

Assembly Meeting

WP 5: Value of Geothermal Production Data

Pejman Shoeibi Omrani, Leila Hashemi, Aron Schouten, Stefan Belfroid, Laura Precupanu | TNO

Sabira Daskapan, Lonneke van Bochove | Stralingsupport BV

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Partners

WP5: Value of Geothermal Production Data

TNO innovation
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hvc.
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Geo4all
innovatieprogramma

Mede mogelijk gemaakt door:  **TKI NIEUW GAS**
Topsector Energie

Content

- **WP 5: Objective and Results**
- **Recap of work on Electrical Submersible Pump (ESP) data**
- **Work on Naturally Occurring Radioactive Material (NORM) data**

Aron Schouten, TNO

Sabira Daskapan, Stralingsupport BV

WP 5: Objectives and Results

Objectives:

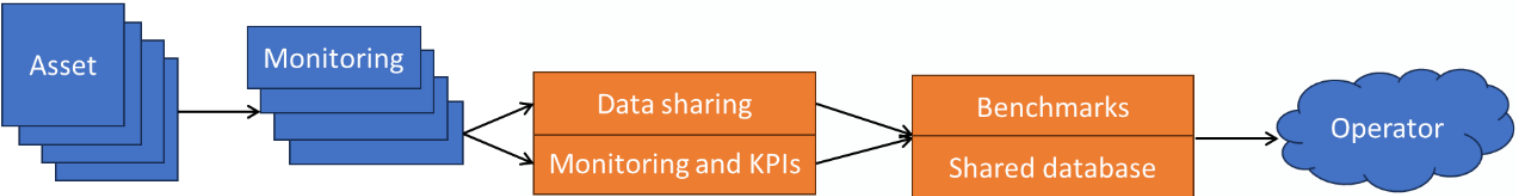
- **Enhance the operation and design** of geothermal installations through better data utilization and acquisition
- Calculate and **benchmark Key Performance Indicators** (KPIs) for geothermal plants, focusing on overall performance and critical components
- Investigate and qualify options for **improved data acquisition**, providing an overview and assessment of monitoring options

Expected Results:

- **Standard templates** for critical components and their key characteristics
- **Benchmark database** for doublet performance and energy consumption
- **Shared database** on equipment performance and failures for better decision-making
- Overview and assessment of **data acquisition and monitoring options**

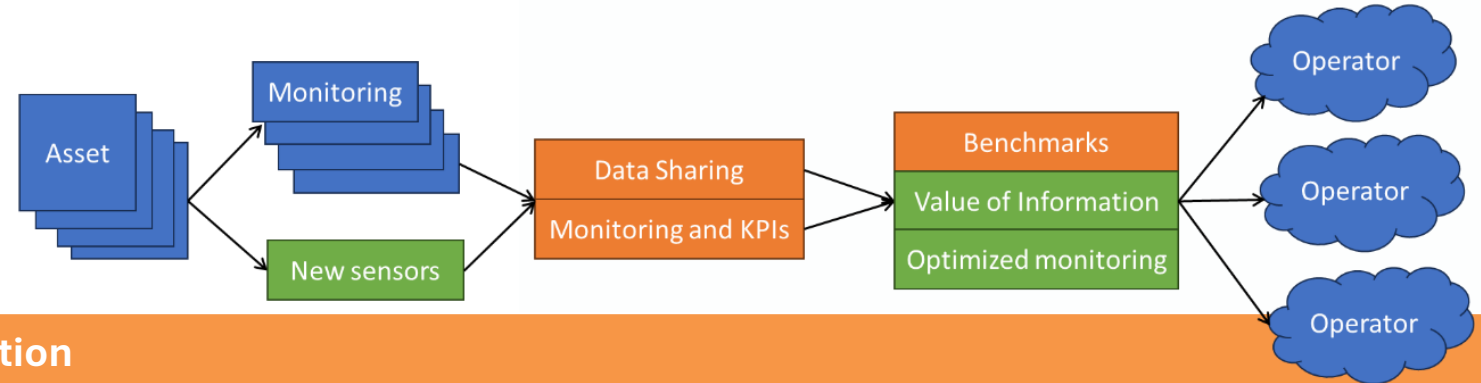
WP 5: Activities

WP5.1: Existing data



Activity	Description
5.1.1 Standards for KPI's	What are the essential data to be collected Can we derive KPIs from existing data in a standardized way? How can we make predictions and recommendations for operational settings or design improvement?
5.1.2 Data sharing and Benchmarking	What is gained by sharing data from multiple assets and what is the added value?

WP5.2: New data



Activity	Description
5.2.1 Data acquisition option evaluation	What options are available and how can we predict/evaluate their added value?
5.2.2 Data acquisition field evaluation	Is the predicted added value in line with field observations?

Recap of work on Electrical Submersible Pump (ESP) data

Pejman Shoeibi Omrani, Leila Hashemi, Aron Schouten, Stefan Belfroid, Laura Precupanu | TNO

Recap of Work on ESP Data

Worked on:

- Data collection & formatting
- Automated feature extraction
 - Service time & uptime
 - Number/duration of start-ups
 - Number/duration of shut-ins
 - Frequency changes
 - Etc.

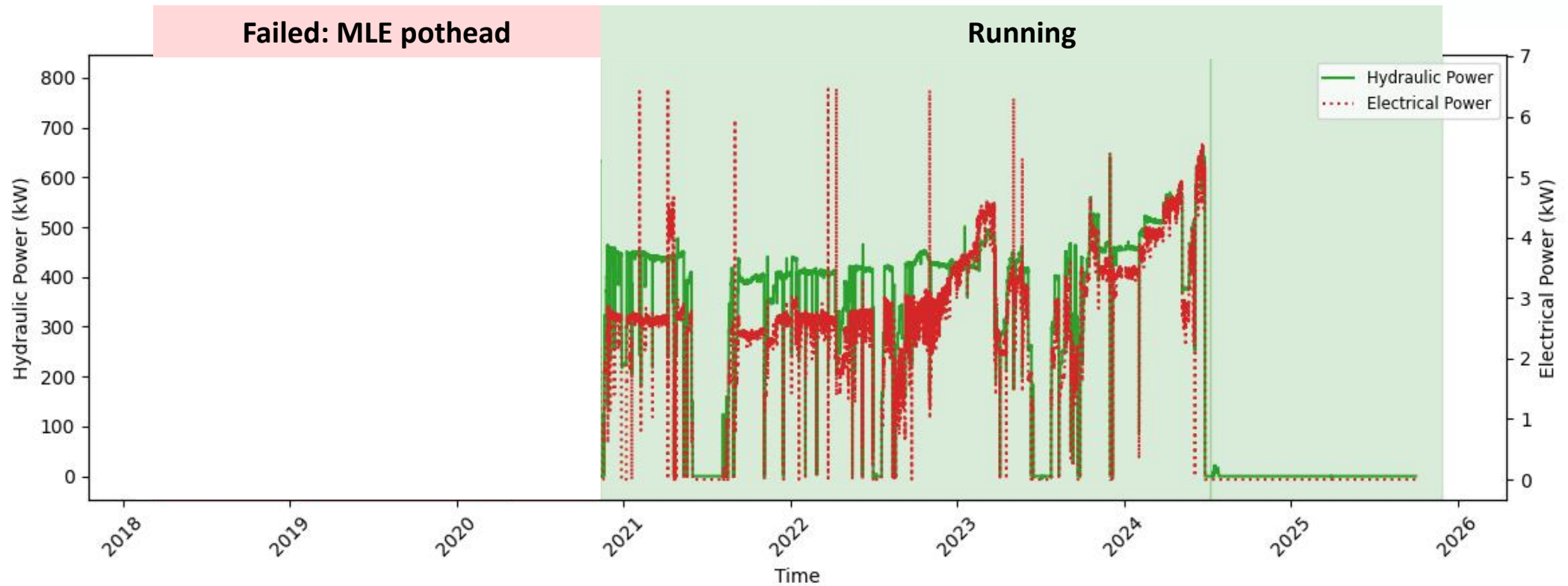
- Preliminary observations
 - E.g.: start-ups, shut-ins and freq. changes are correlated with a shorter service time
- Collaboration with IEG Fraunhofer (workshop)
 - Identified new parameters of interest: Power traces and startup procedure

	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7	Well 8	Well 9	Well 10	Well 11	Well 12	Well 13	Well 13	Well 14	Well 15
Brine flow rate	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes
wellhead pressure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
wellhead temperature	Yes		Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
intake pressure ESP	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes	Yes	Yes
intake temp. ESP	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes	Yes	Yes
discharge pressure ESP							Yes								Yes	Yes
discharge temp. ESP										Yes	Yes					
ESP Motor temperature	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Vibration (Vx)		Yes		Yes	Yes			Yes	Yes	Yes	Yes					
Vibration (Vy, Vz)	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes		
ESP voltage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Freq. ESP	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ESP Elec. Current	Yes		Yes		Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Temp. Upstream Heat exchanger							Yes			Yes	Yes				Yes	Yes
Temp. Downstream HEX							Yes			Yes	Yes				Yes	Yes
Pressure upstream HEX							Yes			Yes	Yes				Yes	Yes
Pressure downstream HEX							Yes			Yes	Yes				Yes	Yes

Recap of Work on ESP Data

ESP power traces:

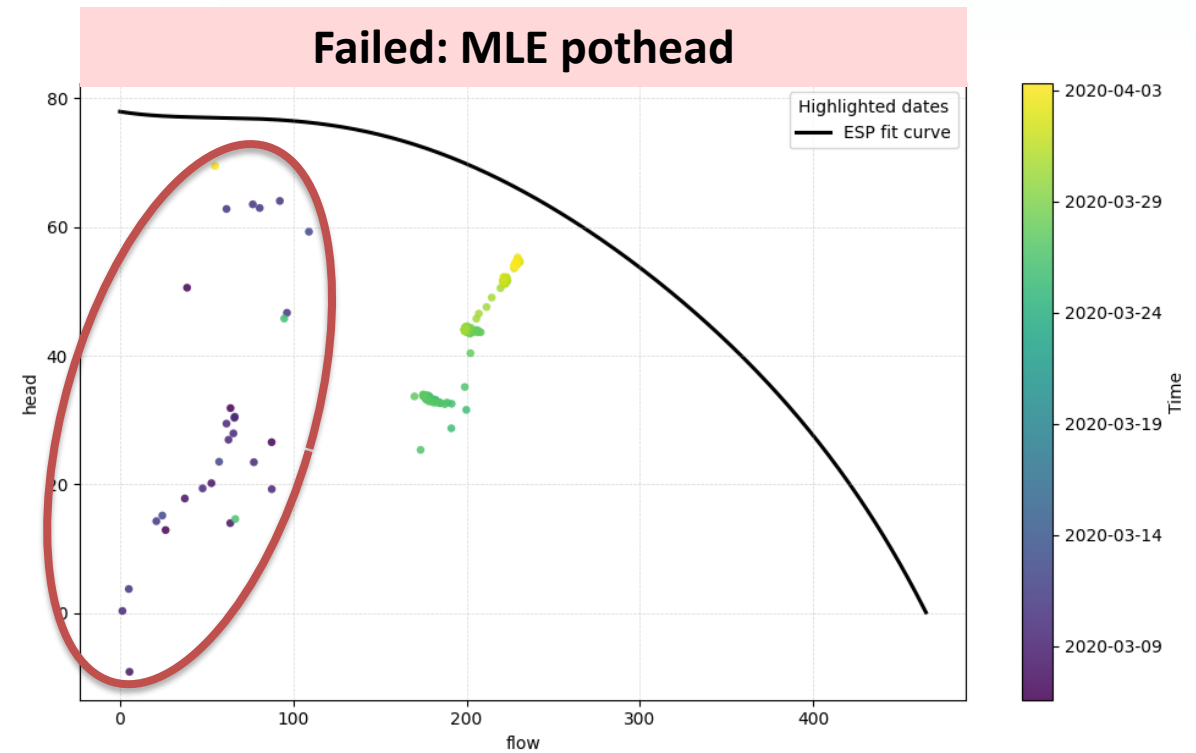
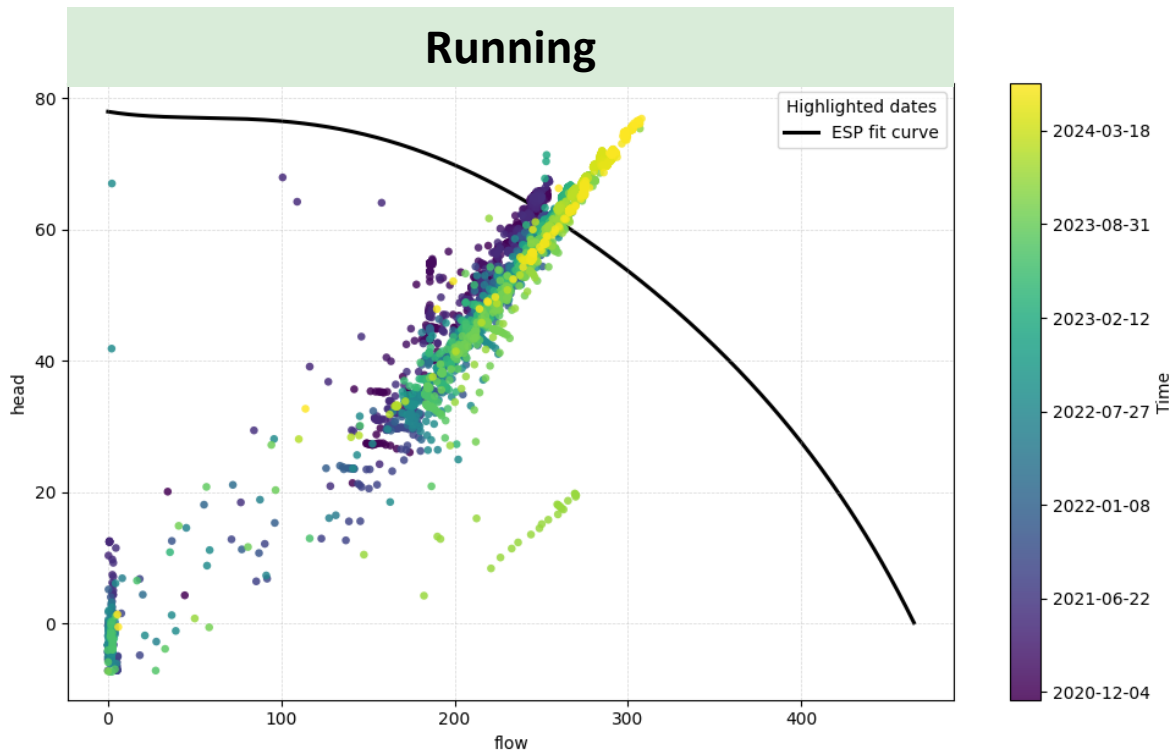
- During normal operation, hydraulic and electrical power align
- Before a failure, power traces show unstable operation



Recap of Work on ESP Data

ESP pump curves:

- Colored points: measured operating conditions at different dates
- Startup pump curve deviations are visible in the failed case but absent in the stable example



Recap of Work on ESP Data

- What's shown here is not our only work on ESPs
 - If interested ask colleagues!



**Shoeibi Omrani, P.S.
(Pejman)**
Senior scientist



Hashemi, L. (Leila)
Scientist Innovator



Precupanu, L.I. (Laura)
Senior Project Manager

Work on Naturally Occurring Radioactive Material (NORM) data

Pejman Shoeibi Omrani, Leila Hashemi, Aron Schouten, Stefan Belfroid, Laura Precupanu | TNO

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Introduction and Follow-up

Goals:

- Alternative waste routes: predict future amounts of NORM waste
- Seek for a correlation between installation criteria and deposition of NORM
- Database for research on NORM deposition: identify the criteria involved in NORM deposit mechanisms
- Prevent the creation of NORM waste
- Research on re-use of NORM waste: exploring more sustainable handling of NORM waste

14

sites represented

6

different formations

23

doublets documented

172

filters with Pb-210 measurements

11

sites with water chemistry

Final results:

- Memo: Setting up overview of types of NORM waste in geothermal operations
- Memo: Predictions of development in growth in waste in geothermal sector
- Memo: Based on TNO analysis look for possibilities of NORM waste reduction
- Reporting on conclusions (conference/journal article)

Overview on NORM Waste

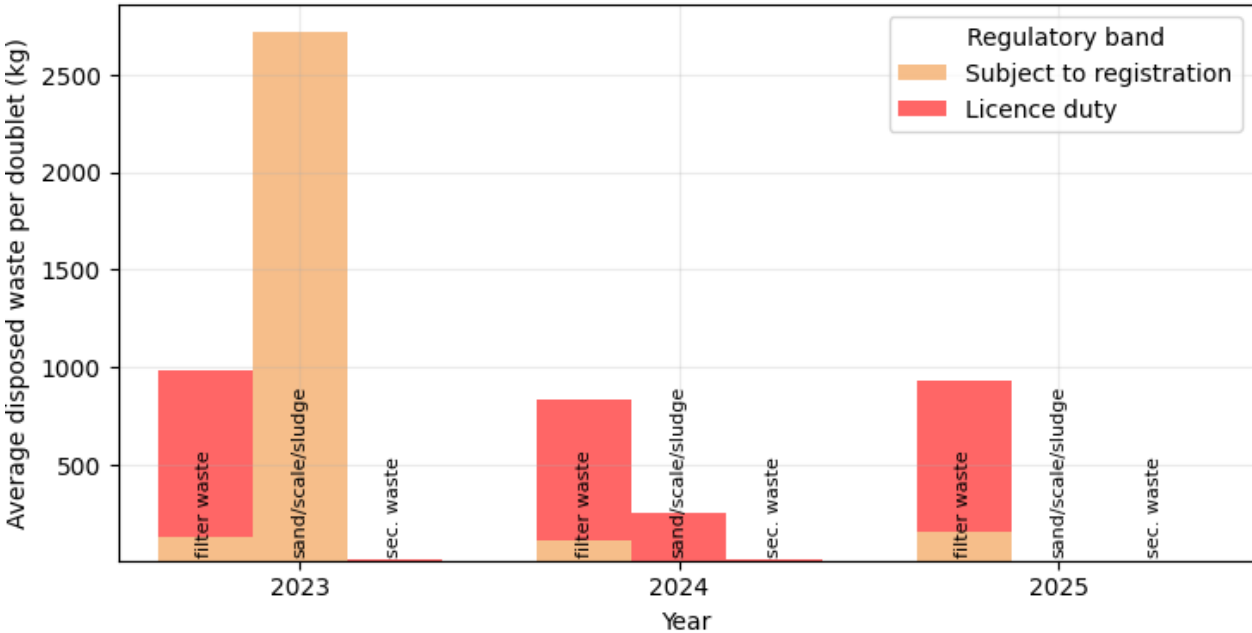
Status quo on waste:

- Amount of disposed waste (kg), averaged per doublet (2023-2025)
 - Breakdown into filter waste, sand/scale/sludge and secondary waste
 - Colors show the required disposal route
 - **Note: Underestimation: RV and surface objects not included**
- NORM waste per doublet: $\pm 1\,914$ kg per year
 - 35 doublets in 2025 $\rightarrow$ 66 990 kg in 2025
- Given expected* growth Masterplan Aardwarmte:
 - 2030: 334 950 kg
 - 2050: 1 339 800 kg
- Given expected* growth Rijksoverheid (EZK):
 - 2030: 133 980 kg
 - 2050: 861 300 kg

Tabel 1 Verwachte groei sector *

Jaar	2018	2025	2030	2050
Sector (Masterplan Aardwarmte)				
Aantal doubletten (#)	17	75	175	700
Toename (aantal nieuwe doubletten per jaar)	1-2	10	20	25
Rijksoverheid, Ministerie van EZK				
Aantal doubletten (#)	17	35	70	450
Toename (aantal nieuwe doubletten per jaar)	2-3	5-10	15-20	20

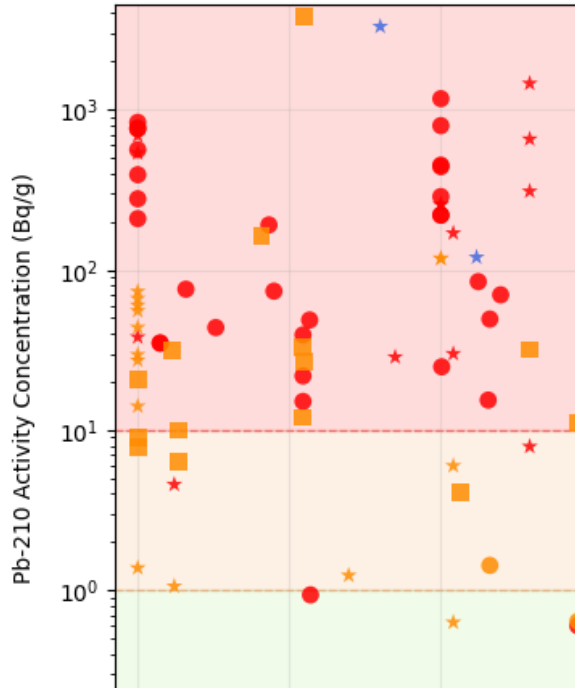
Reality: ± 35 doublets in 2025

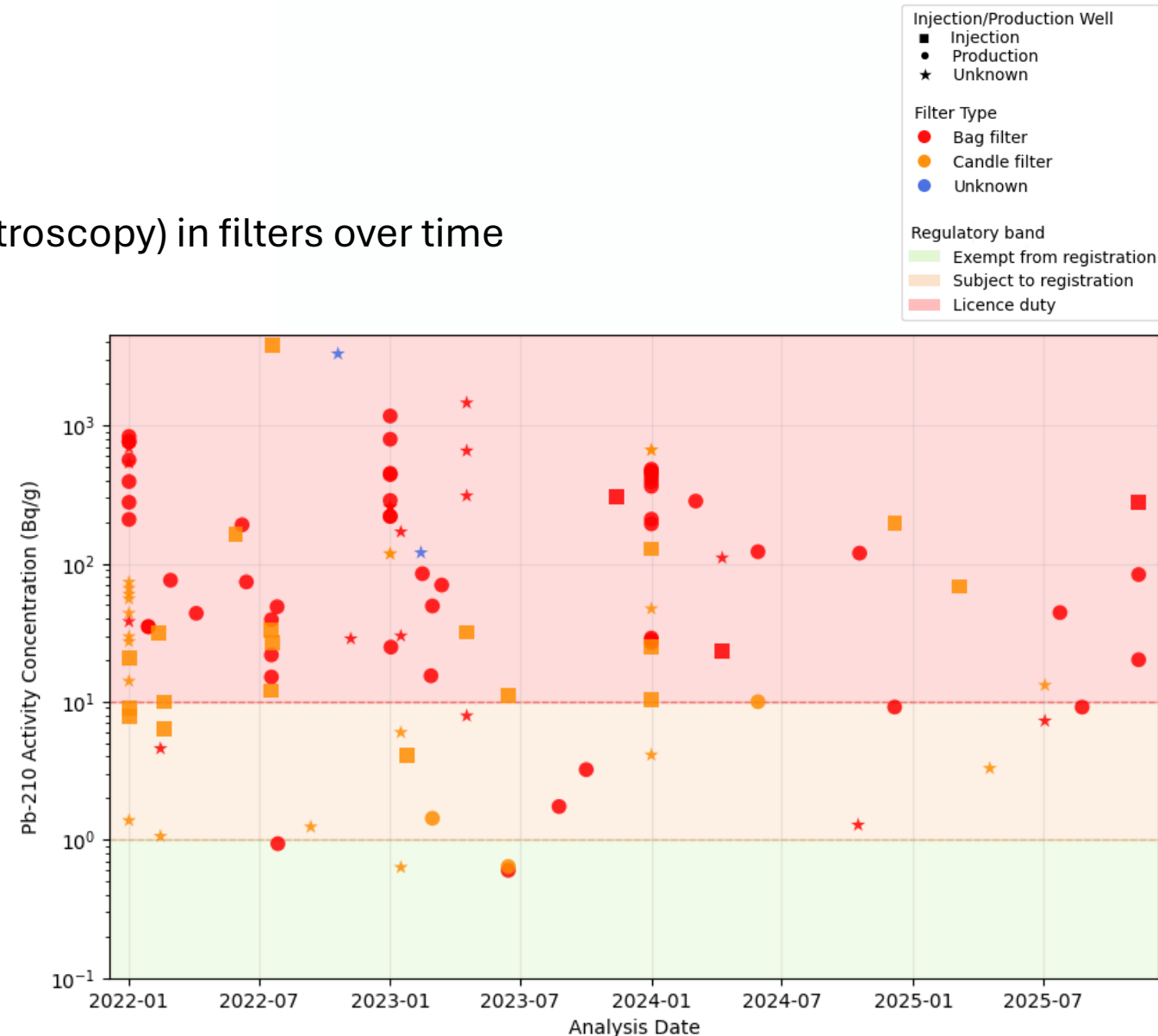


* Geothermie Nederland. (2022). Inventarisatie filterafval uit de geothermie: Systematische dataverzameling geothermisch afval voor een duurzame toekomst.

Overview on NORM waste

Status quo on waste:

- Pb-210 activity concentration (gamma-ray spectroscopy) in filters over time
 - Color: bag vs candle filter
 - Symbol: injection vs production filter
 - Background: regulatory disposal category
 - Data from many operators, clear overview of:
 - Distribution across disposal categories
 - Temporal trend: no in/decrease
 - The (large) variation in activity
 - *Can we predict activity concentrations?*
 - *What are main drivers of high activity?*
- 



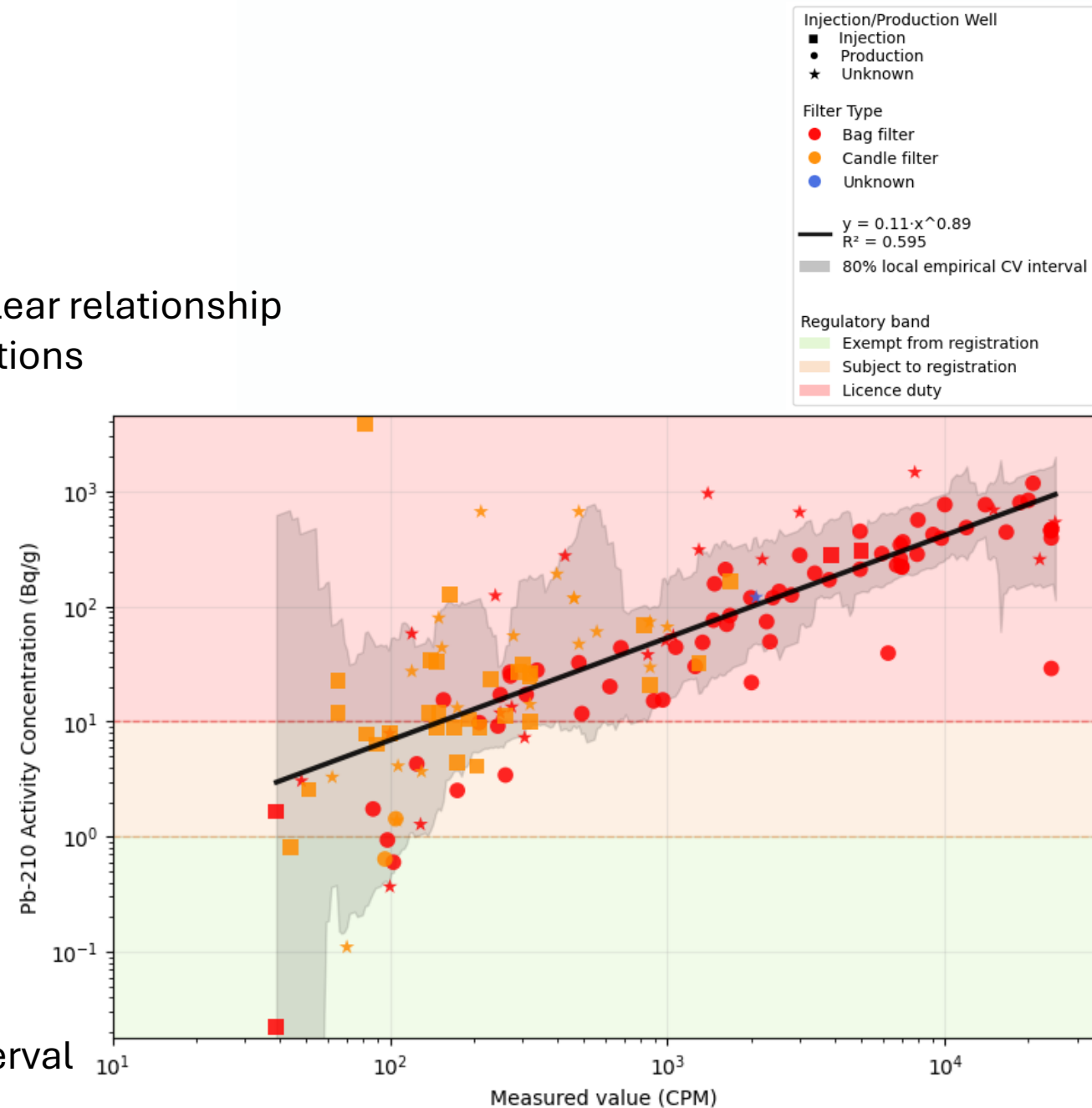
Prediction of NORM waste

Predict activity using CPM:

- CPM and Pb-210 activity concentration show a clear relationship
 - We can fit a model (black line) to make predictions

- Also include a prediction interval (gray area)
 - “Based on prediction performance of the model, a future sample with x CPM is expected to have a Pb-210 activity concentration between y_1 and y_2 approximately 80% of the time.”

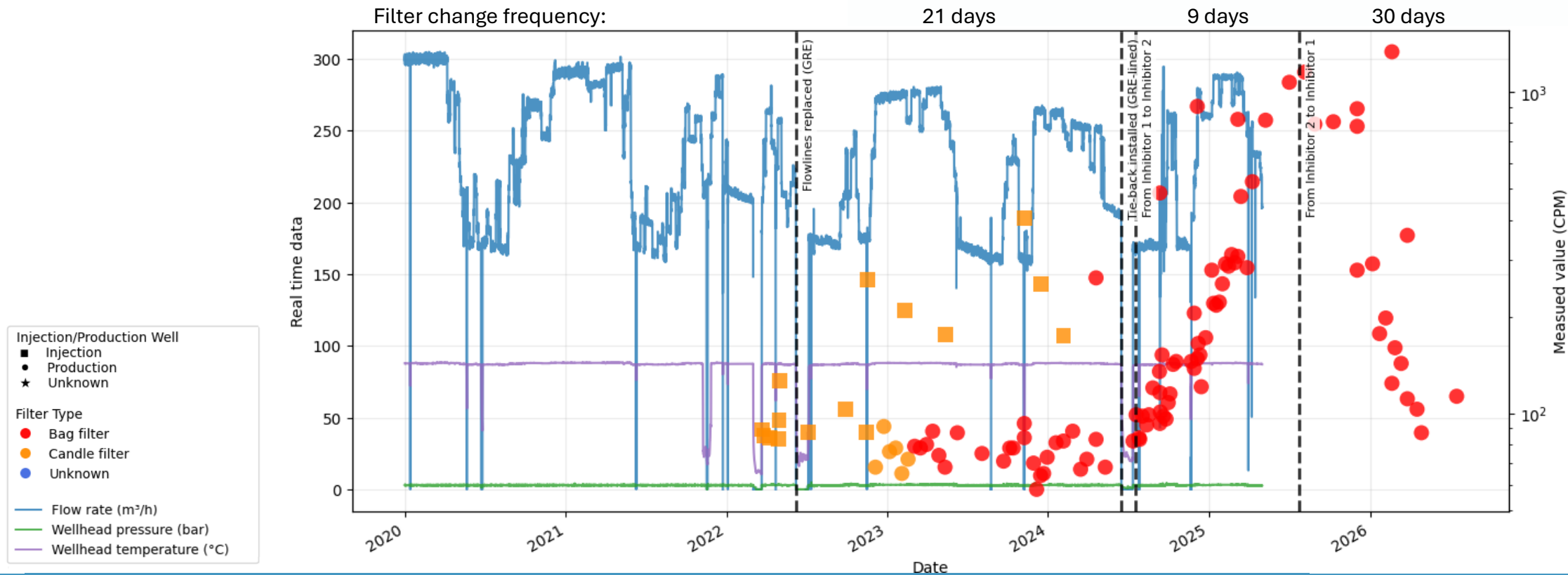
- < 117 CPM: All categories remain possible
- 117-771 CPM: Exempt from registration unlikely
- > 771 CPM: Registration also unlikely
- **Note: Way of measuring differs per operator**
 - Standardized WOW might reduce width of interval



NORM Waste Reduction

What drives NORM activity?

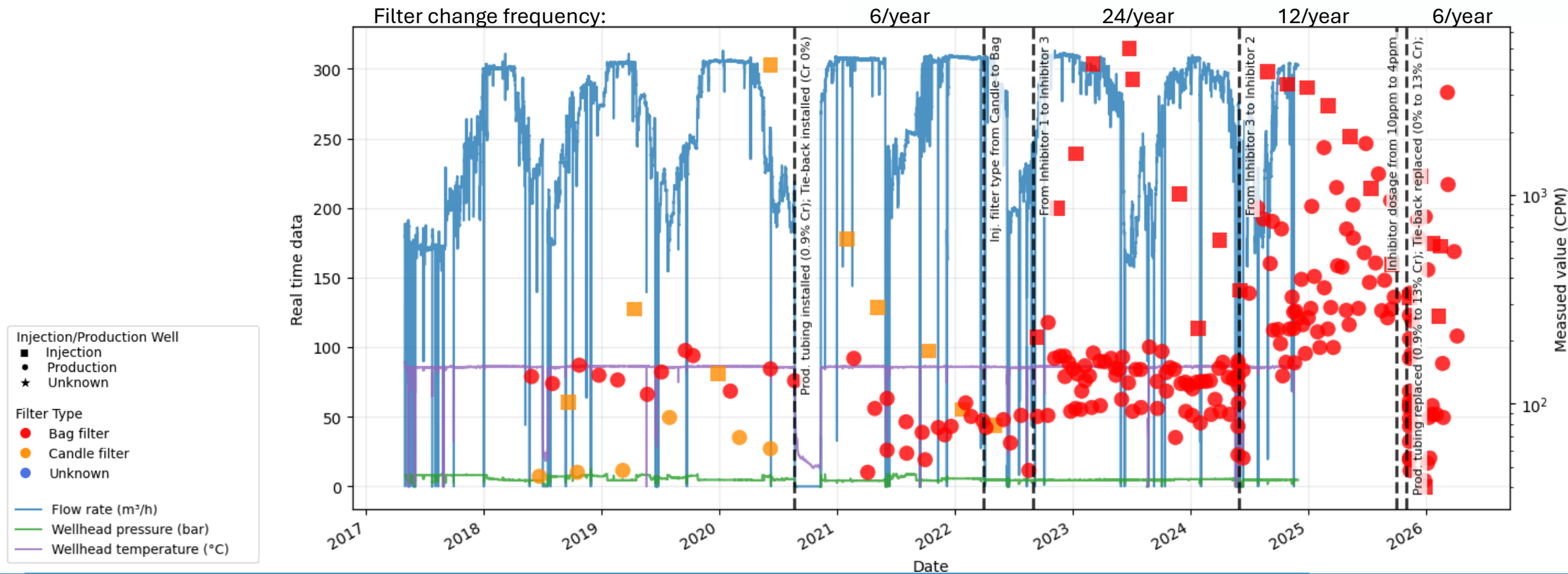
- Zoom into specific projects with detailed register/data collection
 - Operation (production) data, installation changes, inhibitor changes and measured CPM
 - Not only activity, but also exchange frequency rises after inhibitor change



NORM Waste Reduction

What drives NORM activity?

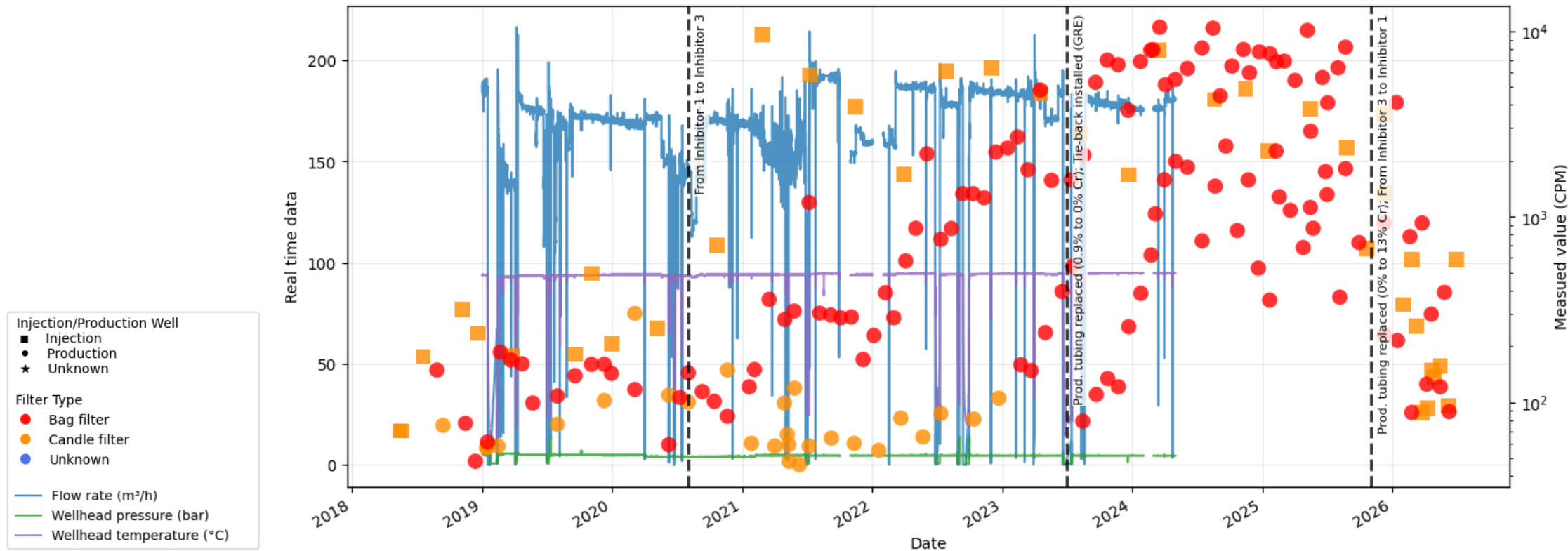
- Another doublet, same observations
 - Material type also seems to have an influence



NORM Waste Reduction

What drives NORM activity?

- No significant change in filter change frequency but significant rise in measured value in filters
- Again, material type seems to have an influence



Summary of Observations

In short:

- Given expected growth of the sector waste management can become a relevant issue that should be anticipated at an early stage
- No significant in- or decrease in activity concentration over time
- Correlation between measured value and activity concentration, but to be able to anticipate the legal status of a measured item more data is needed and the way of measurement needs to be standardized
- When zooming into three selected projects it seems the corrosion inhibitor and material type can influence both activity concentration and change frequency of filters → this information might allow operators to adjust operational parameters and optimize the process and thereby reduce waste generation

What's next:

- Further exploration of the data
- Report findings
- Present at the European Geothermal Workshop 2026, Germany with an oral presentation: *Learnings from 15 Years of Geothermal Operational Data in the Netherlands*