Van: @spidron-weco.com>
Verzonden: dinsdag 17 oktober 2017 11:15
Aan:
CC: Takkebos, D. (Dick);

Onderwerp: Scope omschrijvingen seimiciteits onderzoek WarmteStad
Bijlagen: 20171010 Project scope - SHA exploitation.pdf; 20171010 Project scope - SHA drilling & testing.pdf

Goedemorgen

In opvolging van het telefonische gesprek tussen SodM en Burgemeester en Wethouder op 25 september 2017, ontvang je hierbij de omschrijving van de scope van de uit te voeren onderzoeken:

- SHA boren en testen
  - WarmteStad combineert hierbij de eis zoals vastgelegd in Constatering zorgplicht art. 33 Mbw (dd. 11 mei 2017 kenmerk: DGETM-EO/17059285) en het advies van SodM aan EZ, advies opsporingsvergunning aardwarmte Groningen (dd. 28 september 2017 kenmerk: 17151757).
- SHA exploitatie
  - Hierin beschrijft WarmteStad de vervolgstappen van het onderzoek dat WarmteStad in 2015 heeft opgestart naar de seismische risico's van het project.

Note; In de uitgevoerde Seismic Hazard Assessment (IF/Qcon, 2016) is vastgesteld dat voor het beoogde systeem een level 2 evaluatie vereist is. Conform *Defining the Framework for Seismic Hazard Assessment in Geothermal Projects V0.1* (IF/Qcon, 2016) volstaat een Seismic Hazard Analyse (SHA).

Mocht je naar aanleiding van deze documenten vragen en/of opmerkingen hebben dan hoor ik het graag,

Met vriendelijke groet,

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WarmteStad

Memo

Van	:	
Aan	:	
Status	:	Concept
Datum	:	Tuesday 10 October 2017
Onderwerp	:	Scope of work SHA exploitation

Compose a SHA (seismic risk assessment) for the exploitation of Warmtestad's geothermal project during a period of 30 years. The objectives are highlighted in bullet points and available information is described in cursive below.

1. **Risks of internal reservoir faults**
    - What is the expected risk on seismicity at internal faults and what are the consequences?
        - Determine the expected transmissibility of the internal faults of the reservoir, especially the nearest fault on the North side of the geothermal reservoir.
        - What are the chances that the internal faults are sealing?
        - What is the orientation and dip angle of the fault?
        - Check the expected initial stress situation and its influence on the internal reservoir faults
    - Describe the expected pressure depletion based upon the research by IF (see appendix 4) and SGS (see appendix 7). Include the expected ongoing pressure depletion in bar/year (see appendix 4).
    - Geomechanical simulations to study seismicity response in depleted scenario:
        - 30 bars initial depletion with an ongoing depletion of 1 bar/year.
        - 30 bars initial depletion with an ongoing depletion of 2 bars/year.

    The following information and boundary conditions will be used:

    Virgin reservoir pressure is 390 bar at the top of the reservoir for the producer and 397 bar at the top of the reservoir for the injector (see appendix 19).

    Well trajectories are described in the well design by Ross (see appendix 15).

    The geological parameters are summarized in the review by TNO (see appendix 12).

    Pressure depletion of 0-50 bar according to IF (see appendix 4) and 2-50 bar according to SGS (see appendix 7). Ongoing pressure depletion of max 1 bar/year according to IF (see appendix 4).

    SGS has already calculated tensions in faults in scenario's with pressure depletion (see appendix 8).

    An initial reservoir model was made by Panterra (see appendix 11). The University of Groningen (see appendix 2) has done a separate reservoir study. This model was used by IF/Q-con and updated by SGS (see appendix 9) with additional faults. Both IF/Q-con (appendix 3) and SGS (appendix 8) stated that it is very unlikely that the faults are sealing.

2. **Expected risks at eastern reservoir faults (Bedumer & Groninger gasfield)**
    - The BDM-05 gas well is the closest to the geothermal wells. There are already earthquakes near the eastern boundary fault. Do our pressure cones reach this fault within 30 years? Is there a risk on seismicity due to the geothermal activities?

    SGS has already modelled this (see appendix 8).

3. **Expected risks at western reservoir faults (Pasop gas field)**
    - The PSP gasfield is located approximately 10km west of the geothermal wells. There have been earthquakes in this field in the past, production has stopped. Do our pressure cones reach this field within 30 years? Is there a risk on seismicity due to the geothermal activities?

    SGS has already modelled this (see appendix 8).

4. **Max injection pressure reservoir (studied by IF)**
    - An update of the memo on injectivity and the frac pressure by IF (see appendix 5).

5. **TLS**
    - Design measuring grid
    - Design a concept TLS for the exploitation phase
    - Define the boundary conditions for the TLS (maximum PGV values)
    - Define the risk area for the TLS

    Some information on this is summarized in the Plan of Action TLS by WarmteStad (see appendix 13).

6. **Conclusion**

    Answer most important questions regarding seismicity:
    - What is the expected pressure depletion due to nearby gas production now and in the future?
    - What is the quantified risk on seismicity at internal faults and what are the consequences?
    - What is the quantified risk on seismicity due to geothermal activities at the eastern boundary fault?
    - What is the risk on seismicity due to the geothermal activities at the Pasop gasfield?
    - What is the maximum allowable injection pressure to stay under the frac pressure?
    - How reliable and effective is the TLS?
    - Define the next steps to update the SHA after receiving additional geological data from the drilling of GRN-GT-01.

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Memo

Appendices

1) Alexandros Daniilidis, Leon Doddema & Rien Herber, 2016. Risk assessment of the Groningen geothermal potential: From seismic to reservoir uncertainty using a discrete parameter analysis, Geothermics 64 (2016) 271–288
2) RUG, geological model
3) IF/Q-con, 2016: Hoofdrapport Seismic Hazard Analyse Geothermie WarmteStad Groningen, 65308/BP/20160531
4) IF, 2016: Definition of depletion scenarios, 65308/BP/20160812
5) IF, 2017: maximum injection pressure
6) Q-con, 2016: Geomechanical Study and TLS Design Identifying Relevant Processes, IF003
7) SGS, 2016: Seismic Risk Analysis Zernike Geothermal Project: Phase 1 Summary Report, OGC/NL/HAG/2016/NL30H/DP-WAR-002/FINAL
8) SGS, 2017: Seismic Risk Analysis Zernike Geothermal Project Phase 2 - Summary Report, OGC/NL/HAG/2016/NL30H/DP-WAR-003/FINAL Version
9) SGS, geological model
10) Panterra, 2014: Geothermal Energy in Groningen Geological Investigation, G1111
11) Panterra, geological model
12) TNO, 2015: Advies aanvraag Garantieregeling AARD04001 Aardwarmte ZernikeGeo, AGE 15-10.008.
13) WarmteStad, 2017: Plan of Action TLS
14) IF, 2017: Well test
15) Ross, 2017: Well Design Document - signed
16) TNO, 2012: Deterministische hazard analyse voor geïnduceerde seismiciteit in Nederland
17) NAM, 2016: pressure measurements in Groninger gasfield
18) SGS, 2017: pressure changes after 15-30 years
19) WarmteStad, 2017: Well initialisation Document V2 signed

WarmteStad

Memo

Van	:	
Aan	:	
Status	:	Concept
Datum	:	Tuesday 10 October 2017
Onderwerp	:	Scope of work SHA drilling & testing

Compose a SHA (seismic risk assessment) of the drilling and well-test activities for WarmteStad's geothermal project. The objectives are highlighted in bullet points and available information is described in cursive below.

The SHA will be processed in the following steps: The SHA will be send in to SodM for review and acceptance; SodM will send the SHA together with its findings to the KEM for a second opinion.

1. **Risks during drilling**
   - Determine risk on seismicity during the drilling operations

2. **Risks during testing**
   - Describe the expected pressure depletion based upon the research by IF (see appendix 4) and SGS (see appendix 7). Include the expected ongoing pressure depletion in bar/year (see appendix 4).
   - Determine risk of causing seismicity during the well tests. Production of 5000m3 water per well test, with a maximum flow of 200m3/h at P90 reservoir conditions.

   The following information and boundary conditions will be used:
   Virgin reservoir pressure is 390 bar at top reservoir for the producer and 397 bar at top reservoir for the injector.

   Well trajectories are described in the well design by Ross (see appendix 15).

   The geological parameters are summarized in the review by TNO (see appendix 12).

   IF has described the well test in a short memo (see appendix 14).

   Pressure depletion of 0-50 bar according to IF (see appendix 4) and 2-50 bar according to SGS (see appendix 7). Ongoing pressure depletion of max 1 bar/year according to IF (see appendix 4).

   SGS has calculated tensions in faults in scenario's with pressure depletion (see appendix 8).

   An initial reservoir model was made by Panterra (see appendix 11). The University of Groningen (see appendix 2) has done a separate reservoir study. This model was used by IF/Q-con and updated by SGS (see appendix 9) with additional faults. Both IF/Q-con (appendix 3) and SGS (appendix 8) stated that it is very unlikely that the faults are sealing.

3. **TLS**
    - Design a measering grid
    - Design a concept TLS for the drilling and well-test phase
    - Define the boundary conditions for the TLS (maximum PGV values)
    - Define the risk area for the TLS

    Some information on this is summarized in the Plan of Action TLS by WarmteStad (see appendix 13).

4. **Conclusion**

    Answer most important questions regarding seismicity:
    - What is the quantified risk on seismicity during drilling?
    - What is the quantified risk on seismicity during testing?
    - How reliable and effective is the TLS?

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Appendices

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