

# Modern methods for power plant condition monitoring

RAINE JOKINEN AFRY TEST SERVICES

# AFRY at a glance

## INDUSTRIAL & DIGITAL SOLUTIONS

Advanced Automation  
Connected Products  
Automotive Design & Engineering  
Food & Pharma  
IT Solutions  
Specialized Technical Services  
Systems Management

## PROCESS INDUSTRIES

Bioindustries  
Chemicals  
Pulp, board, paper & tissue  
Mining & Metals  
Smart solutions:  
– Health & Safety  
– Sustainability  
– AFRY Smart Site & digitalisation

## ENERGY

Renewable Energy & Thermal Power  
Hydro  
Transmission & Distribution  
Nuclear  
Contracting

## INFRASTRUCTURE

Transportation  
Buildings  
Project Management  
Water  
Environment  
Architecture & Design

## MANAGEMENT CONSULTING

Energy Sector  
Bioindustry Sector  
Market Analysis  
Strategic Advice  
Operational Excellence  
M&A and Transactions

WE HAVE

**16,000**

Employees globally  
(as of 2021)

WE HAVE APPROX.  
NET SALES

**19 bsek**

in 2020

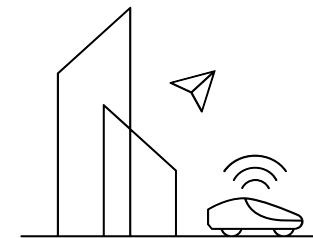
NUMBER OF COUNTRIES  
WITH OFFICES

**>40**

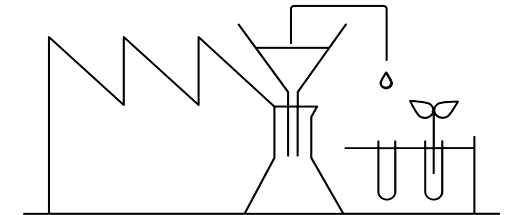
NUMBER OF COUNTRIES  
WITH PROJECTS

**>100**

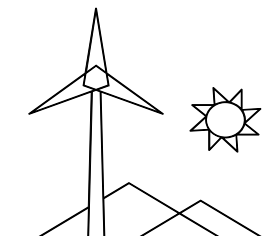
## 4 Growth Drivers



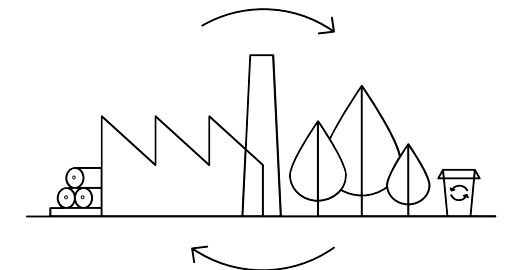
Infrastructure



Food & Life Science



Clean Energy



Bioindustry

# AFRY Test services

- Guarantee, performance and condition monitoring of boilers, turbines and flue gas cleaning systems
- Reliable emission and process values
- Noise and vibration modelling and measurements
- Wind resource energy measurements
- TAS - Technical advisory services
- 3<sup>rd</sup> party verification - Reliable test results for design and process purposes
- Process analysis and consulting



# Condition monitoring

- Vibration measurements
- Noise measurements
- Periodical inspections
- Bearing temperatures
- Elongation measurements
- **Performance tests**



# Performance tests

## 1. Guarantee tests

- tests to ensure the delivered equipment perform as promised
- for total plant and also main equipment (boiler, turbine, flue gas condenser)
- testing mainly with calibrated test instruments installed expressly for testing purposes
- test of guaranteed performance indicators
  - e.g. generator power, steam capacity, boiler efficiency
- comparison to guaranteed values
- measurement methods defined in standards

## 2. Condition monitoring

- similar tests and methods as guarantee tests
- performed traditionally mainly for steam turbines
- test of condition monitoring indicators
  - e.g. expansion efficiencies, flow passing capacities, TTDs
- objective is to find out possible changes in performance indicators & parameters
- comparison to previous test results



# Why performance testing?

## 1. Guarantee tests

- needed so the buyer can safely accept the delivered equipment
  - some parameters have absolute guarantees, and some can be settled with liquidated damages
- baseline for future condition monitoring

## 2. Condition monitoring

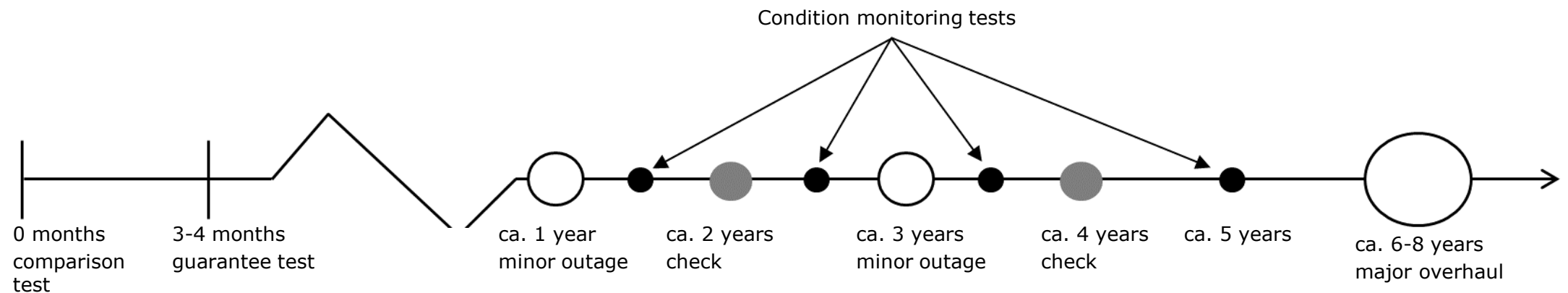
- no direct measurements for the condition monitoring indicators
  - e.g. the mechanical condition of the rotating equipment are monitored continuously
- requirement for measurement accuracy and reliability
- long periods between overhauls
  - get information about possible problems
  - make informed decisions regarding the overhaul



# Steam turbine condition monitoring - Example timeline

Regular condition monitoring tests:

- Secure economic and safe operation
- Maximize turbine life span and efficiency
- Information for overhaul planning



# Test codes & measurement standards

- Boilers
  - EN 12952-15 Water tube boilers and auxiliary installations - Part 15: Acceptance tests
  - ASME PTC 4 Fired Steam Generators
- Steam turbines
  - DIN 1943 Thermal acceptance tests of steam turbines
  - IEC 60953 Rules for steam turbine thermal acceptance tests
  - ASME PTC 6 Steam turbines
- Gas turbines
  - ISO 2314 Gas turbines — Acceptance tests
  - ASME PTC 22 Gas turbines
- Flow measurement
  - ISO 5167 Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full
- Thermodynamical properties
  - IAPWS-97 Thermodynamic Properties of Water and Steam
  - VDI 4670 Thermodynamic properties of humid air and combustion gases

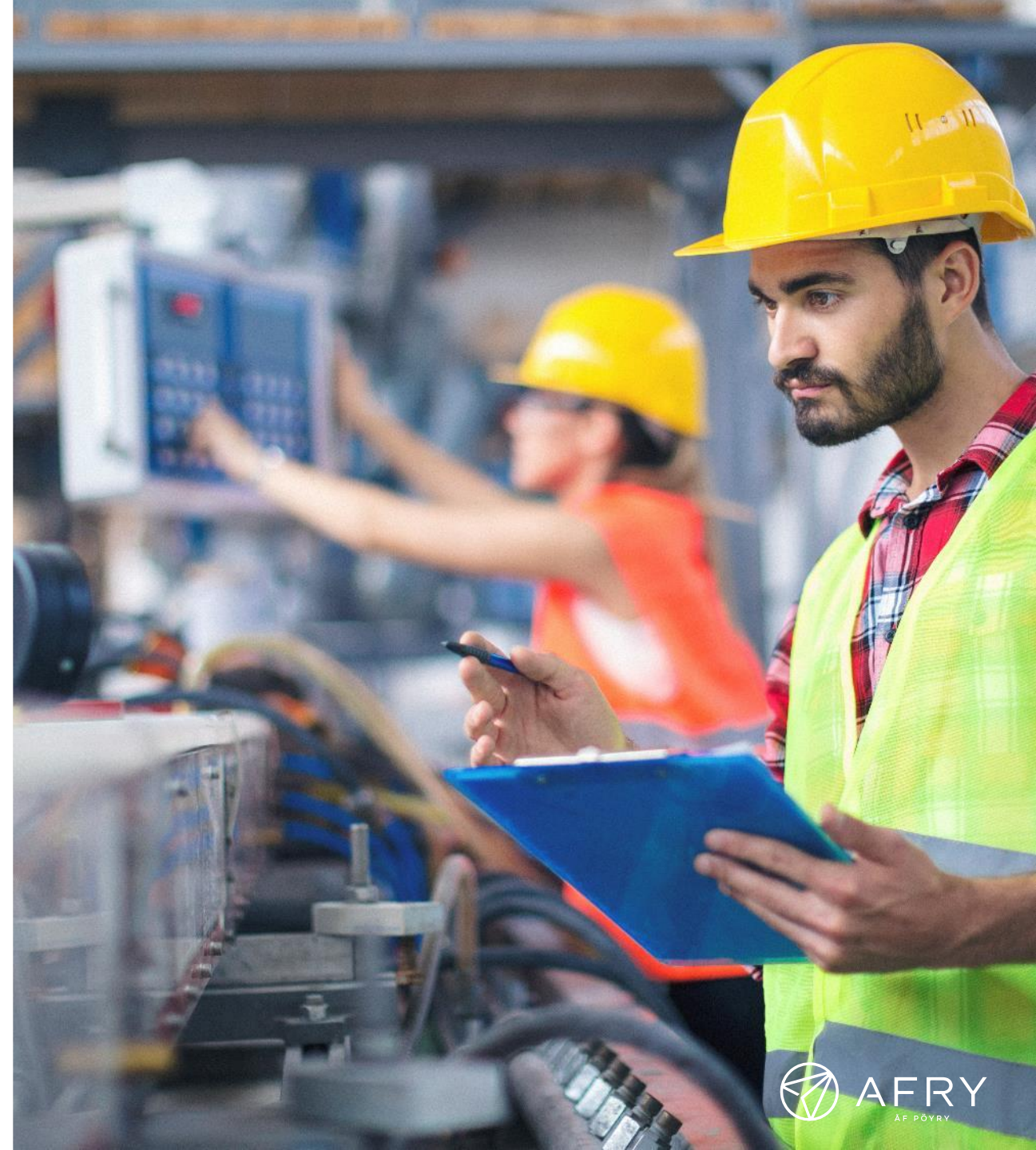




# Evaluating measurement results

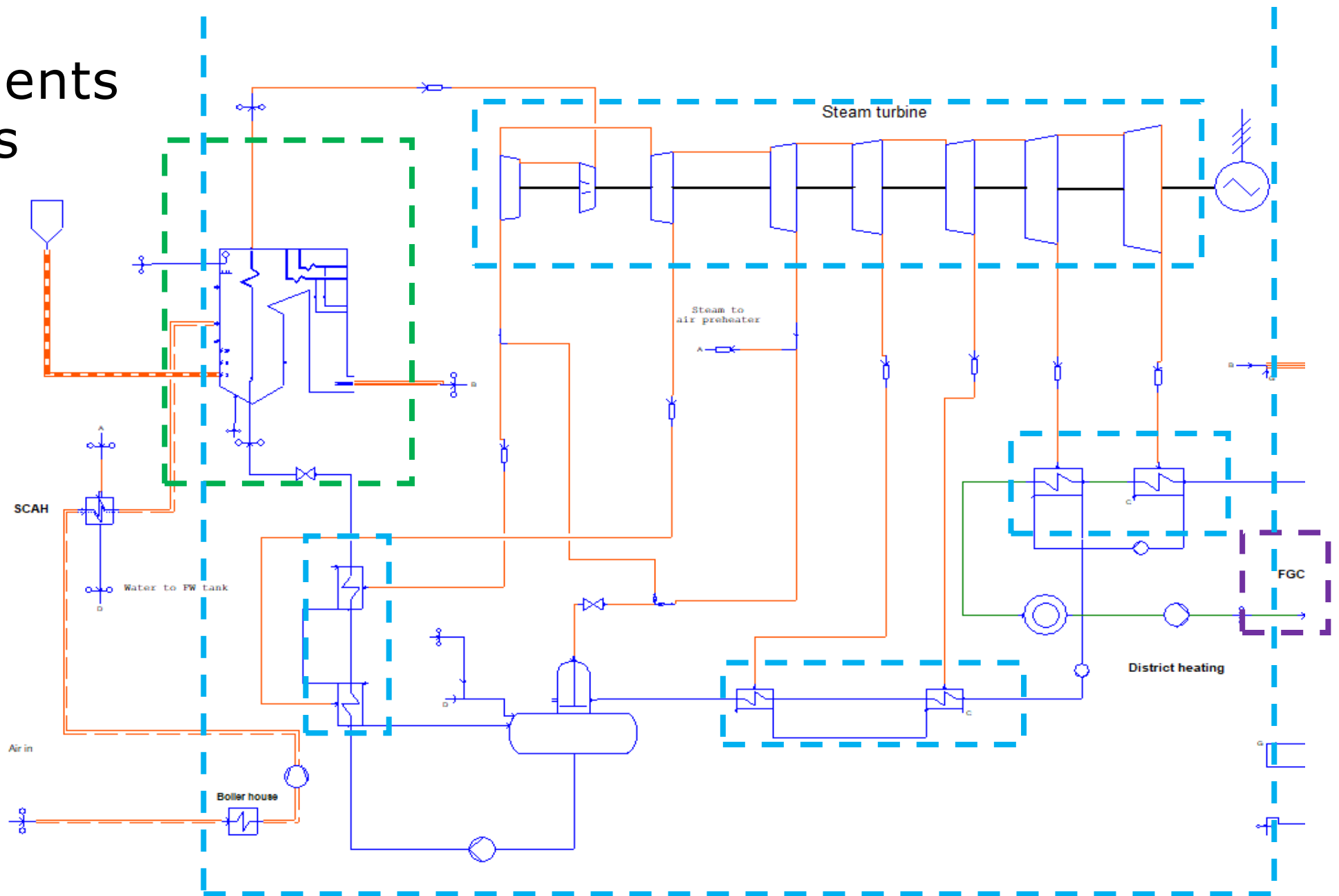
Based on test average values:

- Flow calculations
- Enthalpy calculations
  - steam, water, flue gas & air
- Mass balance calculations
- Heat balance calculations
- Equipment- & test specific calculations
  - isentropic efficiencies
  - flow-passing capacities
  - boiler efficiencies
  - etc.
- Correction calculations
  - needed to make results comparable
  - e.g. heat balance model correction
- Uncertainty calculations



# Measurements & balances

- boiler
- turbine
- FGC





# Project example

## Guarantee test for new plant:

- 85 MW fluidized bed boiler
- 75 MW steam turbine
- 50 MW flue gas condenser
- The tests:
  - 6 turbine test points
  - 4 boiler test points
  - 2 flue gas condenser test points
  - over 2 weeks of testing at site
- Measurements
  - 60 temperatures
  - 25 pressures
  - 10 steam & water flows
  - flue gas emissions
  - indoor & outdoor noise
  - surface temperatures
  - various samples and analysis

Planning – Executing - Reporting



# Continuous online condition monitoring

## Input data

Continuous DCS data

AFRY performance test results

Client DCS data during performance tests

Process model



Model calculations  
Deviation detection  
Machine learning algorithms

## Reporting

Continuous performance analysis and status of plant

Condition monitoring highlights

Improvement options

Condition monitoring prediction





# Continuous online condition monitoring

- Continuous overview of the current asset condition
- Improvement area identification based on calibrated process information
- Minimize failure costs and downtime by pinpointing sneaking deterioration early
- Faster troubleshooting and improved process optimization opportunities
- Automated reporting and prediction analysis

Tailored reporting and set-ups typically needed.



# Parameter examples

- Efficiency / throughput
- Heat transfer surfaces
- Steam and power flows and values
- Leak survey
- Optimisation of emissions and additives
- Pressure drops
- Terminal temperature differences
- Recovered heat and load
- Turbine constants and performance
- Optimisation and operation strategy
- Measurement fault analysis



# Making Future