



Seismic Hazard and Risk Assessment – Screening

Zoetermeer II - VDB-GT-07/08

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SUMMARY

For the development of the Zoetermeer II licence a seismic hazard screening (*SDS* = seismische dreigingsscreening) as part of the Seismic Hazard and Risk Assessment workflow (Mijnlieff et al., 2023) was performed to confirm (or update) the previously established risks of seismicity during geothermal development of doublet VDB-GT-07/ VDB-GT-08. These risks were assessed previously by a Seismic Hazard Risk Analysis Quickscan (Level 1) (Tullip Energy, 2023a).

The Seismic Hazard Risk Analysis Quickscan (Level 1) determined whether there is a risk that a soil vibration will occur as a result of geothermal energy extraction using a methodology that has been established by IF/QCon (Baisch at al. 2016) and resulted in a normalized score of 0.30, associated with a low risk (Tullip Energy, 2023a).

Out of abundance of caution and because guidelines for seismic hazard analysis have been changing in recent times, this project has been screened again following the latest Seismic Hazard Screening (SDS = seismische dreigings screening) methodology as described in Mijnlieff et al. (2023). This screening exercise reconfirmed the negligible seismicity risk for this project because of:

- the good coverage with good quality 3D seismic data,
- the good matrix permeability with proven injector-producer communication,
- the absence of overlap with other mining activities,
- the absence of overlap with the Ruhr Valley Graben area,
- the absence of with major relevant fault zones,
- the absence of faults in its Geothermal Area of Influence (GT-AoI).



NEDERLANDSE SAMENVATTING

Voor de ontwikkeling van het Zoetermeer II - VDB 07/08 doublet is een seismische gevarenscreening (*SDS = seismische dreigingsscreening*) als onderdeel van de *Seismic Hazard and Risk Assessment workflow* (Mijnlieff et al., 2023) uitgevoerd om de eerder vastgestelde risico's van seismiciteit tijdens geothermische ontwikkeling van doublet VDB-GT-07/ VDB-GT-08 te bevestigen (of bij te werken). Deze risico's zijn eerder vastgesteld een *Seismic Hazard Risk Analysis Quickscan (Level 1)* screening (Tullip Energy, 2023a).

De Seismic Hazard Risk Analysis Quickscan (Level 1) heeft de IF/Qcon methodiek gebuikt (Baisch et al., 2016) en geresulteerd in een genormaliseerde score van 0,30, wat is geassocieerd met een laag risico (Tullip Energy, 2023a).

Omdat richtlijnen voor seismische dreigingsanalyse de afgelopen tijd in ontwikkeling zijn geweest, en uit voorzorg, is dit project ook weer gescreend volgens de nieuwe Seismische Dreigings-Screening (SDS) methode zoals beschreven in Mijnlieff et al., 2023. Op grond van de volgende observaties bevestigt deze seismische dreigings-screening of SDS het eerdere, volgens de oude richtlijnen vastgestelde, verwaarloosbare seismiciteitsrisico van dit project:

- 3D seismische gegevens van het project gebied zijn van goede kwaliteit,
- Het geothermische reservoir heeft goede matrix permeabiliteit met bewezen communicatie tussen injector- en producer,
- Er is geen overlap met andere mijnbouwactiviteiten,
- Er is geen overlap met het Roer Dal Slenk gebied,
- Er is geen overlap met een Major Relevant Fault Zones,
- Er geen breuken zijn in het geothermisch invloedsgebied (GT-AoI).

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IPS GENTHERMAL

INTRODUCTION

IPS Geothermal Energy B.V., hereinafter referred to as IPS, operates as a license operator, on behalf of licenser 85 Degrees Renewables 5-8 B.V., hereinafter referred to as 85, a geothermal installation for geothermal heat extraction. IPS & 85 intend to realize a geothermal operation within the Zoetermeer II exploration area (*toewijzing zoekgebied*). The geothermal production plan Zoetermeer II (*winningsplan*) of which was submitted to the Ministry of Economic Affairs and Climate Policy in June 2023 (IPS, 2023). The mining site is located at A.H. Verweijweg (near number 1a as there is no number yet), postal code 2651 LC in Berkel en Rodenrijs (municipality of Lansingerland) in the province of Zuid Holland. This mining location is located within a greenhouse horticulture area. The doublet to be realized in the Zoetermeer II geothermal production plan concerns a new production well (VDB-GT-07) and a new injection well (VDB-GT-08), which will extract geothermal heat from the Nieuwerkerk Formation containing the Delft Sandstone and the package of Alblasserdam at 1755-2362 m depth.

Mining activities, including geothermal energy extraction, are associated with risks. Control and mitigation of these risks, such as the possible cause of seismicity, is of great importance in Dutch geothermal projects. Although the consensus is that the risk associated with the type of geothermal energy projects such as in Zoetermeer II (i.e., low-enthalpy geothermal energy in matrix-dominated sandstone reservoirs) is low (e.g., TNO., 2019; Professors Panel, 2020; TNO-AGE, 2020), guidelines on how to properly assess this risk have been in development over recent years, resulting in a recent change from the *level 1 screening guidelines* (Baisch at al., 2016) to the current *Seismic Hazard and Risk Assessment* workflow (Mijnlieff et al., 2023). To asses if the previously established low seismicity risk for Zoetermeer II - VDB 07/08 could change as a result of the new methodology, a full seismic hazard screening *(SDS = seismische dreigingsscreening)* was carried out and described in this report.

Guidelines for geothermal projects

To assess the risk of local seismicity for geothermal installation VDB-GT07/VDB-GT-08, seismic hazard screening (*SDS* = seismische dreigingsscreening) according to the workflow of figure 1 and 2 (Mijnlieff et al., 2023) was carried out.





PIPS GEOTHERMAL

Seismic Hazard and Risk Assessment - Screening: Zoetermeer II - VDB-GT-07/08

Figure 1. Schematic representation of the SDRA workflow. SDS = Seismic Hazard Screening, SDRA = Seismic Hazard and Risk Assessment (Mijnlieff et al., 2023)



Figure 2 Schematic image of the SDRA showing the steps within Seismic Hazard Screening (SDS) in more detail (Mijnlieff et al., 2023)

With the argumentation in Table 1 the questions in the Seismic Hazard Screening (SDS) decision tree (Figure 2) were answered to arrive at the bottom green box labelled *Negligible Hazard / Risk* (Verwaarloosbare dreiging/ Risico).



Table 1: Answers and argumentation for the Seismic Hazard Screening (SDS) workflow (Figure 2) leading to the negligible risk assessment.

Decision tree question	Answer Y/N	Argumentation or reference
Reservoir communication in a	Yes	Reservoir is the NieuwerKerk Formation with well-
closed or matrix permeable		established matrix permeability and injector-producer
system?		communication in nearby wells.
Sufficient data coverage and	Yes	Covered by good quality (high signal to noise ratio) 3D
quality?		seismic survey, where horizon identification is easy and
		faults up to the seismic resolution can be identified.
Overlap with mining activity?	No	Nearest historic oil and gas activity at > 3 km distance to
		nearest influence area of mining activity
Overlap with Larger Ruhr Valley	No	Doublet VDB-GT07/08 is located in the West
Graben?		Netherlands basin, more than 45 km away from the
		nearest end of the Ruhr Valley Graben
Overlap with major relevant fault	No	No relevant faults have been identified in the Schieland
zone?		Groep in the Netherlands. The closest major relevant
		fault zone in the overlying Rijnland Groep is still more
		than 40 km away from the GT-Aol of doublet VDB-
		GT07/08
Is there a fault in the geothermal	No	Plotting the Geothermal area of influence (Mijnlieff et
area of influence?		al., 2023) on the Base Alblasserdam reservoir depth map
		shows one faults exists within the Geothermal area of
		influence of doublet VDB-GT07/08



Results

Permeability system

The reservoirs of the Nieuwerkerk Formation have a well-established matrix permeability (Panterra, 2021). In the nearby geothermal heat extraction project of Bleiswijk 1b, stable production pressures and flow rates in the past years have shown good pressure communication in the Nieuwerkerk formation (Willems, 2012).

Geothermal Area of Influence

The determination method of the Geothermal Area of Influence (GT-AoI) is described in the new *Seismic Hazard and Risk Assessment for geothermal projects in The Netherlands* report by Mijnlieff et al (2023). This GT-AoI is defined by the zone within two buffers around the production and injection well at reservoir level (Mijnlieff et al, 2023). Because of the maximum deviation of these wells is 38°, buffers were established around the well TD. The buffer around the production well is 300 m (Mijnlieff et al, 2023). The buffer around the injection well is 0.7 x horizontal distance between producer and injector at well TD: $0.7 \times 1358 = 951 m$ (Panterra, 2021). The GT-AoI is the area that envelops these buffers (Figure 3). Note that the GT-AoI of VDB-GT07/08 overlaps with the GT-AOI of VDB-GT05/06. The *Seismic Hazard and Risk Assessment – Screening* of VDB-GT-05/06 is described in in separate report (Tullip Energy, 2023b).



Figure 3 Geothermal area of influence according to methodology of Mijnlieff et al (2023) plotted on the top of the Nieuwerkerk Formation thickness map with identified faults in the area (IPS, 2023).



Data Quality

The Zoetermeer II - VDB 07/08 doublet resides in the middle of the West Netherlands Basin, which is almost entirely covered by high-quality 3D seismic data (Fig 4). Seismic data in the GT-AoI has a high signal to noise ratio, allowing easy horizon and fault identification (Fig 5).



Figure 4, 3D seismic coverage in the West Netherlands basin (NLOG, 2023a), with Geothermal Area of Influence and well trajectories of GT-07 and GT-08.



Figure 5 NE-SW seismic cross section along the injection well VDB-GT08, showing the good seismic quality (Panterra, 2021).



Overlap with Oil and Gas fields

Figure 6 shows there is no (historic) oil or gas activity overlapping with the GT-AoI. The nearest oil or gas activity, as published for SHRA screening (NLOG, 202b), is the abandoned Leidschendam gas field with the closet point of its buffer zone at 3.3 km distance from the northwestern border of the GT-AoI of doublet VDB-GT07/08.



Figure 6 Map showing: 1) Gas and gas producing oil fields onshore The Netherlands, 2) Gas field Aol's (coloured by stratigraphic level) 3) GT-Aol of the Zoetermeer II - VDB 07/08 doublet

Overlap Ruhr Valley Graben or Major Relevant Fault zone

Doublet VDB-GT07/08 is located in the West Netherlands basin, where the boundary of its buffer zone, as established by the GT-AoI determination, is 47.6 km from the nearest point of the Ruhr Valley Graben area (Figure 7). The Nieuwerkerk Formation, containing the reservoirs used for heat production by doublet VDB-GT07/08, is part of the Schieland Groep. Therefore, only major relevant faults of the Schieland groep are relevant for this assessment, and such faults have not been identified (Figure 7). The nearest fault in the overlying Rijnland Groep is 41,9 km north of the GT-AoI.





Figure 7: Map showing all tectonic earthquakes, the seismically active Larger Ruhr Valley Graben Area and the "major relevant fault zone trajectories including their uncertainty bandwidth (NLOG, 2023b).

Fault in geothermal area of Influence

The nearest fault identified is located to the South West, just outside the GT-AoI of doublet VDB-GT07/08 (Fig 3). Since there is no fault present within the GT-AoI, no analysis of the potential for fault reactivation is required.

Conclusions

Following the new Seismic Hazard Screening (SDS = seismische dreigings screening) method as described in Mijnlieff et al., 2023, this project has a negligible seismicity risk, because project benefits from these observations:

- There is good coverage and quality with 3D seismic data,
- There is good matrix permeability with proven injector-producer communication,
- There is no overlap with other mining activity,
- There is no overlap with the Ruhr Valley Graben,
- There is no overlap with a major relevant fault zone,
- There is no fault in its geothermal Area of Influence (GT-AoI).

Therefore, the Seismic Hazard Screening (*seismische dreigings screening or SDS*) assessment according to the guidelines of Mijnlieff et al. (2023) confirmed negligible seismicity risk for this project as per previous analysis under the old guidelines.



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