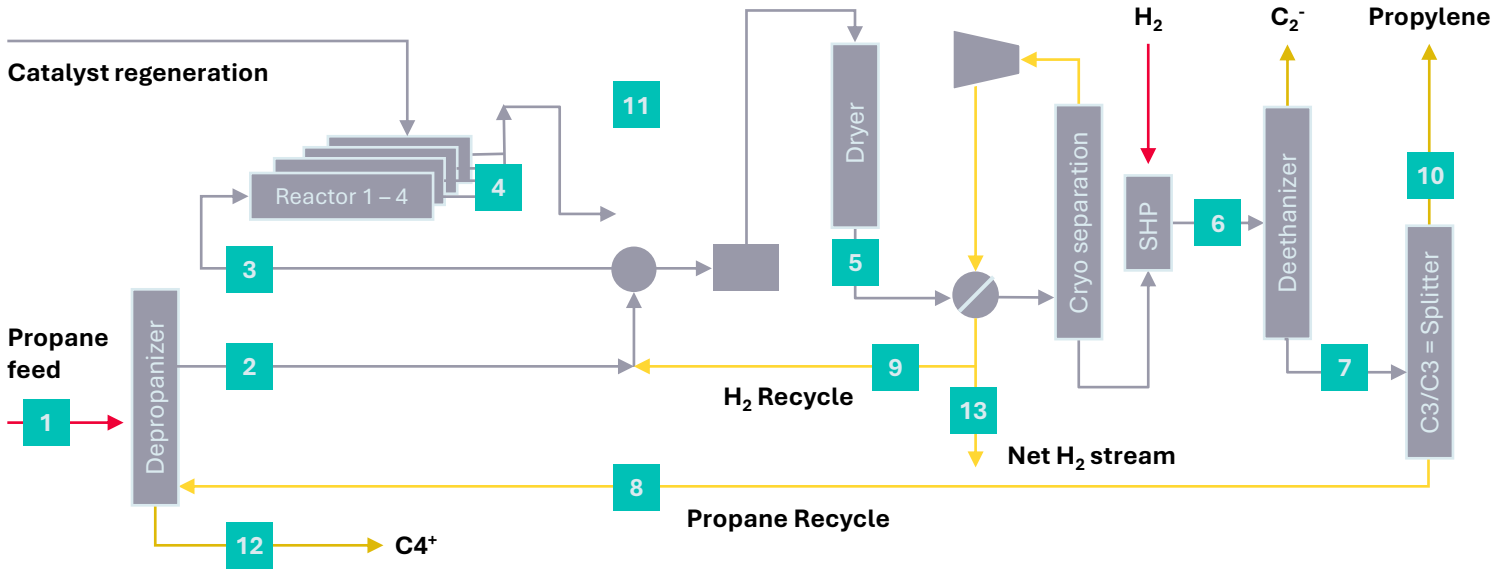
# Digitalization, Data Analytics & AI in Gas Analytics

## Process Analyzers are used for a wide range of applications and are crucial for any process

### Example process plant with analytical measurement points




## What if ...

process analyzers don't deliver the correct information or fail?

## Effects of an unreliable analyzer

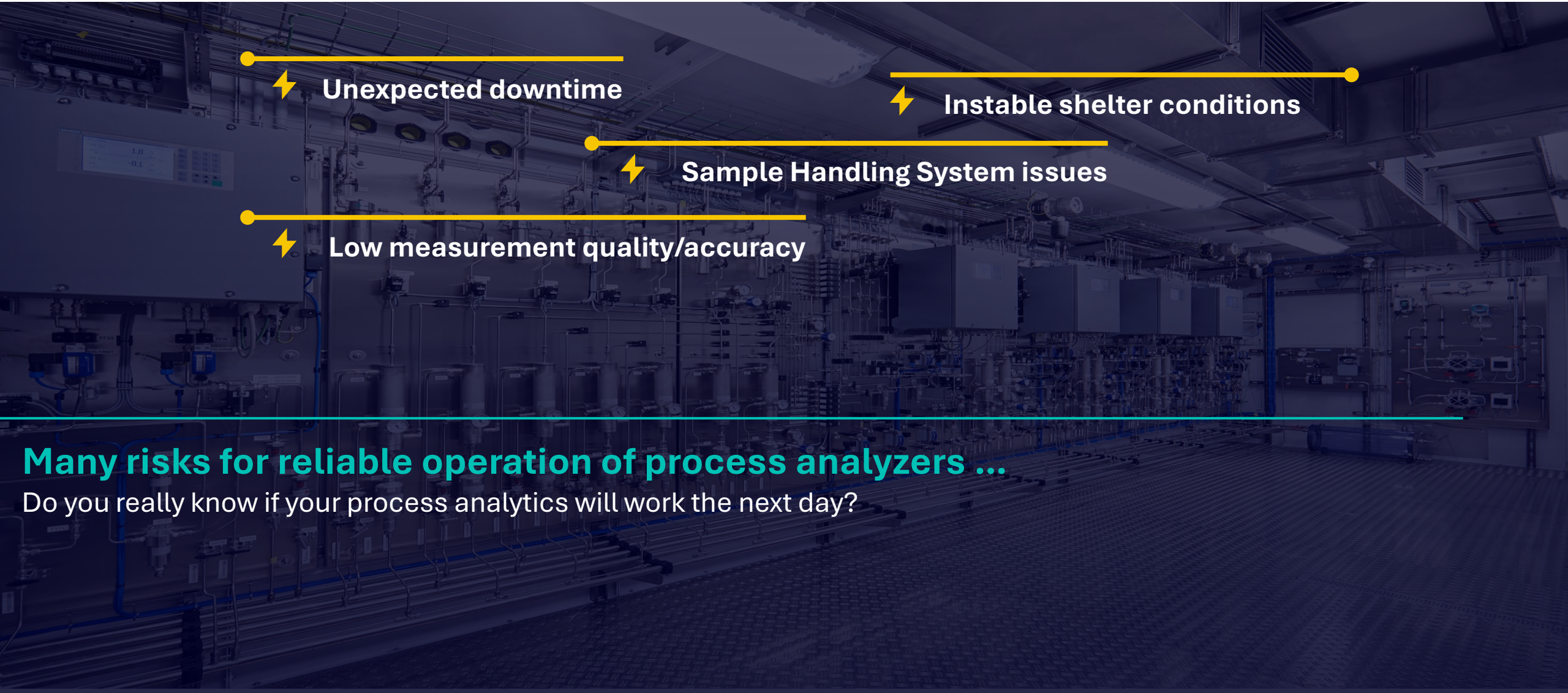
**01** **Processes may be running in a sub-optimal state:**

- Process yield may be lower than expected
- Manufactured product may be of low quality

**02** **Operation costs may be higher than expected**

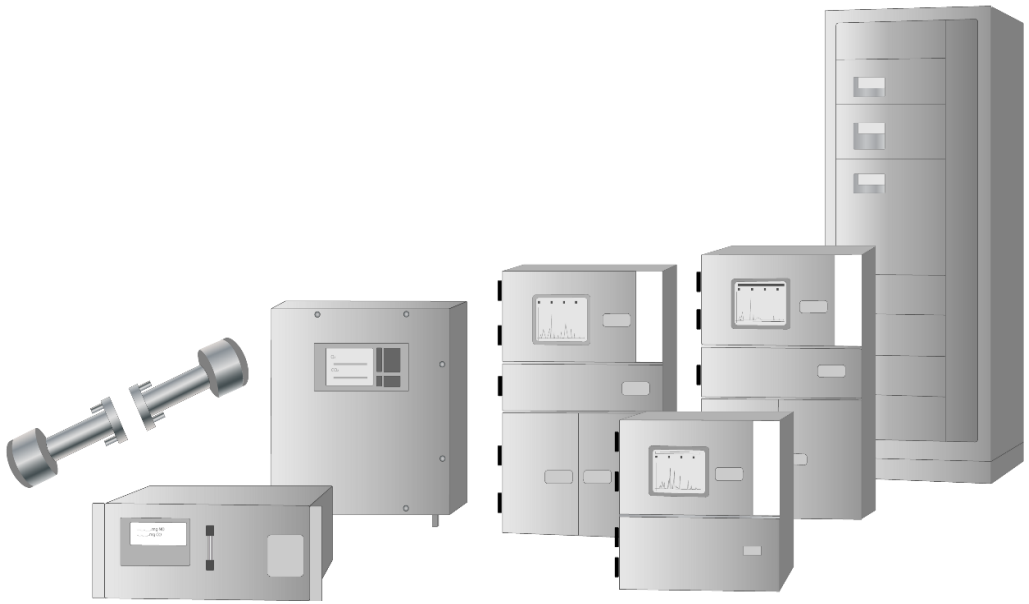
- High maintenance costs
- Excessive energy consumption

**03** **Violations of environmental or safety regulations**




## Many risks for reliable operation of process analyzers ...

Do you really know if your process analytics will work the next day?

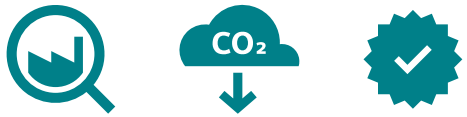


**How can we master the challenges of Process Analyzer Technology and provide the full value for optimized process control?**

**Digitalization, Data Analytics & AI in Gas Analytics as (one) answer!**

# WHY?

## Reliability




**Optimization**

Processes are in optimal state

## Improvement of product quality & output

Manufactured product will have appropriate quality
(not too good, not too bad,
but exactly as required)

## Lower OPEX

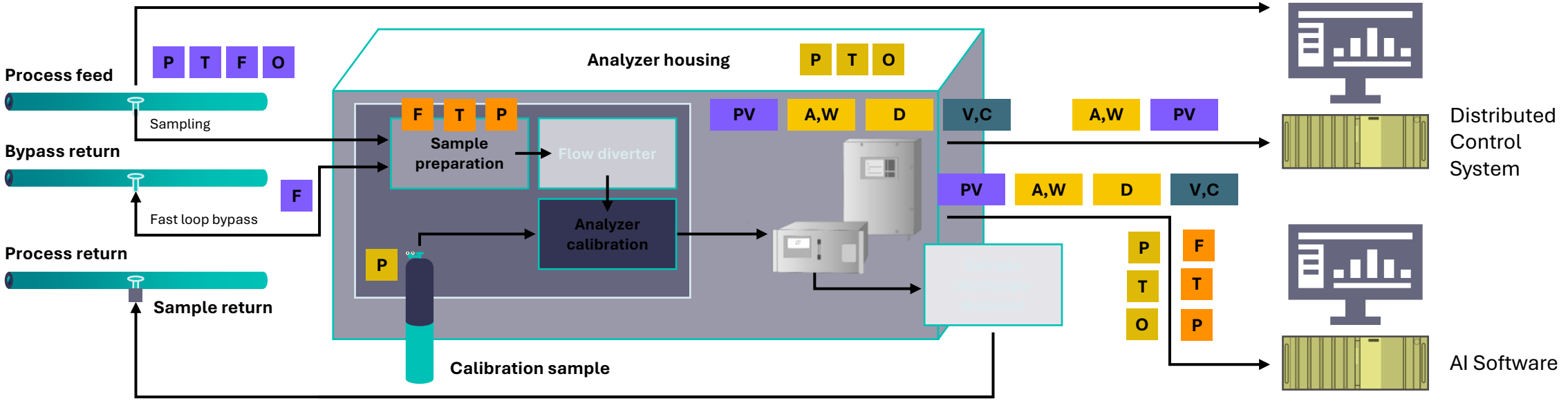
- Lower plant operation costs
- Less maintenance
- Less energy consumption

## Increased yield

Increased plant production yield

Reliable analyzers → Accurate, stable & available information → Optimized process → **Profitable process**

# Today: Much information available from process analyzer is not used, but is useful to enable predictive maintenance with better analytical performance and less maintenance




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Analyzer Information** | PV | Process value | A,W | Alarms, warnings | D | Diagnostic parameter (device health) | V,C | Validation/calibration data |
| **Sample Preparation** | F | Flow | P | Pressure | T | Temperature | | |
| **Shelter** | P T O | Pressure, temperature, other signals | P | Reference gas cylinder pressure | | | | |
| **Process** | P T F O | Other process information such as temperature, pressure, flow, etc. | | | | | | |

› We can use all these data to predict maintenance needs upfront

# What are typical issues of gas analyzer in the field?

- Frequent Validation and Calibration required
- Sample Handling Challenges
- Issues in Measurement Path from Sensor to Detector leads to incorrect measurement
- Failure of components within analyzer leads to unavailable measurement due to downtime

**We need to solve these issues using digitalization and Artificial Intelligence**

## What is Artificial Intelligence?

Artificial Intelligence is the theory and development of computer systems capable of performing tasks that historically required human intelligence such as recognizing speech, making decisions, and identifiying patterns

## What do we want to achieve?

- Continuous, 24/7 and automatized analysis of process analyzers (instead of 1x time per week)
- Early identification of possible issues to inform technicians as soon as possible
- Provide technicians live overview about health status of process analyzers and provide helpful tools

# How can AI make a difference?

Detect potential problems as early as possible

Continuously validate the measurement

Provide replacement value in case of failure

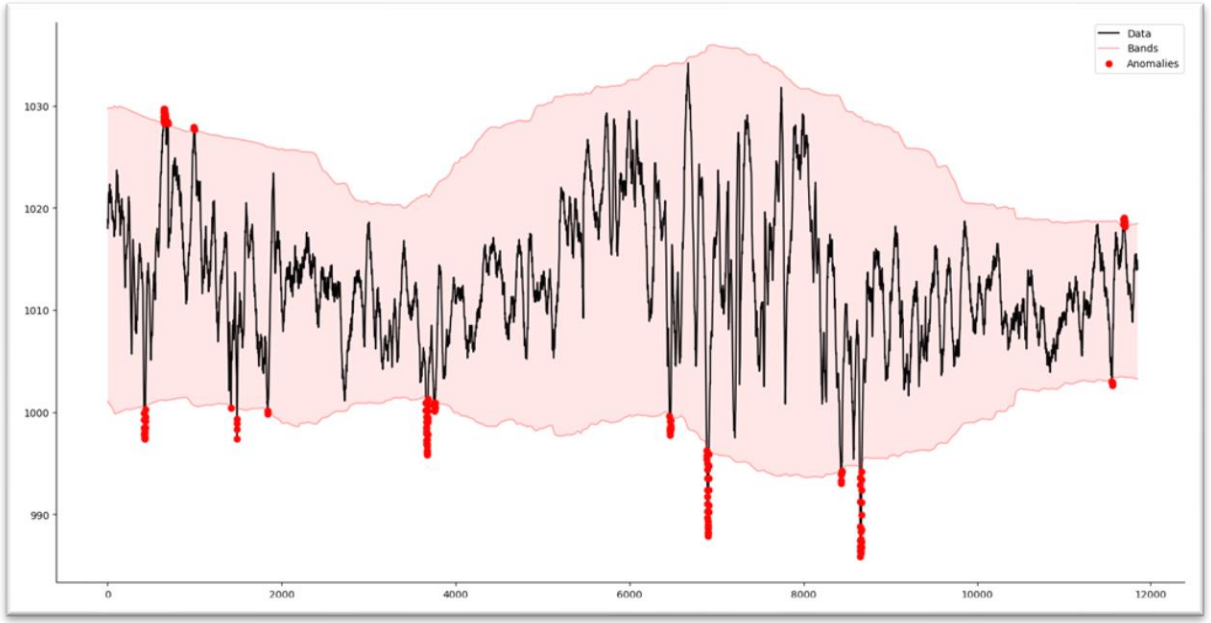
Support technicians to solve problems fast

# Detect potential problems as early as possible

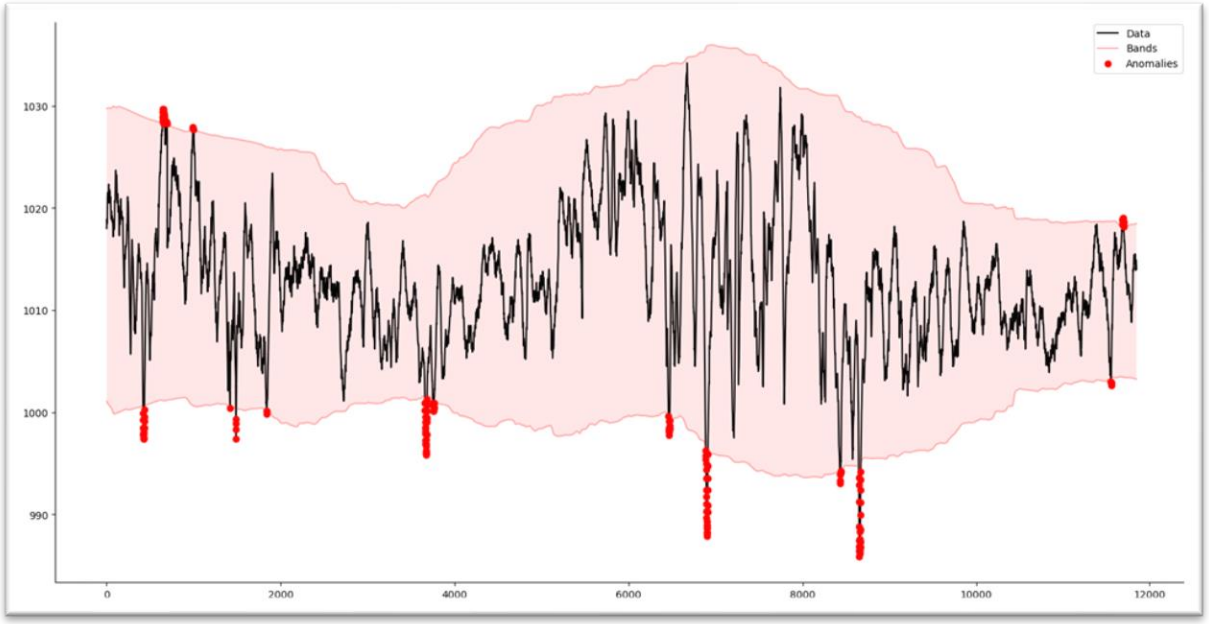
## General approach

- AI learns past behavior of process analyzer and can conclude if live behavior is similar or not
- AI improves itself over time by interaction with user (which behavior is accepted or not

  → changes in measurement values can either by issue with analyzer or change in overall process)
- Software informs technicians about potential issues which needs to be investigated further



# Outlier Detection




**Outlier Detection**

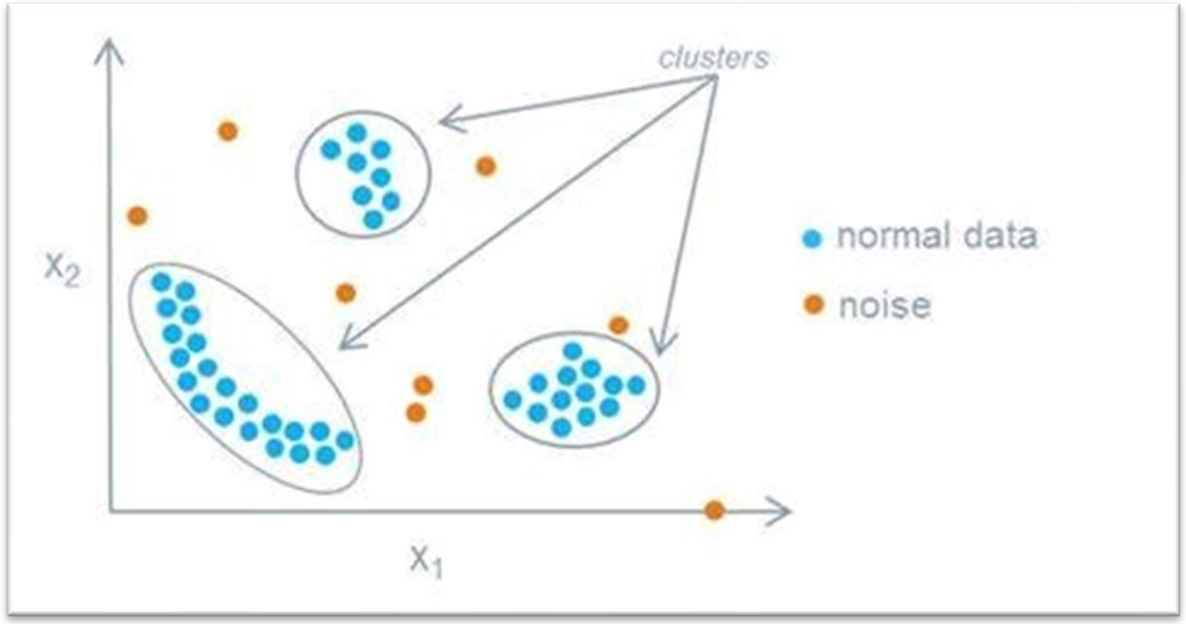
**Scenario:** Recognition of points outside acceptable operating range

**Use Case:**

- Measurement Value Outlier (further root cause analysis required if process or analyzer related)
- Sample Preparation outside of specification
- Problem within analyzer e.g. electronic board might have porblem

**Value:** Easy analysis without configuration of many limits which might be often not known (e.g. what is acceptable operating range of electronic board?)

# Anomaly detection




**Evaluation of behavior of analyzer, even if it is within defined operating levels**

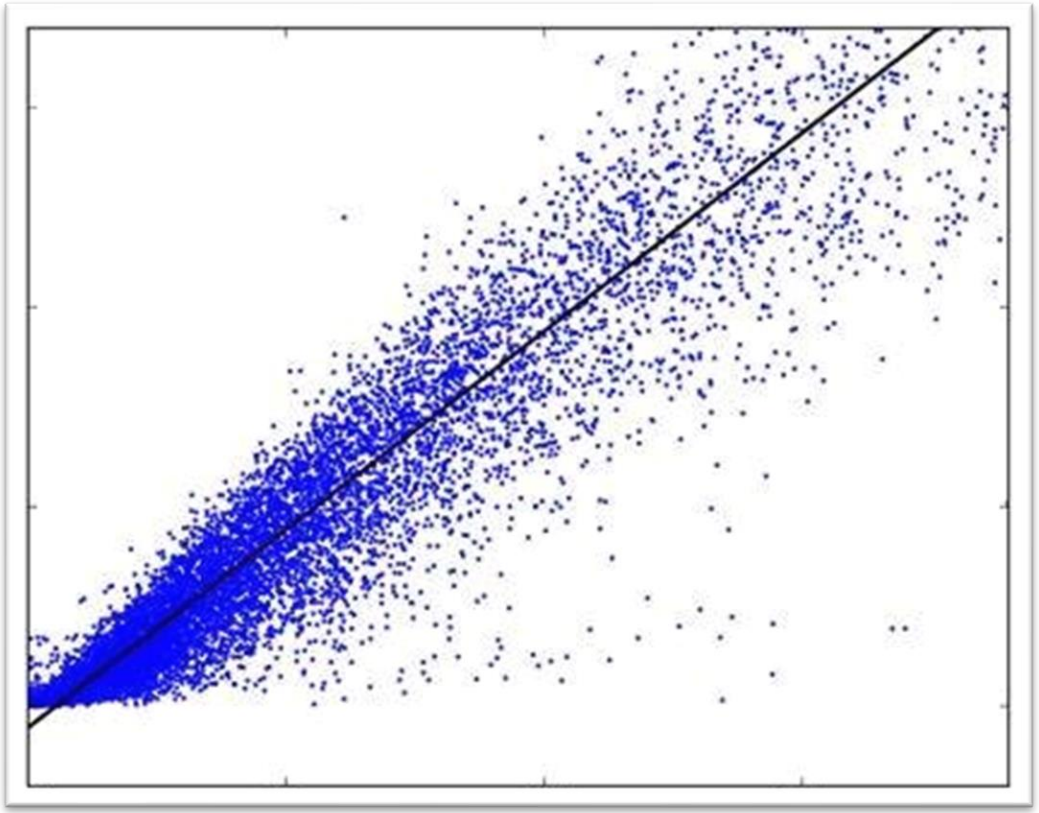
**Scenario:** Analyzed data is within limits, but strange pattern starts e.g. increasing fluctuation

**Use Case:**

- Typical behavior of components which soon will failure like electronics where smaller ‚spikes‘ starts to occurs

**Value:** Early recognition if any strange behavior starts which give technicians advantage to react as soon as possible – even if device still operates.

# Regression analysis



**Regression Analysis to calculate possible impact of trend**

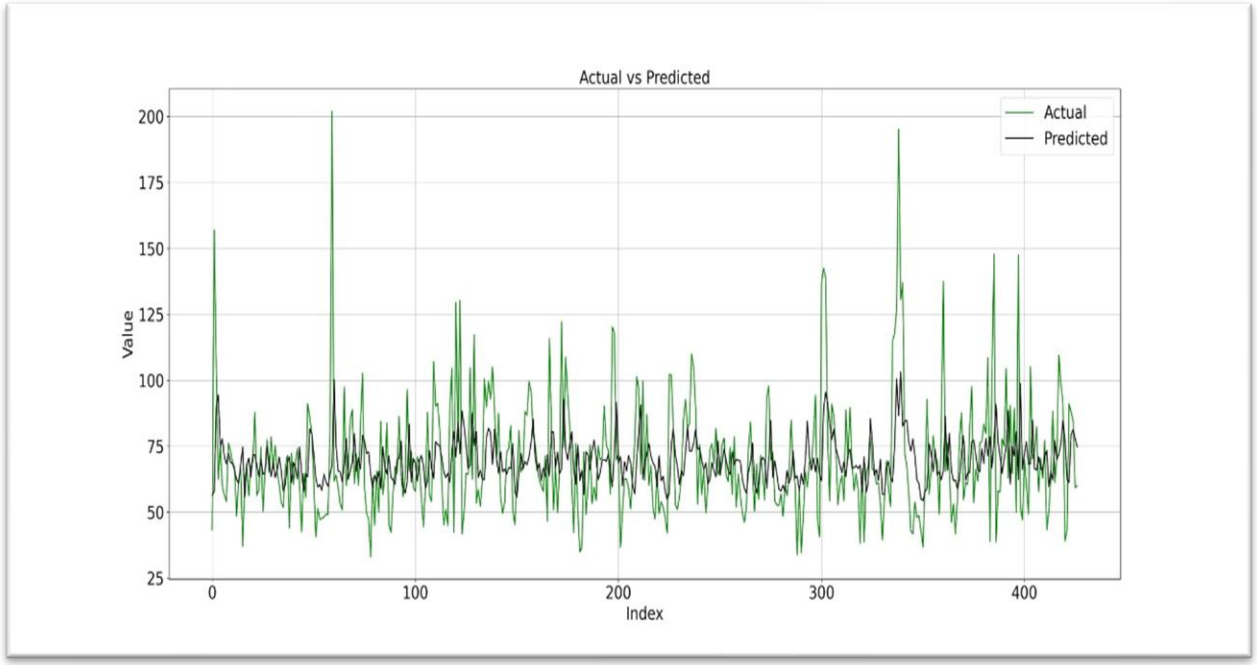
**Scenario:** Drift Recognition - What will happen if drift continues?

**Use Case:**

- Issues in Sample Preparation e.g. small pressure drop over time
- Sensitivity loss of sensor or detector due to aging effects (decrease over longer time)

**Value:** Calculation how much time left until analyzer system will operate outside of acceptable operating range → Initiate pro-active maintenance

# Verification of analyzer performance




**Continuous validation of measurement performance and health status of analyzer**

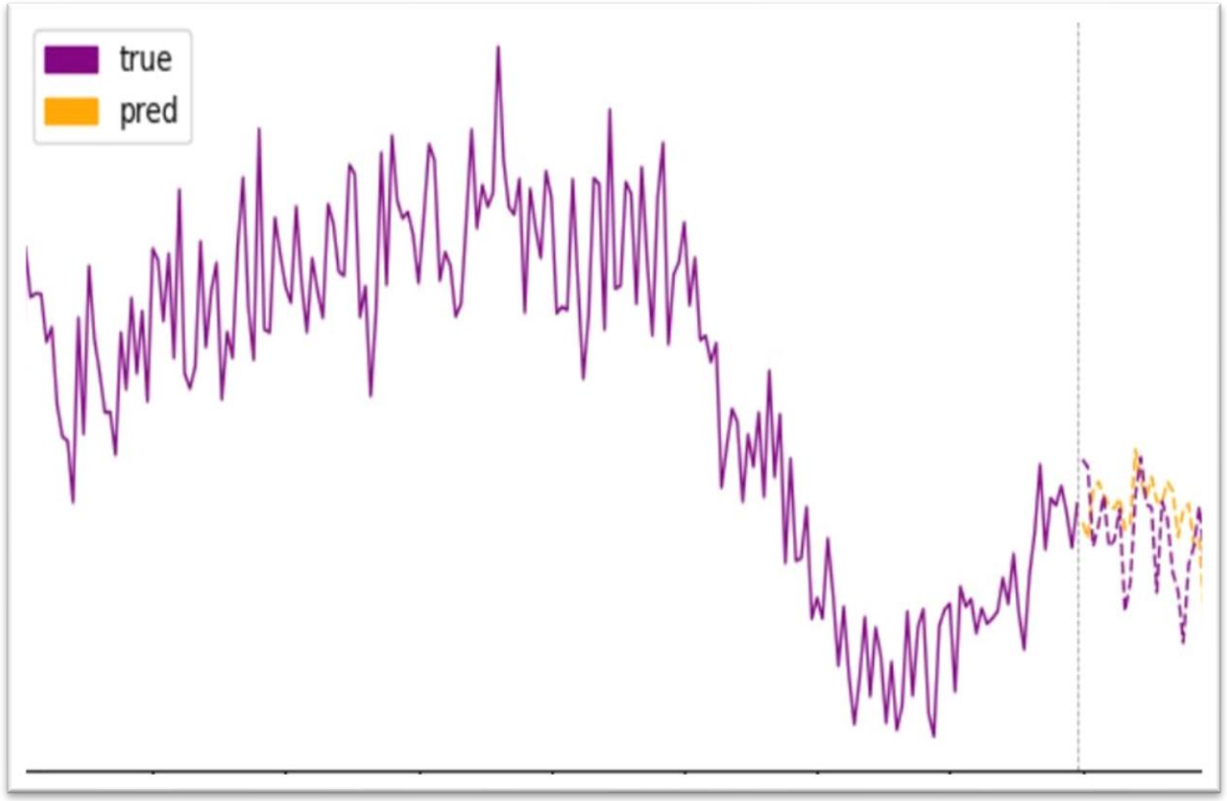
**Scenario:** Detect increasing change over long-time in behavior of analyzer

**Use Case:**

- Identify need of calibration of analyzer
- Aging effect of analyzer

**Value:** Minimize validation efforts and usage of reference gases by continuous validation; Identify long-term trends e.g. by aging within analyzer components

# Predict values in future




**Prediction of values which is used as real-time check if analyzer health status is fine**

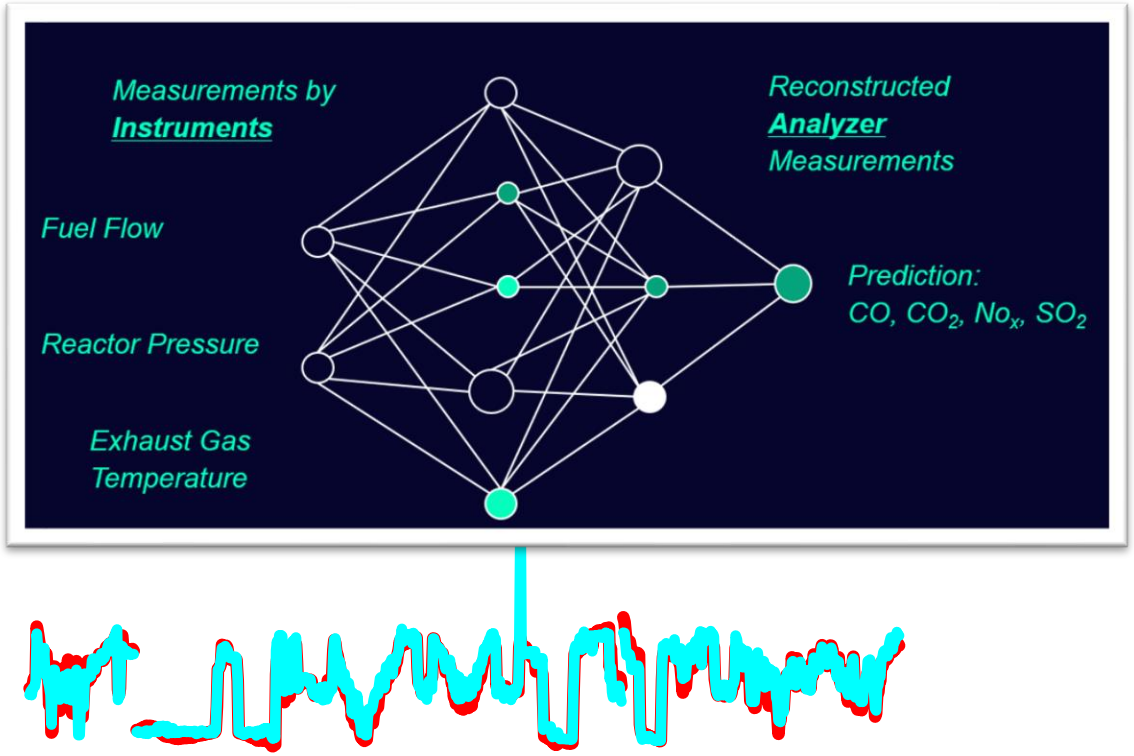
**Scenario:** Near-time future prediction of value for health status analysis or as back-up measurement

**Use Case:**

- Bridge over downtime of some hours by replacing substitution values to process control (with uncertainty)
- Use prediction as reference to check if there is any unusual behavior

**Value:** Live-check of analyzer + still deliver measurement results despite having downtime

# Predict values in future – with even better performance




Example: CO modeling
Comparison CEMS & PEMS

**Use AI to provide measurement results for components which would require gas analyzer systems**

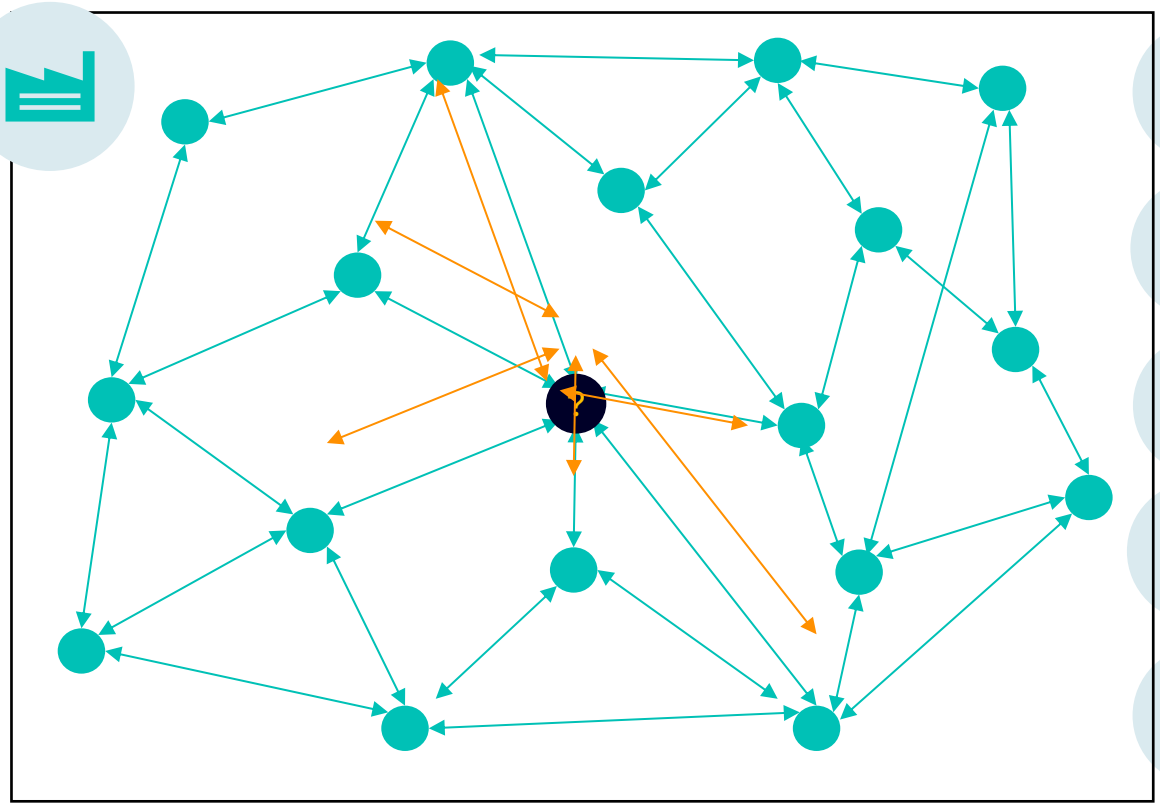
**Scenario:** Analyzer in downtime but process requires provision of measurement value

**Use Case:**

- Environmental authorities requires cotinuosu emission measurement with high availability

**Value:** Provide back-up measurement with high accuracy despite downtime of gas analyzer system

# Combining the data from sensor networks to enable virtual measurement



Process control requires specific measurement. Todays approach: New sensor accepting complexity and costs

Plant has already many sensors installed

Between them, there is a correlation defined by the process

Idea: Can we use these information to predict the target component without an additional sensor

It's possible using a **soft sensor** based on process model

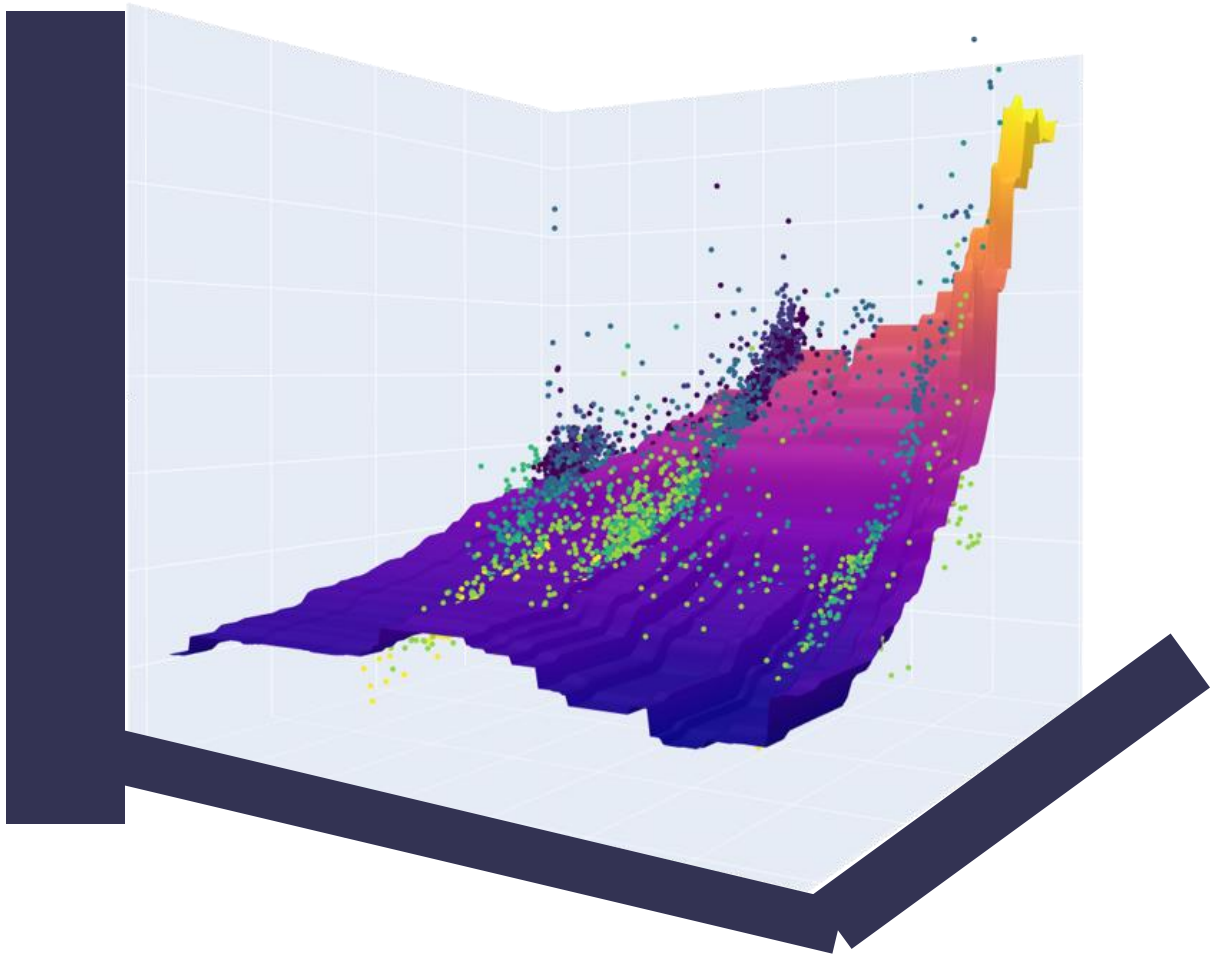
# Use information from existing instruments in process to calculate gas composition

# How does it work?

- AI is analyzing provided historical process data and is defining which parameters influence target values (in this case: emission values)

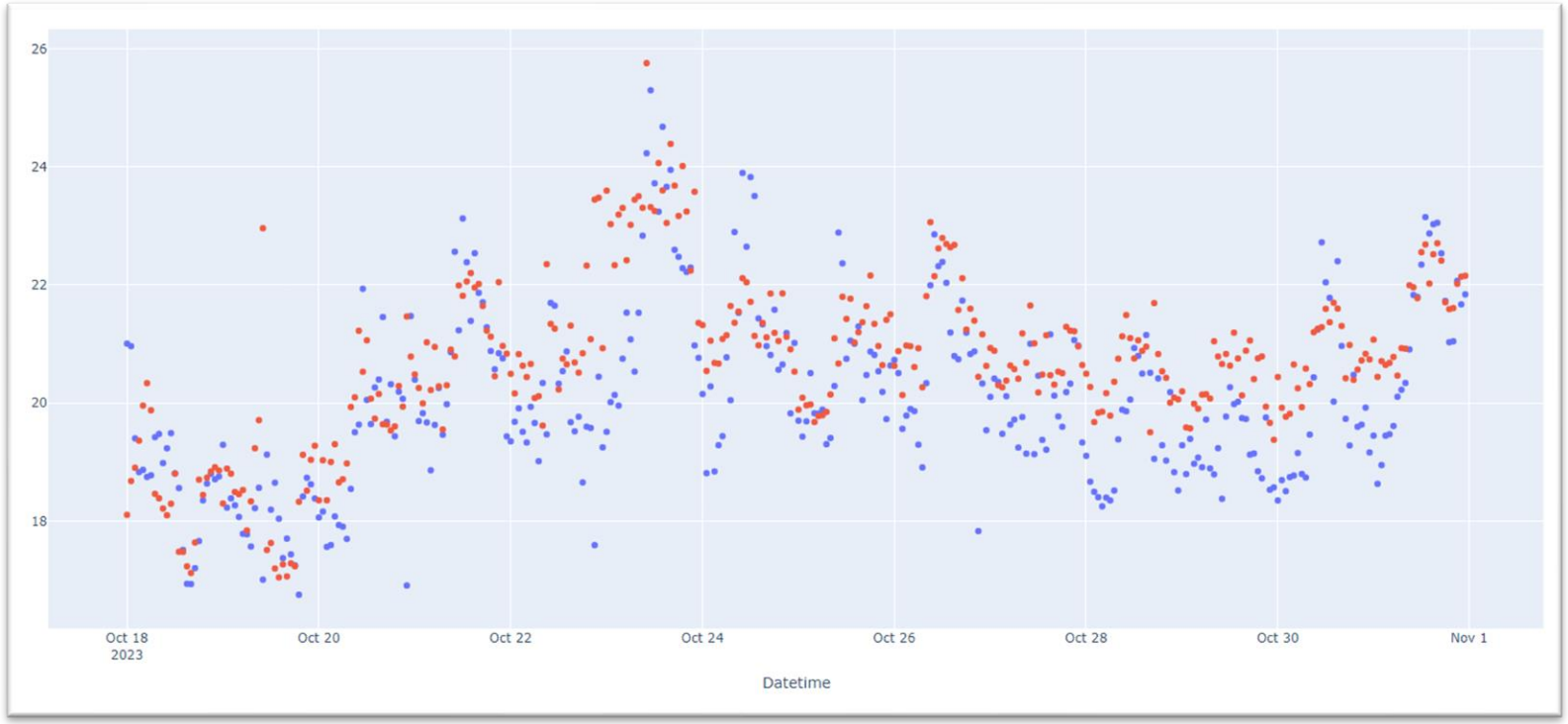
- Typical parameters are fuel flow rate, stack pressure and temperature as well as environmental conditions like humidity

- AI develops mathematic model based on historical data including input parameters and analyzer results and finetunes the model stepwise to come as close as possible to real values



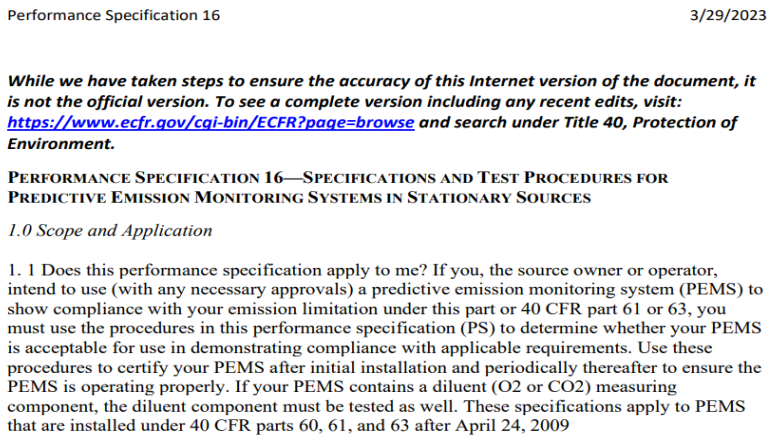
# Exemplary performance for Nox prediction in combustion process within refinery

**Provision of substitution values is possible with high accuracy up to 99%**




Example shows relative accuracy of soft sensor for emission monitoring, in this case Nox in refinery in ASEAN. Accuracy deviation to reference measurement of below +-3%, environmental specification required max +-20% deviation over test period.

# More and more countries approve the usage of this technology as approved back-up or replacement of CEMS systems



Performance Specification 16 3/29/2023

***While we have taken steps to ensure the accuracy of this Internet version of the document, it is not the official version. To see a complete version including any recent edits, visit: https://www.ecfr.gov/cgi-bin/ECFR?page=browse and search under Title 40, Protection of Environment.***

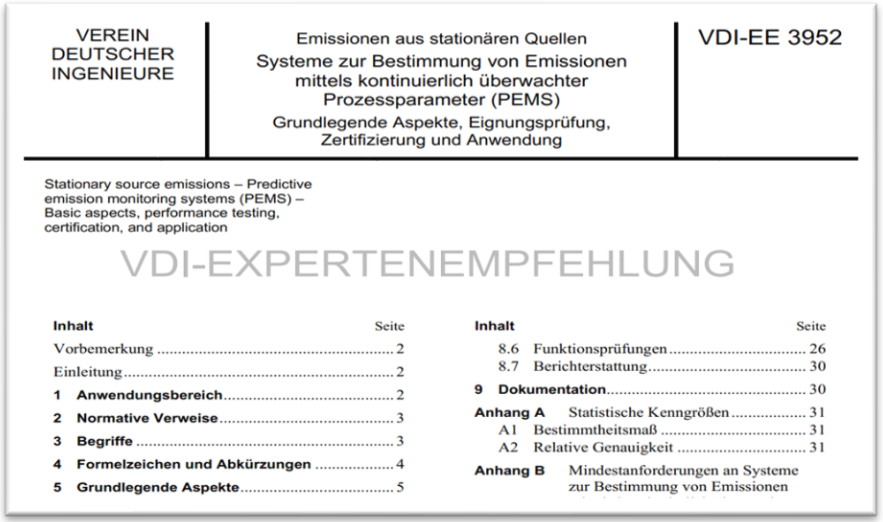
**PERFORMANCE SPECIFICATION 16—SPECIFICATIONS AND TEST PROCEDURES FOR PREDICTIVE EMISSION MONITORING SYSTEMS IN STATIONARY SOURCES**

*1.0 Scope and Application*

1. 1 Does this performance specification apply to me? If you, the source owner or operator, intend to use (with any necessary approvals) a predictive emission monitoring system (PEMS) to show compliance with your emission limitation under this part or 40 CFR part 61 or 63, you must use the procedures in this performance specification (PS) to determine whether your PEMS is acceptable for use in demonstrating compliance with applicable requirements. Use these procedures to certify your PEMS after initial installation and periodically thereafter to ensure the PEMS is operating properly. If your PEMS contains a diluent (O2 or CO2) measuring component, the diluent component must be tested as well. These specifications apply to PEMS that are installed under 40 CFR parts 60, 61, and 63 after April 24, 2009

**EPA-PS16 influenced regulations:**

US, Canada, Middle East, ASEAN (Malaysia, Thailand)



VEREIN DEUTSCHER INGENIEURE

Emissionen aus stationären Quellen
Systeme zur Bestimmung von Emissionen mittels kontinuierlich überwachter Prozessparameter (PEMS)
Grundlegende Aspekte, Eignungsprüfung, Zertifizierung und Anwendung

VDI-EE 3952

Stationary source emissions – Predictive emission monitoring systems (PEMS) – Basic aspects, performance testing, certification, and application

VDI-EXPERTENEMPFEHLUNG

**Inhalt** Seite

Vorbemerkung ... 2
Einleitung ... 2
**1 Anwendungsbereich** ... 2
**2 Normative Verweise** ... 3
**3 Begriffe** ... 3
**4 Formelzeichen und Abkürzungen** ... 4
**5 Grundlegende Aspekte** ... 5

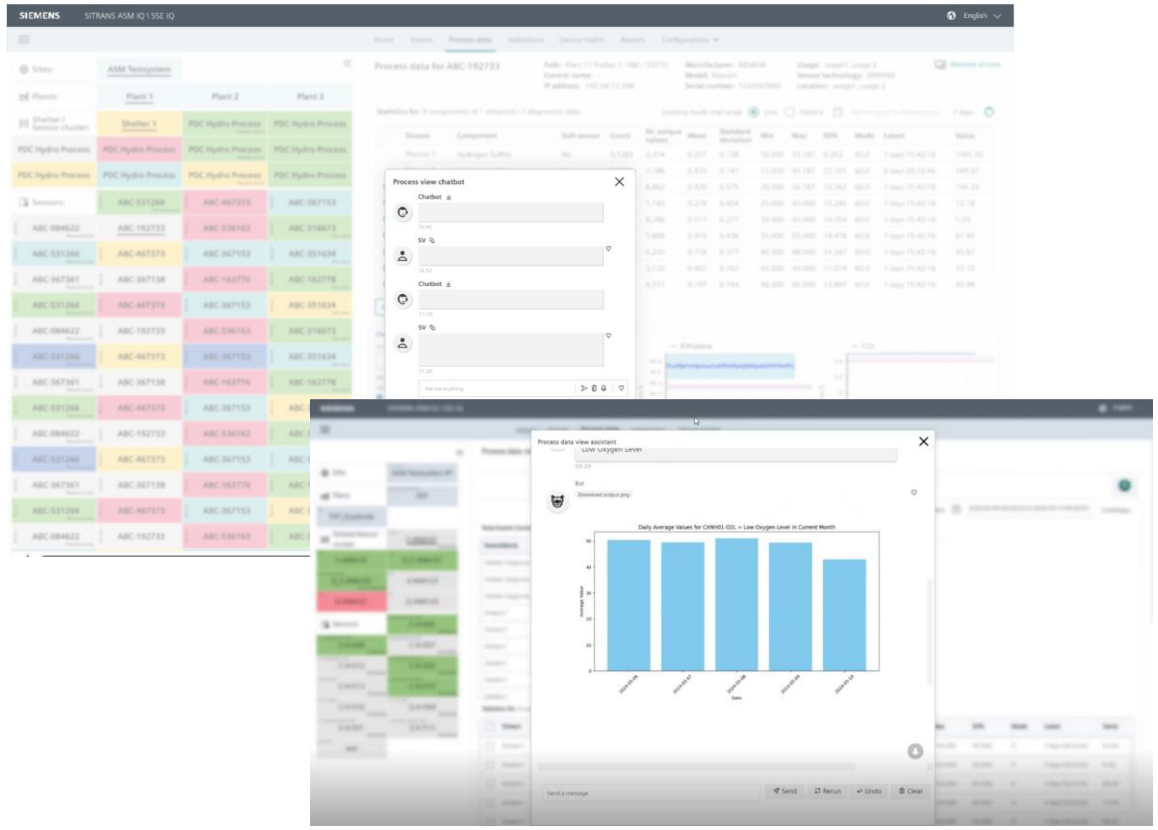
**Inhalt** Seite

8.6 Funktionsprüfungen ... 26
8.7 Berichterstattung ... 30
**9 Dokumentation** ... 30
**Anhang A** Statistische Kenngrößen ... 31
A1 Bestimmtheitsmaß ... 31
A2 Relative Genauigkeit ... 31
**Anhang B** Mindestanforderungen an Systeme zur Bestimmung von Emissionen

**VDI-EE 3952:**

Germany, expected to be taken over in Europe

# Next level of maintenance using Generative AI




**Future of analyzer maintenance using Chatbot based on Generative AI**

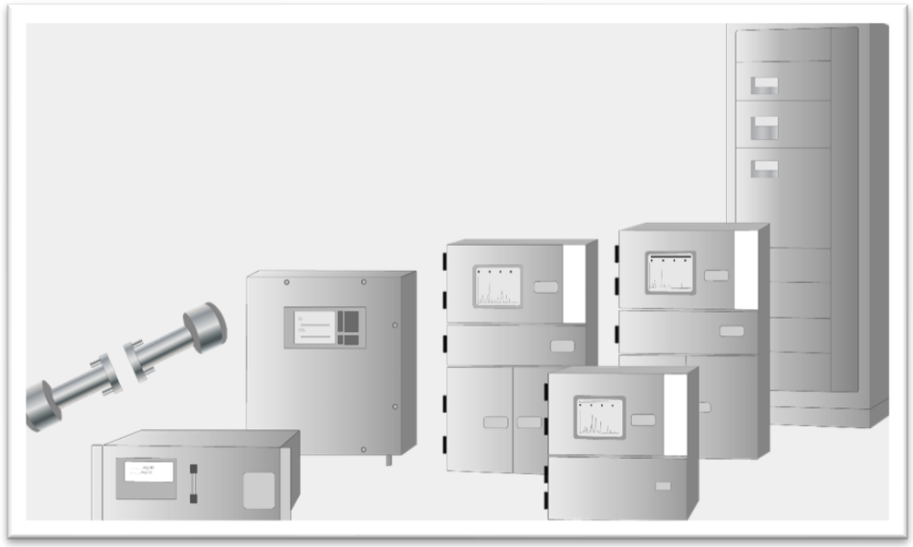
**Scenario:** Technicians wants to find out how to solve a specific occured problem

**Use Case:**

- Provide recommendations automatically out of manuals without search
- Show similar cases in the past with same or comparable analyzers

**Value:** Make it easier to maintain process analyzer by making expert knowledge available for everyone

# Conclusion



- ✓ Powerful Artificial Intelligence can be used to detect issues with analyzer as soon as possible
- ✓ AI can be used to simplify maintenance e.g. by providing historical recommendations
- ✓ Process Analyzers can be backed-up by solutions like PEMS to provide values despite downtime

**Digitalization combined with reliable gas analyzer systems are key for next level of automation and process optimization**

ADAGE

**Imagine. Ideate. Innovate.**

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