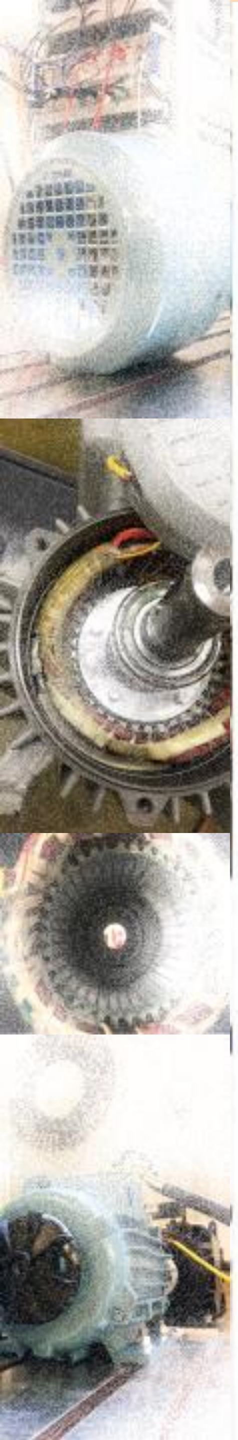
Energy Efficient End-use Equipment
International Energy Agency

Electric Motor Systems
EMSA

How can digitalisation enable savings in motor systems?

Konstantin Kulterer, Austrian Energy Agency
02 July 2024



Introduction EMSA Electric Motor Systems Platform

Technology Collaboration Programme
by iea

4E Energy Efficient End-use Equipment
International Energy Agency

4E Electric Motor Systems
EMSA

IEA TCP 4E - Energy Efficient End-Use Equipment

- energy efficient equipment
- 15 members (EMSA + CA, CN, FR, JP, KR, UK)

EMSA - Electric Motor Systems Platform

- Raise awareness, share information, initiate collaborative research & development projects and transfer experience to support good policy development for energy efficient electric motor systems
  - international standards, testing, coordination
  - digitalisation of motor systems, classification
  - tools and outreach
- 9 members (AU, AT, DK, EC, NL, NZ, SE, CH, US)

www.iea-4e.org/emsa

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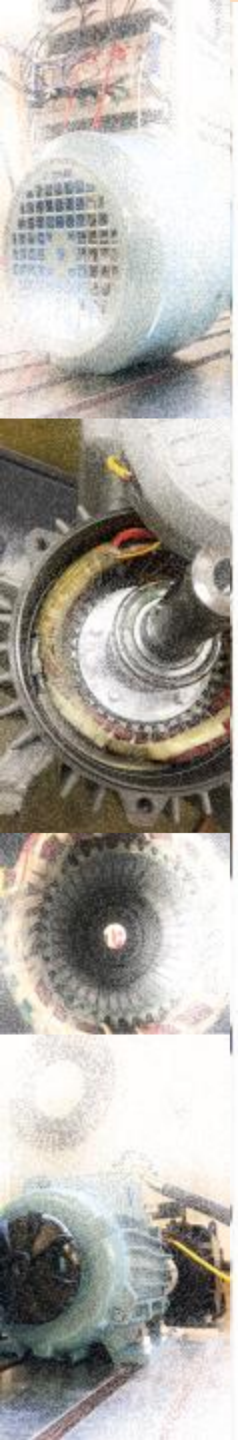
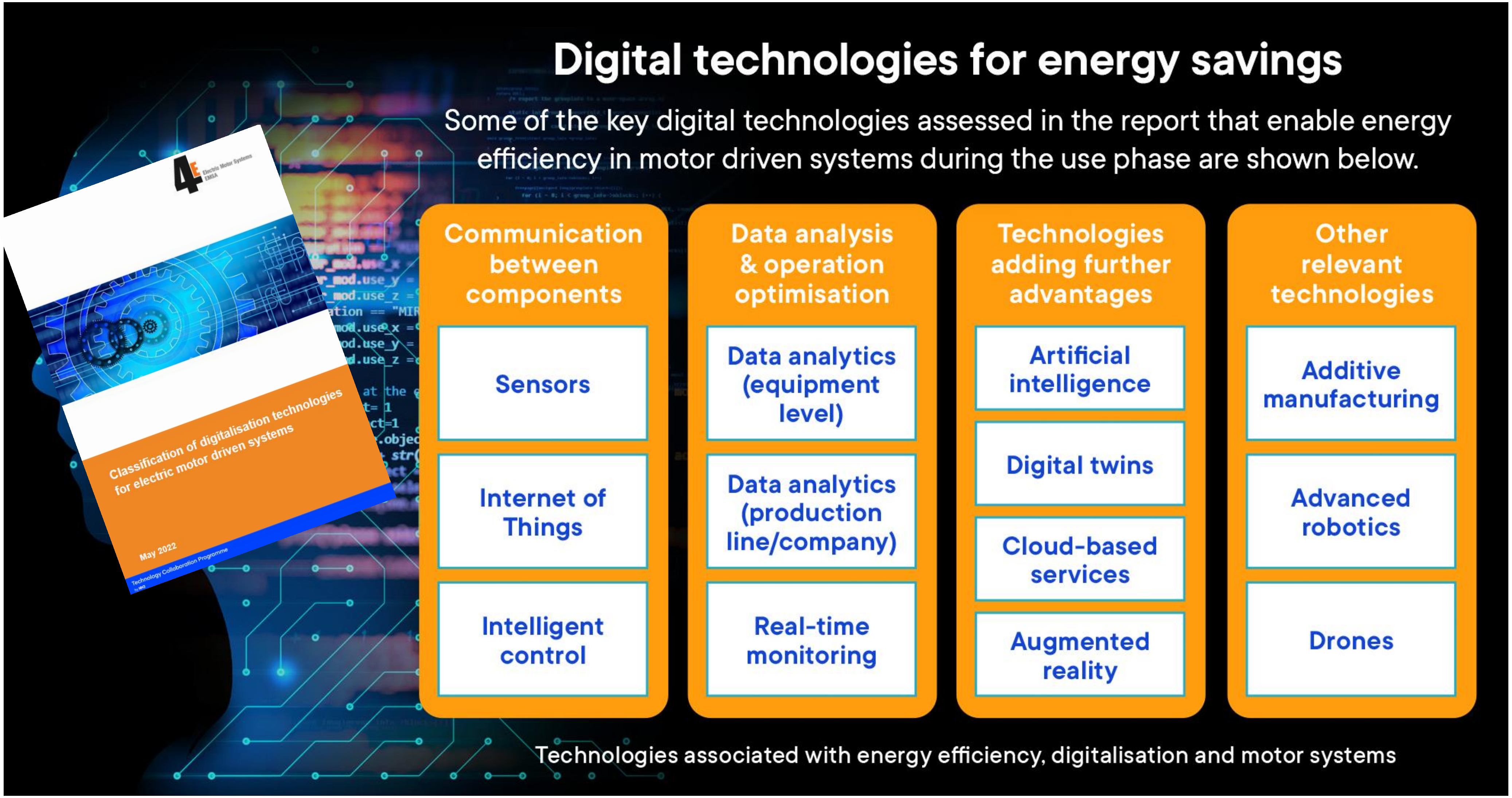
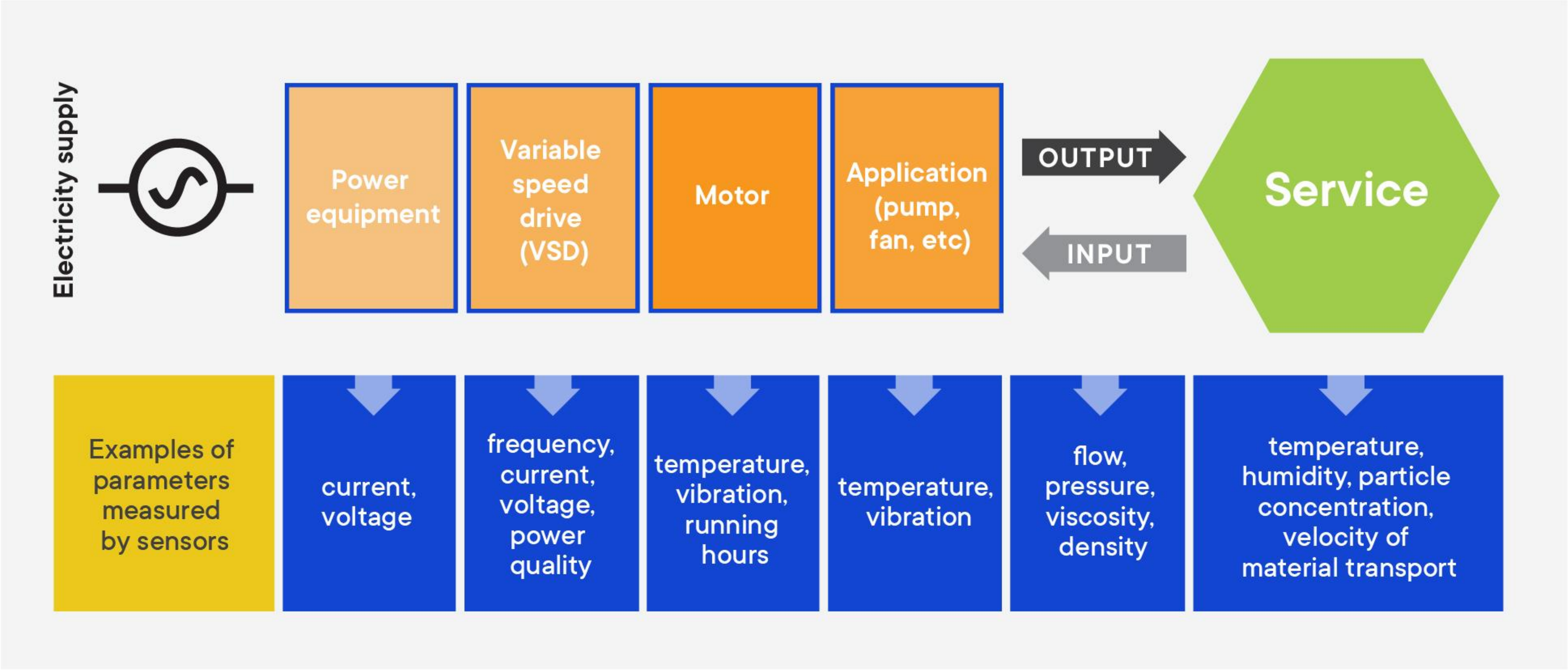
Report ‘Classification of digital technologies for motor systems‘





Policy Brief, potential areas of measurements and of application



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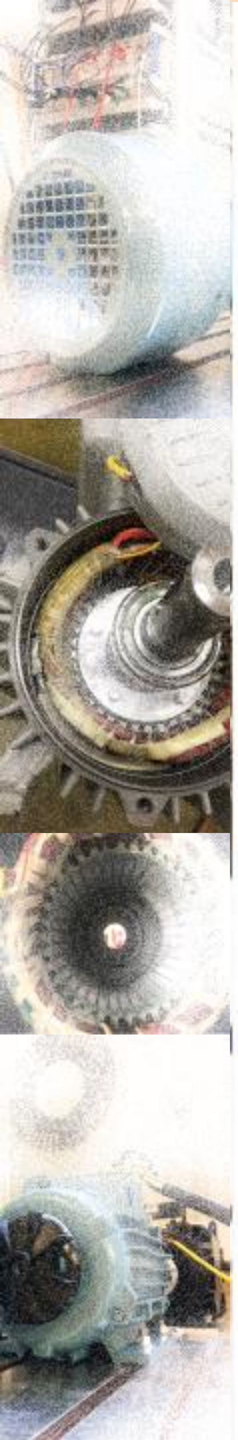

Targets and possibilities of digitalisation concerning energy reduction

- Requirements to report and achieve targets for water, energy and CO_2 consumption
- Reduction of electricity consumption during non-production times; weekend shutdowns
- Reporting and analysis of energy effect of different parameter-settings
- Automated leak detection in compressed air systems
- Operation of chiller systems based on weather forecasts
- Preventive maintenance of machines (detection of pressure fluctuations in pumps, wear monitoring for electric motors)
- Condition monitoring of machines through vibration analysis
- Load management of different machines to profit from different price periods
- Simulation of systems before they are actually installed

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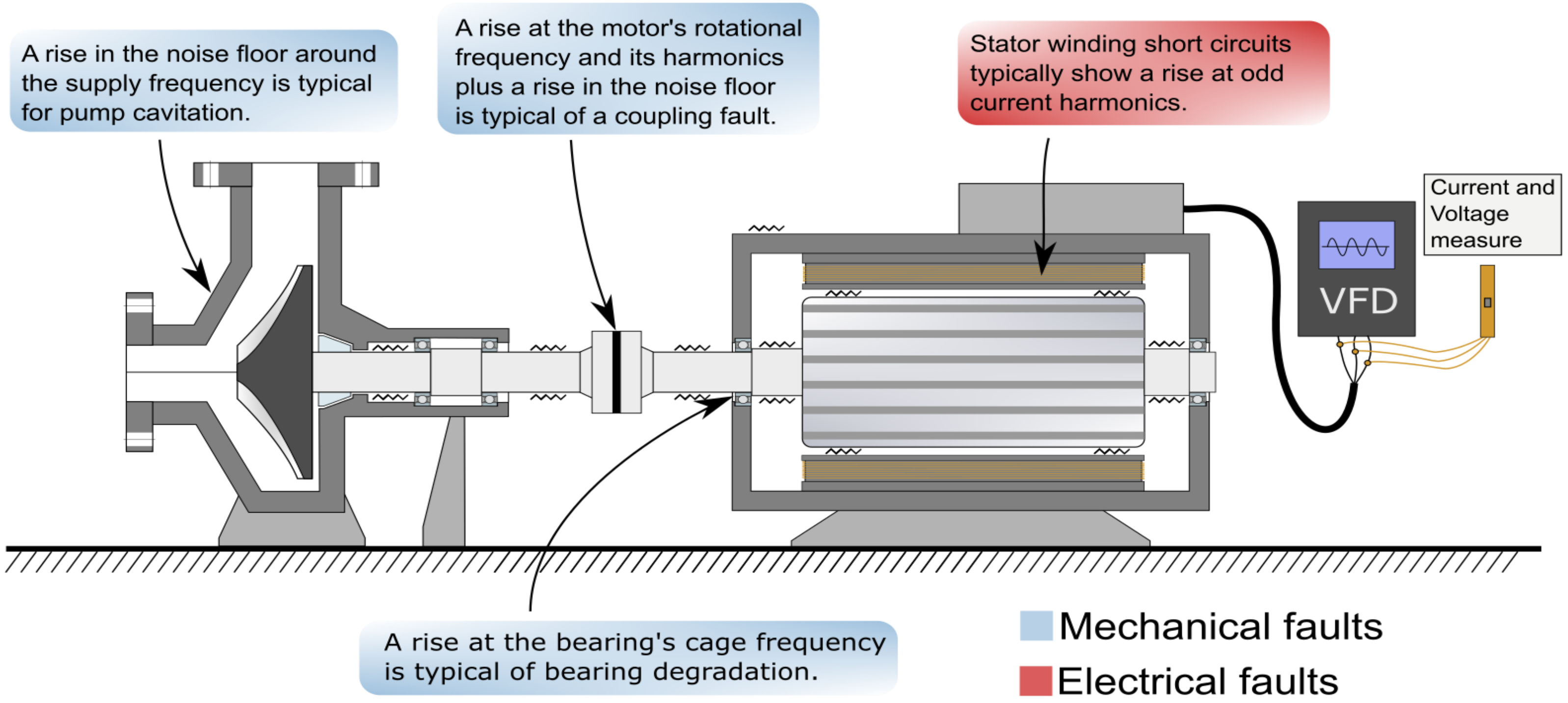
Obstacles

For End Use Companies

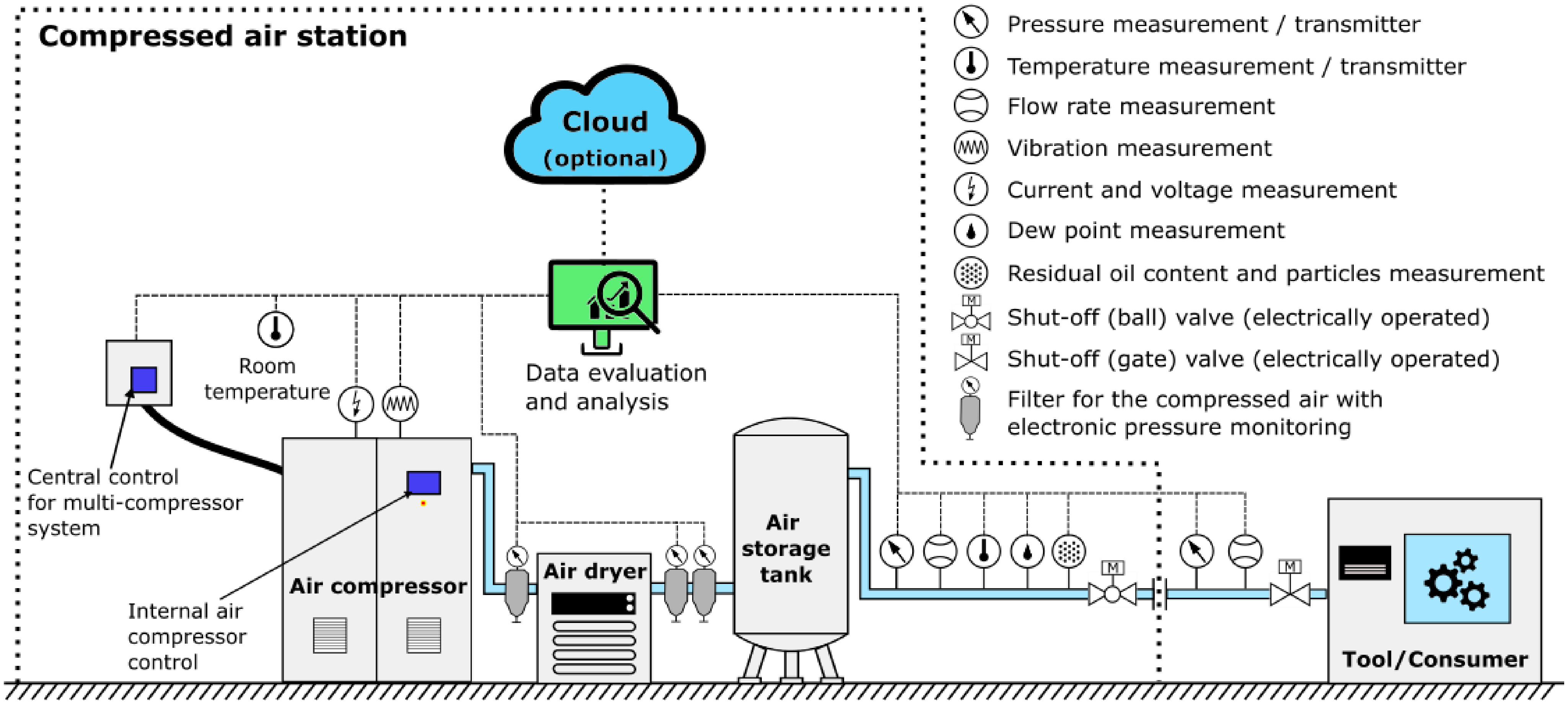
- Need for standardised data formats
- Lack of competence
- Scarce resources
- Low awareness
- Strict profitability requirements
- Difficulties in data collection and handling
- Cybersecurity at risk

Options for detecting malfunctions through current and voltage analysis



Source: AEA based on Samotics E-Book: ESA - Electrical signature analysis explained, p 14, figure 9

Measuring points for the digitalization of compressed air systems

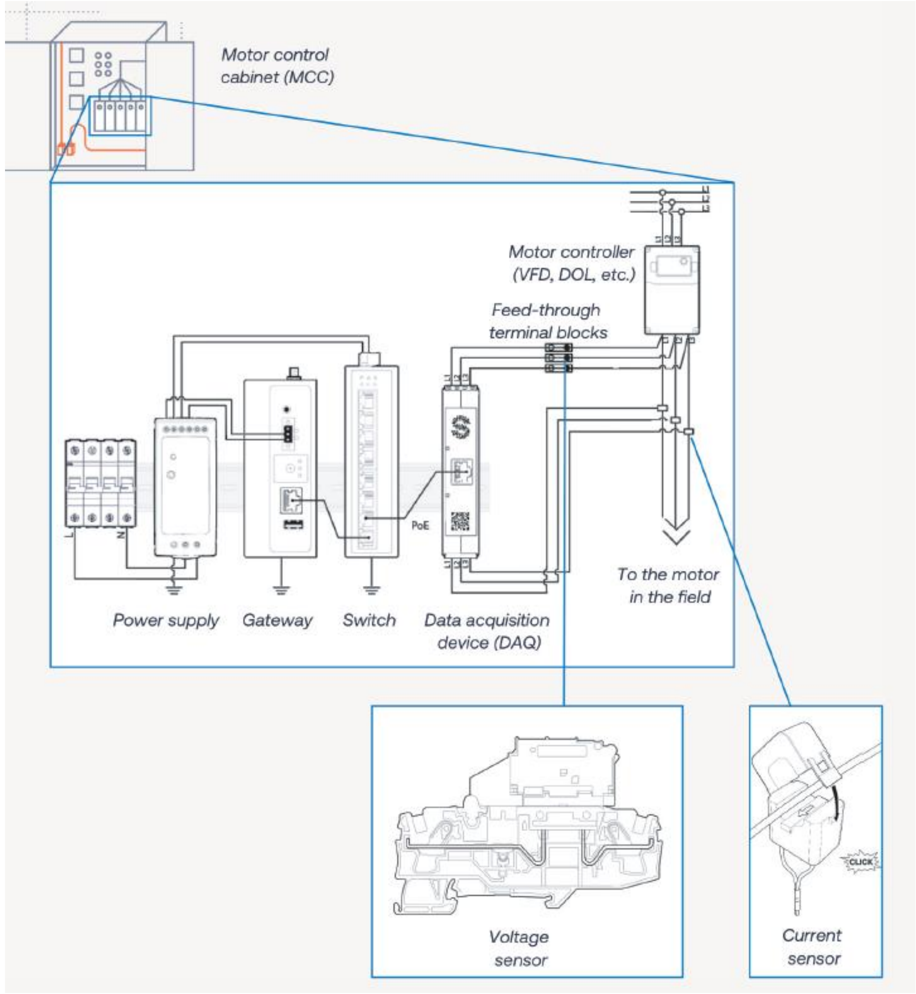


Pumps - Yorkshire Case, UK

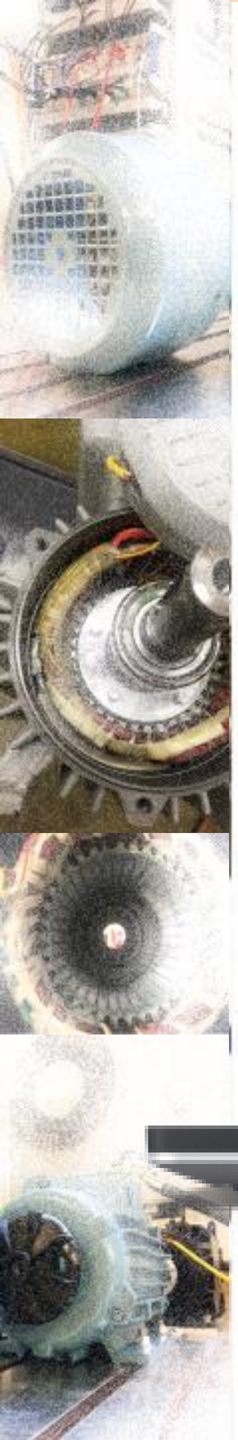
Yorkshire Water, a water supply and sewerage company in the United Kingdom, has applied electrical signature analysis (ESA) for the condition monitoring of its pumps.

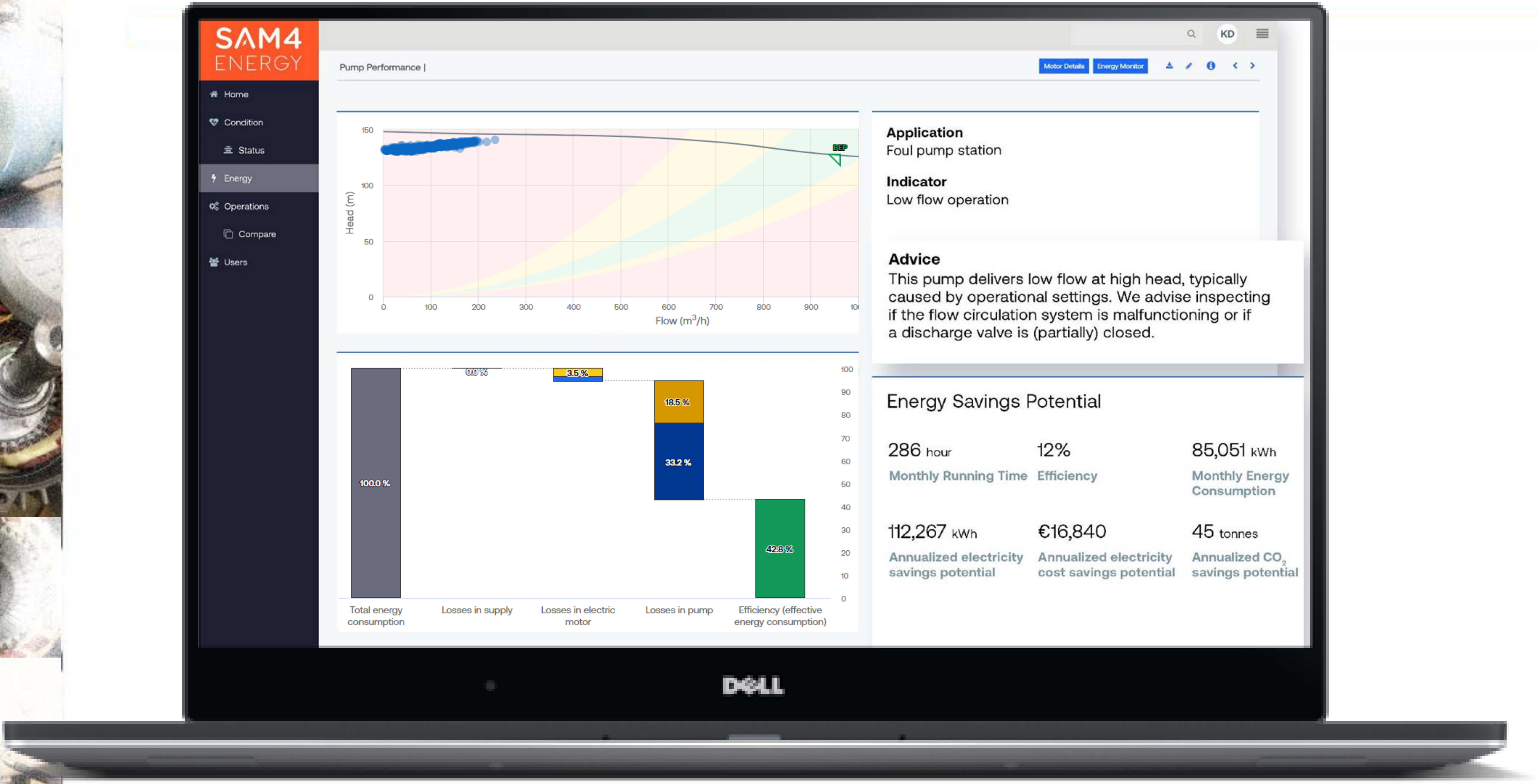
The ESA solution has been installed by Samotics.

In total, 4’000 assets are to be monitored 24/7.



Source: Samotics GmbH, EMSA Catalogue of Case Studies Report, 2024





Source: Samotics

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Costs/Benefits

This project covers a 11.5 million EUR expenditure for hardware and services

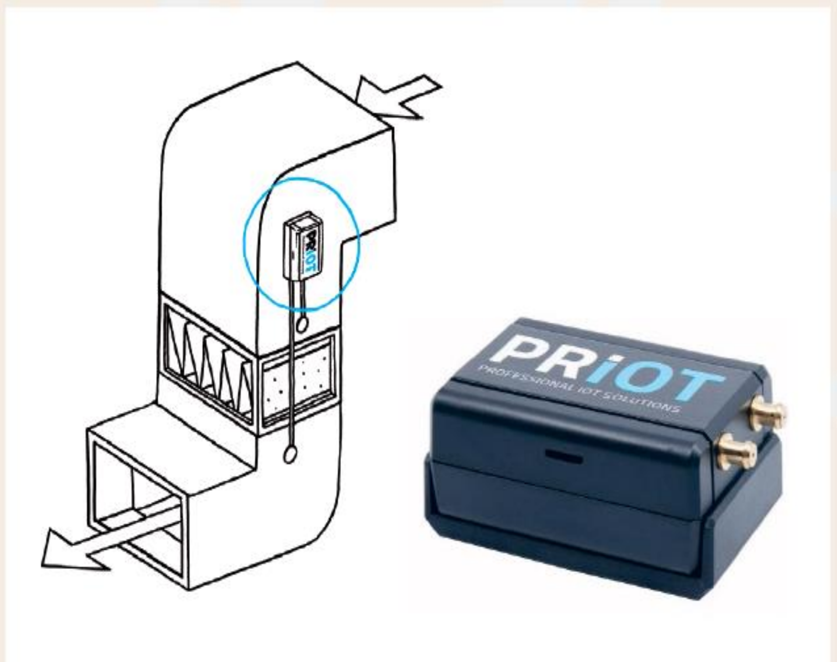
- The investment cost is 500 - 1,000 EUR per asset, exclusive installation cost
- The cost for monitoring is around 500-800 EUR per asset per year.

Benefits

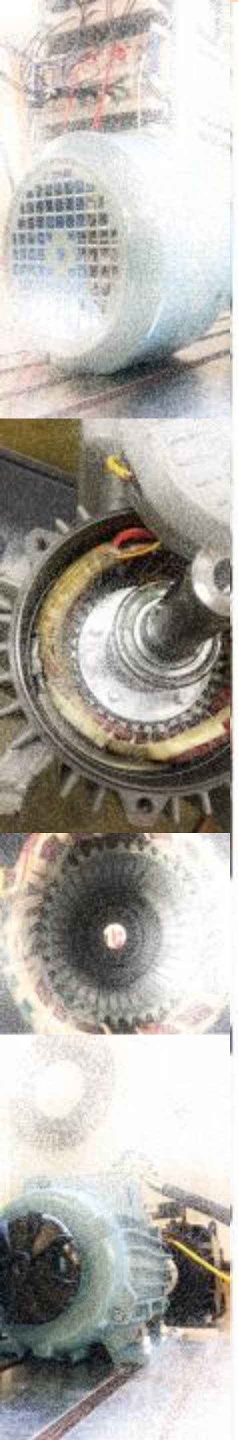
- Improve the reliability/increase the uptime (performance) of the asset base
- Lower maintenance cost of submersed assets e.g. borehole pumps
- Eliminate unplanned breakdowns, especially of critical high-risk assets
- Lower the energy use of assets, by eliminating inefficiencies/energy waste e.g. through improved control, bearings, belts, parts and components:
  - The energy and CO_2 emission savings are expected to be up to 15 %
- The return on investment is expected to be below 0.5 year.

Fan Systems - Priot Case, Switzerland

- Ventilation for regulating temperature in server sites, introducing air from the outside into the building through filters.
- PrIoT applies IoT sensors to detect clogged air filters in ventilation systems at server sites, allowing a more accurate timing for the exchange of the filter.
- Characteristics of typical system:
  - running hours around 2’000 per year
  - nominal power ranging down to 0.55 kW
  - average airflow of 2’500 m3/h



Source: EMSA Catalogue of Case Studies Report, 2024

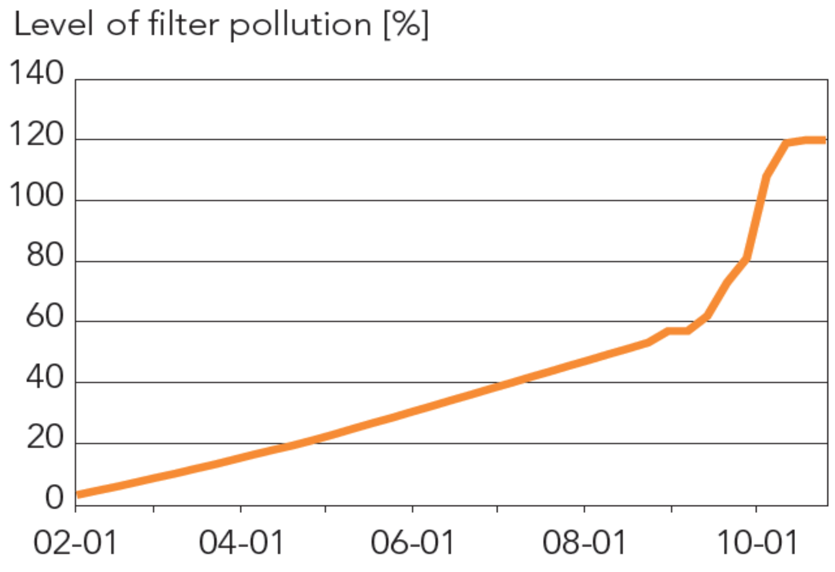


Measures

- Pressure difference, room temperature, humidity recorded by the Filter Monitoring Device (PRiOT FiMo).
- Data transferred by LoRAWAN to the cloud-based system, filter pollution status assessed
- Creation of a Digital Twin, replicating the ventilation system using measurement data.
- Automated filter maintenance process: monitoring through the sensor, establishment of a pollution threshold according manufacturer info and real-time analysis against that threshold. (pressure difference)
- When pollution level surpassing threshold, notifications via SMS, e-mail, or phone, intuitive dashboard.
- Automated filter order is triggered via a data interface to the filter manufacturer.

Impact/Result

- Power drawn is linearly dependent on pressured drop, increased by factor 2.5 when filter is clogged, maintenance occurred every 6 months, filter changed when pollution level was 80% (typically after 12 months of operation)
- If filter changed after 9 instead of 12 months the ventilation system would operate with a polluted filter during 3 more months, consuming instead of 6’510 kWh only 5’180 kWh
- 1’329 kWh (20 %) could be saved.
- Investment cost: 1000 EUR.
- Several advantages: decrease in frequency of on-site maintenance (factor of three), extension of filter life time, quick recognition of non-optimal operation
- Payback on maintenance cost: 2 years



Source: EMSA Catalogue of Case Studies Report, 2024

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Fan Systems - Coca-Cola HBC, Austria

- Largest company in Austria in the non-alcoholic beverages segment, 800 employees
- The plant's 18 largest ventilation systems consume around 10% of the total electricity requirement (around 3 GWh before optimization).
- Ventilation systems were also running at full capacity on non-production days

Source: Coca-Cola HBC, EMSA Catalogue of Case Studies Report, 2024

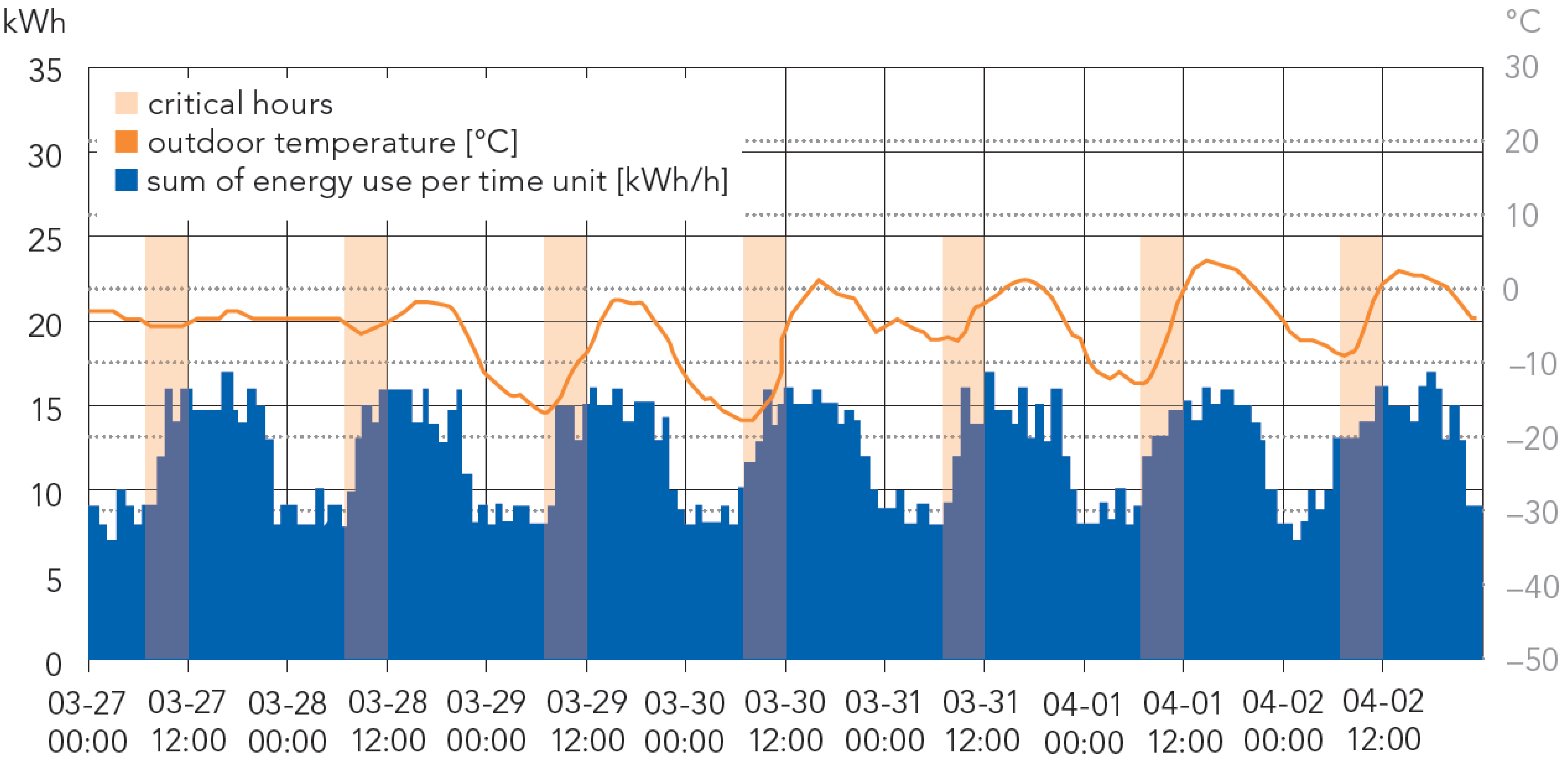
Measures/Benefits

- VSD - to enable the demand-based air change rate
- Minimum volume flow defined if production machines are switched off
- On/off status of the production system now triggers ventilation control (half/full volume flow or target pressure)
- Installation of a building management system
- All ventilation systems integrated into energy monitoring system.
- Savings of 15% electricity, payback-time: 3 years

Cooling Systems - IKEA CASE, Sweden

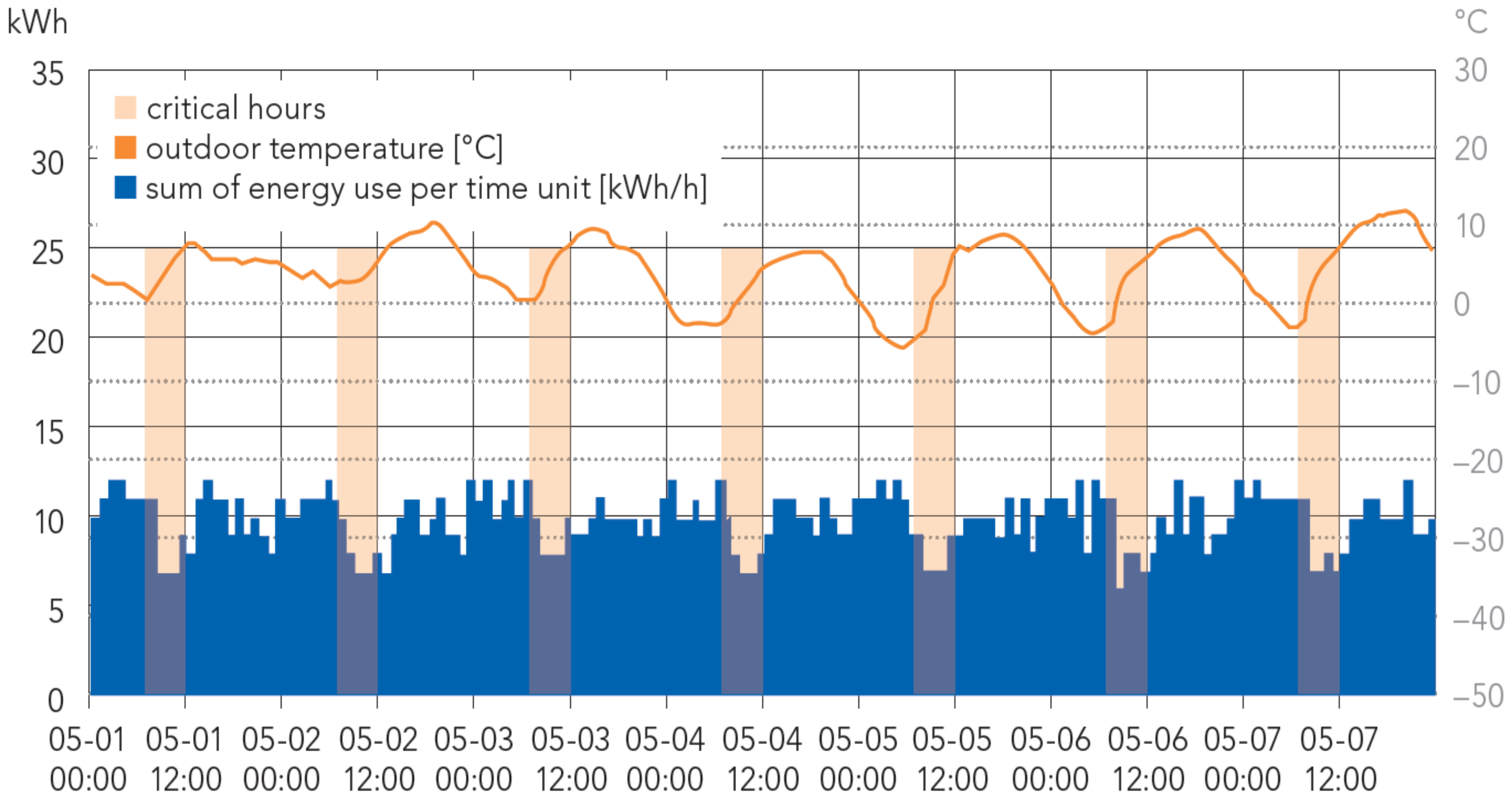
- IKEA store in Uppsala, Sweden, includes a restaurant and a cafeteria with refrigeration and freezer rooms as well as display cabinets.
- Rack compressors in the system. Several compressors are frequency controlled; operation in on-off mode common
- Centrally controlled with Huurre «itop» control system ClimaCheck online performance monitoring
- Cold storages were cooled down some degrees more than the normal setpoint during night, when the price is lower
- The compressors were also load limited during critical hours

Consumption Test 1



Source: EMSA Catalogue of Case Studies Report, 2024

Consumption Test 1



lowered energy consumption of up to 20 %

Source: EMSA Catalogue of Case Studies Report, 2024

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Compressed Air - Hamilton Bonaduz, Switzerland

- Company for automated liquid handling workstations
- 3 fixed speed, 2 VSD controlled screw compressors (15-50 kW, KAESER, Worthington)
- 8 bar, 7.5 bar system, 24 hours; 488 MWh/a
- Specific energy consumption:
  126 Wh/m³

Source: EMSA Catalogue of Case Studies Report, 2024

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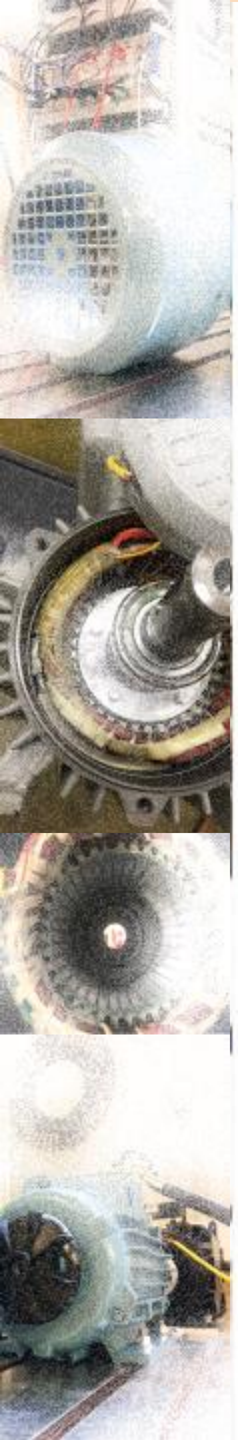
Measures

- Installation of Sigma Air Manager 4.0 KAESER, central adpative monitor and control system
- Communication to refrigeration dryers and compressors
- System connected to filter system, pressure sensors and drainage system (lower level)
- System connected to internal network, for company-wide remote monitoring (higher level)
- Installation of 3 compressors (37 kW), 2 of them with VSD
- Compressors tested inlab simulating customers facility in digital twin format
- Remote support through virtual version of compressor system at KAESERs offices
- Compressor system detects optimal operating points according to pressure need and air volume produced (in operation) with the goal to increase overall-system wide efficiency

Source: EMSA Catalogue of Case Studies Report, 2024



Cost / Benefit

- Control: 10,000 EUR
- Compressors: 80,000 EUR
- Installation (pipes...): 10,000 EUR
- Payback: Control: 2.2 years; Compressors 8.9 years

- System run at 7.5 bar (instead of 8 bar)
- Constant pressure
- Air pressure automatically adapts to changes in production line
- Less Energy consumption:
  - 106 Wh/m^3 (minus 16%) (lower pressure: 5 %; optimised control: 6%, new compressors: 5%)
  - Because of production increase: 544 MWh/a

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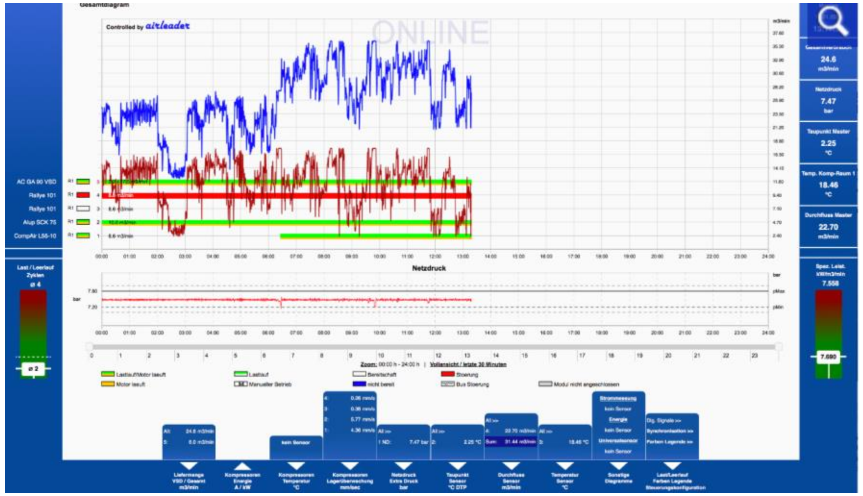
Compressed Air - Capita MFG GmbH, Austria

- Production facility of Snowboards
- 2 fixed speed, 1 VSD controlled compressor with refrigeration dryer (total 135 kW installed)
- Measurement and analysis of Unternehmen Druckluftoptimierung – Ing. Christian Steinbrugger
- Too many compressors in operation and switched on/off very often
- Too many idle hours with fluctuating pressure curves.

Source: CAPiTA MFG GmbH

Measures taken

- Installation of manufacturer-independent higher-level control system (Airleader Master).
- Incl.: power measurement, bearing vibration monitoring with energy monitoring and alarm as well as service management
- A second pressure sensor on the compressed air tank on the ground floor
- Sensor for dew point, room temperature
- Data recorded monitored, alarm value, signal by online monitoring system



Source: https://www.airleader.de/

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Benefits

- Increase of load hours from 75 % to 99 %
- Reduction of idling hours from 25 % to 1 %.
- Specific compressed air performance indicator in kWh/m^3 has been optimised
- System monitoring: Report, information on the compressed air station per day, calendar week or month as required. (energy, pressure…)
- The energy saving for the compressed air station: around 30 %
- Payback: very short

Data Collection in Production Halls, Austria

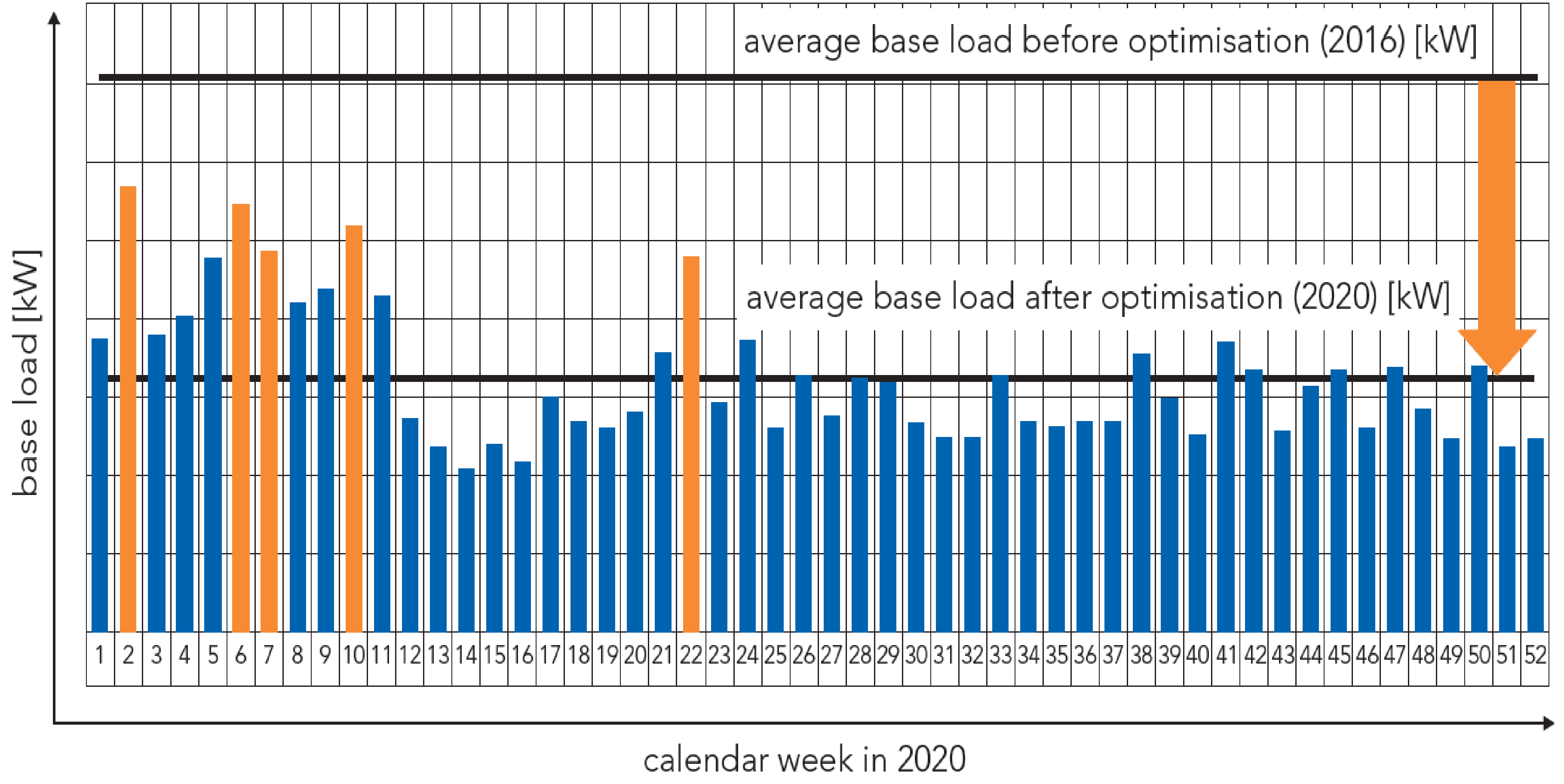
- Data collection system at BMW Group plant in Steyr
- Includes energy supply, right down to small consumers in individual machines
- Central recording and monitoring of electricity and compressed air consumption of individual production lines, visualisation on site
- Recording of electrical power consumption of various consumers per line
- Calculation of energy consumption per unit or per shift, visualisation of the degree of utilisation of machines in the form of efficiency classes A-F
- Recording of cooling and cold water, cooling lubricants and heat

Source: BMW Group Werk Steyr, EMSA Catalogue of Case Studies Report, 2024

Reduction of base load during non-production times

- Definition of clear targets in kW per line
- Responsibility of the control centres for achieving the set base load target values after the end of production of the last shift
- Weekly evaluation of these shutdowns, manual monitoring; automation with reporting tool and alarm message in preparation
- Savings for electrical consumers in the line (e.g. drive motors) but also for lighting and compressed air

Reduction of electrical base load by 52%

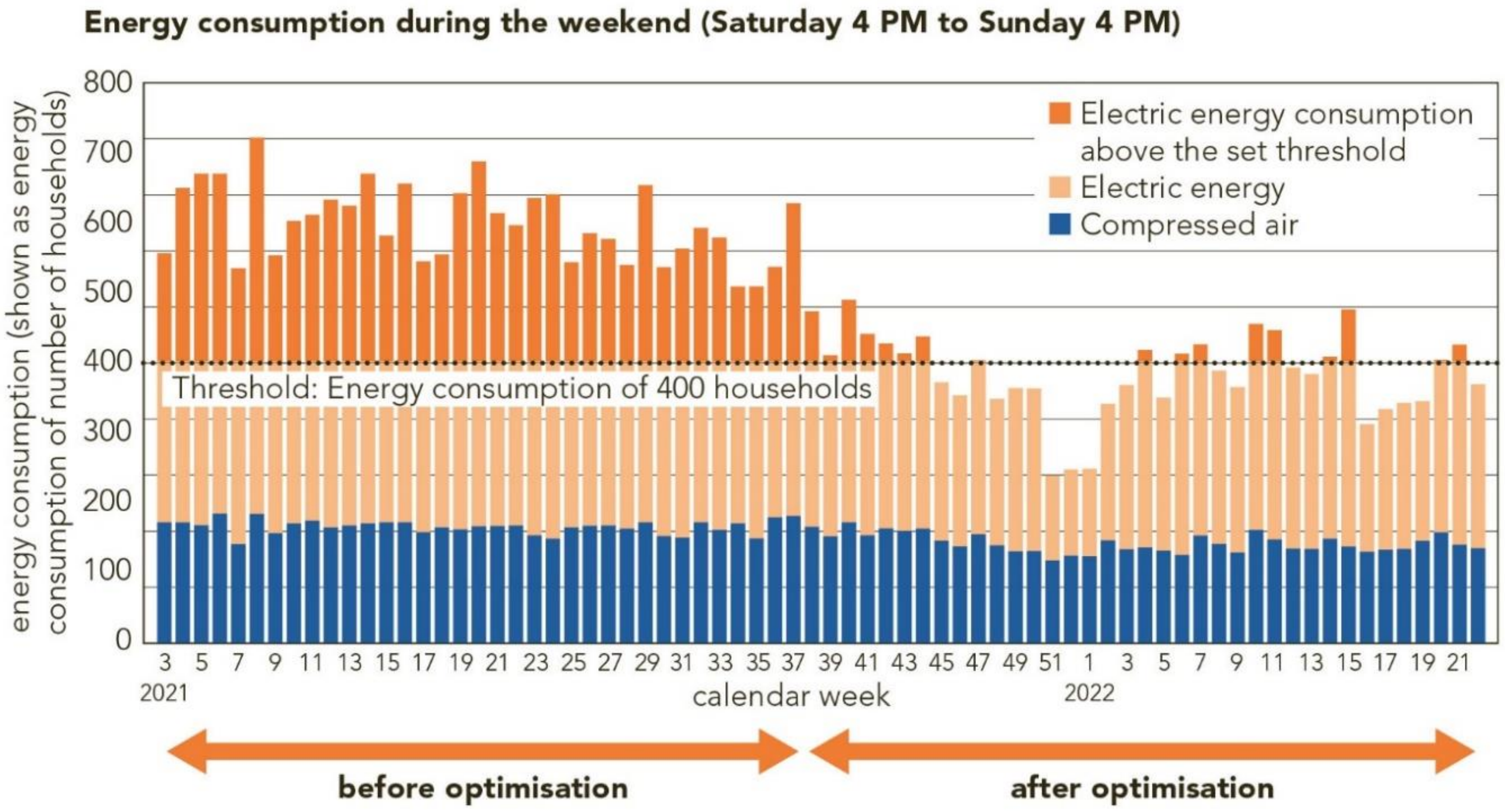


Source: BMW Group Werk Steyr, EMSA Catalogue of Case Studies Report, 2024

INNIO Jenbacher: Energy shutdown over the weekend, Austria

- One of many projects for CO_2-optimised production
- Checked together with the operating and maintenance staff in the pilot area of around 55 production machines: Which machines remain switched on at the weekend after the end of the shift and why?
- Where possible, implementation of technical measures on the machines
- Definition and automation of precise switch-off states

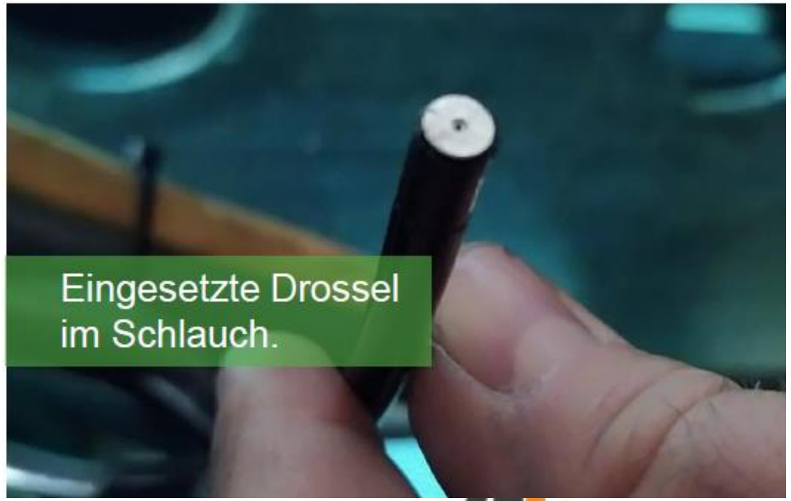
Energy shutdown over the weekend



Source: INNIO Jenbacher, EMSA Catalogue of Case Studies Report, 2024

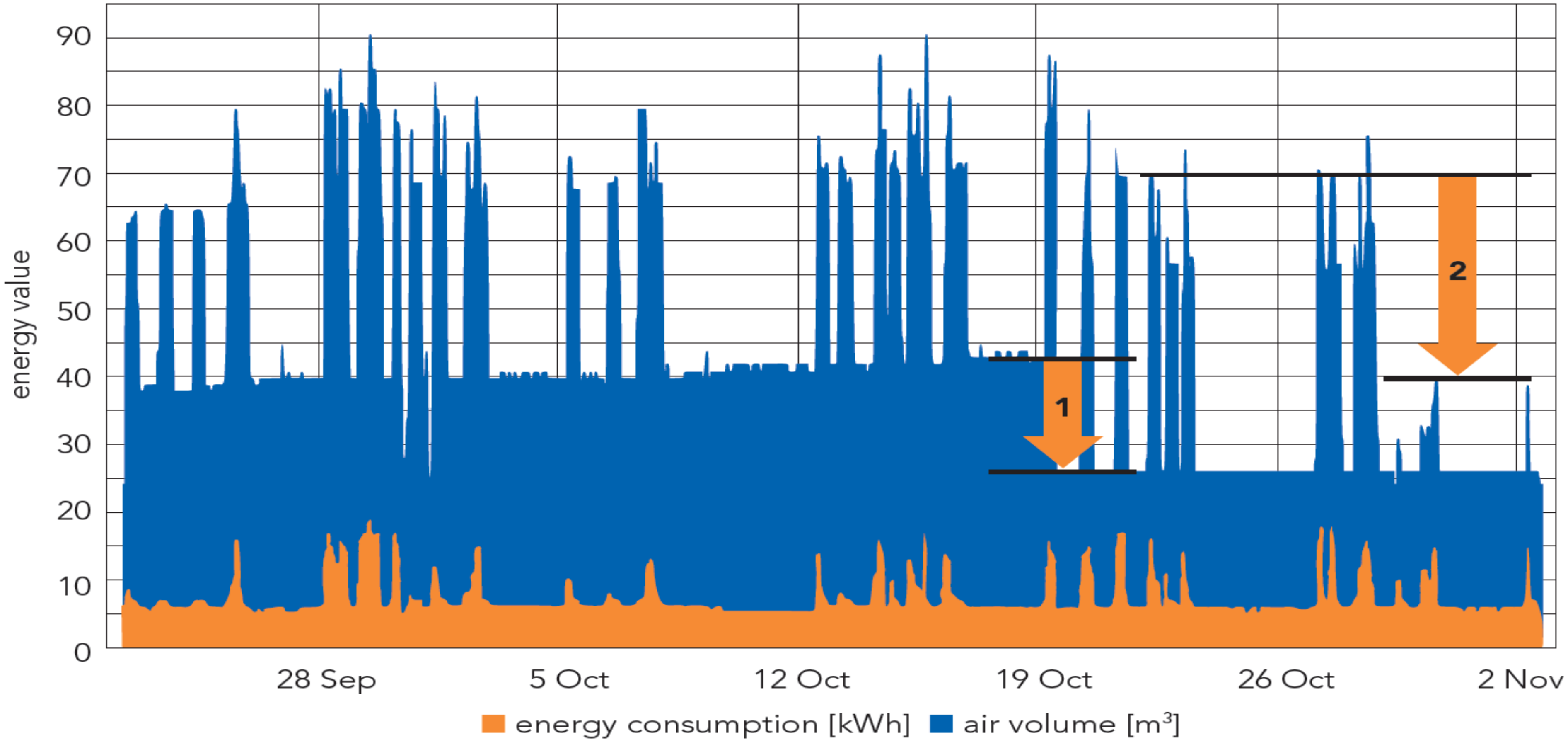
Condition Monitoring

- Isolation and rectification of incidents using energy measurement as part of condition monitoring
- Detachment of compressed air hose to spindle unit solution from fitting, blowing out of built-in air throttles;
- increased compressed air requirement when simply connecting the hoses
- Only recognisable through visualisation, measures taken immediately and compressed air loss stopped (third of full load compressed air requirement)



Source: INNIO Jenbacher

Monitoring of Compressed Air Production



Source: INNIO Jenbacher, EMSA Catalogue of Case Studies Report, 2024

Conclusions

1) Digitalisation is an enabler to create transparency in terms of when and how energy is being used. This is a crucial first step when it comes to the optimisation of motor systems' operation.

2) The potential savings vary greatly, depending on:

- a. Is the information that is provided through the digital solution used to implement optimisation measures?
- b. What is the starting point, i.e. is the motor system already optimised to some level (e.g. use of a VSD)?

3) Energy savings are not always the primary driver but rather a side-effect of the optimisation. Non-energy benefits play a more decisive role

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