



## Sensorless condition monitoring for ESPs

*SAM4 is Samotics' Smart Asset Monitoring solution that is based on electrical signature analysis*

June 2023

# Company introduction



- Samotics is a **Dutch technology company** founded in '15
- Using artificial intelligence, we provide **solutions to eliminate unplanned downtime, improve performance, and reduce energy waste** in industrial electric motors and rotating equipment
- We are the market leader in **electrical signature analysis** technology

75+

employees

+125

customers

10+

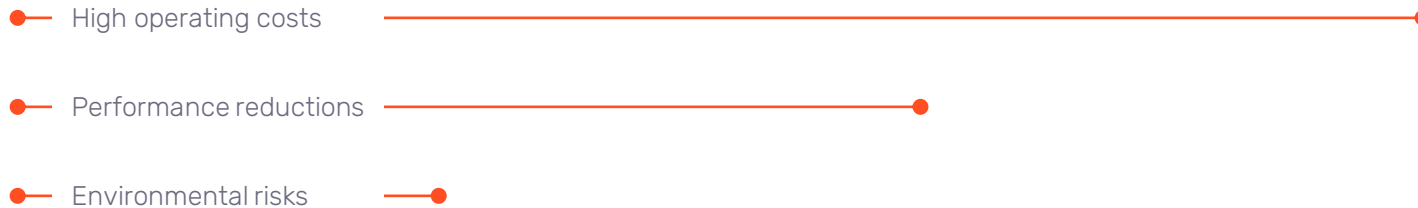
countries



Electric submersible pumps are mission critical assets, and single points of failure. Optimizing their efficiency, reliability and uptime is essential.



# ESPs have critical problems



SAM4 is a plug & play monitoring system for ESPs that detects faults at an early stage and offers real-time, actionable insights that help to increase performance, reliability and energy efficiency.

*It performs better than traditional systems, at a fraction of the costs.*



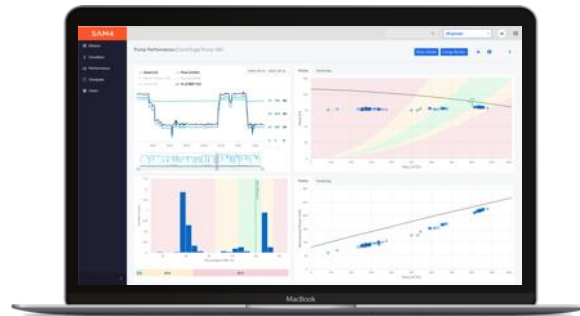
SAM4s provides real-time actionable information to improve performance, reliability, and energy efficiency

Identify failing and degrading assets



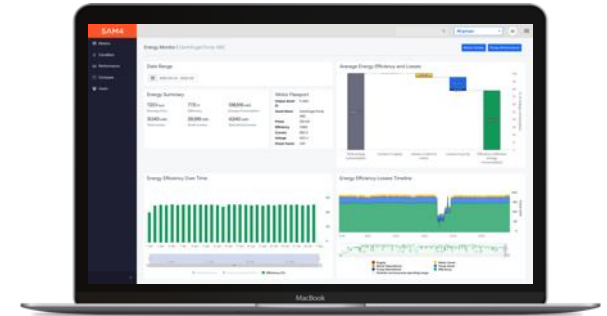
*asset health*

Continuously optimize performance...



*pump performance*

...and energy efficiency



*energy efficiency*



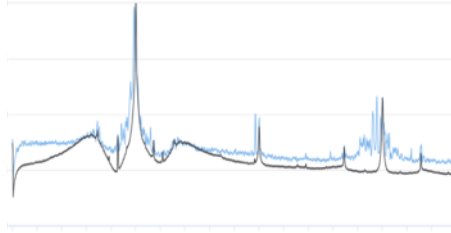
It is a plug & play system that analyses high-frequency electrical data from inside the motor control cabinet

### Installs inside the motor control cabinet



*High-frequency electrical data acquisition*

### Cloud & Edge signal processing & AI analytics



*Turns data into health, performance, and energy efficiency information*

### Real-time, actionable information and alerts

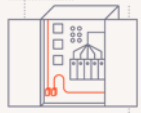


*Asset health, performance, and energy insights*

SAM4 is based on Electrical Signature Analysis (ESA) technology, which is the general term for asset monitoring techniques that analyse current and voltage sinewaves to provide insights into the **condition, performance and energy consumption of electric motors and rotating equipment**



# SAM4 offers several key benefits, that jointly drive value-add



## EASY TO INSTALL

Monitors from inside the motor control cabinet, without the need to install any sensors downhole



## HIGH DETECTION ACCURACY

Detects faults across the entire drivetrain with +90% accuracy, and alerts for harmful operating conditions



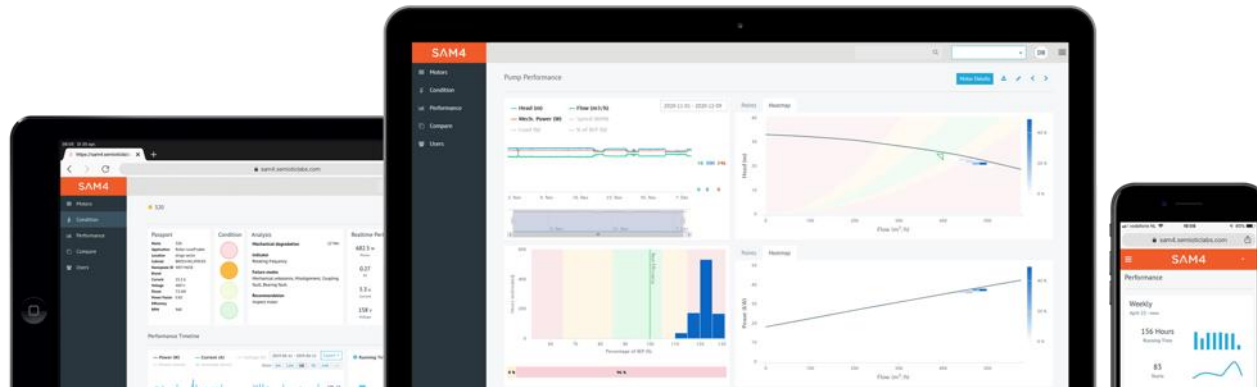
## ACTIONABLE INSIGHTS

Offers actionable insights that help to improve the pumps' performance and energy efficiency

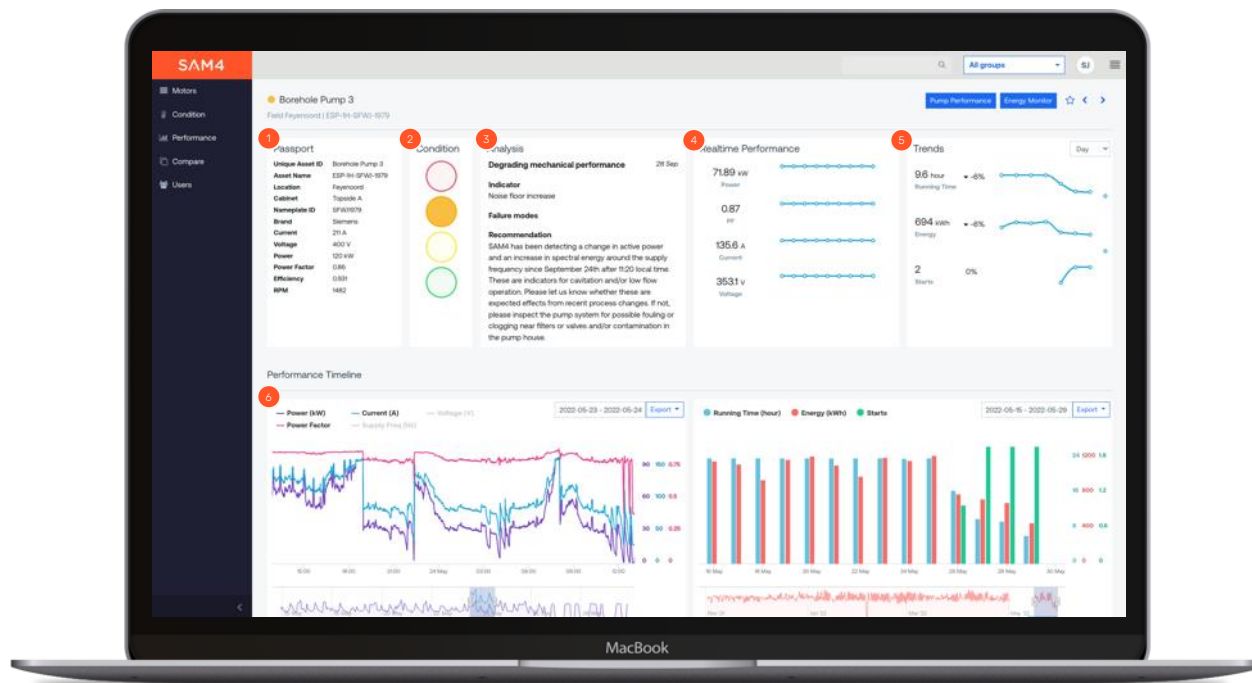


## PROVIDED AS A SERVICE

Provided as a service and available across the globe based on 24/7 support



# SAM4 monitors 24/7, detects developing faults at an early stage, and sends an alert when that happens



- 1 Asset information
- 2 Urgency indication
- 3 Failure analysis

- 4 Real-time energy metrics
- 5 Performance trends
- 6 Performance timelines

## Detectable faults & process issues (non-exhaustive list)

### Power Source

- Current PQ
- Harmonic distortion
- Voltage unbalance

### Coupling

- Coupling eccentricity
- Unbalance
- Misalignment

### AC motor

- Bearing faults
- Broken rotor bars
- Winding looseness

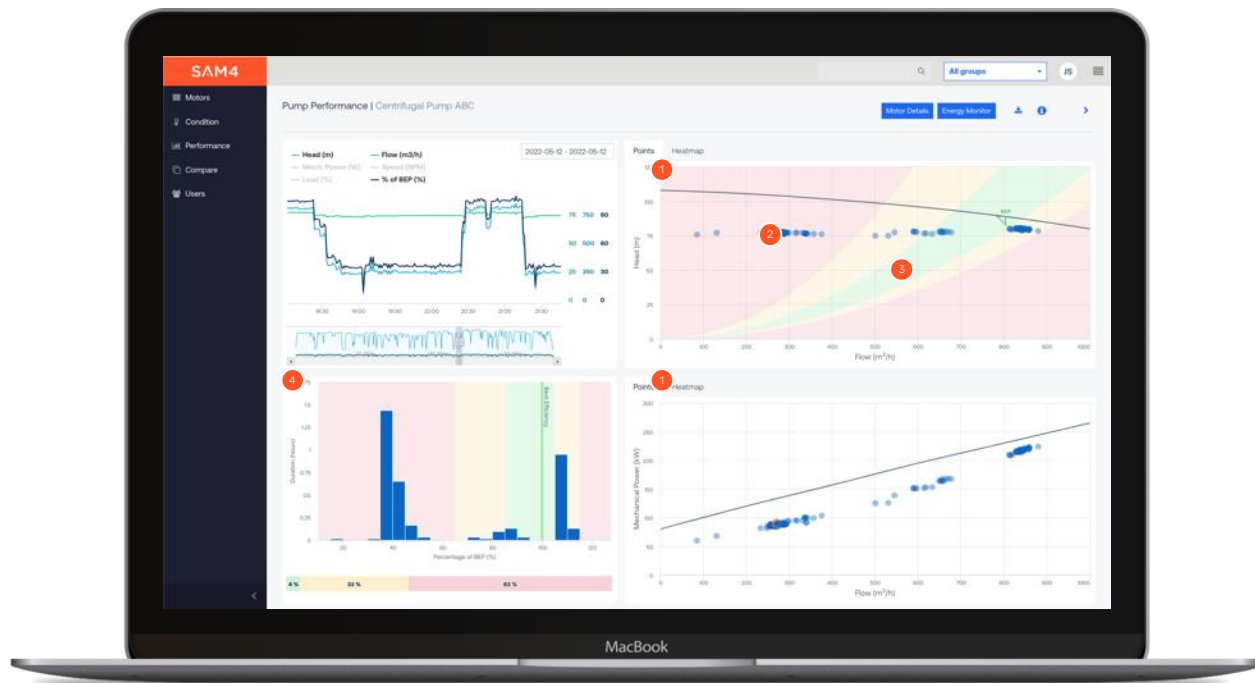
### Pump

- Cavitation
- Sand & solids intake
- Gas intake issues





# The real-time pump performance curve enables operators to optimize performance and run time

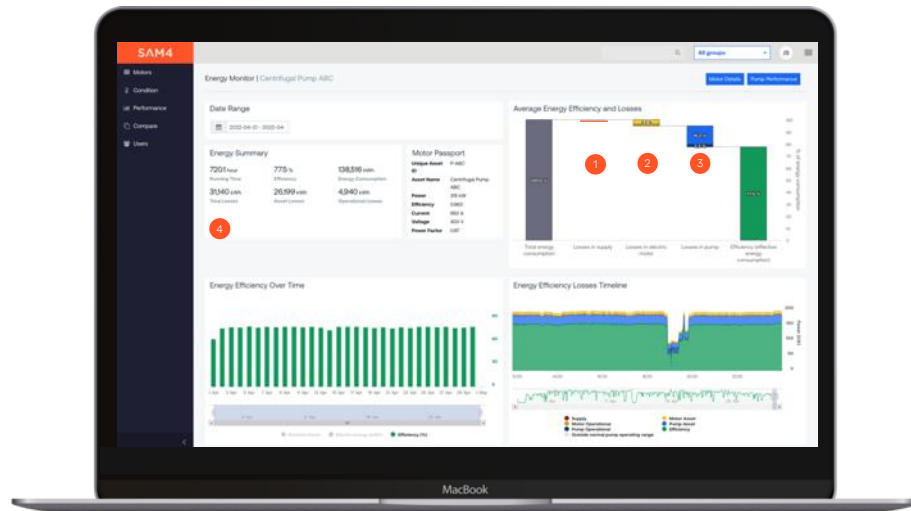


SAM4 automatically plots a centrifugal pump's operating points relative to its BEP, in real time. Thanks to the pump affinity laws, you can use the pump's wheel speed and power consumption to track changes in head and flow as it operates. Wheel speed and power consumption, in turn, are directly related to the instantaneous current and voltage the pump's motor is drawing. And current and voltage are precisely what SAM4 measures.

- 1 Pump & power curve
- 2 Blue dots represent an operating point
- 3 Ideal, acceptable and damage-prone operating ranges
- 4 Histogram of Relative Power vs. Percentage of BEP (%)
- 5 Time spent in the various zones during the selected timeframe

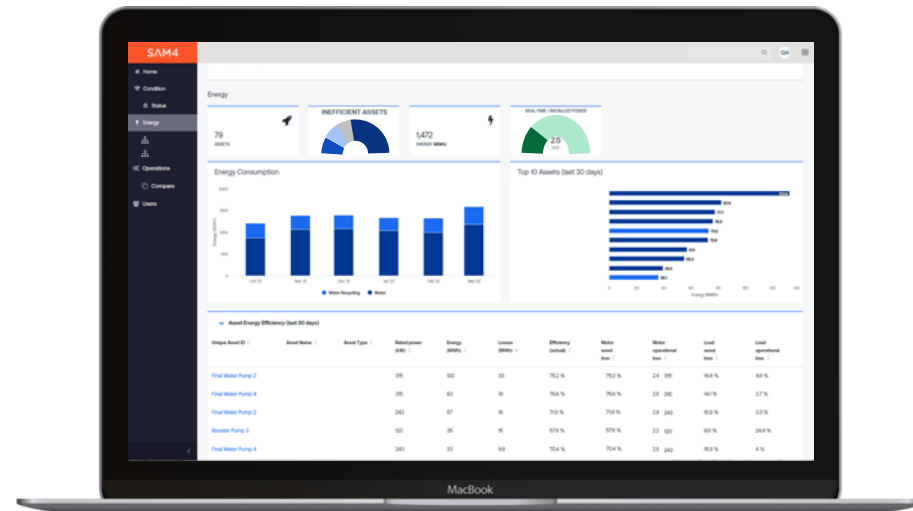


# Asset-level energy efficiency insights & reporting enable energy cost reductions of 10-15%



The energy efficiency dashboard breaks down energy inefficiencies into several components:

- 1 Inefficiencies within the electrical supply,
- 2 within the motor, broken down into design vs operational losses,
- 3 within the pump, broken down into design vs operational losses,
- 4 and presents a summary of potential energy savings



SAM4 ENERGY is independently available as a dedicated energy monitoring service, or as an add-on to SAM4.

It provides asset-, site-, and corporate-level identification and reporting on energy use, energy efficiency, and energy savings potential. SAM4 ENERGY includes a service that delivers concrete action plans to turn insights into savings.



# Early warning of VFD/control issues on a borehole pump

## Set-up

Borehole pumps are often used to pump up spring water to be processed and turned into drinking water. As a result, these pumps are often located in remote locations which are not easily accessible to maintenance personnel.

SAM4 triggered alarms on multiple anomalous patterns:

- an increase in noise on the frequency spectrum
- atypical behavior in active power for this particular asset
- sudden increases in total harmonic distortion

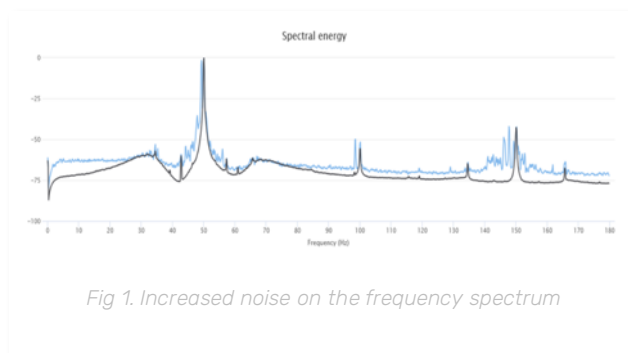


Fig 1. Increased noise on the frequency spectrum

## Detection

SAM4 detected an unstable supply frequency with an increase in active power and a decrease in power factor. This is an indicator of a pump struggling to keep its speed and load stable and therefore is likely to fail on short notice.

After being notified of the detected anomalies, the customer performed an inspection and found issues related to the variable frequency drive (VFD). The pump was overshooting the maximum current when supplied with 50 Hz.



Fig 2. Unexpected behaviour in active power for this asset

## Result

As a result of these discoveries the maintenance team adjusted the inverter settings of the VFD to prevent the pump from overshooting. A failure to notify the customer of these anomalies could have led to the pump failing which in turn could have led to a hefty loss of supply capacity.

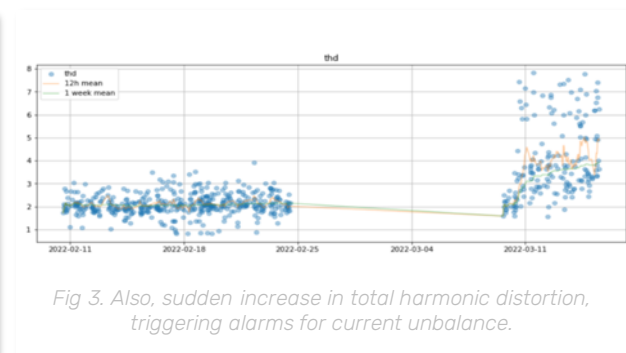


Fig 3. Also, sudden increase in total harmonic distortion, triggering alarms for current unbalance.

# Early warning of submersed borehole pump degradation

## Set-up

SAM4 is not solely used to monitor borehole pumps in extremely remote locations. In this specific case it detected **mechanical unbalance on a submerged borehole pump** in a larger production facility.



## Detection

The anomaly was flagged when a sudden increase of spectral energy at the rotational frequency of one specific pump was detected. **This is a clear indication of mechanical unbalance.** The customer was immediately notified upon which the decision was made to manually inspect and subsequently maintain the pump.

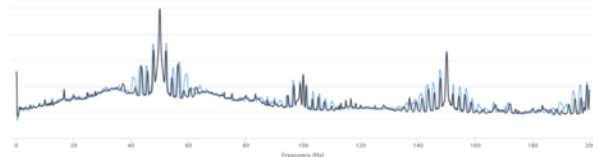


Fig 1. Spectral comparison between healthy and anomalous behavior

## Result

After the maintenance actions had been completed, the data confirmed that the pump's condition had stabilized.

**If the system had not flagged the anomaly, it could have led to serious pump damage and as a result significant supply capacity losses.**



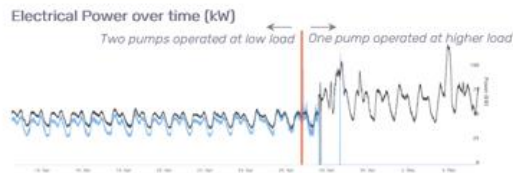
Fig 2. Sudden increase spectral energy at rotational frequency of the motor



# Energy optimization offers a strong ROI for pumps

## Use case 1: process optimization

Two pumps operate on low-load simultaneously



**Situation:** two pumps in a pumping station frequently operated in parallel, both operating at low loads, reducing their energy efficiency

**Recommendation:** switch to one pump operation, allowing it to run close to nominal load, increasing pump station efficiency

**ROI: >1000%**

No CAPEX investment required, efficiency improvement of 10 – 25% realized

## Use case 2: drivetrain optimization

Oil booster pump largely over-sized for operations



**Situation:** two oil booster pumps are operated at low flow conditions, resulting in high inefficiencies and energy loss

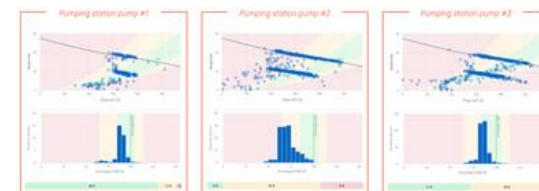
**Recommendation:** hydraulically re-rate pumps to operate efficiently at lower flows, allowing the existing pump to deliver required flow at lower power

**ROI: >175 - 200%**

Including CAPEX and labor costs, based solely on energy savings

## Use case 3: asset optimization

Three identical pumps operate vastly different



**Situation:** from three identical pumps, one operates less efficient than others. After analysis, it became clear this was caused by a broken impeller

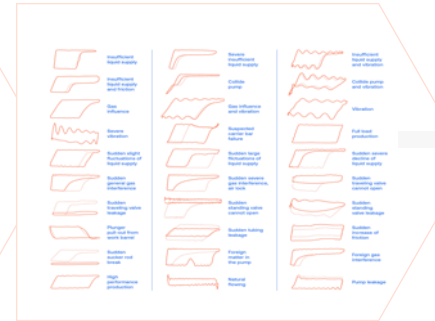
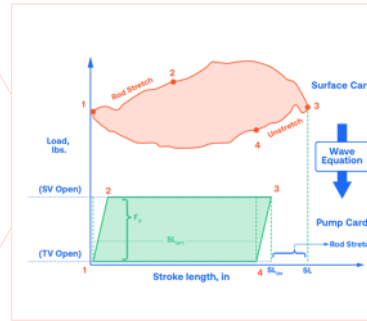
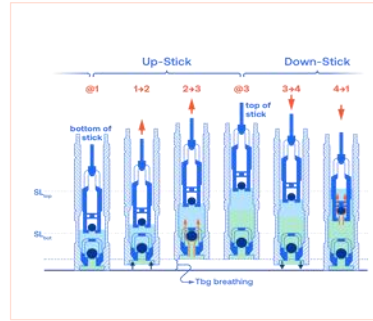
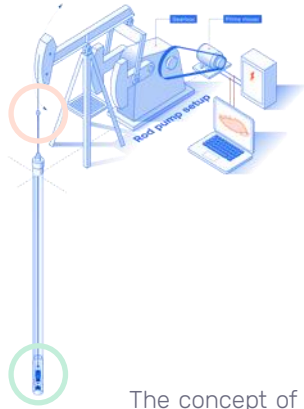
**Recommendation:** repair is unavoidable, full pump replacement is advised over part replacement - based on an ROI-calculation

**ROI: >30%**

Including CAPEX and labor costs, based solely on energy savings



# SAM4 for SRPs is under development and planned for launch in Q2, 2023



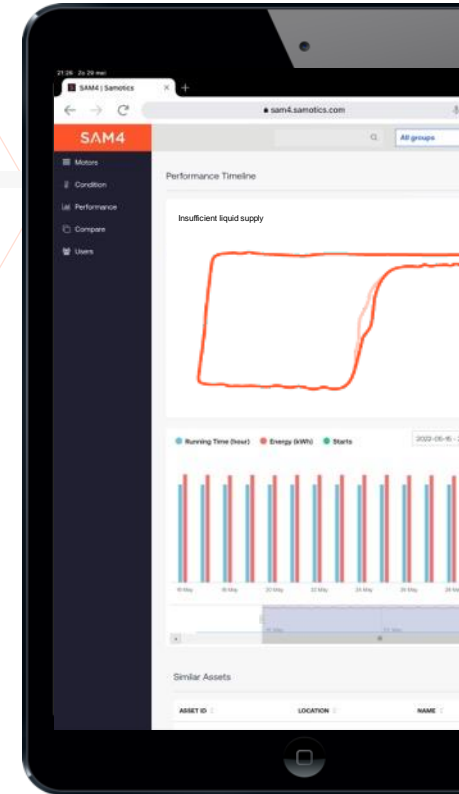
The concept of the *sensorless* dyno card is based on a similar (but not the same) approach as Samotics' *sensorless* pump performance curve.

SAM4 calculates a large variety of physical and process-related parameters, such as load, rotating speed and torque. These parameters, combined with pump characteristics and the wave equation, are used to calculate the force gauge values of a dynamometer.

This enables the system to detect faults on the pump, without the need to install a load cell, either topside or downhole.

Today, SAM4 detects faults on motor, belt and gearbox. Once the solution for rod pumps has been validated it'll detect faults on the rod pump as well.

**SAM4 for sucker rod pumps' launch is planned for Q2, 2023.**



# Development status: detectable failures

## Motor

- ✓ Bearing degradation
- ✓ Mechanical and electrical unbalance
- ✓ Broken rotor bars
- ✓ ...

## Belt

- ✓ Belt slip
- ✓ Belt wear
- ✓ Misalignment

## Gearbox

- ✓ Cracked gear teeth
- ✓ Misalignment
- ✓ Eccentricities
- ✓ ...

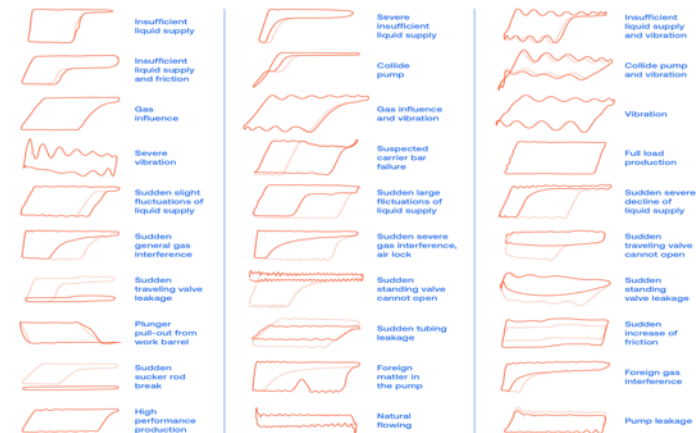
## Power supply

- ✓ Power quality issues
- ✓ Current/voltage unbalance
- ✓ Voltage distortion
- ✓ ...

Proven technology

## Rod pump issues

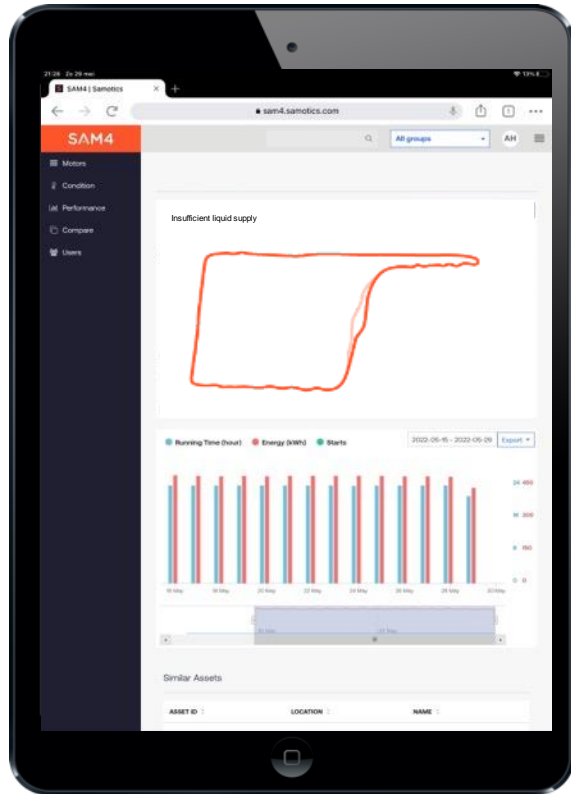
- ❑ (Severe) vibration
- ❑ Friction
- ❑ Pump leakage
- ❑ Insufficient liquid supply
- ❑ Tubing leakage
- ❑ ...



In development



# Can you help us set up a field trial?



2-10

**trial**

on 2-10 rod  
pumps

2

**requirements**

(mobile) internet  
access to load  
cell data



**planning**

1 day of data  
12 months of  
monitoring  
  
installed  
this summer



# The trial in more detail

## Technology validation test on 2-10 SRPs

- We'll install SAM4 on between 2 and 10 SRPs, depending on availability.
- At least one of the pumps has a load cell attached, and we have access to the data<sup>1</sup>.
- Samotics provides hardware, software, and monitoring for 12 months<sup>2</sup>.
- An internet connection needs to be available (Ethernet, Wi-Fi, or 4G).

## Implementation process

- We'll start with a project kickoff, during which we'll discuss the pilot plan and logistics.
- We'll deliver an installation plan and ship SAM4 devices.
- Your in-house team or a contractor installs the system. This requires an hour of downtime per pump.
- Dashboards are available directly after installation.

## IT security & product certification

- SAM4 measures only current and voltage. It cannot influence the operations of the pump. It is not connected to local IT/OT systems.
- SAM4 is ISO 270001 certified.
- SAM4s DAQ is CE/UL certified. All other components are Commercial Of The Shelf products.

(1) Alternatively, we'll install a load cell.

(2) We'd be happy to continue monitoring the pumps for 12 months after installation. The validation test itself will be concluded in 1-2 days.



# Thank you

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