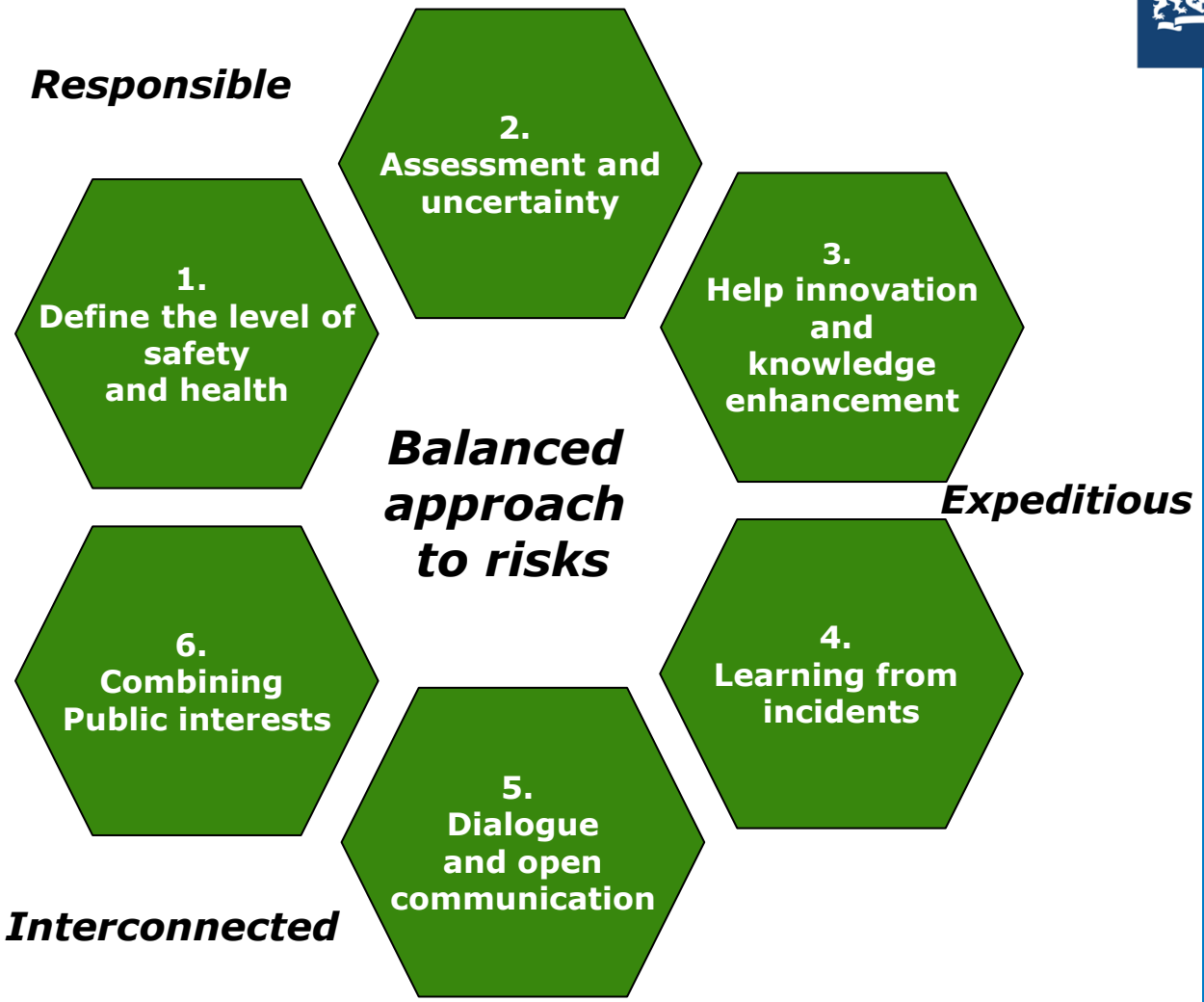


Ministerie van Klimaat en Groene Groei

Policy on induced seismicity in the Netherlands

Dr. Karin van Thienen-Visser

Drs. Rob Smal

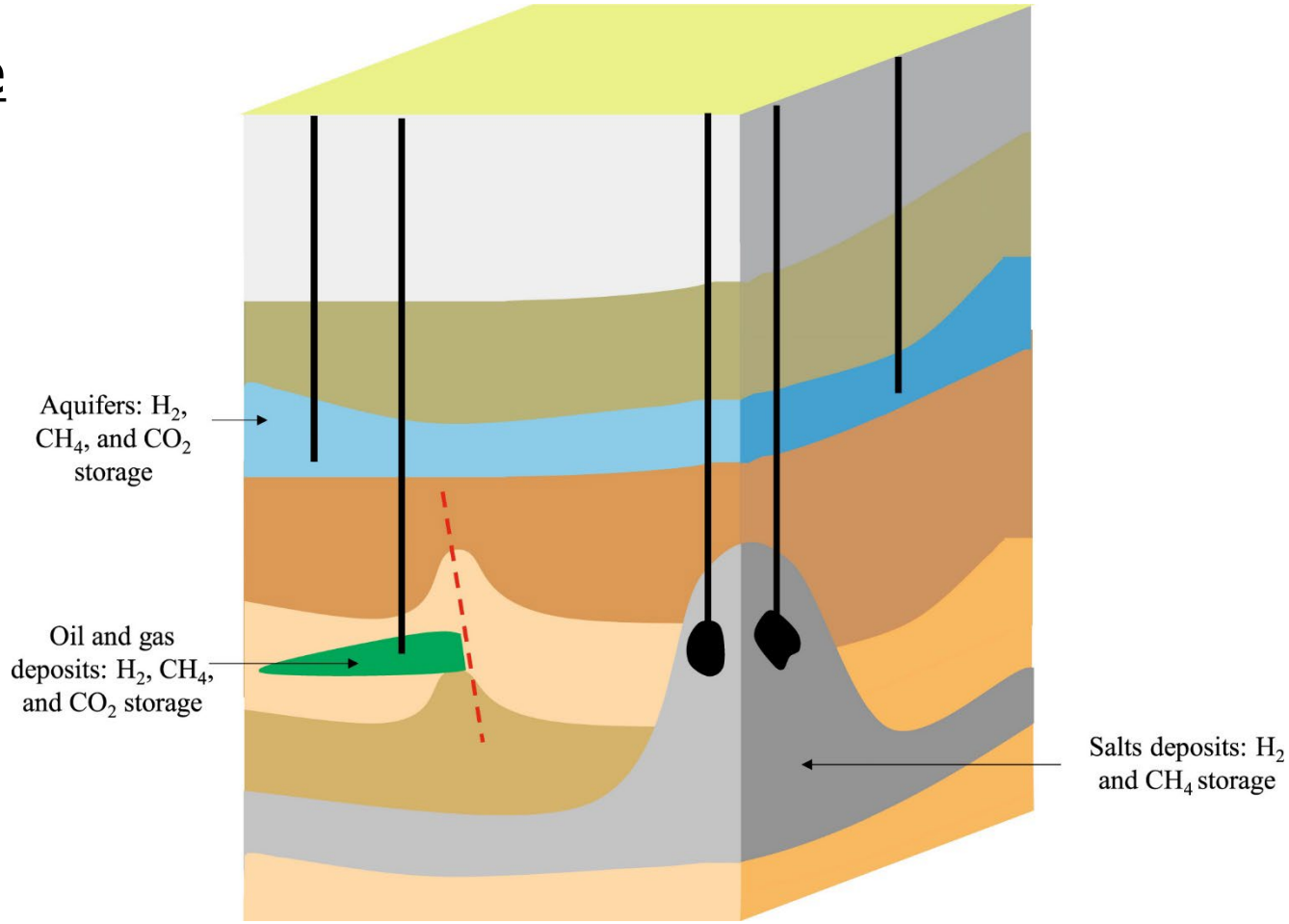
Sustainable use of the subsurface

now and in the future

- Important role for the subsurface

  From production to storage

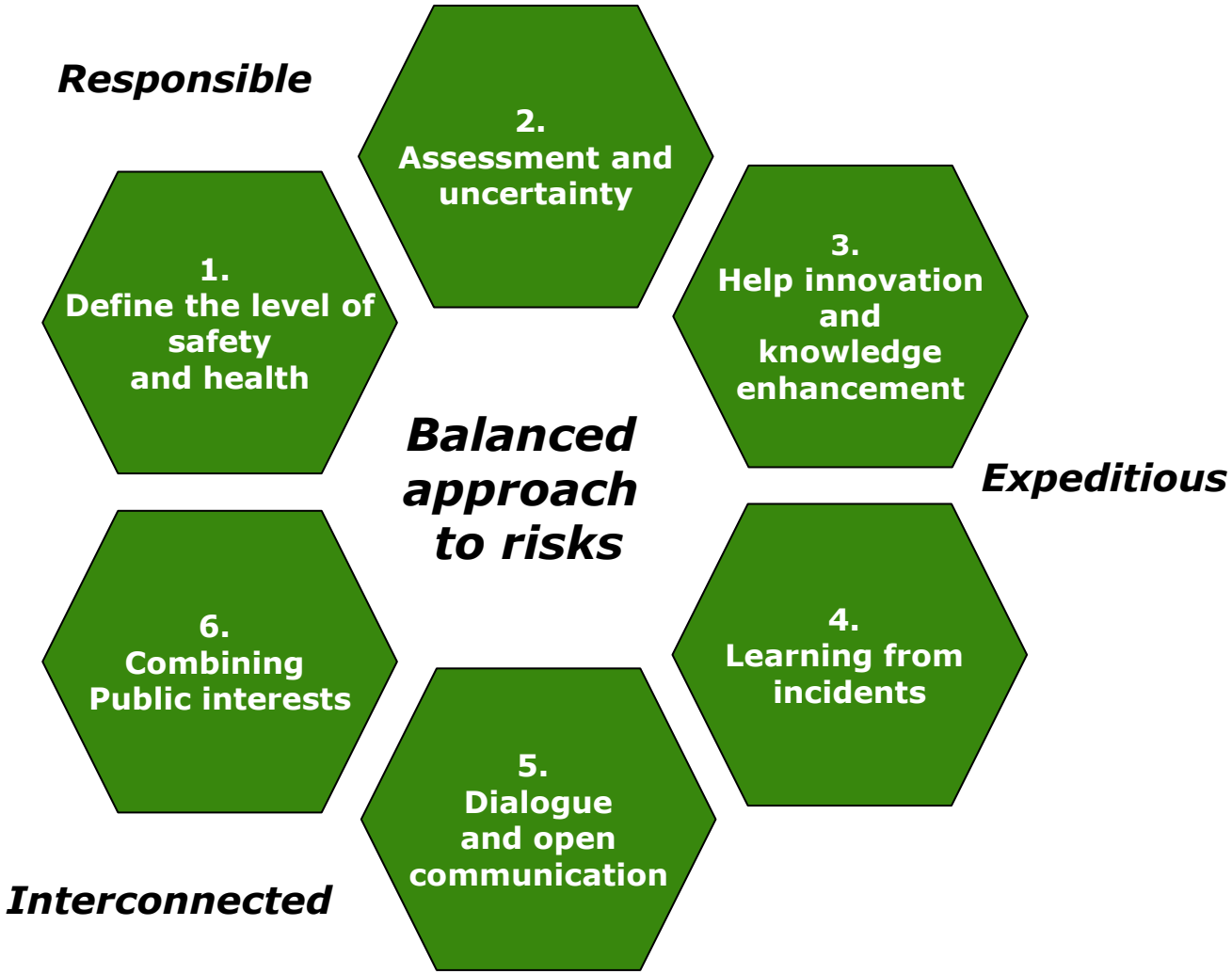
  - Gas production
    - 1/3 of current energy consumption
    - Production in NL before import
  - Gas storage
  - Geothermal energy
  - Salt production and storage
    - Raw material
      - Strategic independence
      - Reliable availability
    - Hydrogen storage
      - Energy transition
  - CO_2 storage



Source Al-Shafi et al., https://doi.org/10.1016/j.egyr.2023.05.236

Risk in the Energy Transition

The policy principles



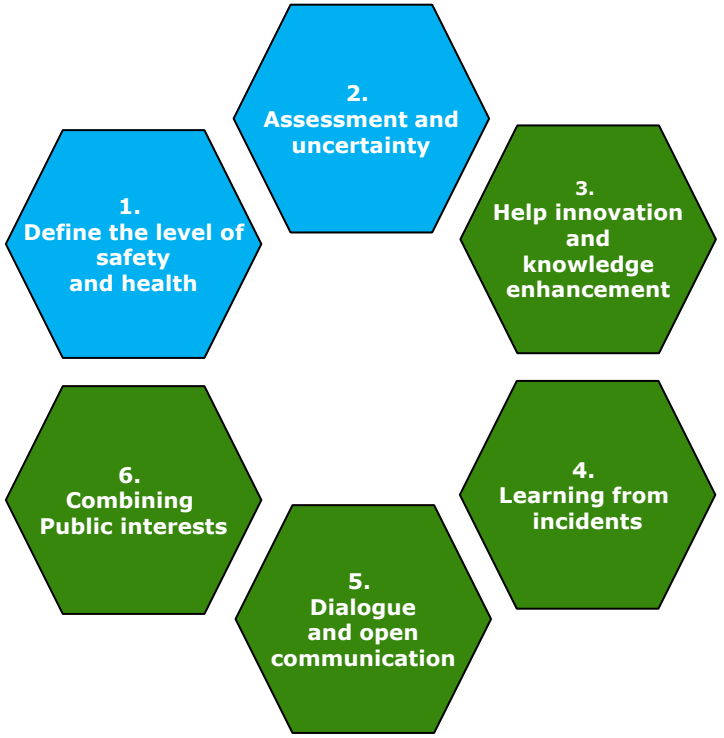
*source: Letter to Parliament, November 4th 2022 Dealing responsible with safety and health in the energy transition (Dutch: *verantwoord omgaan met veiligheid en gezondheid in de energietransitie)*

Policy principle 1 & 2: Responsible

The new energy system is equally safe and healthy as the current

1. <u>High level of safety and health</u>
   - Define safety norms (LPR 10^{-5})
   - The residual risk is acceptable
   - Transition period for new activities

2. <u>Risk assessment and uncertainty</u>
   - Uncertainty as part of risk
   - Quantitative methods versus qualitative methods
   - Precaution
   - Monitoring and progressive insight → knowledge increases → incorporation in policy



Policy principle 3 and 4: Expeditious

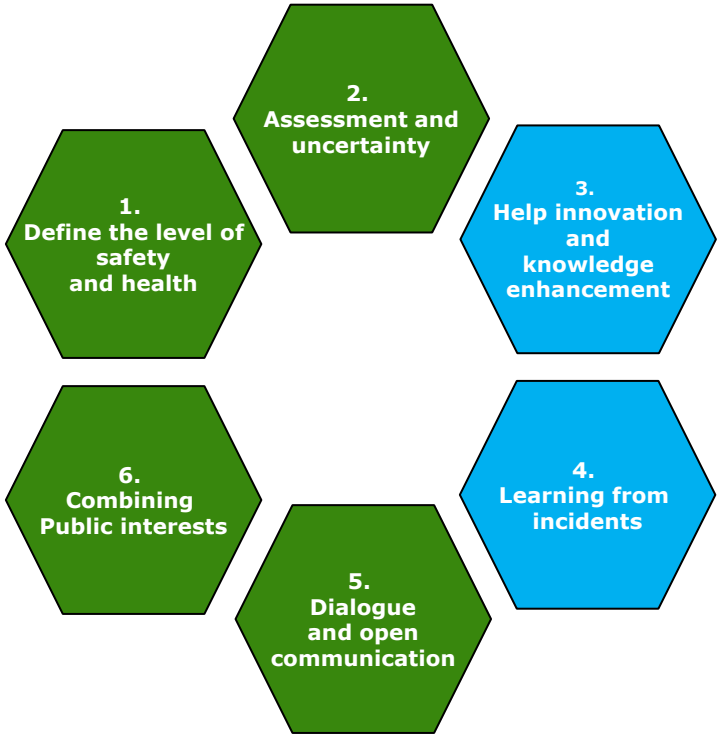
Room for experimentation, learning from incidents, apply new insights

3. Help innovation and knowledge enhancement

- Guidelines (if policy or regulation is missing)
- Room for innovation (allow pilots under certain conditions)
- Monitoring (to reduce uncertainty)
- Knowledge increase, knowledge sharing, knowledge programs

4. Drawing lessons from incidents

- Incidents are inevitable and damage needs to be compensated
- Lessons learned → reduce probability of resurrence, possible reduction of effects
- Not emotions but facts as basis for lessons and improvements
- Open sharing of information (by everyone)
- Process improvements in risk assessment methodologies



Policy principle 5 & 6: Interconnected

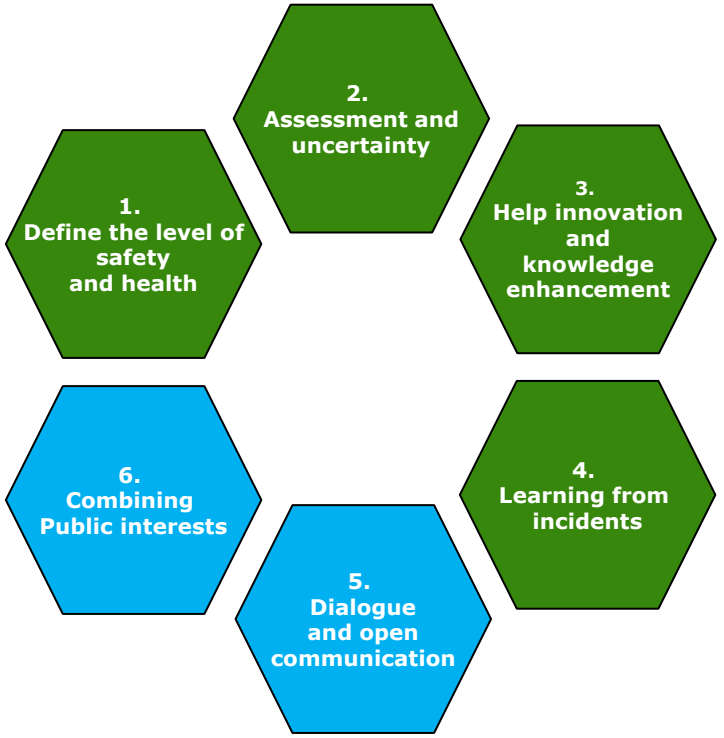
Act as one government and in connection with society

5. Dialogue and open communication

- Active, open and transparent
- Balanced: societal importance, risks and downsides
- In context: in comparison to other risks (natural gas)
- Considerations: perceptions and acceptance of risk
- Perspective for actions (e.g. joint fact finding)

6. Combining public interests

- If necessary, solve bottle necks
- Broad consideration of public interests of energy (clean, affordable, reliable, safe, etc.)
- Collaboration on all levels (national – regional - local)
- Evaluation of the policy principles



Seismic risk policy

Risk policy principles

1. Define the level of safety and health
2. Assessment and uncertainty
3. Innovation and knowledge enhancement
4. Drawing lessons from incidents
5. Open communication
6. Combining ambitions

Actions

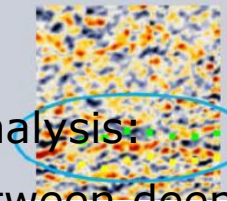
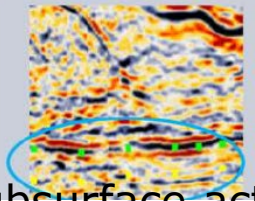
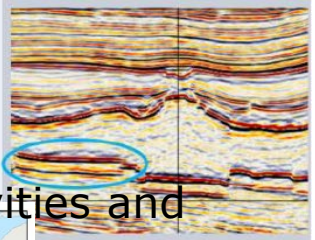
1. LPR<10^{-5}
   - how to define the norm for activities with little/no induced seismicity?
2. Reduce uncertainties
3. Research programs, independent research
4. Parliamentary inquiry Groningen gas production
5. Open accessible data, open accessible knowledge
6. Seismicity risks due to different activities are dealt with in a similar matter

Uncertainty*

* In seismic risk analysis

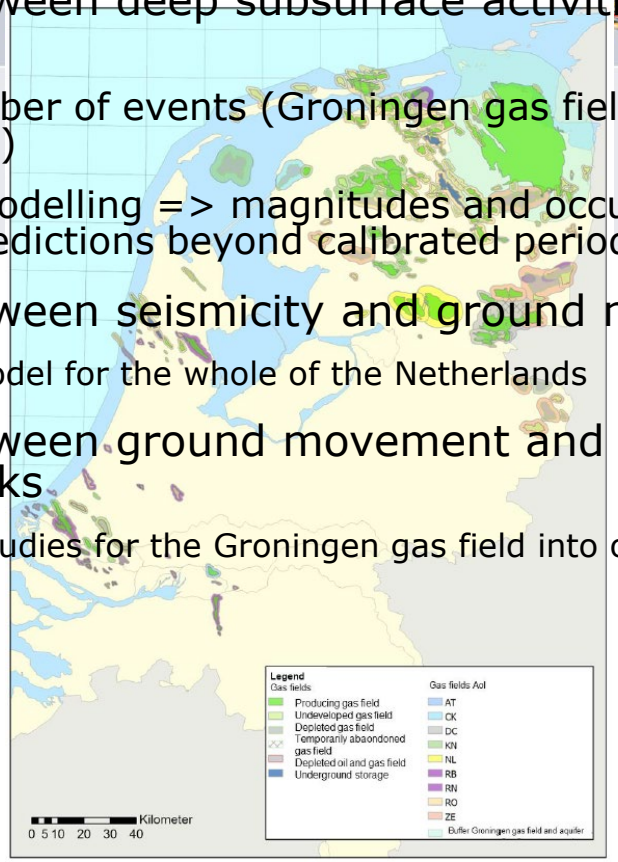
- Limited data availability
  - 3-D insight in the deep subsurface
  - Seismicity data coverage

  } Focused in areas of oil and gas production
- Deep subsurface
  - Presence of faults
  - Characteristics of layering
  - Stress conditions in subsurface
    - Stress changes due to activities

	Poor	Moderate	Good to excellent
Data example			
Description	• Small number of events (Groningen gas field > 900 since 1991) • Physical modelling => magnitudes and occurence of events, predictions beyond calibrated period		Horizon identification is easy and faults up to seismic resolution can be identified Horizontal noise ratio

Seismic risk analysis:

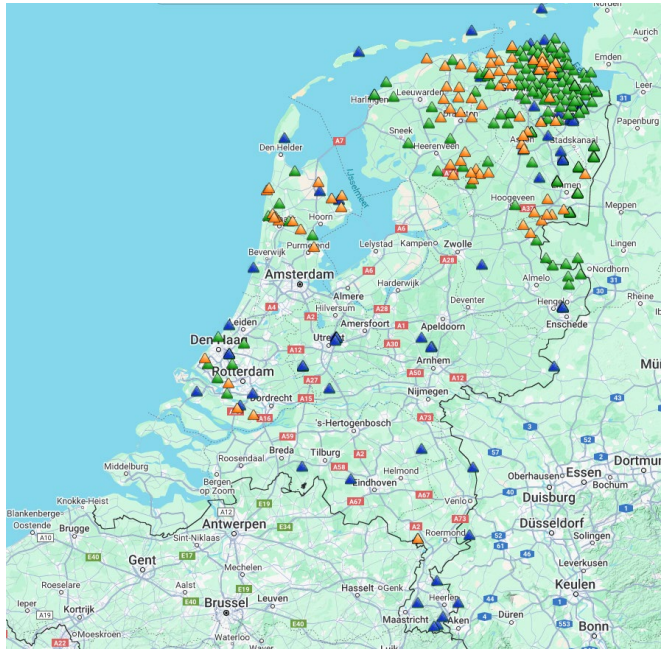
- Relation between deep subsurface activities and seismicity
  - Small number of events (Groningen gas field > 900 since 1991)
  - Physical modelling => magnitudes and occurence of events, predictions beyond calibrated period
- Relation between seismicity and ground movement
  - PGA/PGV model for the whole of the Netherlands
- Relation between ground movement and damages/risks
  - Extending studies for the Groningen gas field into other areas



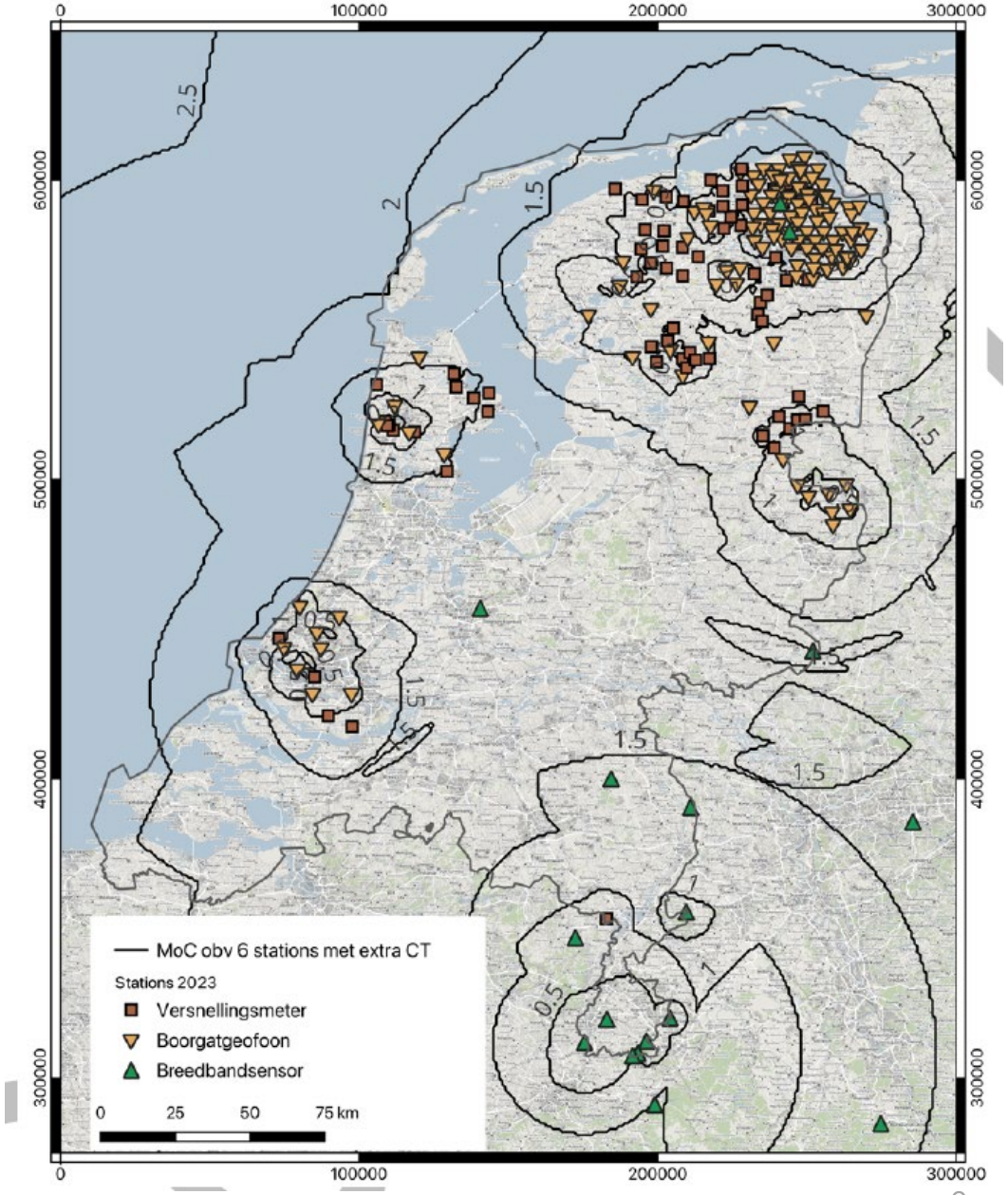
Source: seismic hazard and risk assessment, report TNO and EBN, November 16th 2023

Decreasing uncertainty by increasing seismicity data 2024-2028

Extension of the seismic network
goal: observe magnitudes ≥ 1,5 with local densification (M ≥ 1) around activities in the deep subsurface



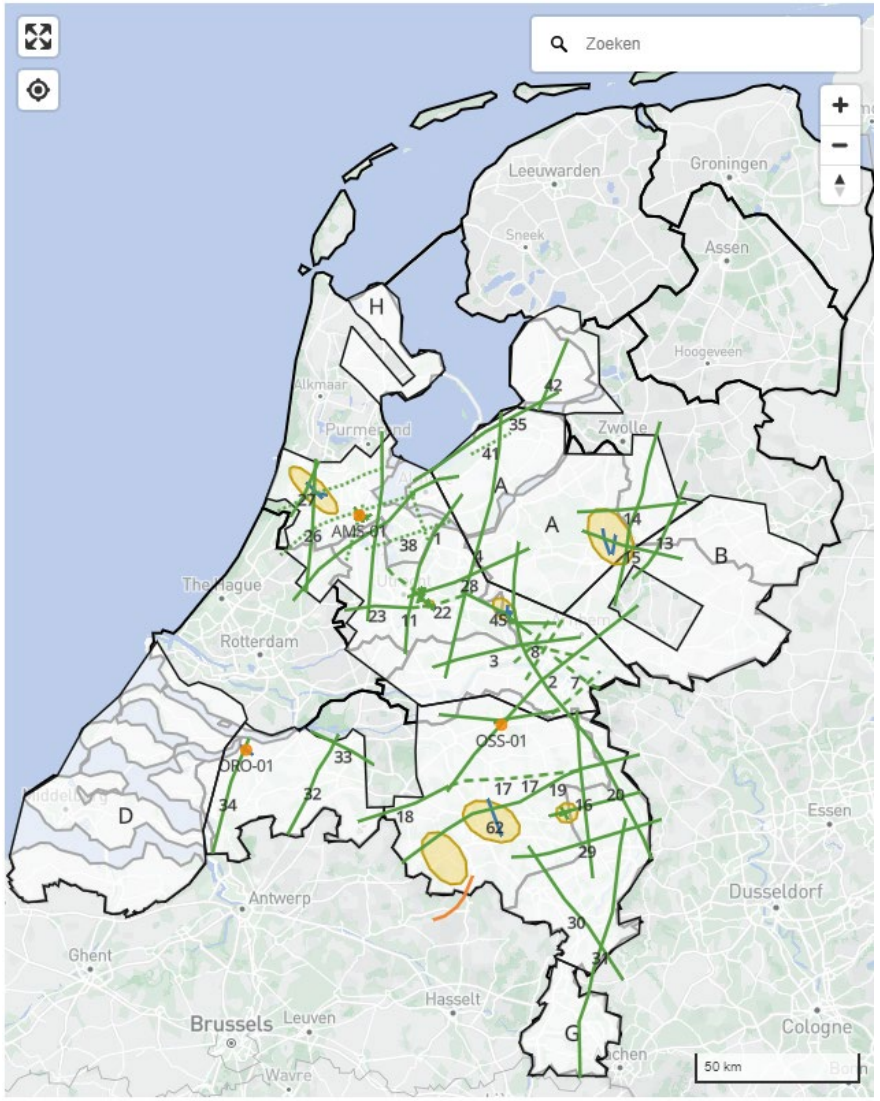
Source, KNMI dec 2024



Source, KNMI report 2024

Decreasing uncertainty by increasing seismic data coverage

Filling in the blanks:
- New 2D seismic lines
- Reprocessing old seismic data
- Research wells



Source: SCAN

Decreasing uncertainty by research

KEMprogramma.nl

GeoKennisNL

DeepNL NWO

H2 Hydrogen TCP

Task 42 underground hydrogen storage

Mining activity versus H&R type		Seismic hazards and risks	Subsidence hazards and risks	Environmental hazards and risks
Oil and gas reservoir production	Groningen	KEM-02, KEM-04, KEM-05, KEM-08, KEM-09, KEM-14, KEM-19a, KEM-19b, KEM-24a, KEM-24b, KEM-34, KEM-36	KEM-19a, KEM-19b	KEM-18, KEM-19a, KEM-19b
	Small gas fields	KEM-07	KEM-16a	KEM-16b
	Oil fields			
Underground storage in porous reservoirs	Methane cyclic storage	KEM-01, KEM-48	KEM-48	KEM-48
	Hydrogen cyclic storage	KEM-39		
	Production water injection	KEM-24a		
	CO2 storage	KEM-27, KEM-39	KEM-27	KEM-27
Geothermal reservoir energy production	Conventional doublet systems	KEM-06, KEM-15	KEM-06	KEM-06, KEM-18
	Enhanced Geoth. Systems (EGS)	KEM-06	KEM-06	KEM-06
Salt cavern development and production	Shallow caverns (<750m)		KEM-17	
	Deep Caverns (>750m)		KEM-16a, KEM-17, KEM-26	KEM-13
Underground storage in caverns	Methane cyclic storage			
	Oil strategic storage			
	Hydrogen cyclic storage	KEM-28	KEM-28	KEM-28
	Nitrogen cyclic storage			
	Compressed Air			
Mining infrastructures	Wells	KEM-31		KEM-13, KEM-18, KEM-28
	Installations	KEM-31		KEM-33
	Pipelines	KEM-31		
Coal mining domains and infrastructure	Limburg			

H&R measures vs H&R type		Seismic risks	Subsidence risks	Environmental risks
Public HRA instruments		KEM-03, KEM-10, KEM-34	KEM-03, KEM-16a, KEM-16b, KEM-47	
Public monitoring systems		KEM-11, KEM-27		
Public norms, TL systems and mitigating actions				

Legend		5 = high	3 = medium	1 = low

Priorities and KEM research projects

Seismic risk policy

Risk policy principles

1. Define the level of safety and health
2. Assessment and uncertainty
3. Innovation and knowledge enhancement
4. Drawing lessons from incidents
5. Open communication
6. Combining ambitions

Ongoing action points

1. LPR<10^{-5}

Risk analysis methods are developed and refined

2. Extension of seismic monitoring netwerk, seismic data coverage

3. Knowledge program effects of mining, GEOKennisNL

4. Groningen seismicity => learning and drawing lessons

5. Knowledge is shared (website KEM, DEEP-NL, nlog.nl EPOS-NL) open publications, source codes, Geological Survey of the Netherlands (PIO, BRO)

6. Seismicity risks due to different activities are dealt with in a similar matter

Questions?

Safe and responsible use of the subsurface

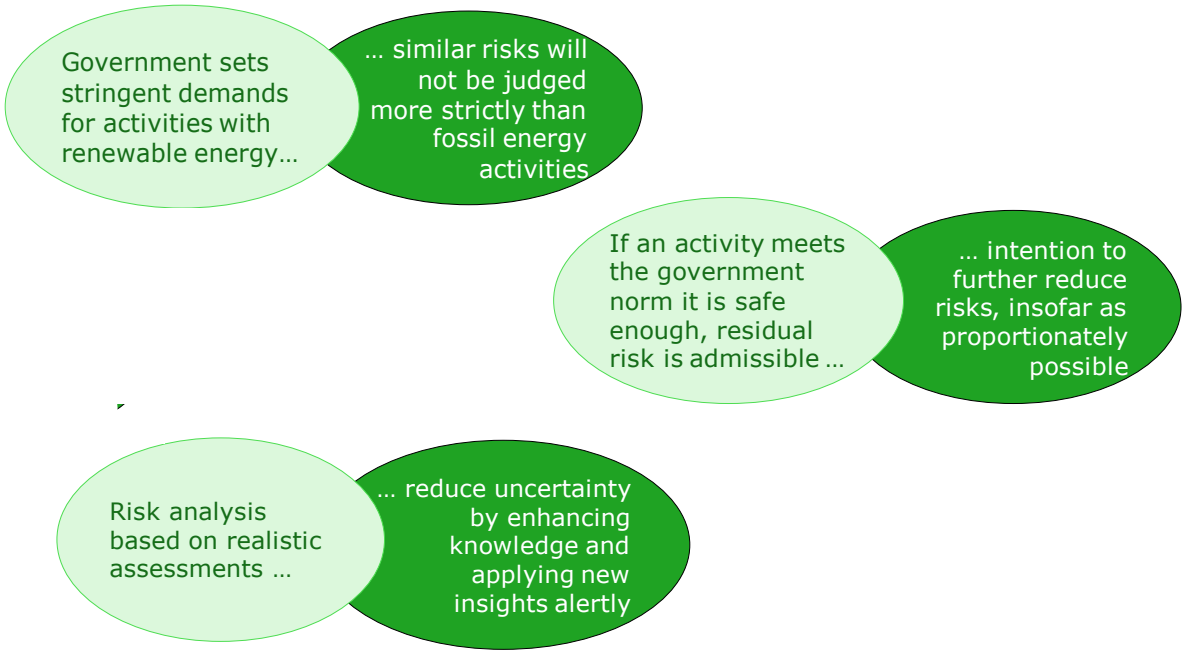
- Safe:
  - Risk analysis => mining law
    - Subsidence risk
    - Seismicity risk
    - Environmental risk

Norm LPR < 10^{-5}

- Responsible:
  - Socially responsible
  - Avoid damages occurring
  - Importance of the energy transition → Commission Mining Damage
  - Strategic independence
  - Reliable availability

Intern gebruik

Balanced approach to risk
combining perspectives



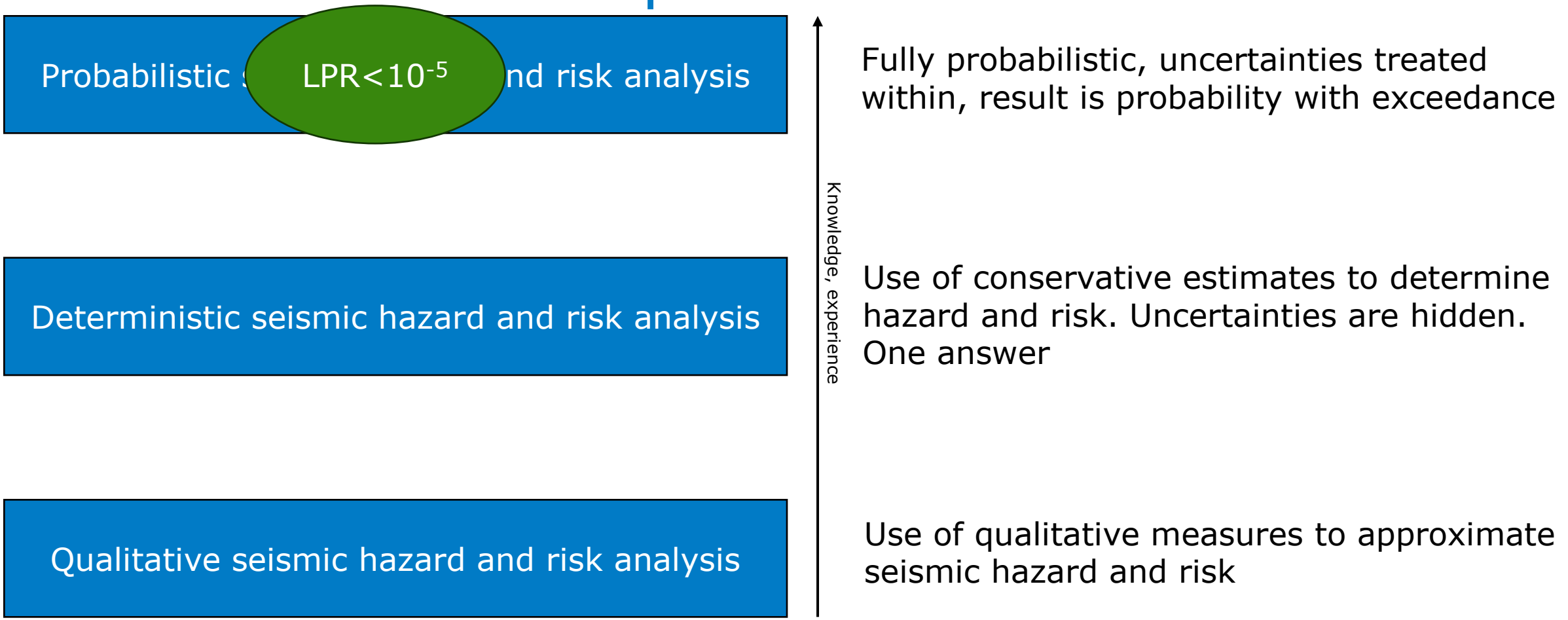
Induced seismicity

- Same norm for all subsurface activities (LPR< 10^{-5})
- Policy will be updated
- Research is needed to:
  - enhance knowledge
  - reduce uncertainties
  - apply new insights

Intern gebruik

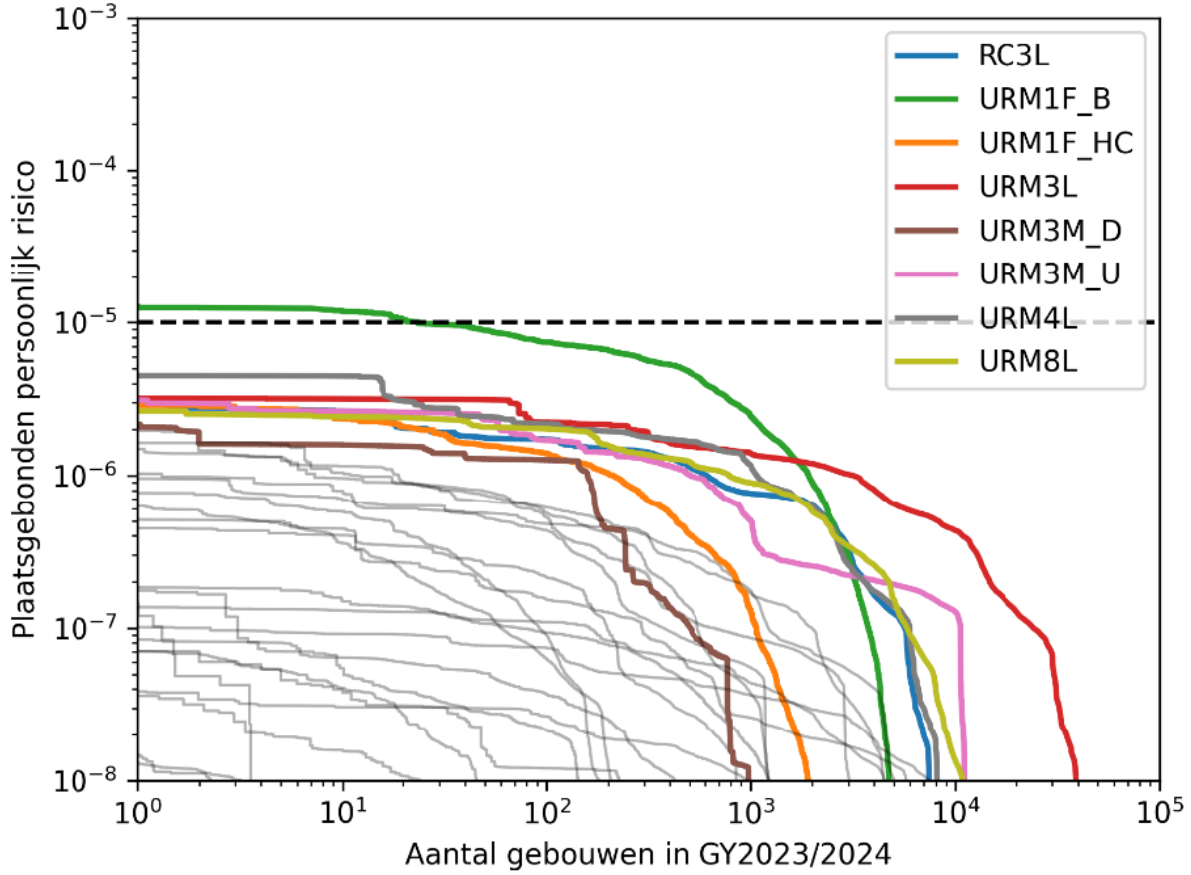
Source: folder dealing with risks in the Dutch energy transition, conference June 27th

Seismic hazard and risk analysis in the Netherlands for deep subsurface activities



Intern gebruik

Fully probabilistic risk analysis



- Norm LPR<10^{-5}
- Different typologies
- Number of buildings above the norm per year

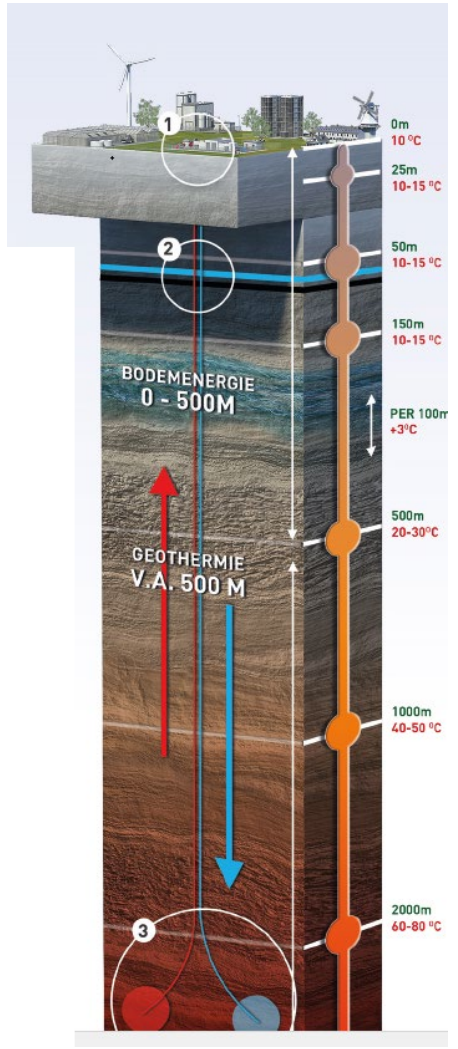
- Mining law satisfied
- Unanswered: which buildings?

Intern gebruik

Geothermal heat production

Policy
- Mining law
  - Description of the expected ground movement
  - If necessary:
    - Safety risk => norm for LPR
    - Risk for damages to buildings and infrastructure
    - Risk of disrupting functionality infrastructure
    - Measures to prevent surface movement
    - Measures to prevent or limit damages due to surface movement

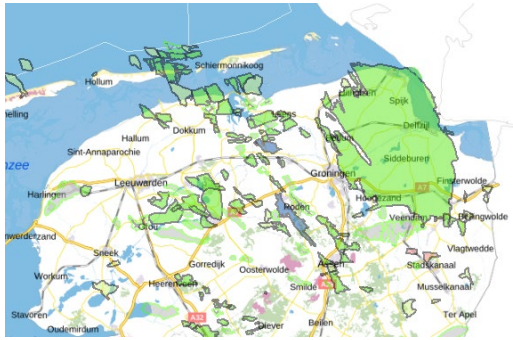
- License can be rejected if:
    - Unacceptable risks for safety (LPR>10^{-5})
    - Unacceptable damage (financial capacity)
- Lisence holder needs to take all measures that are reasonable to prevent risk and damage



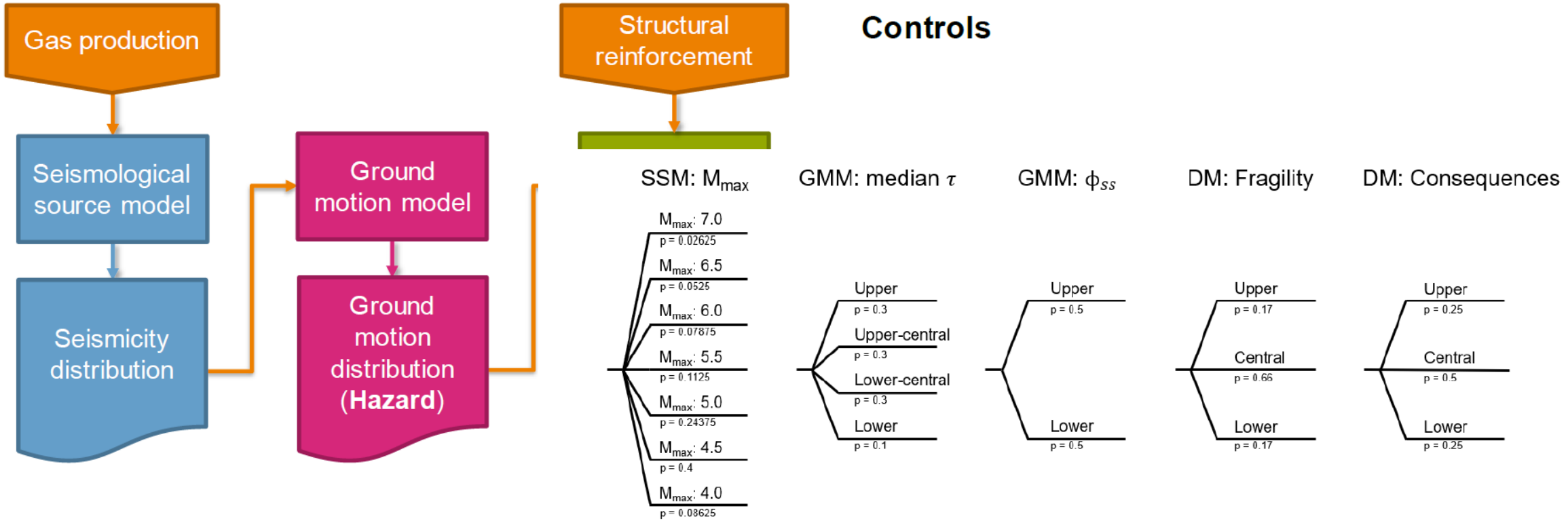
Intern gebruik

Source: seismic hazard and risk assessment, report TNO and EBN, November 16th 2023

Public* seismic hazard and risk analysis Groningen



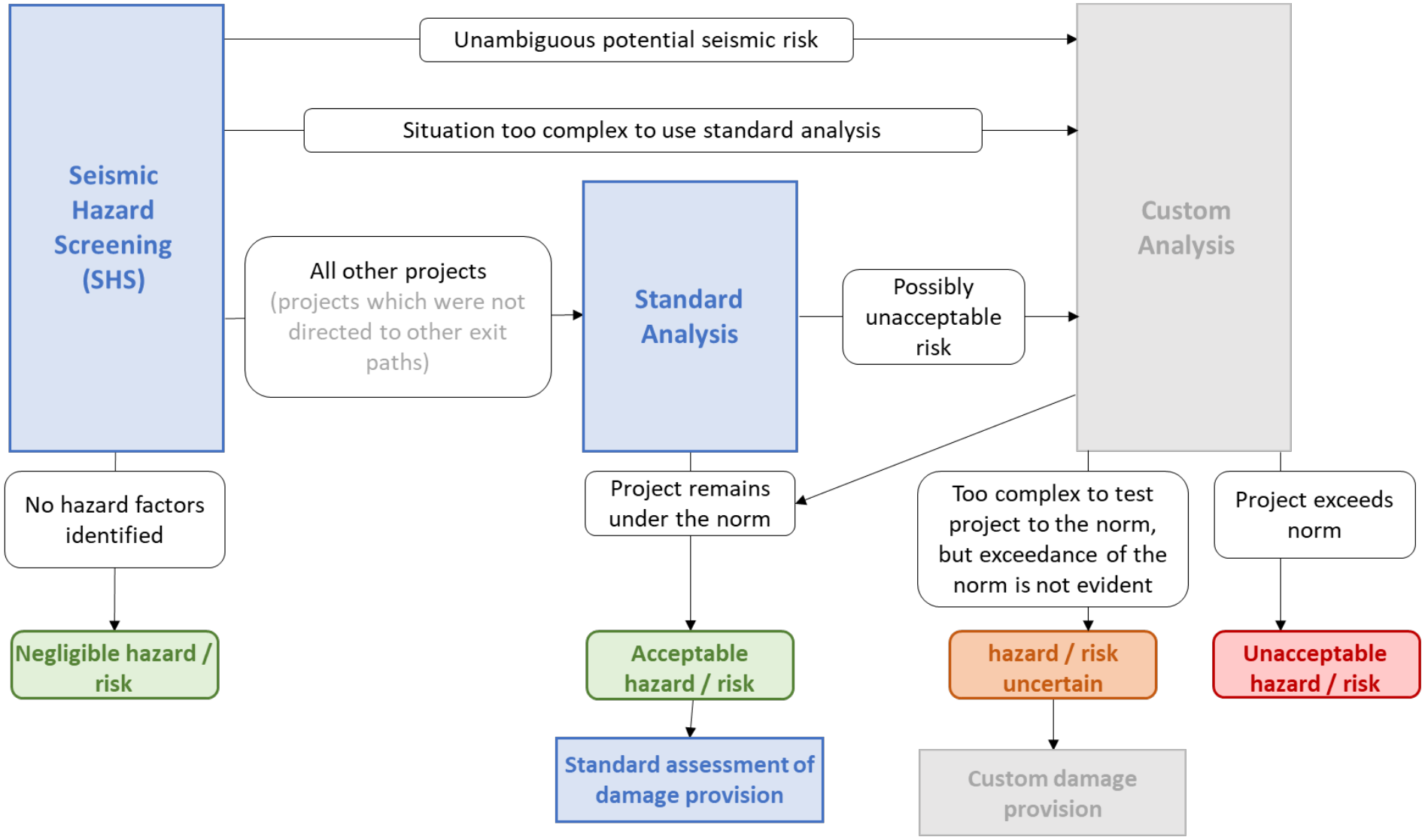
* https://www.nlog.nl/broncode-groningen-modelketen



Intern gebruik

Source: hazard and risk assessment Groningen 2023, report TNO

SHRA geothermal



Schematic depiction of the main features of the SHRA-geothermal procedure. Blue = standard procedure, grey = 'custom' procedure. Green, orange en red = possible outcomes after following the SHRA steps.

Source: seismic hazard and risk assessment, report TNO and EBN, November 16th 2023

Intern gebruik