

› INTRODUCTION TO SALT MINING IN THE NETHERLANDS

A life-cycle perspective

Ingrid Kroon, Serge van Gessel, Bogdan Orlic, Remco Groenenberg, Jaap Breunese

Workshop: Regulatory and technical requirements for responsible abandonment and re-use of salt caverns

TNO-Utrecht, 11-12 November 2019

RESPONSIBLE ABANDONMENT AND RE-USE OF CAVERNS



The Netherlands, January 1st 2019

Salt production

- 16 production licences:
cumulative salt production 6,7 million tonnes
- 0 exploration licences

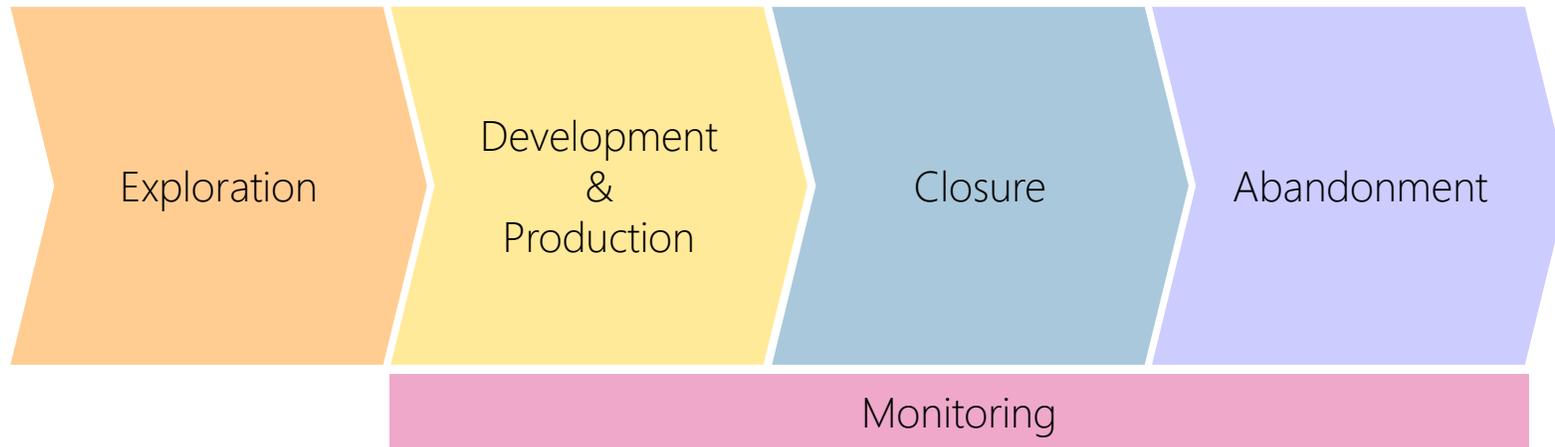
Subsurface storage

- 9 storage licences, including some caverns:
 - 1 natural gas storage (Zuidwending)
 - 1 strategic oil storage (Twenthe-Rijn De Marssteden)
 - 2 nitrogen storages (Winschoten II en Winschoten III)

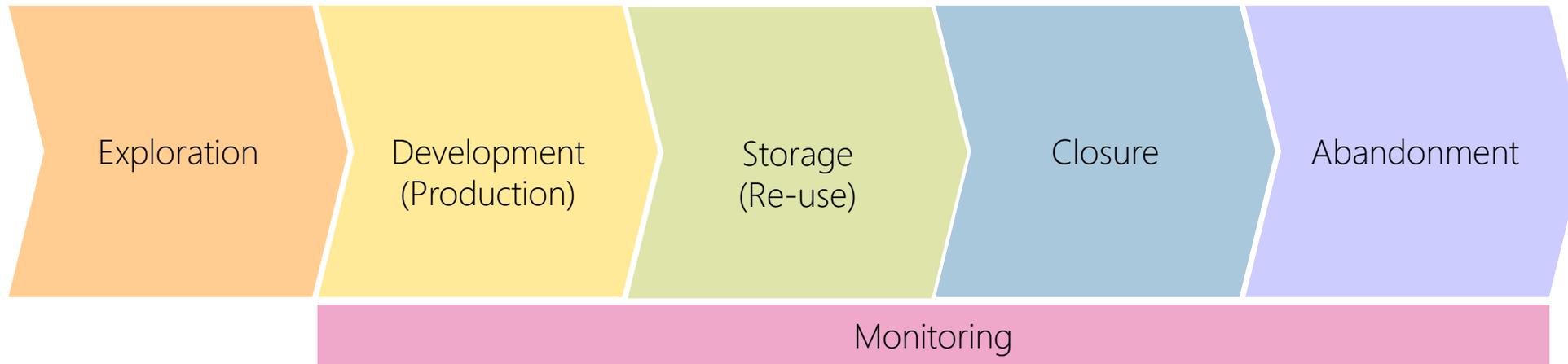
Cavern closure/abandonment ratio

- High

SALT MINING LIFE CYCLE



SALT STORAGE LIFE CYCLE



PHYSICAL ASPECTS

Subsurface

- Presence of minerals
- Depth, structure, age, facies etc.
- Brine composition
- Insolubles
- Future well trajectory
- Future cavern design

Surface

- Future mining location
- Future processing facilities
- Transportation to market
- Future potential mining effects (HSE)
- Documentation of data and methods

Potentie lage cavernes

 Mogelijk geschikt

Potentie hoge cavernes

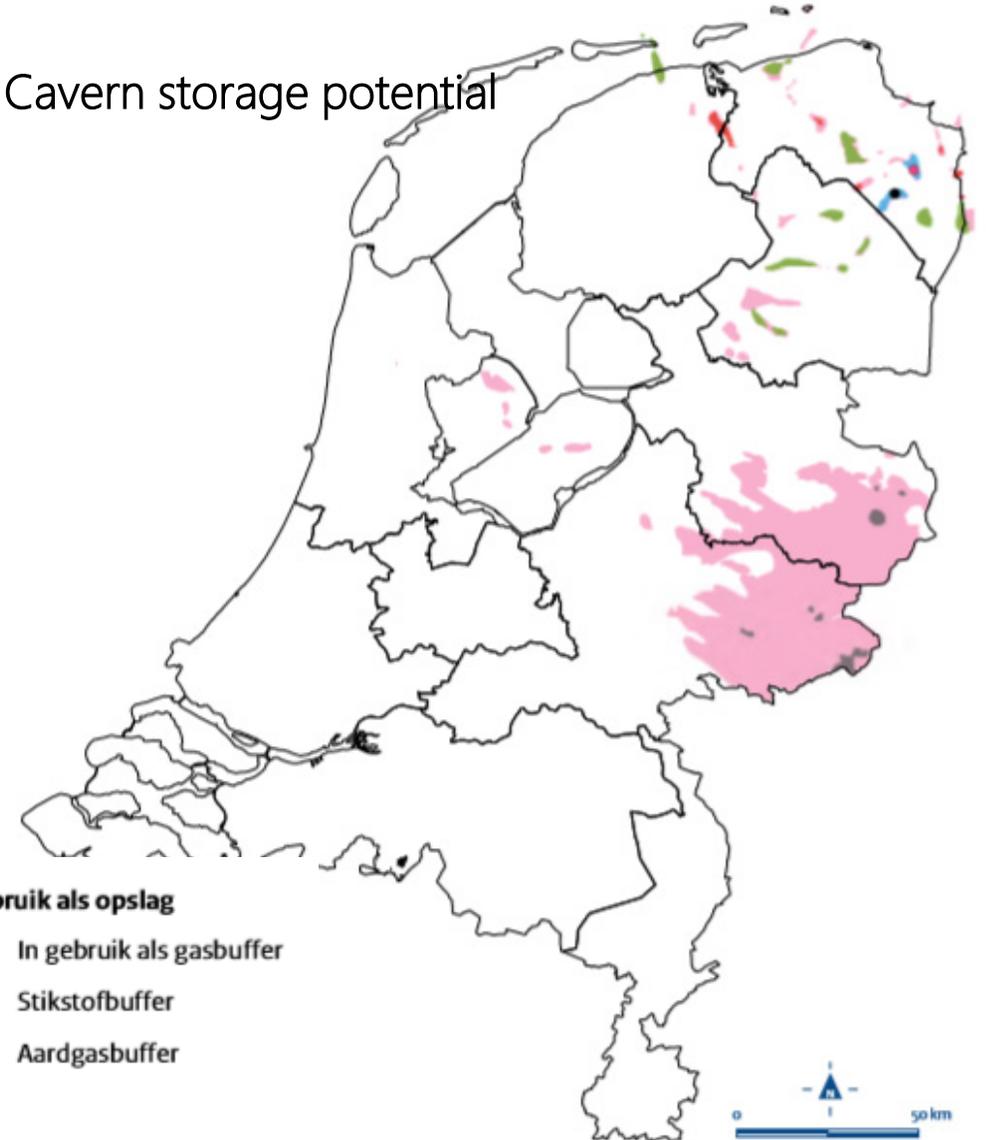
 Mogelijk geschikt

 Waarschijnlijk ongeschikt

 Geschiktheid onbekend

RESEARCH

Cavern storage potential



In gebruik als opslag

 In gebruik als gasbuffer

 Stikstofbuffer

 Aardgasbuffer

Exploration

PHYSICAL ASPECTS

Subsurface

- Well trajectory and completion
- Salt Formation physical behaviour
- Salt Formation chemical behaviour
- Cavern depth, shape, volume
- Brine composition and volume
- Insolubles
- Mining additives

Surface

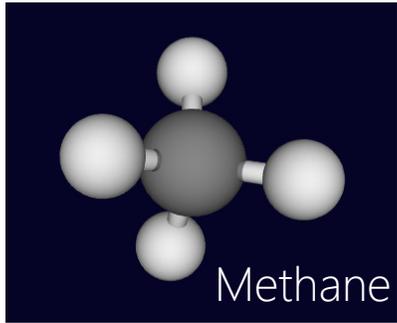
- Mining location
- Processing facilities
- Transportation to market
- Prevention of mining effects (HSE)
- Mitigation of hazards and risks (HSE)
- Monitoring network
- Documentation of data and methods

RESEARCH

Solution mining

- Maintenance
- Well control and integrity
- Brine production and processing
- Cavern development and stability
- Recovery of mining additives
- Prevention/mitigation of mining effects
 - ✓ Prognosis
 - ✓ Monitoring prognosed effects
 - ✓ Monitoring effectiveness of mitigation measures

Business as usual?



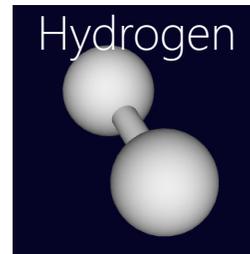
PHYSICAL ASPECTS

Subsurface

- Well design, trajectory, (re-)completion
- Salt Formation physical behaviour
- Salt Formation chemical behaviour
- Cavern depth, shape, volume
- Brine and insolubles
- Mining additives
- Physical behaviour stored gas or fluid
- Chemical behaviour stored gas or fluid
- Cyclic loading effects

Surface

- Mining location
- Processing facilities
- Transport to market
- Brine disposal?
- Prevention of mining effects (HSE)
- Mitigation of hazards and risks (HSE)
- Monitoring network
- Documentation of data and methods

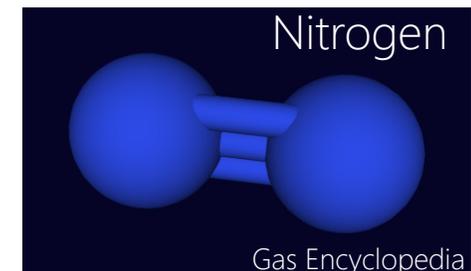


RESEARCH

Storage

- Development and feasibility
- Well control and integrity
- Injection and production rate
- Cavern development and stability
- Recovery of mining additives
- Maintenance
- Prevention/mitigation of mining effects
 - ✓ Prognosis
 - ✓ Monitoring prognosed effects
 - ✓ Monitoring effectiveness of mitigation measures

Providing flexibility and strategic reserves for the future energy system?!



Storage

PHYSICAL ASPECTS

Subsurface

- Well (shut in or suspended)
- Salt Formation physical behaviour
- Salt Formation chemical behaviour
- Cavern depth, shape, volume
- Brine volume and composition
- Mining additives
- Physical behaviour stored gas or fluid
- Chemical behaviour stored gas or fluid

Surface

- Mining location
- Processing facilities
- Prevention of mining effects (HSE)
- Mitigation of hazards and risks (HSE)
- Monitoring network
- Documentation of data and methods

RESEARCH

Closure

- Maintenance
- Recovery of mining additives
- Recovery of stored gas or fluid
- Well control and integrity
- Cavern development and stability
- Prevention/mitigation of mining effects
 - ✓ Prognosis
 - ✓ Monitoring prognosed effects
 - ✓ Monitoring effectiveness of mitigation measures

What is needed to progress from closure to abandonment?

Closure

PHYSICAL ASPECTS

Subsurface

- Well abandonment
- Salt Formation physical behaviour
- Salt Formation chemical behaviour
- Cavern depth, shape, volume
- Brine
- Physical behaviour of additive remnants
- Chemical behaviour additive remnants
- Physical behaviour remnants gas or fluid
- Chemical behaviour remnants gas or fluid
- Solids?

Surface

- Site and facility decommissioning
- Prevention of mining effects (HSE)
- Mitigation of hazards and risks (HSE)
- Monitoring network
- Documentation of data and methods

RESEARCH



De Limburger, August 3 2018

PHYSICAL ASPECTS

Subsurface

- Well
- Salt Formation
- Cavern
- Brine
- Insolubles
- Overburden
- Additives
- Gas or fluid
- Solids?

Surface

- Mining location
- Processing facilities
- Prevention of mining effects (HSE)
- Mitigation of hazards and risks (HSE)
- Monitoring network
- Documentation of data and methods

RESEARCH

Monitoring

- (Long term) physical system behaviour
- (Long term) chemical system behaviour
- Interaction of system components
- Prevention/mitigation of mining effects
 - ✓ Prognosis
 - ✓ Monitoring prognosed effects
 - ✓ Monitoring effectiveness of mitigation measures

Closing the loop: available mitigating measures?

FUTURE TECHNICAL REQUIREMENTS ...?!



The Netherlands, January 1st 2030

Salt production

- X production licences:
cumulative salt production Y million tonnes
- Z exploration licences

Subsurface storage

- A storage licences, including the following caverns:
 - B natural gas storages
 - C oil storages
 - D nitrogen storages
 - E compressed air storages
 - F hydrogen storages

Cavern closure/abandonment ratio

- Low?

A satellite view of Earth from space, showing the Western Hemisphere. The Americas are visible in the center, with the Atlantic Ocean to the right and the Pacific Ocean to the left. The image is rotated 90 degrees clockwise. The text 'TNO innovation for life' is in the top left corner, and 'THANK YOU FOR YOUR ATTENTION' is in the bottom left corner.

TNO innovation
for life

› **THANK YOU FOR
YOUR ATTENTION**