# Digital Twin of Geothermal Assets Assisting the Production and Operational Decisions

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Presentation for GeoTHERM 2024

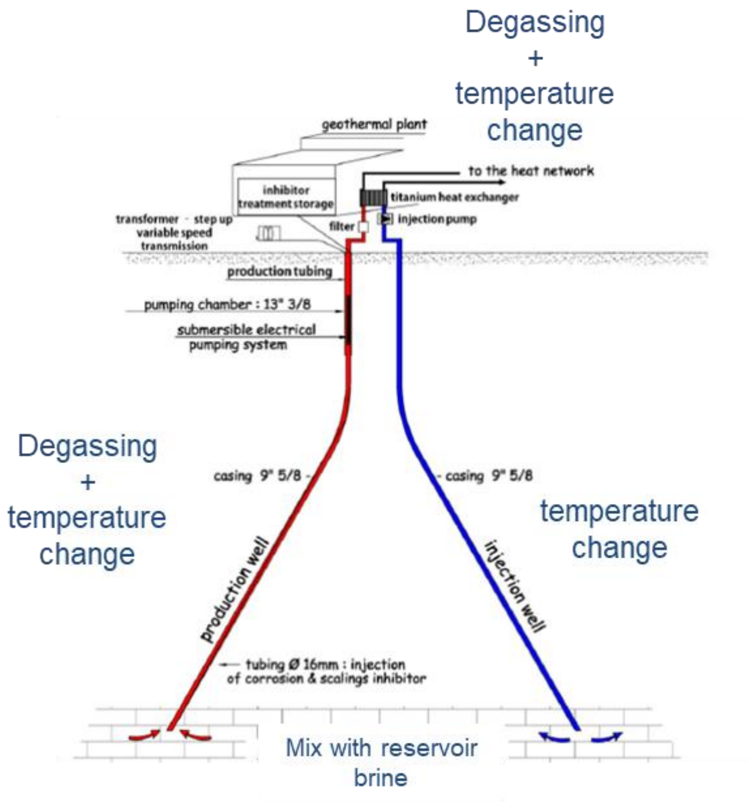
GeoTHERM expo & congress

*Photo generated by AI*

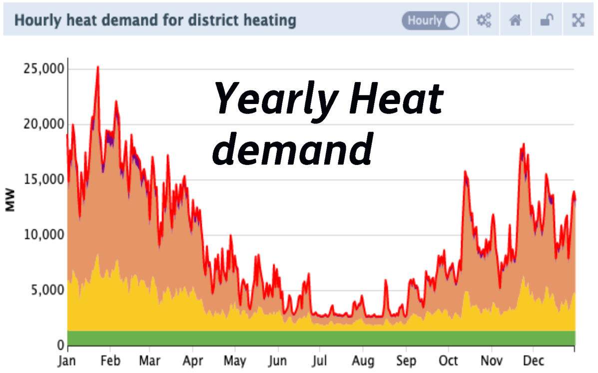
# Motivation

- Growth in geothermal assets in NL and worldwide
- Increasingly complex production and operation
  - Responding to heat demand with a minimum environmental footprint
  - Complex operational challenges
  - Planned and unplanned maintenance
  - Learning curve for operators needs to be accelerated

- Need for a centralized, fast, optimum and robust operational decisions employing data in the life cycle of a plant




*From Kervevan et al., 2014*

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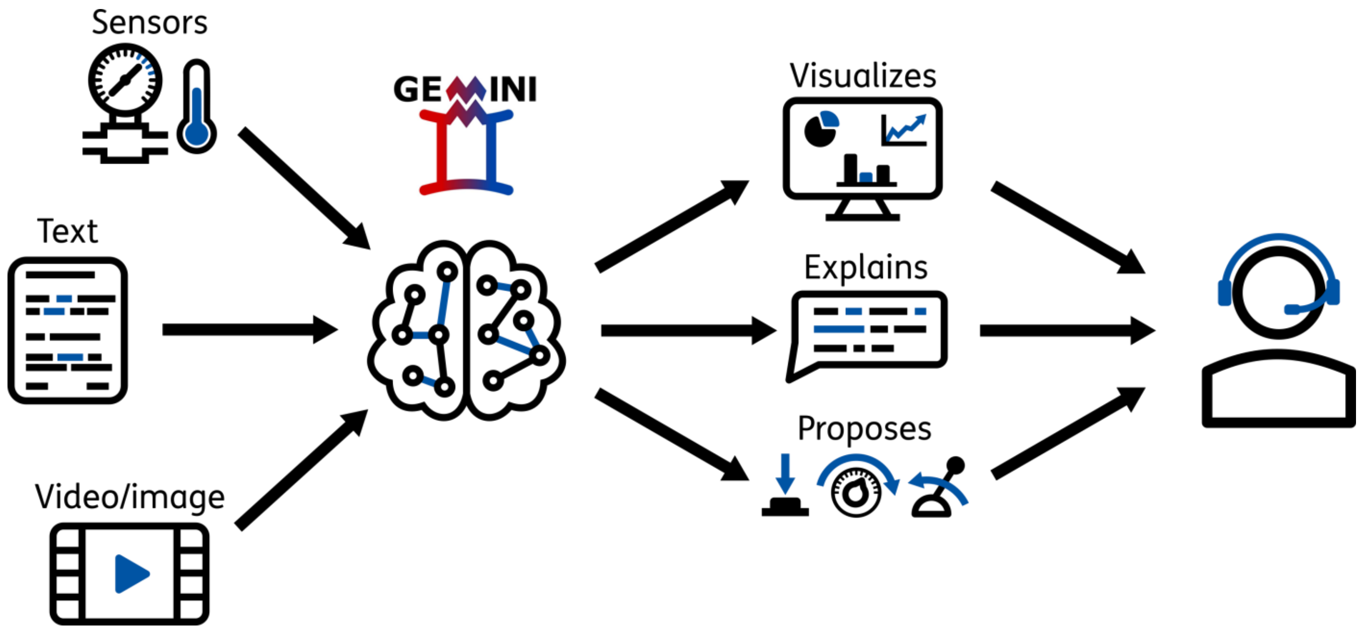
# Motivation


# Vision: Optimum Operational Decisions

- Towards an intelligent decision support framework

- Increase production efficiency
- Reduce risks and emissions
- Accelerate the learning curve in the sector
- Enabling the knowledge transfer from experienced operators to young operators



# Development and Demonstration Projects

nieuwe warmte nu

- A national growth fund project in the Netherlands to demonstrate GEMINI in geothermal systems and ATES
  - 3 sites, Live demonstrations
  - Monitoring the implementation for > 6 months
  - Full value chain onboard
  - An Open-Access tool to be available in 2025
  - Open-source libraries to be released in 2026

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Aardyn Geothermie ontwikkeling & beheer

hvc energie en hergebruik

Helin

WEP work well together

Rijksdienst voor Ondernemend Nederland

# Digital Twin of Geothermal Assets

- A virtual representation that serves as the real-time digital counterpart of a physical object or process (NASA)
- Dynamic processes, dynamic system changing overtime, variable demand, uncertainties in subsurface and surface processes
- Why? Minimize maintenance cost, maximize production, Reduce environmental footprint, ...

Physical object

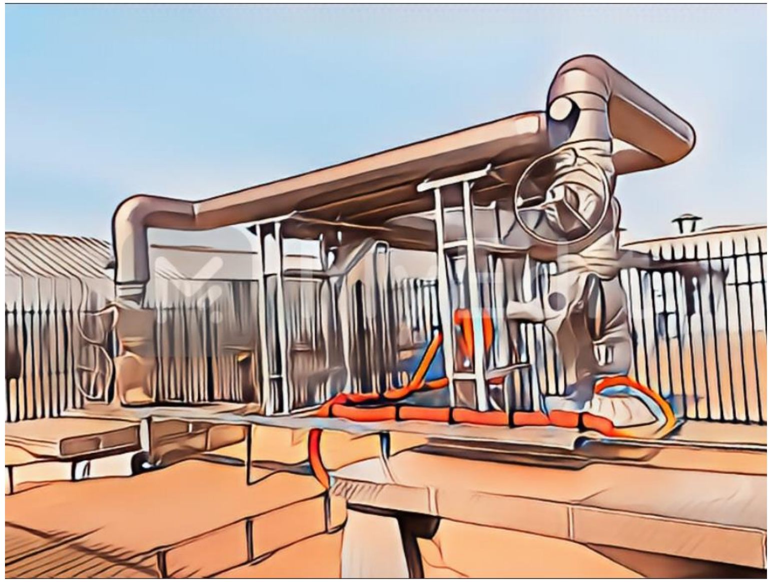
Static and real-time data

Mechanisms

Data exchange

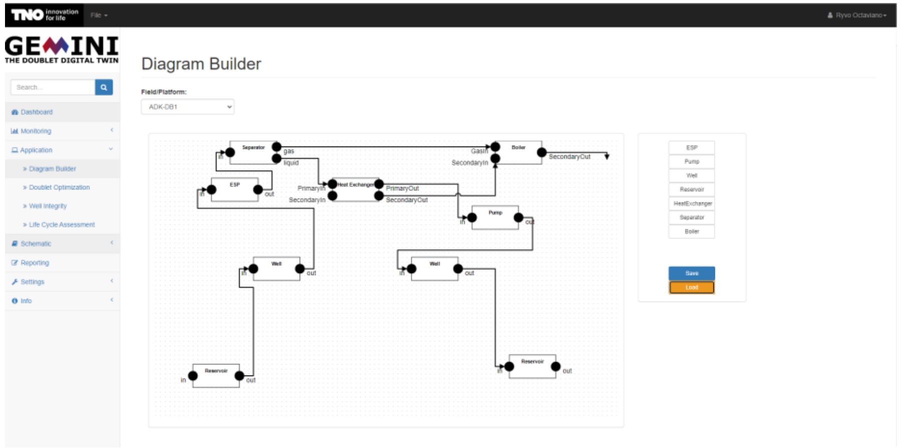
Information, actions and feedbacks

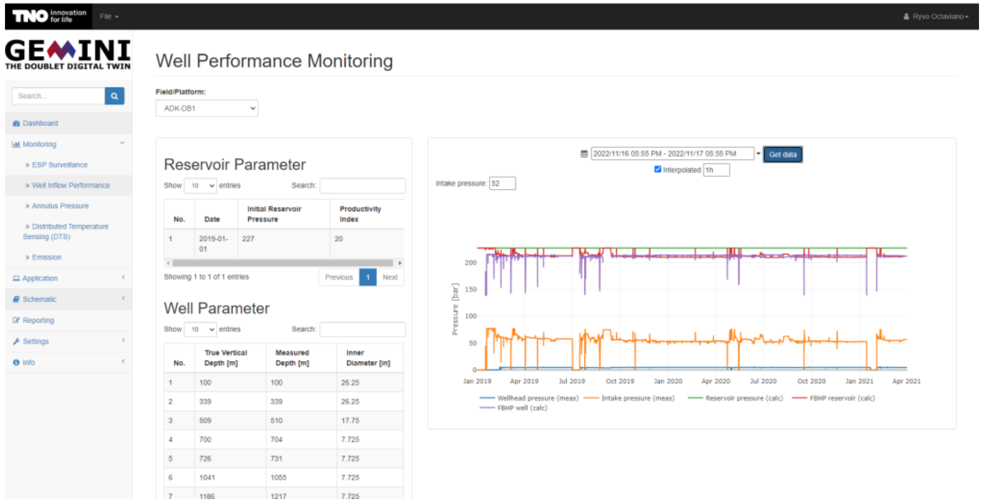
Digital object

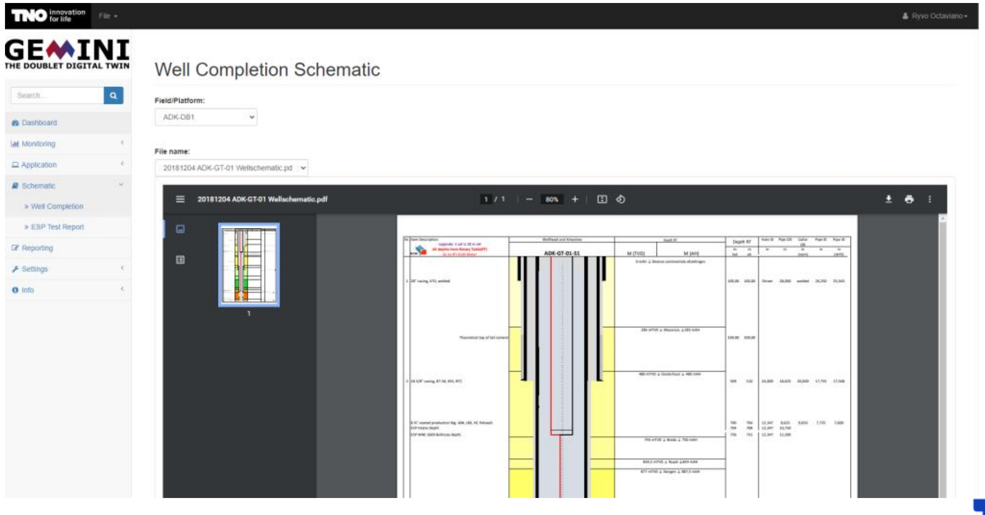


# GEMINI

- A flexible web-based framework for real-time **monitoring, forecasting** and **optimization**
- Act as an assistant to the operators of geothermal and ATES systems
- Centralized location to access all the (updated) data
  - Performance, integrity and environmental footprint monitoring
  - Critical processes (scaling, erosion, corrosion)
  - Production and operation advisory system



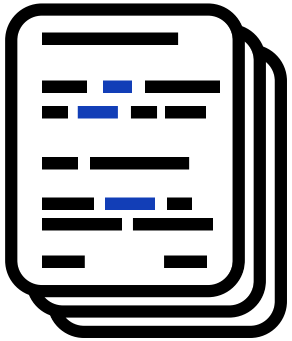



# Case studies

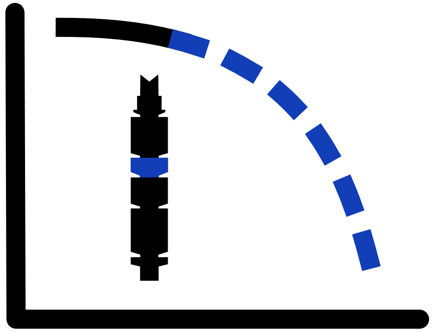
- Three sites:
  - Trias Westland
  - HAL
  - GENOVATIVE Storage well at RCSG

- The functionalities to be developed and demonstrated in the project:

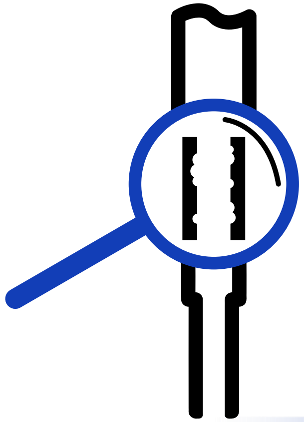
**Text data analysis**



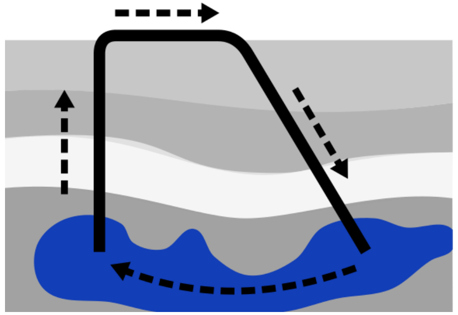
**Predictive maintenance**



**Well integrity management**



**Subsurface integration**

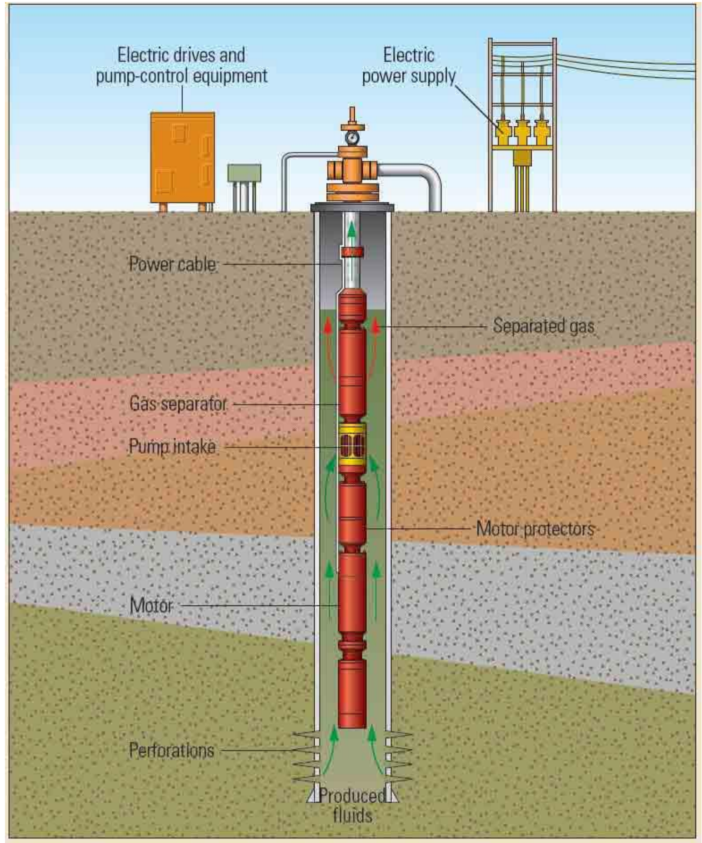


# Example: Predictive maintenance

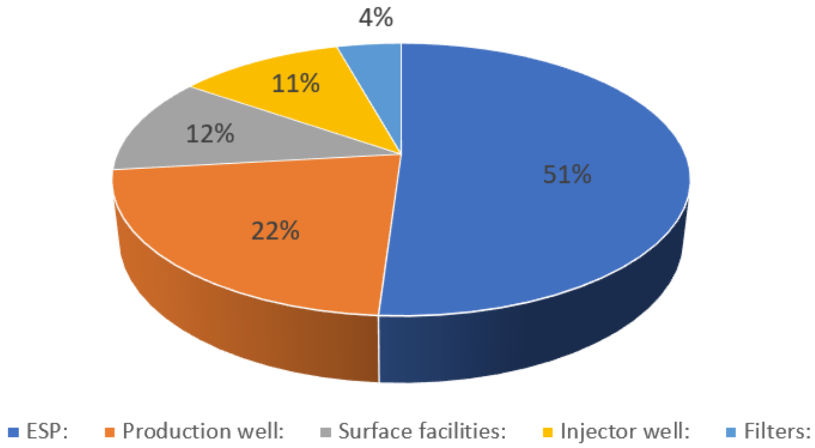
A critical equipment in geothermal assets is ESP;

- Sometimes relatively **short lifetime** (~ 1-2 years)
- ESP operational envelope should accommodate with production variations (P, rates, clogging,...)
- Lack of **proactive monitoring** of system performance during operation
- High **costs** associated with **ESP inspection** and **replacement**

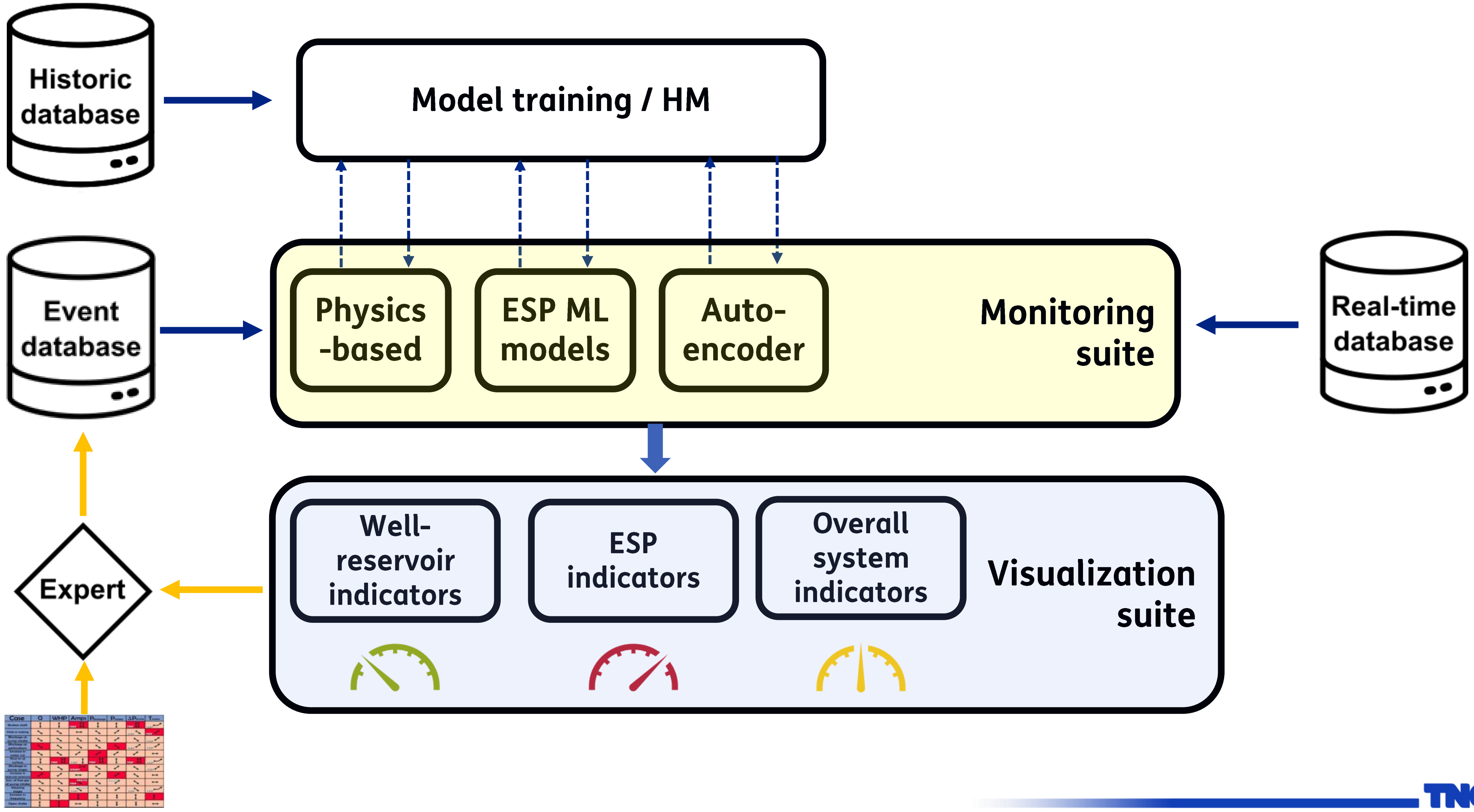
**Suboptimum operation** of the ESP caused by lack of proper monitoring and operator errors



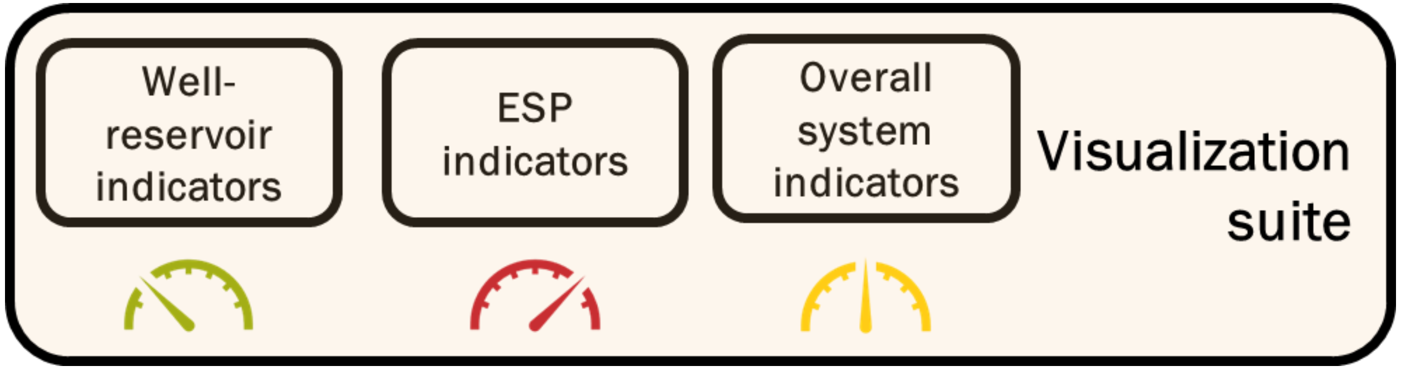

Annual OPEX of each component, operator 1

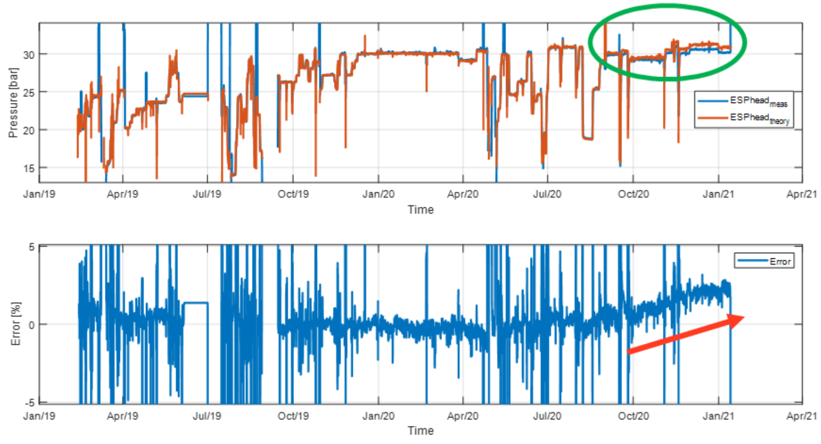


# Workflow for Predictive Maintenance

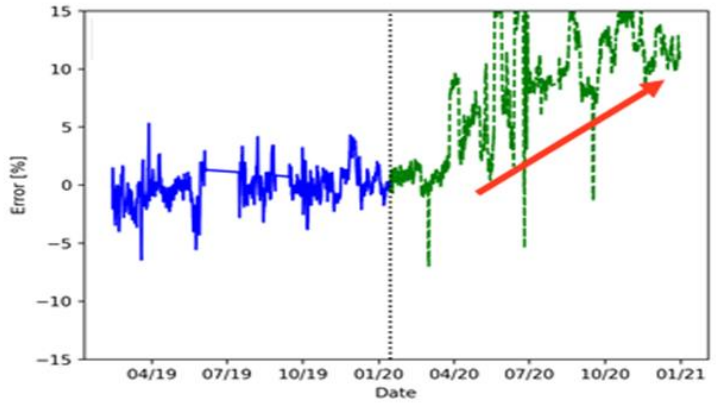


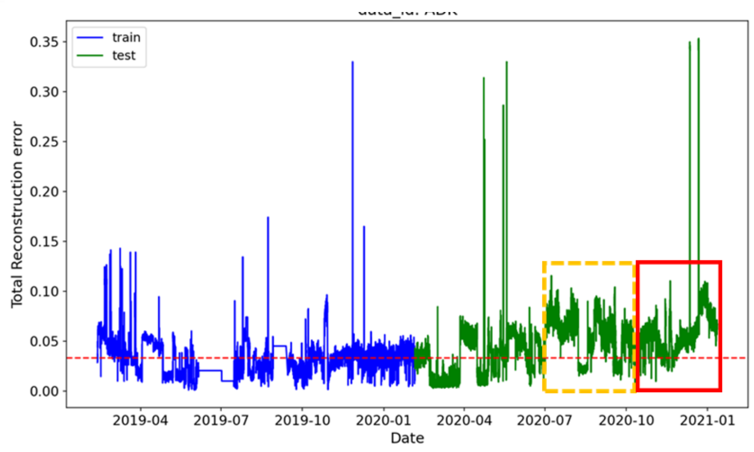
# Example: Predictive maintenance




ESP vibration

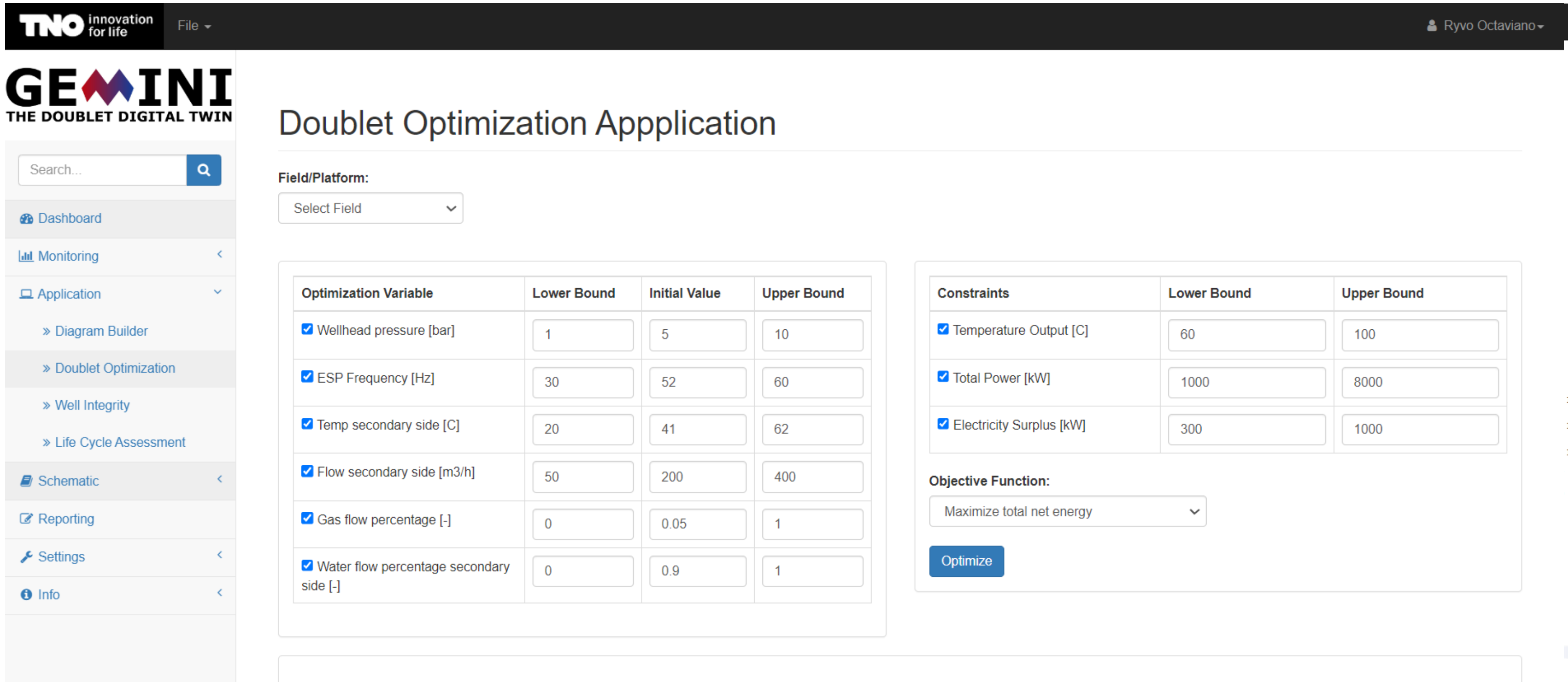



Early signs of degradation visible 6 months prior to the failure.

# Virtual Platform – Operation Scenarios Evaluation

- Optimize geothermal operating condition parameters
- Maximizing the following objective functions:
  - Total produced power
  - Minimum power consumption
  - Minimum CO2 emission

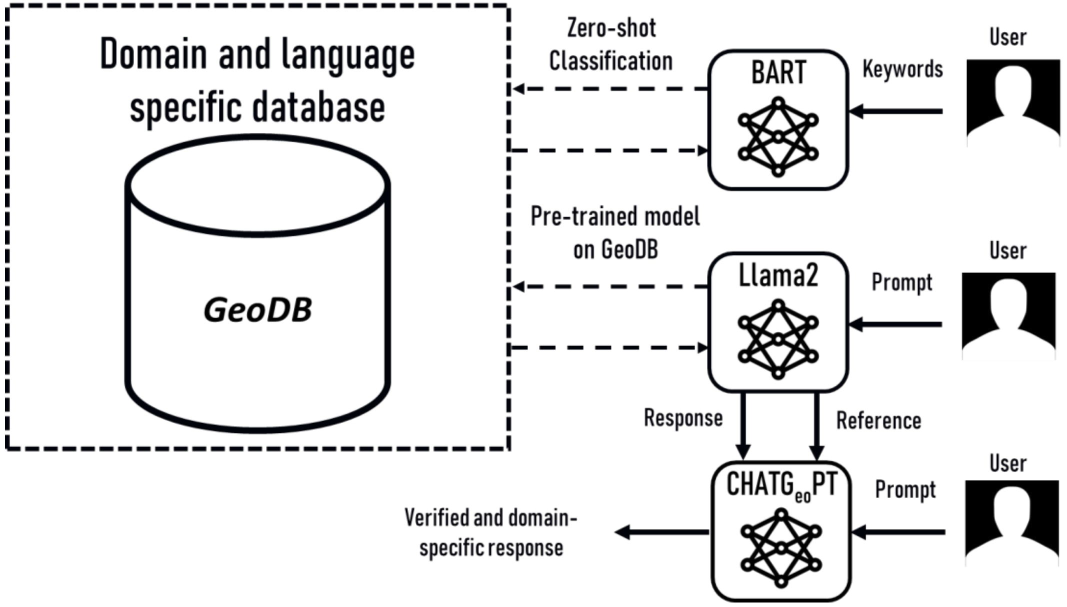


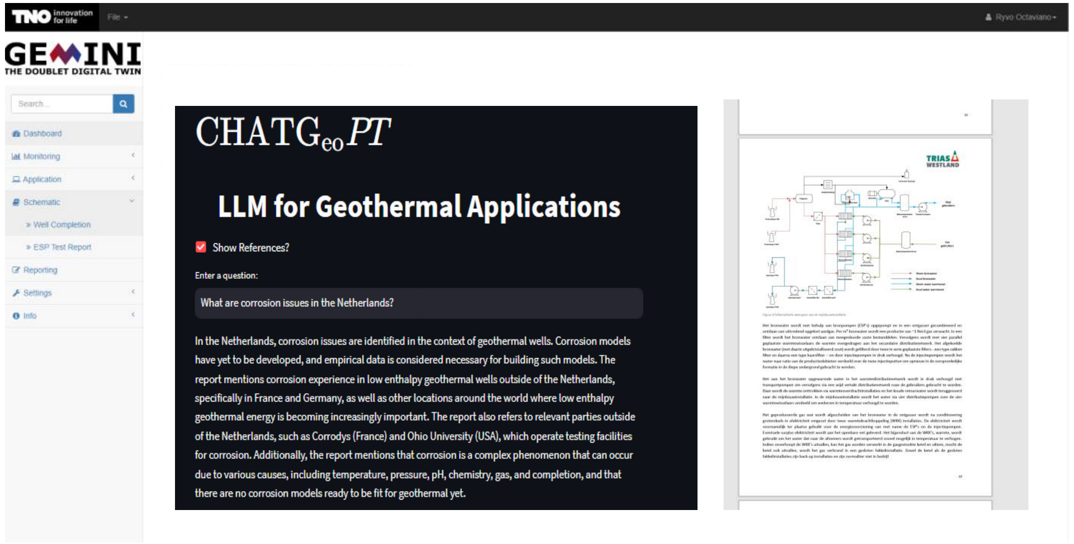

# Faster Access to Documents

- On average 20% of time is spent to search for the correct document
  - Shift and maintenance reports
  - Tests reports
  - Product catalogues and specifications

- The rise in Large Language Model (LLM) can significantly speed up the process

- ChatGeoPT functionality in GEMINI:
  - Connecting to a large publication and article database
  - Connecting to company internal documents
  - Provide references for the provided responses



# Why Open-Source?

| Project goals | Why open source? |
| --- | --- |
| • Improvement efficiency, flexibility and safety | • Efficient tool development for a growing market |
| • Efficient & uniform data for<br>• regulators and other stakeholders<br>• benchmarking and for collective learning<br>• monitoring system performance and emission | • Common set of public (open source) models for the calculation of key parameters |
| • Accelerate sector learning | • Transparent and trustworthy workflows which are reviewed by the whole community |

# Summary

- Digital twins can improve the operation of geothermal assets aiming at saving cost, increasing production and reduce downtime.

- A workflow is proposed to be demonstrated and being made open-source for the geothermal assets (direct use, heating).

- Further extension to power systems is possible.

- You can already be part of the community.

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Acknowledgement: Aardyn, HVC, Well Engineering Partners, Helin, Geothermie Nederland, The Netherlands Enterprise Agency (RVO)