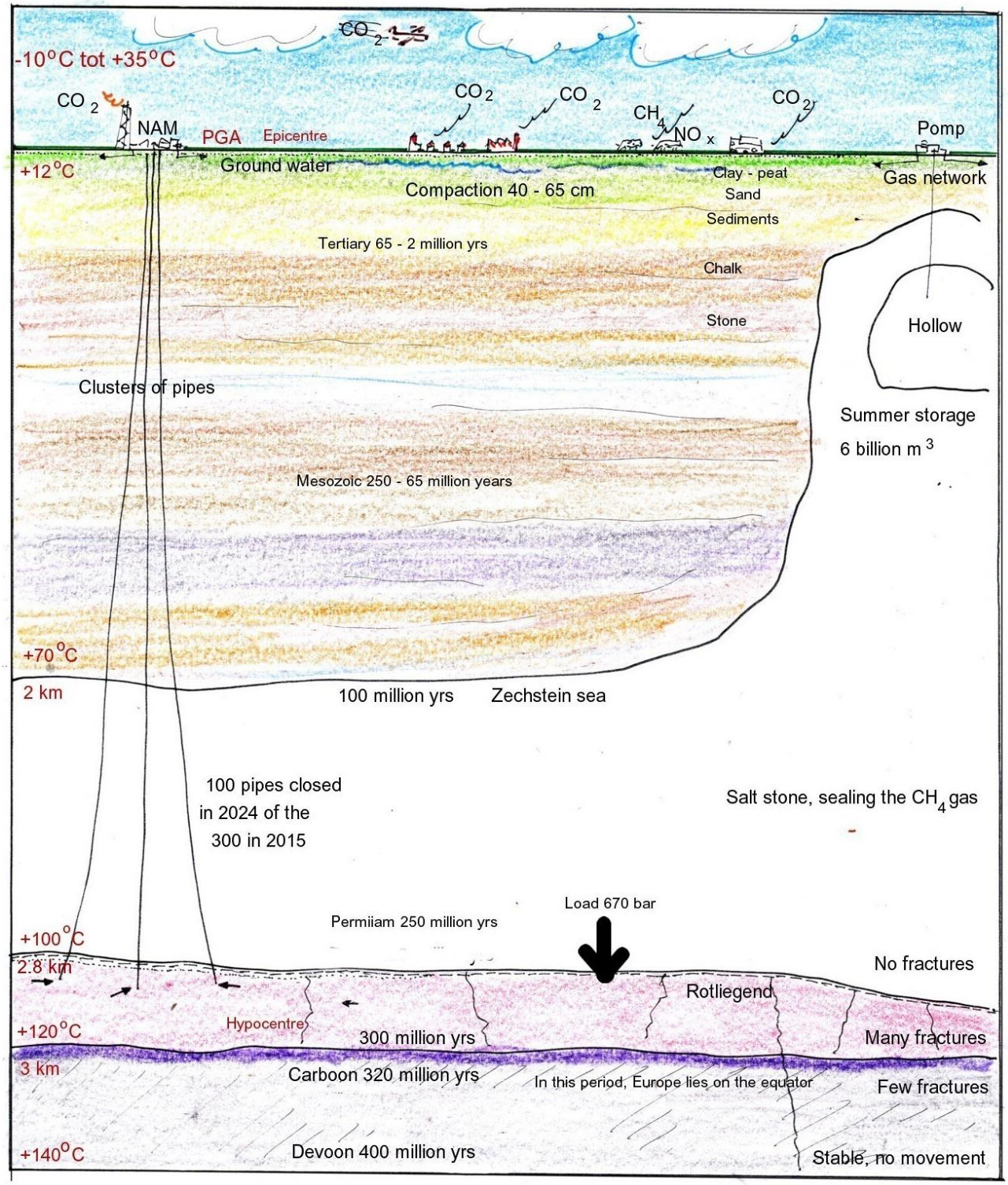
Oil companies do not have this obligation for storage or compensation and are only focused on quick profits, whereas the negative consequences of combustion and CO_2 emissions must be borne by the society. Other problems associated with the extraction of natural gas, such as ground surface subsidence (consequences for water management, dikes, sewerage, subsidence) are only partially compensated from the large financial profit of the NAM/government, but with other fossil fuel extraction companies (coal, oil), even that is not the case.



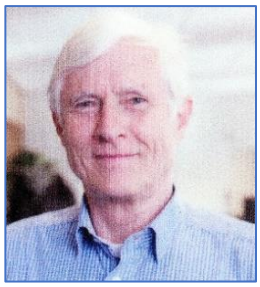
Gerealiseerde en verwachte productie van het Groningen gasveld conform het winningsplan (2007). http://www.nlog.nl/nl/reserves/Groningen.html

Page 5 right: Schematic presentation of the different layers of the underground in the province of Groningen

Gas production by year (green) and the planned production (blue) from Until 1990 mainly elastic compaction took place.



When natural gas is gradually extracted, the gas pressure in the sandstone becomes lower. An elastic compression of the sandstone then first takes place. With further pressure reduction, collapse occurs around the borehole area. This produces a measurable vibration/tremor. These vibrations can damage weak masonry houses. Shocks greater than PGAg 0.02 can be felt by residents. The compaction leads to subsidence which affects water management.



Structural-seismic engineer Sjoerd Nienhuys: “By extracting (less) gas in a spread and controlled manner, so that no large pressure differences arise, there will be no major shocks or earthquakes. However, NAM has significantly increased gas production since 2000 to sell a lot of (cheap) natural gas abroad.”

“The NAM itself could have adjusted production to a lower level, so that there would be no more serious earthquakes, but that was **against their profit motive** and the 2007-2013 Extraction Plan.”

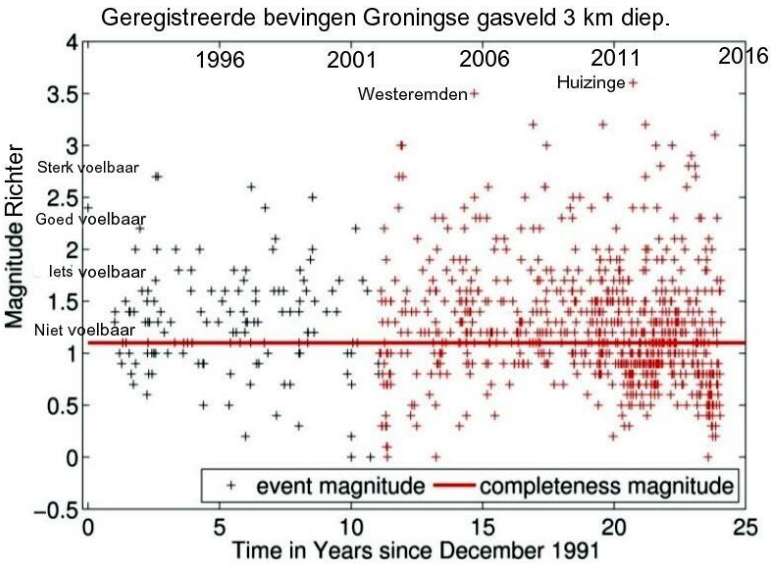
2009. The establishment of the Groningen Soil Movement (Groninger Bodem Beweging, GBB) after the number of clearly noticeable tremors had increased sharply since 2003, and especially in 2006.

Registered earthquakes Groningen gasfield.

Since 1990, NAM has started measuring earthquakes more accurately.

These are indicated on the Richter scale.

At some measuring points the PGAg on the surface was also measured.

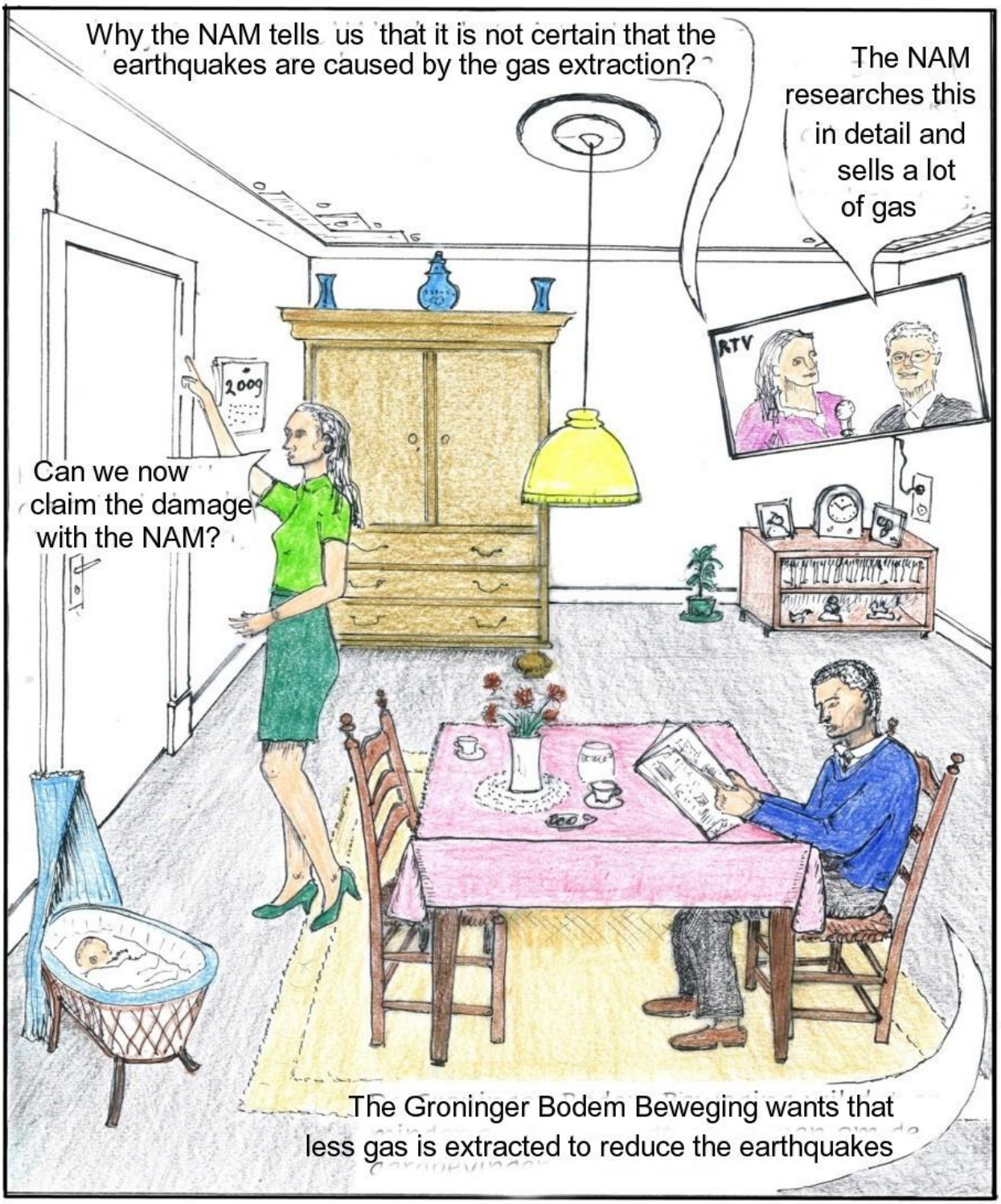


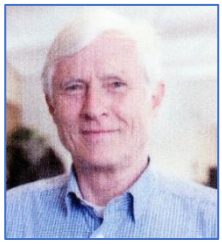
Chapter 1 of the book 'Sustainable Recovery and Strengthening of Homes in Groningen' contains 30 differences between tectonic and induced earthquakes. Although the strength of both is expressed on the Richter scale, there are large differences in duration, frequency, vertical, horizontal displacement and aftershocks, making the effect on buildings quite different. The media regularly shows images of major tectonic earthquakes and the number of victims worldwide.

By comparing this information with the heavily exaggerated Mmax forecasts of the KNMI-NAM, the population is misinformed, and **the public is unfairly frightened.**

News reports on TV.
Earthquake Java, May 26, 2006.
***Richter 6.2**. More than 250 dead.*

News items on TV:
Earthquake L'Aquila, Italy 06-04-2009.
***Richter 6.3.** 250 dead.*





Since 1990, NAM has been conducting research into compaction and the relationship between gas extraction and earthquakes. The NAM estimated in 2005 that the maximum earthquake could be Richter 4.1.
On April 6, 2009, there is an earthquake in Italy, L'Aquila of Richter 6.3 with 300 deaths. This is shown extensively on TV.

Because the tremors are increasingly felt, extra attention is being paid to them. For example, more attention is paid to news reports about earthquakes abroad. Tens to hundreds of deaths are often caused by collapsing houses and other buildings.

Many residents in Groningen discover that there are cracks in their brick homes, which may be caused by the earthquakes. Many masoned brick houses in the Netherlands have cracks. The causes can be many, such as (there are more than 20 causes):

- Old houses from before 1960 that have weak or shallow foundations.
- Houses with different foundation depths, such as partial basements.
- Houses on wet peat or clay soil subject to changes in the groundwater level.
- Trees close to the house that extract water, causing subsidence.
- Traffic vibrations: these are like mild earthquakes.
- Connected building extensions with different foundations or upper building loads.

Groningen has many old houses, but little maintenance was carried out in the province due to years of poor employment and little income. The arrival of gas extraction was not accompanied by many new jobs.

Although a lot of money was earned from gas extraction, very little flowed back to the province (<1%). This is the result of a capitalist revenue model of the mining industry and the need of the government (liberal parties of CDA and VVD) to spend that money on general matters. Decentralization or investing in the extraction area of the province of Groningen was not discussed.

In early 2011 there was a major earthquake in New Zealand. It resulted in a lot of damage to buildings that resemble Dutch houses, but with relatively few deaths. Many new buildings met already the regulations for 'seismic-resistant' construction. Almost half of the deaths were caused by the top facades of brick buildings falling onto the sidewalk in the shopping street. You don't see that, **in two seconds your fate is sealed.**

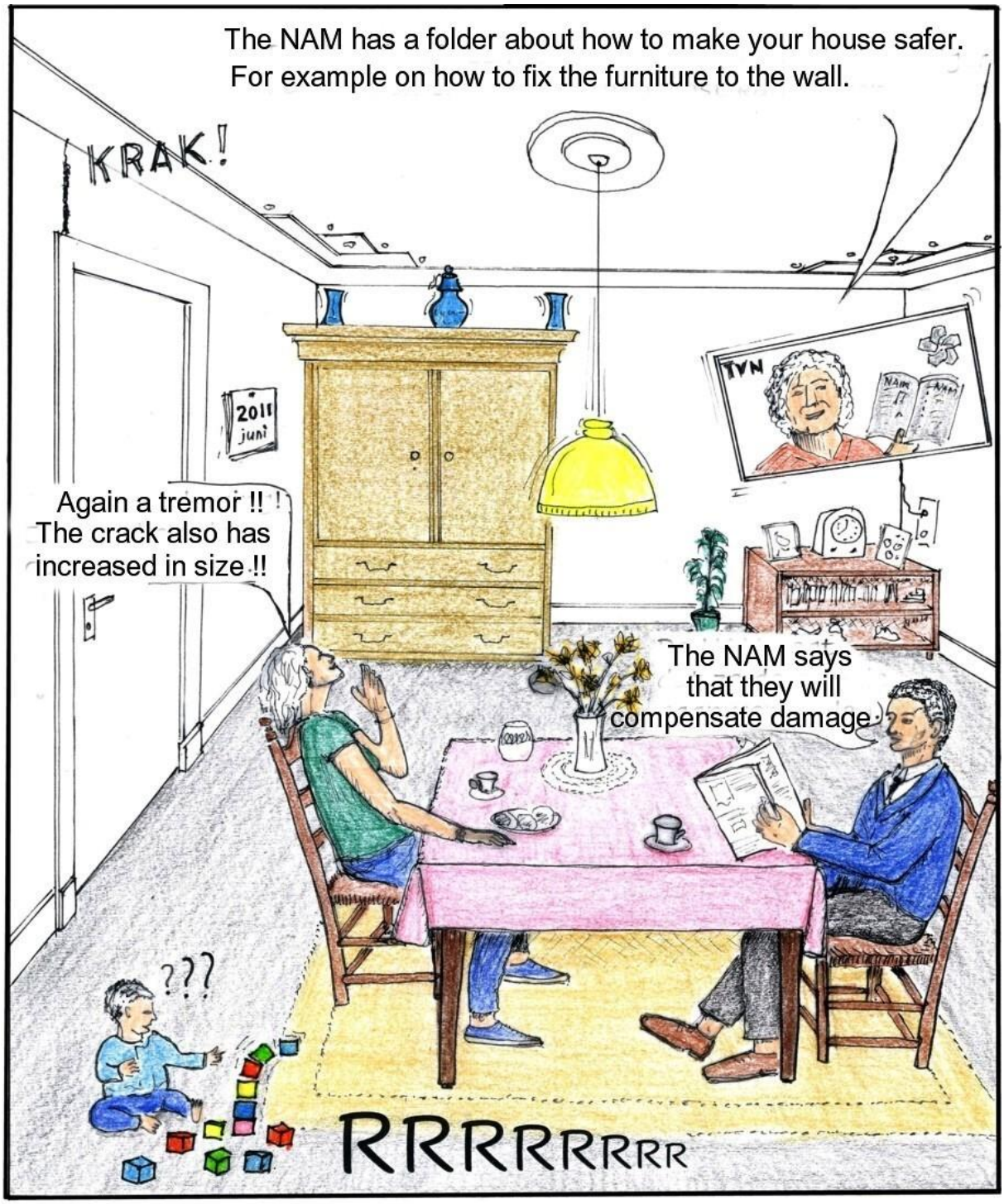
Some buildings in Christchurch, New Zealand are somewhat comparable to Dutch housing.

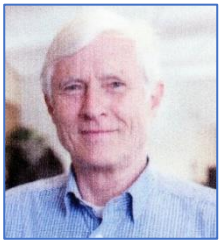
About half of the victims are due to the falling of gable ends along shopping streets.

News reports on TV
New Zealand earthquake February 22, 2011.
Judge 6.3. 180 dead

The New Zealand government has made every effort to repair or replace the buildings, adjust and update the regulations for 'seismic strengthening'.

Due to the active attitude of the government towards this hardly foreseeable natural disaster, the residents of Christchurch suffered little trauma from it.





In June 2011 there was a Richter 3.2 earthquake with a PGAg 0.027. This was felt as far away as the city of Groningen. With a PGAg 0.2 seismic reinforcement is mandatory in seismic/tectonic countries. The risk of collapse of unreinforced masonry is then very high.

The heaviest induced earthquakes in the province of Groningen are a maximum of PGAg 0.1 and can cause a lot of damage to masonry buildings.

The Metro passes under your house.

The tremor felt at the Earth's surface (epicenter) often has an extension in the duration of the shock generated in the hypocenter. This is due to soft, elastic clay or peat soils.

In addition, elastic buildings will vibrate a little more than rigid ones but will experience little damage. Brick buildings are stiff and brittle, and it is therefore almost inevitable that cracks will develop in the masonry of old houses. First at the corners of the door and window openings.

Until 2009, the NAM denied that the damage was caused by the earthquakes, but did start light repair work if the homeowners held the NAM liable in writing.

Although the NAM had calculated that the earthquakes could reach Richter 4, with a possible PGAg of between 0.1 and 0.15, no initiative was taken on preventive strengthening of old houses, not even to check whether the houses could withstand such shocks without partially or completely collapsing. NAM had no knowledge of common building construction.

The NAM did produce a brochure about what to do in the event of an earthquake, such as securing your tall cabinets to the wall and ducking under a sturdy table in the event of an earthquake. “Stay away from windows as they may crack.” This brochure was not appreciated by the population.

These types of recommendations were not relevant in the case of Groningen, because the earthquakes lasted very short. The first two seconds you try to understand what is going on, and after that the biggest shock has already passed. To run outside is completely nonsense. There is no time for that at all, while outside a gable or chimney could be coming down. The media regularly proposes the idea that you can quickly run outside. If you're in bed, you won't wake up properly until it's over.

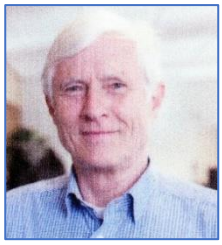
In Guatemala/El Salvador, many buildings are built according to the 'earthquake resistant' code, but not the older buildings. If the gables and chimneys are not properly anchored, they will fall and cause many casualties. Same as in New Zealand.

News: Guatemala earthquake November 7, 2012.

***Richter 7.4**. More than 50 dead.*

The old brick Dutch or Groningen housing construction is not designed or resistant to minor earthquakes and will crack everywhere. With repeated shocks the damage will continue to increase.

The NAM knew that with the high gas production the (initially light) shocks would become increasingly heavier and more frequent, but had no plans for (seismic)reinforcement, only for cosmetic repairs.



NAM's estimate was that there would be one earthquake of at the most PGAg 0.6 to 0.7 every year, and that damage to the buildings would remain limited.

The income was many times higher than the possible costs.

The NAM had no knowledge of the strength of the buildings.

The Huizinge earthquake of August 16, 2012, was in fact a double shock, which is why it lasted slightly longer (about 10 seconds) than the previous and later earthquakes.

The NAM management announced that the damage caused by the earthquakes would be “generously compensated”. The estimate was that around 1,500 damage reports were financially manageable. The previous “repairs” were only a few thousand euros each, so at most 30 million euros, compared to the 300,000 million euros that had already been earned so far, this cost was limited (0.01%).

2012/2013. A clear damage protocol was drawn up after the 2012 Huizinge earthquake.

A = **Obvious** new earthquake damage with fresh cracks with sharp edges. The wall repair will be reimbursed.

B = **Unclear** whether it is a fresh damage or an old one. The repair of the wall will also be reimbursed. The damage assessment expert must make the assessment generously.

C = **Old damage**. Can be recognized by dirty cracks, cobwebs or moss in the cracks. This damage will not be reimbursed because these are old defects. By generous compensation for A and B damage, it is often possible that the C damage can also be eliminated with the same budget.

This seemed a reasonable arrangement, but was not sufficient, because many old houses already had slight subsidence due to the many small vibrations over the past decades. Because this damage was difficult to assess, NAM excluded this damage from investigation and compensation (including the instructions for inspectors from the newly established Centre of Safe Housing, the CVW).

The next argument for reducing costs for NAM was that 'own defects' such as 'construction defects' or 'poor building maintenance' were not the responsibility of NAM. So, if there was a crack in the house that was due to the aging of the building, or construction error, it was excluded from the compensation scheme.

Before 1960, many homes in Groningen were built under old building regulations that did not consider higher loads due to wind, let alone earthquakes.

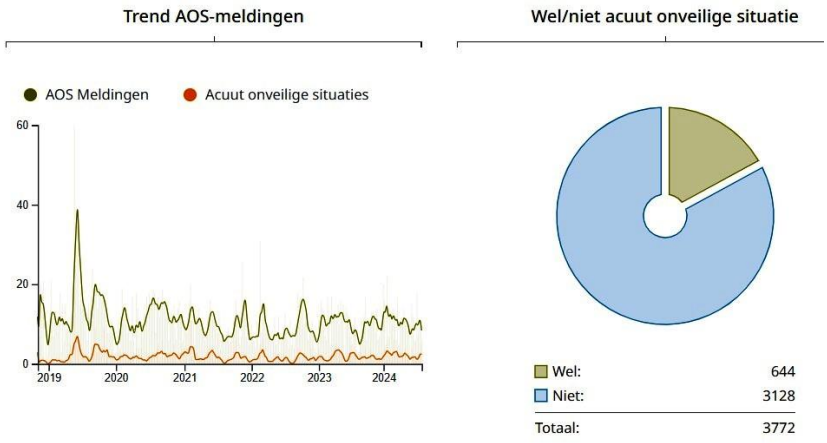
The next strange thing was that the NAM wanted to remove/hide the A and B cracks, but used little or no wall reinforcement, while they had already calculated that the earthquakes could become **stronger** than the Huizinge earthquake and would also occur **more often**.

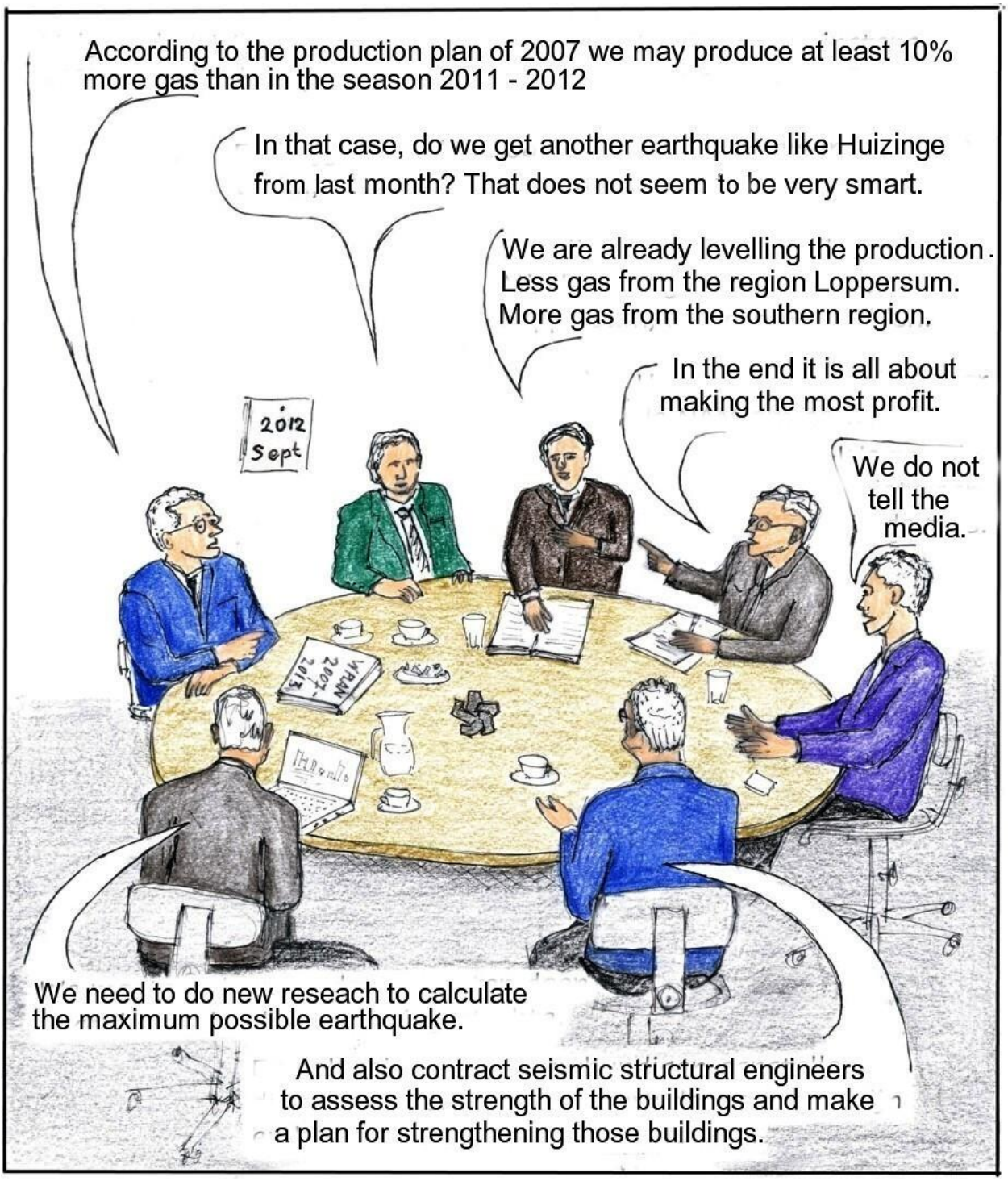
Graph: Reports on acute unsafe situations.

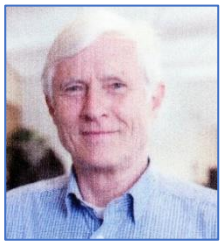
The Huizinge earthquake brought many risky situations to light.

Risky in the sense that if a new similar earthquake were to occur, it would pose a potential hazard.

So, they had at least one or at most two years to remove those risks.







The 2007-2013 extraction plan had a maximum amount of gas that had not yet been produced. Based on the past periods between the larger earthquakes and the production leveling that had already been introduced, it could be stated that it would take approximately 2 years before another earthquake of the Huizinge strength would occur.

This was perceived as an acceptable risk and cost item.

After the 2012 Huizinge earthquake, the KNMI[2] was commissioned to calculate what the maximum earthquake could be if natural gas were to continue to be extracted at high capacity. The KNMI had previously made calculations on small tremors related to the oil extraction in Drenthe, another province in The Netherlands.

The KNMI was not asked how much natural gas could be extracted so that the earthquakes did not become larger than the Huizinge earthquake. The basic problem of the question to the KNMI was that it was always based on **profit maximization** by the NAM, or the maximum amount of gas you can extract. The KNMI therefore **calculated the heaviest possible earthquake** according to the operating schedules provided.

According to official calculation methods for tectonic earthquakes, you should apply an incremental factor for each uncertainty. These factors can vary from 10% to a much higher percentage. By stacking and multiplying these uncertainties, the maximum earthquake becomes considerably higher than the really possible earthquake.

Structural-seismic analysis

The international seismic expert and experienced engineering firm Arup was contracted in 2012 to plan and make calculations for the recovery/strengthening operation in the province of Groningen (350,000 buildings). Extensive risk analyzes and planning proposals about this gigantic operation were presented internally to NAM since the end of 2013.

The Arup reports were based on the well-known methods of seismic risk assessment and recovery operations applicable to tectonic earthquakes. This method states that the highest risks (in the event of a new earthquake) must first be removed, and that buildings where many people gather have the highest priority. After all, if a public building collapses, such as a school or stadium or town hall, there would be an extra-large number of victims.

Based on the estimates of the gradually increasing strength of the Groningen earthquakes over the years, one would have a few years to carry out the 'seismic reinforcements' from the epicenter (municipality of Loppersum). It was clear from the start that it would be a very large-scale operation, which would require many construction workers.

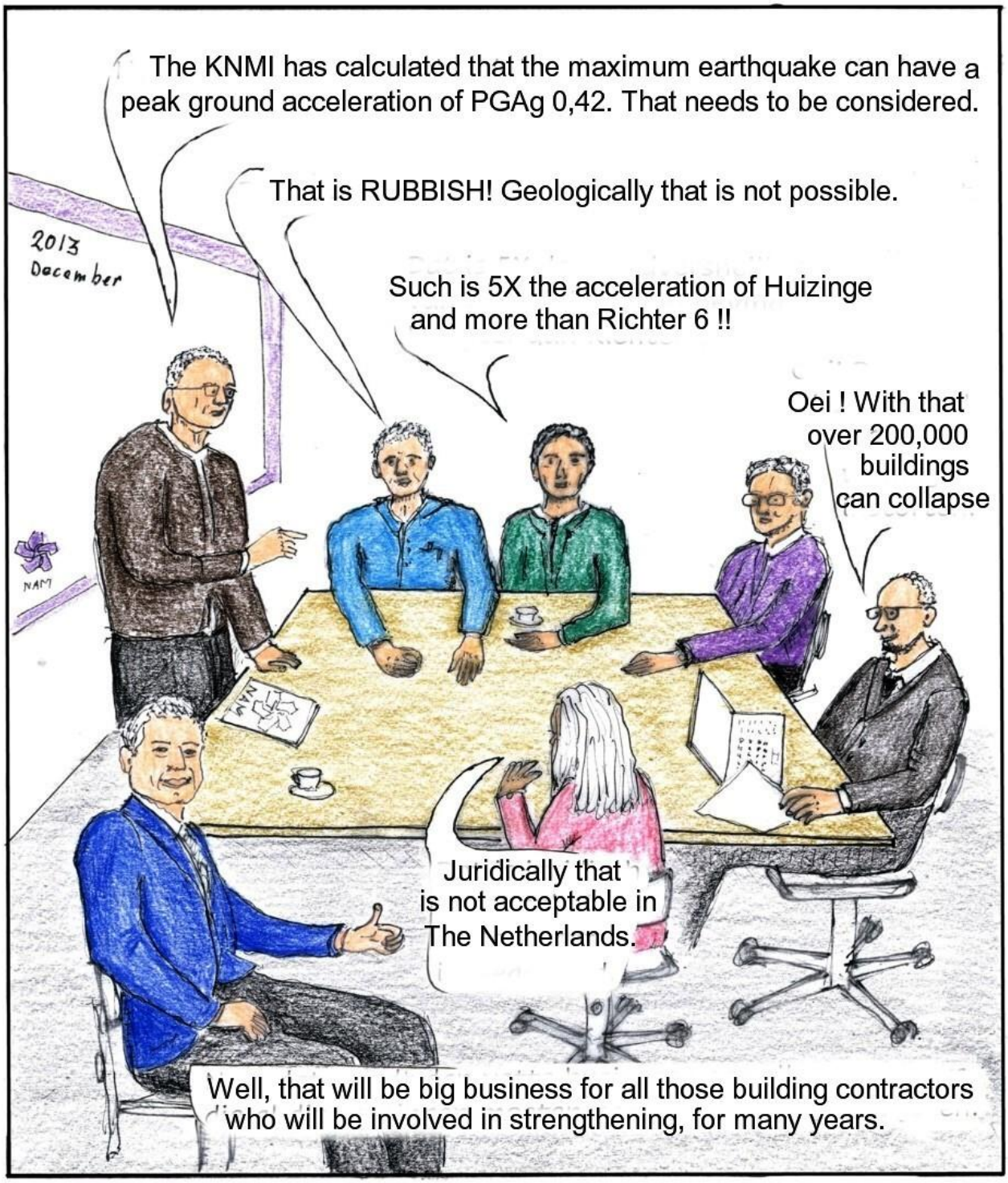
If Arup's plans were to be implemented, the financial and economic consequences for NAM would be very large, much greater than the NAM had ever estimated. The phases of implementation as planned would last more than 10 years and amount to tens of billions of euros.

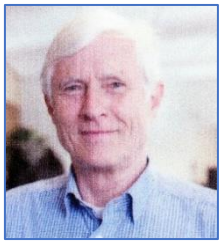
Builders and construction workers.

Due to the serious lack of construction workers and especially the lack of seismic engineers in Groningen, many specialists were attracted from outside the province and the suggestion was made that seismic training for construction workers should be provided. Those construction workers should have some basic knowledge about 'seismic-resistant' strengthening and construction of brick masoned houses.

At that time, there was no Dutch information about 'seismic-resistant' building, nor about the 'seismic strengthening' of old brick homes such as are present in Groningen.

[2] The Royal National Meteorological Institute (KNMI) is the national institute in The Netherlands to study tectonic and induced earthquakes and is recognized as the authority on the subject. Their statements were not questioned.





The external expert commentary in the new version of the 2013 extraction plan, about the KNMI calculation, indicates that there are two major calculation errors.

The NAM made a very big mistake by <u>not</u> stating that they would ensure that the tremors would <u>not exceed</u> the Huizinge 2012 earthquake with PGAg 0.1

PGAg 0,42. HELP!!!

The big surprise at the end of 2013 was the calculation of the PGAg by KNMI (with PGAg 0.42), which was much higher than what Arup had calculated at the beginning of 2013 being PGAg 0.25.

In these situations, neither the NAM nor the KNMI nor Arup asked for an opinion about gas extraction and whether it was wise to keep gas production from the Groningen field so high that you could get many more tremors and heavier earthquakes.

The KNMI had no interest in the amount of construction work that the large-scale strengthening or new house construction could entail and could therefore have advised that a very high PGA was undesirable. One could expect the KNMI to have some knowledge of the structural consequences of major earthquakes. After all, there were plenty of examples of collapsed villages with hundreds of victims around the world.

While the natural gas exploitation horizon in 2012 had a maximum of only 30 years, the calculations were extended to 475 and 2475 years. Quite nonsensical for induced earthquakes that, practically speaking, you can immediately reduce by stopping gas extraction.

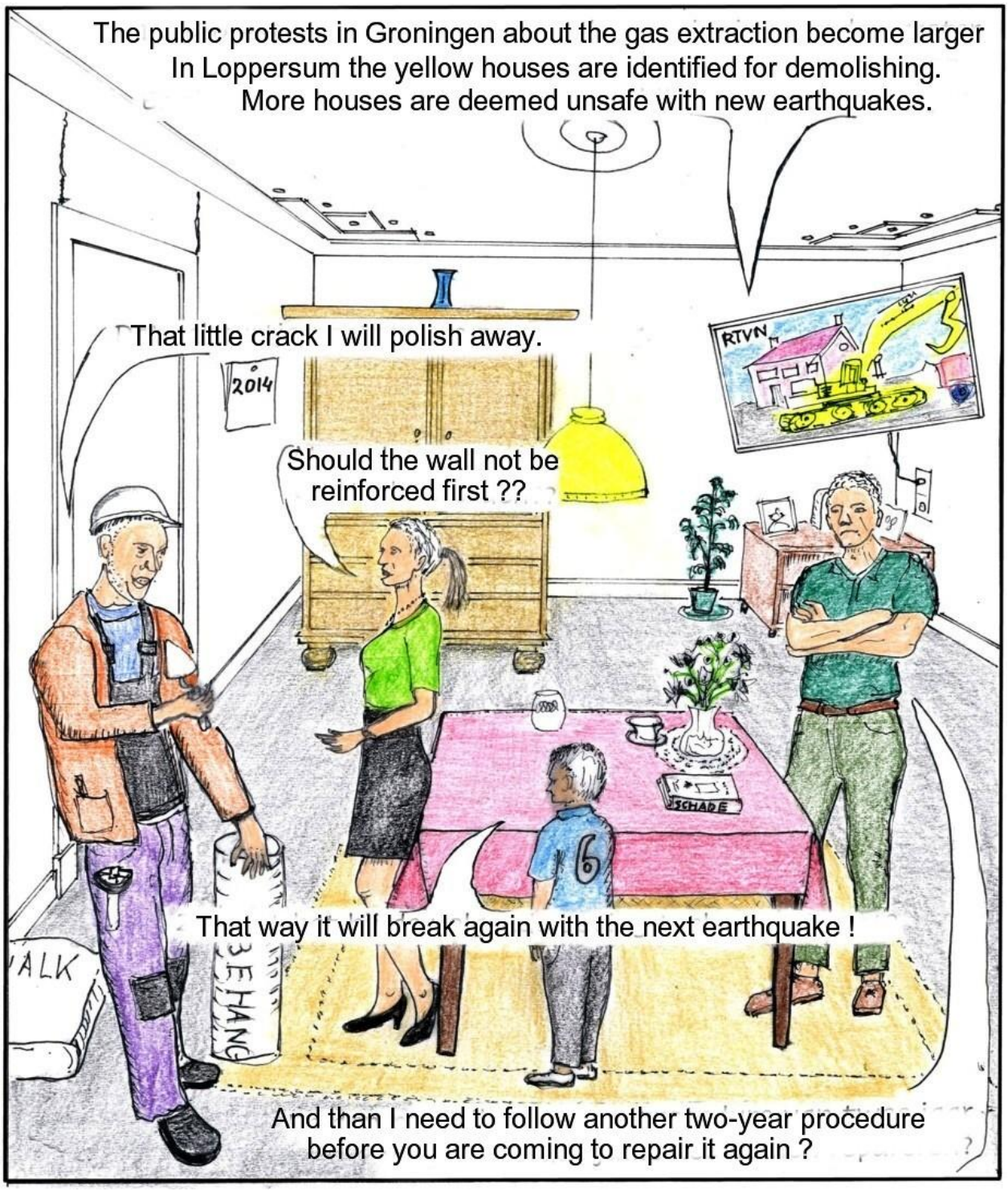
In addition, the KNMI made at least two concept errors in the calculation. These only became clear after the proposal for the amended Extraction Plan 2013 was made public by the Parliamentary Inquiry Committee on Groningen Earthquakes in 2020. This contained the relevant comments from external seismic experts about these draft errors. Previously, that document was 'Confidential'.

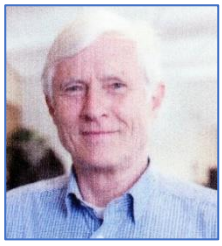
> The KNMI calculation assumed that the entire gas field would collapse/crush at once. Given the width-height ratio of 50 km/0.2 km, this is impossible. The local collapse cannot be more than half a square km at most. There is also no horizontal displacement in the hypocenter.

In addition, no account was taken of the structure and thickness of the tough salt rock (Zechstein) that prevents a major collapse from occurring, but also that a possible collapse will be immediately inhibited by the instant pressure increase, including the pressure increase in the adjacent areas around the initial collapse. The salt rock also greatly slows down the occurrence of possible earthquakes.

Not only the KNMI comes up with the very high PGAg, but the NAM goes along with it and publishes the results. The construction industry should strengthen the houses according to the very high PGA, and the population is **being frightened** by the severe earthquake forecasts.

Nothing is explained.





The NAM (KNMI) reports that the earthquakes can have a strength of Mmax Richter 6.5. That is about 100 times as heavy as the Huizinge 2012 earthquake.

At the same time, the houses are being only cosmetically repaired as if there will never be an earthquake again. That is not logical and not correct.

The KNMI and NAM are making a few big mistakes here.

It is not explained to the public what the Mmax means, namely, it is an earthquake that will never occur.

- It is not indicated which increasing uncertainty factors have been applied and stacked. The zero chance that the Mmax will occur is not explained.

- It is stated that this theoretical value applies over a period of 2475 years, while the natural gas will be used up within 30 years, or 50 years if you were to extract it very slowly.

- In addition to the high PGAg, a Richter value of 6.5 to 7.0 is also indicated, while in practice the tectonic Richter value causes many times more damage than an induced earthquake. This has to do with the maximum horizontal deflection or ground displacement, which can be up to 10 times greater in a tectonic earthquake. Also, the long-lasting tremors and the large number of aftershocks of the tectonic earthquakes can last for weeks. Each time the Groningen earthquake is just a single shock with only a few cm displacement.

- The NAM has not included the information from the external experts about the new, adjusted (confidential) Extraction Plan 2013, or had the KNMI ordered to revise their calculations. These experts stated which major calculation errors the KNMI made. These reports only became available in 2020 with the Parliamentary Inquiry Committee on Groningen Earthquakes.

The biggest mistake of the NAM is that they adopted and published the PGAg value from the KNMI instead of stating that:
“We are going to ensure that new earthquakes do not become larger than the Huizinge earthquake.”

After all, in the Netherlands it is not permitted to deliberately cause damage to personal property. Not even if you can attribute a major general interest to it. This argument was used by the (right-wing VVD) politicians as the general interest of the entire population and the security of gas supply. After all, in the meantime since 1970 almost every household in The Netherlands was connected to natural gas.

NAM's economic business interests came first, above the interests of the residents.

These very high PGAg and Richter values have laid **the foundation for growing anxiety, fear and stress** among the Groningen population. Nothing is explained. The KNMI takes the position that they are the experts. Committees and institutions adopt the very high Mmax and PGA values without asking critical questions, as if that is simply allowed/possible.

NAM (unjustly) is skimping on compensation and repair. The subsequent re-inspections and arbitration and lengthy damage reports **increase the stress** of the homeowners who reported their damage.

The combination with news reports about major earthquakes worldwide, with a lack of explanation of the meaning of the KNMI-NAM forecast of the Mmax, **makes the Groningen population nervous** about what could come next.

Images in the press and on TV.

Nepal, Gorkha earthquakes 25-04 and 12-05 2014
***Richter 7.8 and 7.4** respectively*
> 9000 deaths.

At the same time, some cracks are being removed cosmetically, but that does not help if stronger earthquakes occur; those walls will be cracking again. Foundation damage and 'own defect' (caused by owner or lack of maintenance) are not included. About these shortcomings, immediate arbitration and new inspections are the result.

Only a few homes are designated for 'seismic strengthening' according to the PGAg 0.42.
Such is a very extensive and heavy reinforcement that costs three times as much as the entire house value. With the suggested Mmax, the house may not collapse, but usually is greatly damaged and is total loss. The 'strengthening to prevent damage' of these homes was not economically realistic, unless you set them to 'Base insulation'. In that case it would also cost also many times the value of the house.

Moreover, there is no understanding among the population about what 'seismic strengthening' entails. That is also not explained. It means that if the calculated maximum earthquake (PGA) occurs, the 'seismically reinforced' house will just not collapse. In practice, this means that at Mmax the house is economically total loss and will probably have to be demolished.

At the same time, the 'high-risk' houses were tackled from the Loppersum epicenter outwards. In 2014, heavy brick chimneys and other 'high-risk' elements were removed or secured from no fewer than 3,000 houses. This means 'seismic strengthening', but only at a PGAg max 0.1 or there about.

There is a big difference between the measures that are implemented for a PGAg 0.1 and the KNMI-NAM assumed value that continues to stick to a PGAg 0.42. **That is not explained.**

The balance of the reinforcement operation was drawn up at the end of 2014. The 3,000 homes that are 'seismically reinforced' did not count for "political reasons". Perhaps because they are not entirely 'seismically reinforced' for a PGAg 0.42, like only a few other houses. The official annual balance therefore sates that there is almost **no progress in the strengthening process.**

The population is not happy about this, because the next earthquake could be coming.

The stress and fear increases.

Photo left by JC Krans BV.

Photo right by De Eemskrant.

The 43 Jarino houses from the 1960s construction period in Loppersum, were the first to be demolished (2015), because serious construction defects came to light due to the Huizinge earthquake.

In theory you could 'seismically strengthen' the houses, but the foundations turned out to be inadequate. Furthermore, if you were to strengthen them, you must also thermally insulate them according to the Building Code. That should be on the outside. What you then have are low ceiling houses that have a mediocre layout and that cost more than 3X as much as new and will be severely cracked at an Mmax.

It is possible to install houses on Base Insulation, but that is also a very expensive operation for low-rise houses. There was no low-cost Base Insulation method suitable for these types of brick houses. The NAM did not want to finance the proposed local development.[3]

Based on these simple cost calculations, demolition and new construction was the best option. This would apply to more than 27,000 homes in Groningen: a large number in the Delfzijl region.

In 2015, the KNMI lowered the Mmax from PGAg 0.42 to PGAg 0.36 or between Richter 5 and 6.
That would result in “only” 100,000 house collapses with approximately 10,000 deaths.

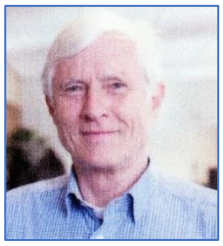
The NEN Commission (Netherlands Normalization Institute which drew up the Dutch earthquake code) adopted this PGAg value and made it the general guideline for 'seismic strengthening' of buildings in the Groningen region. This construction-savvy committee also accepted the PGA data from the KNMI/NAM without verification and asked no questions.

Because these issues were extensively reported in the news, especially in Groningen, the population did **not become more reassured about their safety.**

NAM wanted to distance itself from damage handling and set up the Center for Safe Living (Centrum Veilig Wonen, CVW), but they were instructed by NAM that foundation damage should not be assessed. This was not an improvement, and the number of arbitrations and new claims reports continued to rise.

This also affects the stress of those affected.

[3] For more information about 'Base insulation' see chapter 5 of the book "Duurzaam Herstel en Versterken van Woningen in Groningen’ www.nienhuys.info second page.



The media are spreading dramatic and catchy messages as information and entertainment, without explaining the background or what it exactly means.

Due to the listener's lack of knowledge, they can draw their own (wrong) conclusions, that will influence their emotions.

*In May 2015, former PvdA (socialist party) minister Hans Alders (Queen's Commissioner in Groningen) was appointed National Coordinator for Groningen by the cabinet. Hans Alders must ensure better **safety** and quality of life for Groningen residents. As a new service, the NCG must: "speed up the large-scale reinforcement of houses and other buildings."*

*From this moment on, the term **'safety'** is used more and more often. From now on, **safety** is a key issue.*

The Meijdam Commission.

In 2015, the Meijdam Commission was installed by the Ministry of Economic Affairs, which must provide advice on **safety and risks** in the Groningen region. The Ministry still has a major interest in ensuring that gas extraction (as planned by the NAM and approved by the Ministry) continues and is not substantially reduced.

The Meijdam Committee (like other institutions) does not investigate whether the Mmax forecast of the new PGAg 0.36 (Richter 5 to 6) provided by the KNMI-NAM is realistic or what it means exactly. One of the members of the committee is the earthquake expert from the KNMI.

This rather politically oriented committee has come up with a shocking assessment that the **safety standard** for the earthquake region can be **adjusted downwards to 10^{-5}**. In other words, there could be **ten times as many deaths as with a national disaster with a safety risk 10^{-6}.**

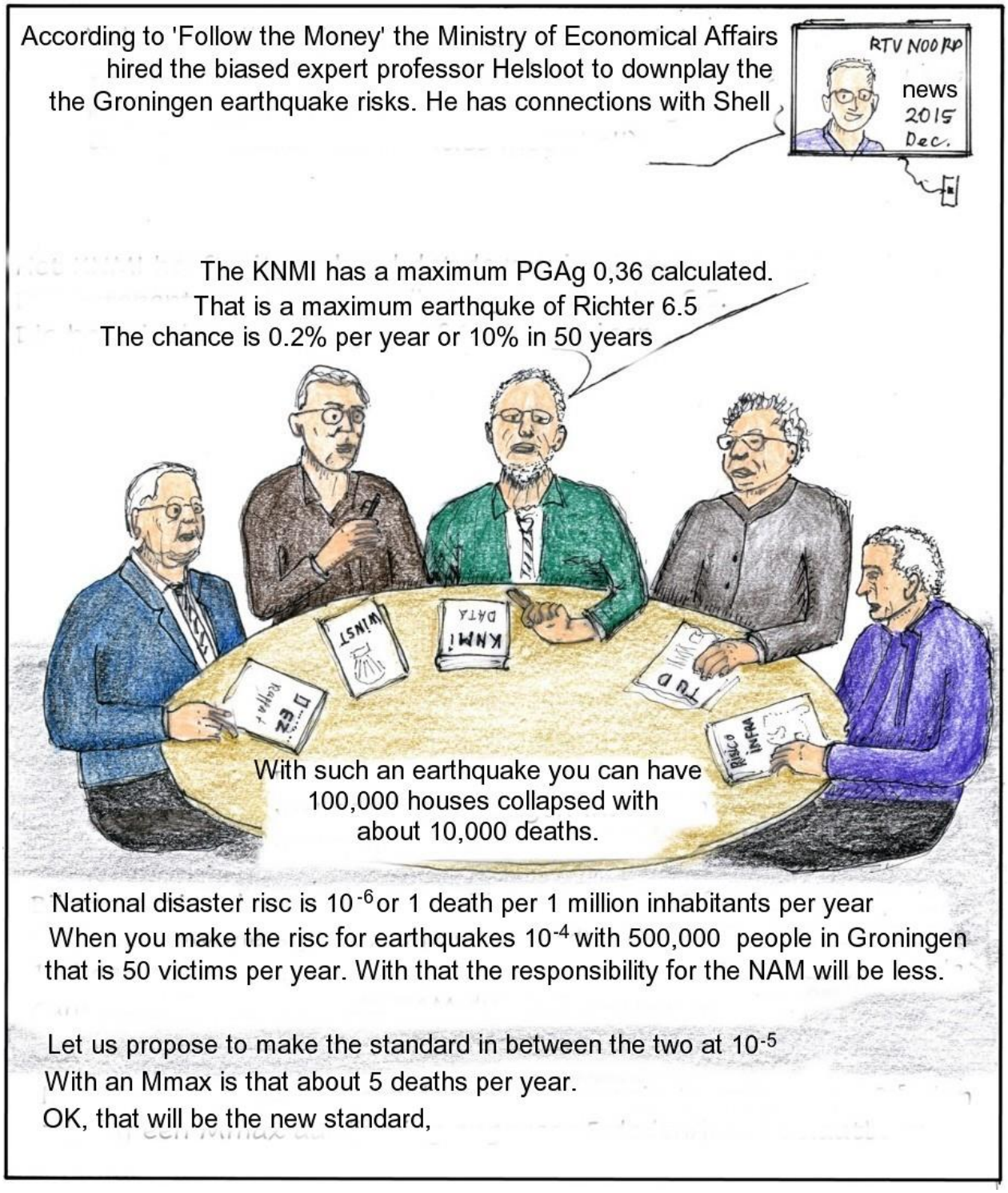
By lowering the safety standard for Groningen from 10^{-6} to 10^{-5}, they protect the NAM (industry) and the government (budget) from liability for more deaths. That is commercial thinking without considering the interests of the population[4].

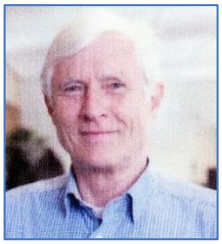
“The Meijdam Committee could have told the NAM that the earthquakes should not exceed the PGAg 0.1 (≈ Richter 3.7); that was a good safety measure.”

In addition to the **reduction in earthquake safety**, you could estimate that the large-scale increase in construction traffic on the narrow Groningen roads and construction activities would result in many traffic casualties. The construction work itself also. Later, the RUG researchers claim that up to **five deaths per year** may occur due to **increased stress and slow and often poor financial handling of claims files.**

The National Coordinator for Groningen (NCG), that took over the management of the seismic strengthening in the province, in 2024 still applies this **degraded safety standard** of 10^{-5}.

[4] From the commission report it is not clear who said or proposed what during the discussions.





The Meijdam Commission does not investigate whether the KNMI value is correct. Apart from the fact that the KNMI's Mmax forecast is exaggerated, the Meijdam Commission comes up with a highly reprehensible weakening of the safety standard for national disasters.

Does the Ministry have much influence here?

Images from the TV and the press.

Italy, Amatrice 23 August 2016
Richter 6.2 *300 deaths.*

Because earthquakes are in the public eye, a lot of visual information is provided each time about the **debris and victims**. In 2016 it happened again, but closer in Italy.

It is important in this case that the Richter values of the earthquake in Italy approximately correspond to the Richter values of the Mmax earthquake forecast for Groningen as specified by the KNMI.

The first reaction of the population is therefore: **"Is this what we can expect too? and when?"**

"The statement by the NAM management: "Even if you turn off the gas tap, the tremors keep coming", was probably devised by the NAM legal department.

It is not qualified in strength, frequency or time-lapse. The statement suggests that it makes little difference whether you turn off the gas tap or not and that major earthquakes can still occur anyway. The statement is therefore vague, but legally not wrong.

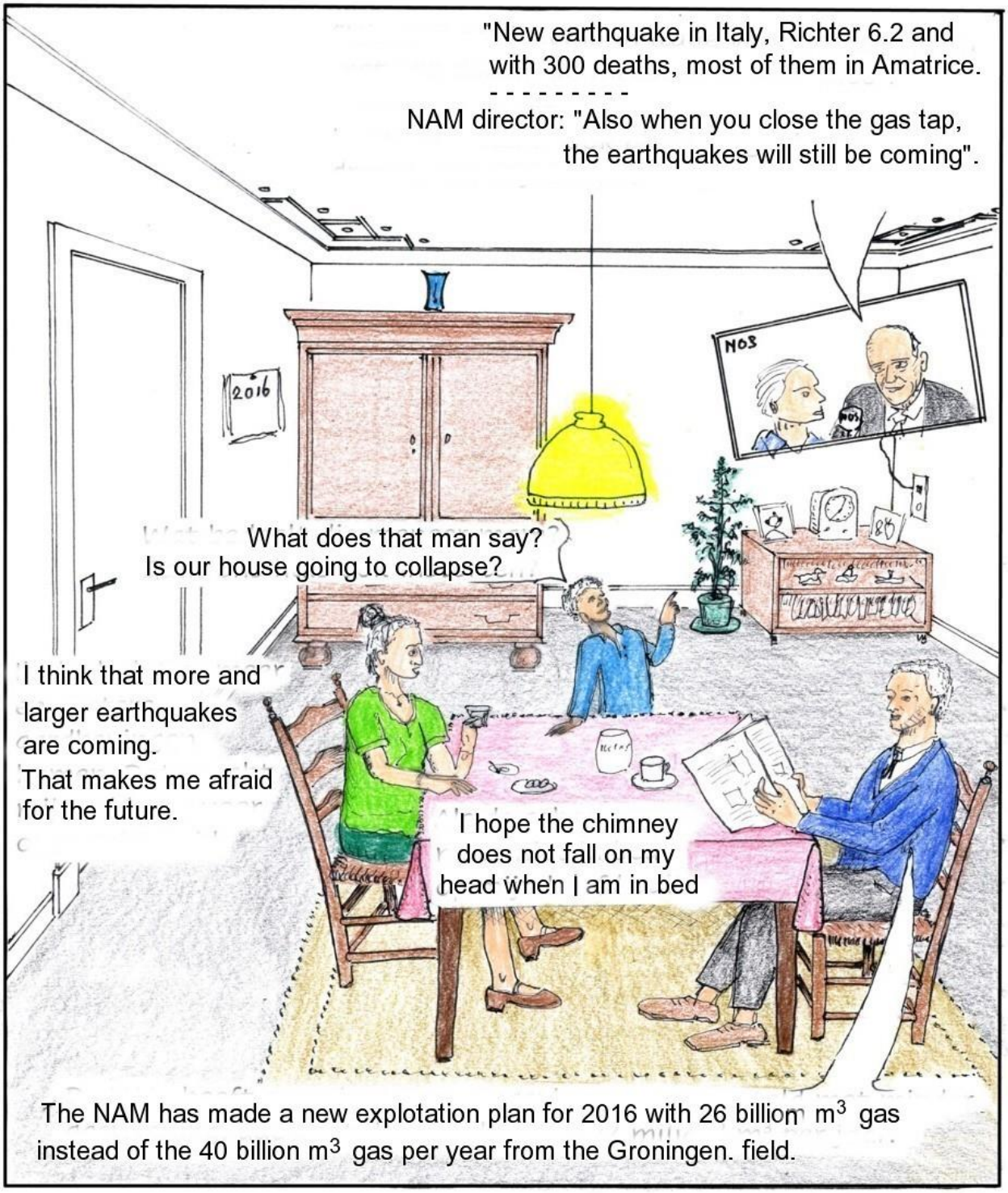
The fact that more and heavier earthquakes may occur, as is repeatedly claimed by the KNMI and the committees and has now also been recorded by the NEN in the seismic code of the National Practice Guideline (NPR9998), is based on the KNMI's over-excessive calculations. The NPR factually is not a standard, but it is implemented as a real standard.

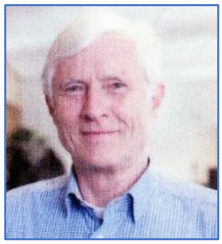
This NAM statement is mainly based on their desire to extract as much gas as possible from the Groningen gas field for as long as possible. The houses are weaker than expected and the reinforcement campaign will cost much more money than expected. Those costs will reduce NAM's profits, but profits must be maximized. After all, there is still 800 billion m^3 of natural gas in the Groningen field in 2015.
This does not reduce the anxiety of many Groningen residents.

During the 2020 Parliamentary Inquiry Committee on Groningen Earthquakes, this statement was repeated by the NAM management, but no one asked for an explanation. Too complicated for a political committee?

With the media showing repeatedly catastrophic earthquakes in detail, public fear in Groningen is growing. Will this also happen to us?

The media registers this and this increases the fear and stress about larger earthquakes."





This often-repeated statement by the NAM management was devised by the NAM legal department. It says nothing about their strength or frequency, but makes residents increasingly concerned.
News of major earthquakes fuels that fear.

Sociologists have been conducting studies among the Groningen population since 2016 to investigate the impact of the earthquakes and conducted dozens of interviews with damage victims. In addition to the **fear of more serious earthquakes** that has been acquired since 2015, there is also the **anger and perceived powerlessness** about the **slow recovery work** and the bureaucratic, ungenerous treatment of their damage claims. Together these are **stress-increasing factors**.

When asked in a kitchen table interview: “Are you stressed because of the fear of bigger earthquakes?”, the answer will be positive. This is not an open question, but directive.
When you are asked: "Are you dissatisfied with the handling of your claim file?", in many cases the answer is affirmative. Many dissatisfied persons were interviewed.

The slow recovery work is partly due to the disaster prevention model that public buildings (schools) should be strengthened first, and private housing construction the last. That is not explained. The 'high-risk' elements such as chimneys have already been addressed in the epicenter area. However, this was not seen by politicians as housing reinforcement.

The combination of repeated statements by politicians about **safety** and quality of life in Groningen in combination with the KNMI promises/forecasts of **more serious earthquakes** in the future and the demolition of very weak terraced houses, **further strengthens the atmosphere of insecurity and fear**.

In the meantime, gas will no longer be extracted from the central Loppersum cluster in 2016, and the total production of natural gas will be sharply reduced, but gas will still be extracted from southeastern clusters. Due to this relocation of extraction, the epicenter of the largest earthquakes will also move more to the southeast, but here too, the thick salt rock will cause a considerable delay before this manifests itself as a mild earthquake.

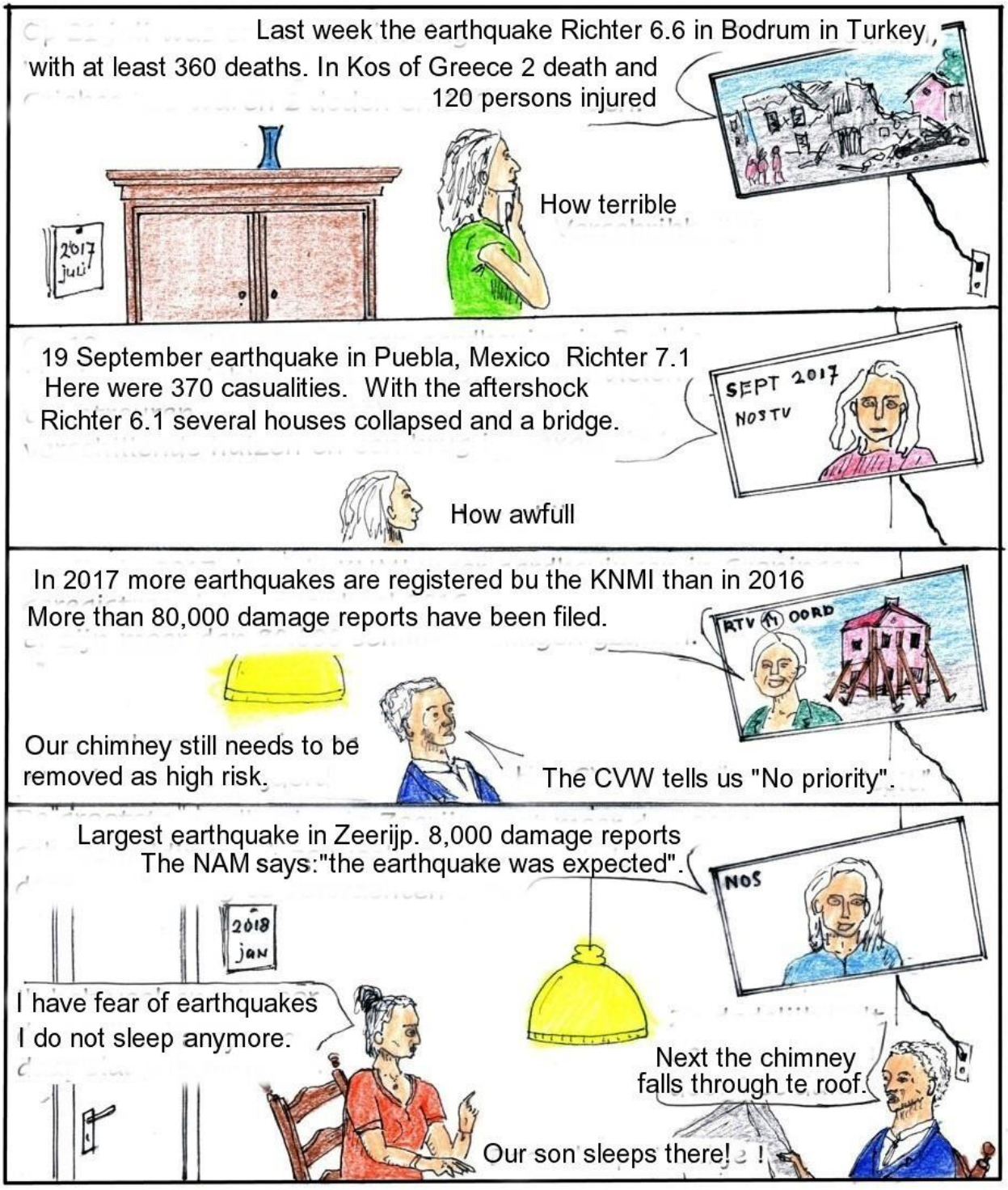
The latest forecast calculation of the Mmax for 2017 is set at Richter 4.4 with a probability of exceedance of 10%. That is **10 times as heavy as the Zeerijp earthquake** of 08 Jan-2018. The NPR9998 will not be adjusted immediately. The instructions for housing construction remain based on the much too high PGAg. Based on the same high PGA value, the **decision is made to demolish thousands of terraced houses.**

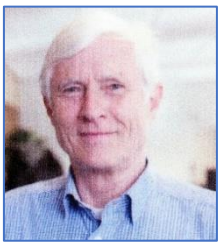
The indication of Richter 4.4 in 2017. The graphs in the TNO[5] report remain unclear to the layman, because you could deduce from them that there is still a chance of earthquakes of Richter 6.0 or 6.5, while no PGA is indicated.

Figuur 1. Door expert team voorgestelde verdeling van M_{max} voor Groningen (Bommer and Van Elk, 2017) met de gewichtsfactoren.

Figure 1. By experts proposed spread for the Mmax in Groningen (Bommer and Van Elk. 2017) with weight factors.

[5] TNO is by law the Netherlands Organization for Applied Scientific Research, created in 1932.





The media pays a lot of attention to earthquakes. The differences between tectonic and induced earthquakes are not explained. The KNMI forecast is for very heavy future earthquakes (error). Seismic strengthening is first for public buildings such as schools. Together this results in enhanced ***feelings of fear*** *among the people of Groningen.*

NAM had increased natural gas production!

NAM's increase in natural gas production in 2012, after the Huizinge earthquake, is extremely reprehensible and can almost be called criminal. Something like: Accelerate at an orange traffic light (danger!). **You may not deliberately endanger the safety of the population**. The NAM estimate was that things would not progress quickly (a few years' delay was estimated before the subsequent earthquake). Apparently, the NAM itself did not believe in the KNMI's excessive earthquake forecasts and took the reducing aspects of the Zechstein layer into account.

That a new earthquake in January 2018 would occur near the village of Zeerijp, more to the southeast than Loppersum, was indeed expected (as the NAM said), because an additional amount of gas was extracted there during the 2012-2013 season, although leveling was taking place. That increased gas production, after the Huizinge 2012 earthquake, with the subsequent limited continuation of gas production in the entire Groningen gas field, only resulted in the Zeerijp earthquake three and a half years later.

This delay is the effect of the thick salt rock layer (Zechstein) which spreads the direct effect of the pressure drop over a larger area, and because of which the collapse and shocks remain smaller but occur more often. Due to the ground conditions of the upper 30 meters, the PGAg 0.11 was slightly higher than that of Huizinge, but the strength of the earthquake (hypocenter) was slightly less; Richter 3.4 instead of 3.6.

The fact that more (small) earthquakes were registered in 2017 than in 2016 is also reason for the people of Groningen to say; "*You see that the tremors are getting stronger and more frequent*."

The 2018 Zeerijp earthquake confirms and **reinforces the feeling of fear** that is constantly being claimed[6].

The increased number of damage reports (8,000) and repeat damage **delays the repair program.**

The updated (since 2002) SBR Vibration Guideline[7] was released in 2017. This guideline is used by the NAM to limit the influence area of the earthquakes. Many Groningen residents see the lower limit value of PGAg 0.05 as a method of the NAM to reduce damage responsibility based on a reduced area of influence[8].

The report by the organization 'Gronings Perspectief' (Perspective for Groningen) and the RUG (Rijks Universiteit Groningen) is published about the **great fear and stress of the affected population**. This report and the findings, again, are widely reported in the media. Every drama is used by the media to get attention. **This confirms and strengthens the feelings of fear.**

The RUG report is a detailed observation, in which **feelings of insecurity and fear** are documented with **compelling stories**, but they did not recognize or investigate the influence of incorrect Richter and PGA information from the NAM-KNMI media on the public. That is probably beyond the purview of sociologists and psychiatrists.

[6] When all official bodies tell us that Lee Harvey Oswald shot and killed American President J. F. Kennedy, then everyone will believe it. There are more examples (religion).
[7] SBR. Stichting Bouw Research. The Non-profit Foundation for Building Research produced a vibration guideline.
[8] From this moment on, this lower limit value will also be entered in the KNMI Web tool. However, even with periodic shocks of PGAg 0.05, weak foundations on soft/wet soils can also subside further.

The RUG report about the social impact of the earthquakes is the result of two years research among thousands of persons from Groningen.

There exist an increase of stress-related health problems, parly caused by the slow procedures of compensation.

The unrest among the Groningen residents increases due to improperly handled damage claims, due to the uncertain furure and their vulnerable financial position.

64 interviews have been conducted with the affected Groningen residents through which distressing situations came to light.

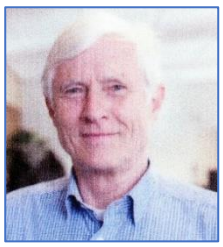
The end report by the RUG was presented in January 2018.

The researchers consider the research shokking. It is estimated that in the future more than five deaths will occur per year due to health related stress problems.

"Over more than 85,000 people in Groningen suffer from multiple damage to their houses.

From this group are 10,000 inhabitants that actually have stress and health problems".

"Residents with multiple earthquake damage have poorer health and feel less safe".



With short, induced earthquakes (PGAg ≈ 0.1) there is <u>hardly any safety risk</u>. Due to the very slow recovery and damage procedures and resulting arbitration, the population's financial security was seriously affected. The RUG report confirms this, but also reinforces these problems through significant media attention.

This increased the stress, while the **feeling of insecurity** continued to be fueled by the <u>excessively high earthquake forecasts</u>.

In May 2018, Hans Alders, who was NCG (National Coordinator Groningen) since June 2015 leaves, after Minister Wiebes (of Economic Affairs) suggested that almost 1,600 fewer homes need to be reinforced because the gas tap is closing.

NCG De Boer then left in October 2015 because the course taken in the earthquake area "does not match his vision".

Technically speaking (seismic code), no homes needed to be 'seismically reinforced' at all, because with the **actual earthquake strengths of PGAg < 0.1 no buildings would collapse.** However, the condition is that after such an earthquake wall repair should take place before the next earthquake to prevent progression of damage. However, the repair process is bureaucratically slow and costs a fortune.

Based on the extreme calculations of the KNMI that were not corrected by the NAM, the entire reinforcement task was derailed. 'Seismic strengthening' would not be economically feasible with the PGA value (0.36) specified in the 2015 NPR9998. On the one hand, several buildings and monuments were already placed on Base-isolation, while on the other hand, large numbers of homes were designated for demolition and new construction.

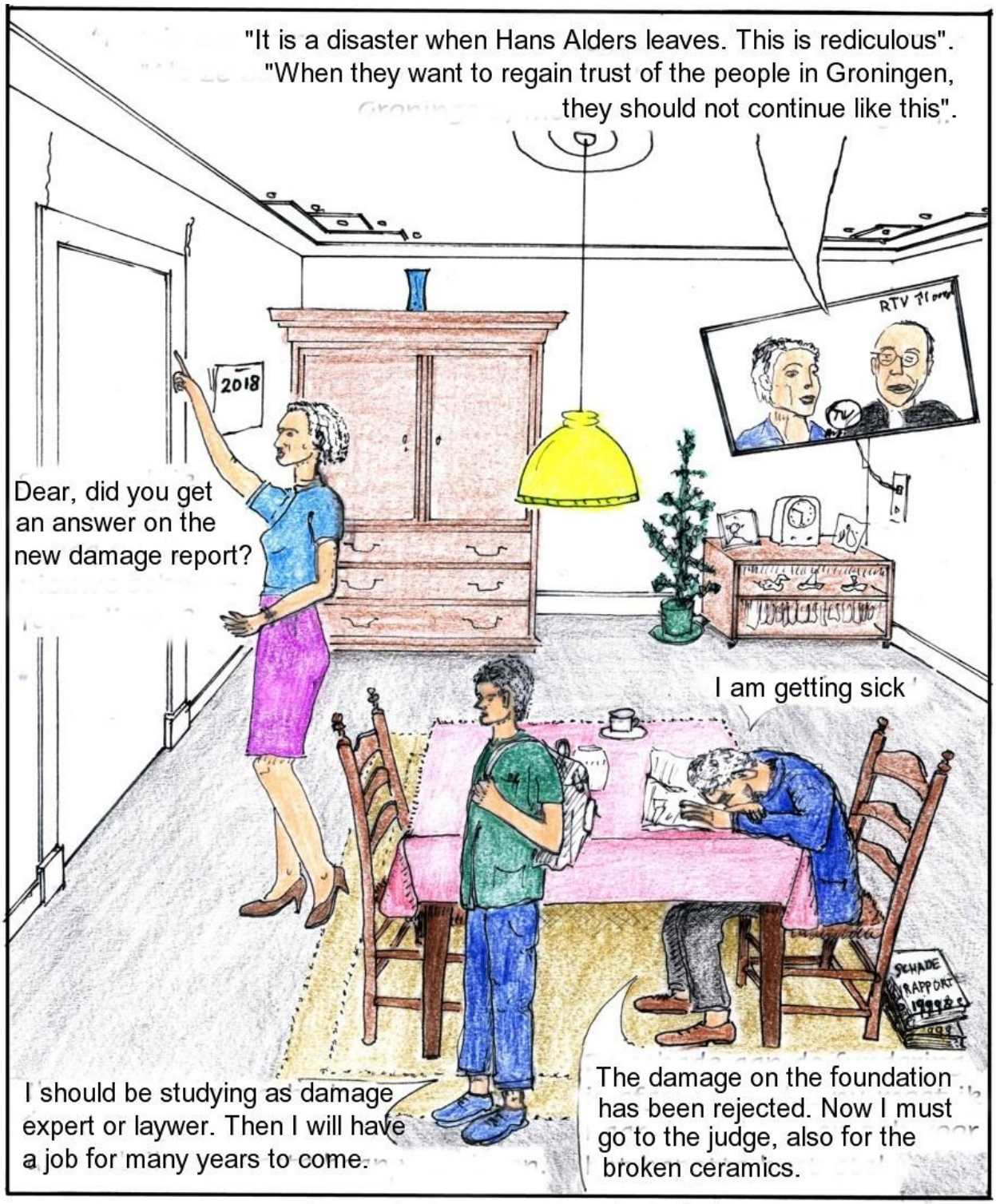
Due to the sky-high costs of both strengthening operations (Base isolation or strengthening), the strategy arose not to rush with further 'seismic reinforcements' and to wait for a reduction in the PGA value in the NPR9998. It was evident that the PGA value would decrease with less gas extraction and pressure leveling. After all, with a lower PGA the 'seismic strengthening' until just short of collapse is less complex. Although the KNMI and TNO eventually made some Mmax adjustments, this was usually only implemented **six months later** in the NPR9998. Even then the PGA values were still much higher than reality.

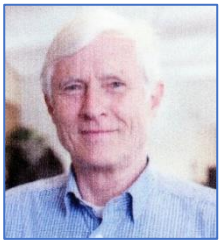
It is evident that a reduction in the previous number of 'seismically strengthened' homes was possible. However, the population does not want a home that does just not collapse at an Mmax.

The Minister of Economic Affairs is looking for measures to limit the costs for NAM, instead of returning a large part of the billion-dollar profits to the Groningen population and restoring confidence.

It can be stated that in the event of earthquakes of approximately PGAg < 0.1, such as Huizinge and Zeerijp, there is **no immediate risk of collapse of old masonry houses** (provided they are not already dilapidated). In the Groningen situation, after these earthquakes, there are two years to carry out wall repairs.

In fact, the safety of the Groningen population has never been in danger.





The NCG agreement from 2014, promising thousands of new-build homes, is being undermined. The 2018 Zeerijp earthquake is the result of increasing gas production during 2012-2013 in the south. It seemed that the tremors are getting stronger while they are decreasing. The NPR9998 is not adjusted until the end of 2018. The PGA-max then remains approximately 100% higher than the actual expected value.

Summary:

- It started around 2000 with the NAM denying that the earthquakes were the result of gas extraction, while they themselves were busy investigating the relationship.
- While the NAM itself had calculated that the tremors could reach maximum PGAg 0.15, they only carried out minor repairs as if there would never be any new tremors.
- After the Huizinge 2012 earthquake, the NAM commissioned the KNMI to calculate the heaviest possible earthquake, based on a revenue model that was most favorable to them. This, instead of asking how the earthquakes could be limited to being smaller than the Huizinge earthquake.
- In 2013, the seismic consultant Arup calculated a PGA that was more than twice as high as the Huizinge earthquake, which would cause extensive damage to brick houses throughout the province with many collapses and deaths. NAM or ARUP did not argue that such a thing was inadmissible.
- Although 'generous recovery' was said to have taken place since the Huizinge earthquake, this was not the case. The opposite: rejecting foundation investigations was a basic instruction.
- Just after the Huizinge earthquake and before the end of the 2013 Extraction Period, NAM increased natural gas production to achieve the planned/promised quota.
- At the end of 2013, the KNMI came up with very high Mmax and PGA calculations, which were adopted by the NAM without asking critical questions. External experts had indicated at least two major calculation errors in the new version of the 2013 Extraction Plan. The NAM kept the document confidential and did not instruct the KNMI to recalculate.
- It was not explained what the high Mmax meant or how it was calculated. No questions were asked whether such earthquakes were legally permissible.
- The media echoed (amplified) the message of the very high forecasts and continued to report extensively on other major earthquakes around the world. The many differences between tectonic and induced earthquakes, or what constitutes ‘seismic reinforcement’ were not explained to the public.
- During 2014, about 3,000 high-risk elements such as chimneys and gables in the epicenter area were already identified and secured, but this did not count for the politicians.
- Several monumental buildings were placed on Base isolation, being the only way to protect these buildings against the very high earthquakes of the KNMI forecast. However, this method was not economical for regular housing construction.
- Several poorly built terraced houses in Loppersum were identified for demolition and new construction, which was many times cheaper than 'seismic strengthening' against the high value.
- The heavily exaggerated PGA values were added to NPR9998 by the NEN committee. This committee, being sufficiently skilled in construction technology, did not state that the generation of such severe earthquakes, which would cause tens of thousands of homes to collapse, was inadmissible.
- The Meijdam Special Technical Committee on safety also did not investigate the high prognosis Mmax, but even lowered the safety standard from 10^{-6} to 10^{-5}.
- The NCG developed the 'Recovery in Confidence, Confidence in Recovery' plan, with a budget of only 1.2 billion euros, but the strengthening program did not really move faster.
- The CVW, which apparently followed the instructions of the NAM, was replaced by the NCG for 'seismic strengthening' and the IMG for building repairs without strengthening.
- In 2023, the SodM[9] formulated a different definition for safety, this time based on feeling.
- Until 2024, there will still be many thousands of claims that have not been resolved.

The safety of the people of Groningen has never been in danger.

[9] SodM. Staatstoezicht op de Mijnen, State supervision on the mining industry.

Apart from the foregoing, the author of this illustrated booklet believes that:

A. Mining should not be managed by commercial parties and only realized by companies without a capitalist profit motive. A significant portion of the net proceeds would have to be invested in the extraction region. When extracting fossil fuels, future CO_2 emissions must be immediately compensated by, for example in forestry. When fossil fuels are incinerated, CO_2 emissions will have to be captured or compensated. This also concerns international aviation and shipping.

B. The above will greatly increase the cost of fossil fuels, but in today's society (capitalist, populist, subsidizing) that is the only way to reduce consumption and reduce the negative effect of CO_2 emissions and the very rapid climate change, a million times faster than the formation of the fuels.

C. Sustainable biogas must be optimally generated from all animal manure and other biological residual flows that can produce sustainable biogas.

D. The quality of life, or the prosperity of a society, should not be measured based on finances related to production and consumption, but should be based on the quality of life, health and happiness.

E. All damage caused by induced earthquakes must be fully compensated and the buildings repaired and possibly reinforced in such a way that no new earthquake damage occurs.

F. When structurally strengthening the outer shell of the building, better insulation is a basic form of improving sustainability. This should be seen as compensation for the damage suffered.

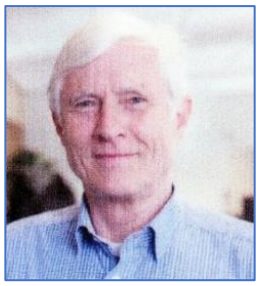
G. Rejecting foundation research is a fundamental error in the Groningen earthquake process. Due to small and frequent vibrations (also with a PGAg 0.05), weak foundations can sag and deform when there are soft/elastic/wet soils.

H. Financing of building improvements that cannot be paid for by the homeowner, can be drawn from a provincial building fund and settled upon the sale of the building.

I. Methods to reduce the responsibility and costs of building investigation or rehabilitation for the earthquakes, such as adjusting the safety standard, are objectionable.

J. Calculating the theoretical Mmax for induced earthquakes for 475 or 2475 years is an internal matter. Without detailed and understandable information, this theoretical **Mmax should not be shared with the public.**

K. The party causing the earthquake damage must limit any tremors in such a way that they do not pose any risk to the population. **The Mmax is not relevant**.



Due to the heavily exaggerated PGA forecasts and the Mmax by the KNMI and published by the NAM and dubious information from the NAM, people lived under the certain assumption that very serious earthquakes would occur in the future. In that case, thousands of houses in Groningen would collapse.

The safety of the people of Groningen was therefore at risk. This is not legally permitted in The Netherlands.

The recovery program was not set up 'generously' as the NAM promised, but the NAM introduced more and more restrictions, and it was very bureaucratic causing a lot of arbitration.

The media echoed the forecasts of major future earthquakes for Groningen and focused on the extreme situations, including major earthquakes in the world.

The fear of future major earthquakes and insecurity, together with the financial problems for residents, has led to excessive fear and stress among the Groningen population. This was widely reported in the media, which had a self-reinforcing effect.

With a sharp reduction in the gas extraction and pressure leveling in the sandstone, earthquakes are becoming increasingly smaller and more time spaced. The GBB had been demanding this for years.

However, the KNMI's earthquake forecasts remained extremely high because they were based on the extreme production wishes (profit) of the NAM, without considering the interests of the population.

After the August 2012 Huizinge earthquake, NAM increased gas extraction in 2012-2013, which resulted in another earthquake in Zeerijp in January 2018, three and a half years later.

Due to the earthquake in Zeerijp, many Groningen residents continued to believe until 2024 that more serious earthquakes could occur, causing many homes to collapse, resulting in many deaths.

This publication presents this sad history with a few illustrations.