Reduce your energy costs in utilities

Efficient energy management for steam, compressed air, heating, cooling and industrial gases

Endress+Hauser
People for Process Automation

Working together to save energy and cut costs

Boost your competitiveness by reducing energy consumption

Dear Readers,

By saving energy, companies reduce their operating costs and therefore increase their competitiveness. However, many companies are still unaware of how much energy they actually use – not least because they lack an adequate energy management system or the necessary instrumentation to measure energy consumption. Yet there are so many potential areas to save in utilities networks involving steam, compressed air, heating, cooling and industrial gases. Comprehensive energy monitoring can typically cut energy consumption by 5 to 15%. The questions raised in this context always remain the same:

- As a maintenance technician, specialist engineer or operations manager, how can I increase transparency regarding energy flows?
- How can I uncover potential savings?
- How can I increase plant efficiency and drive down my operating and energy costs? And which energy performance indicators do I need to do this?
- Which measuring equipment do I require to forecast the future energy needs of my production units?
- How can I modify my processes in order to fulfill legal regulations, work guidelines or quality audit requirements?

You can fully count on Endress+Hauser to answer all these questions. As an all-in-one provider in the field of automation, we offer you everything you need for comprehensive energy monitoring from a single source:

- Customized solutions for the widest range of energy applications
- Professional planning, commissioning and maintenance of energy monitoring systems
- Engineering and project management for simple solutions (e.g. monitoring of boiler efficiency) right through to system solutions
- Robust, tried-and-tested measuring instruments offering outstanding precision and repeatability
- Smart devices for data logging and data transfer
- Precise measurement of energy flows with calibrated instruments as required by EMAS, ISO 14001 and ISO 50001
- Expert advice from qualified specialists
- Global service network

More information about our energy solutions

Index

What our customers say

"Endress+Hauser's energy management solution enabled us to uncover the potential energy savings in our steam utilities network. By implementing the measures based on the information obtained, we succeeded in reducing our steam consumption by 35%. The entire project, including instrumentation and the implementation of measures to reduce energy in our steam system, paid for itself within a year. A key success factor for the project was the excellent support provided by Endress+Hauser's service organization."

Daniel Henriet / Head of Technology and Energy
Bières de Chimay S.A. (Belgium)

"Endress+Hauser conducted a potential analysis of energy technology at our company that identified the measures we can take to save resources and which even make sense financially. With Endress+Hauser, we have found a strong partner for our universal target agreement, and we can also use the data for our ISO 14001 environmental system."

Thomas Hirschi / Technical Manager
Temmentec AG, Sumiswald (Switzerland)

"Endress+Hauser carried out a professional potential analysis. This uncovered considerable savings potential with regard to waste heat recovery in the cooling machines and the hot water system. We're now working together with Endress+Hauser to implement the measures identified."

Ralf Bödeker / Technology Manager
Orior Menu AG – Le Patron (Switzerland)

"We had quite a complicated site much like a labyrinth delivering heat. When Endress+Hauser's Energy Efficiency Manager came to our site, he was much more proactive in working out what it was we needed and not just what he could sell me – it was a breath of fresh air. The guidance, advice and support from Endress+Hauser was instrumental to the success of our energy scheme."

Mark Foden / Energy & Environment Manager
UHSM – University Hospital of South Manchester NHS Foundation Trust (UK)

You can only monitor what you measure

Successful energy management according to ISO 50001 and ISO 50006

Utilities such as gas, steam and water provide energy for plant operation in all sectors of industry. Vast quantities of energy are expended in producing, transporting and distributing fluids, for example compressed air, steam, natural gas, cooling or hot water.
Every plant operator's goal must therefore be to run and control their process as efficiently as possible. The basis for this is measuring equipment that can objectively measure energy flows, energy consumption and process data according to ISO 50001 and ISO 50006, and present the results as energy performance indicators (EnPI ▸ page 5).
Endress+Hauser has everything you need for this task, offering customers top-quality measuring devices, system components and smart solutions to suit your application.

Energy management – Your benefits throughout the life cycle

- Central availability of measured data
- Transparency on all fluid and energy flows
- Easy identification of energy loss
- Efficient charging to cost centers
- Security of supply thanks to permanent monitoring of operation and process variables

ISO 50001 – Energy management

This standard specifies that any organization wishing to set up an energy management system according to the ISO 50001 standard must capture energy performance indicators (EnPI). These indicators must be regularly reported, checked and compared against an energy baseline (reference prior to the introduction of energy efficiency measures). On the basis of this information, potential areas for savings are evaluated and improvement measures initiated. This can be for a process, a plant, a building or an entire factory complex (▸ page 6).

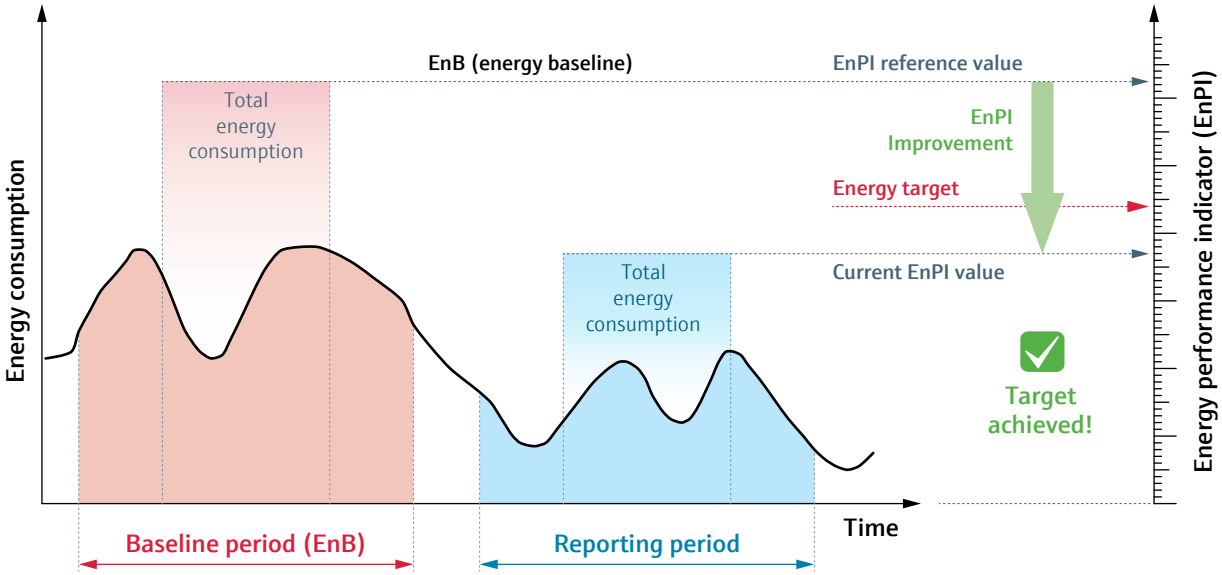
! Performance indicators and their trends over time are ultimately used to monitor and demonstrate the success of energy optimization measures.

ISO 50006 – Energy performance indicators

This standard provides step-by-step guidance to companies on how to establish robust energy performance indicators (EnPI) and a solid energy baseline (EnB) for the purpose of later comparison. The standard also contains several real-life examples, as it is often difficult to identify the variables that are relevant in an energy system and properly factor them in when determining the EnPIs. These variables can include weather conditions, the balance period, the plant size, variations in production, or the type of energy source.

! The comparison of performance indicators is considered the most important control instrument in an energy management system. For lasting energy optimization, a more in-depth analysis of the measured data is therefore indispensable, such as in the form of absolute values, limit values, time frames or ratios. This often involves a continuous learning process over a longer period of time (example ▸ pages 46–47).

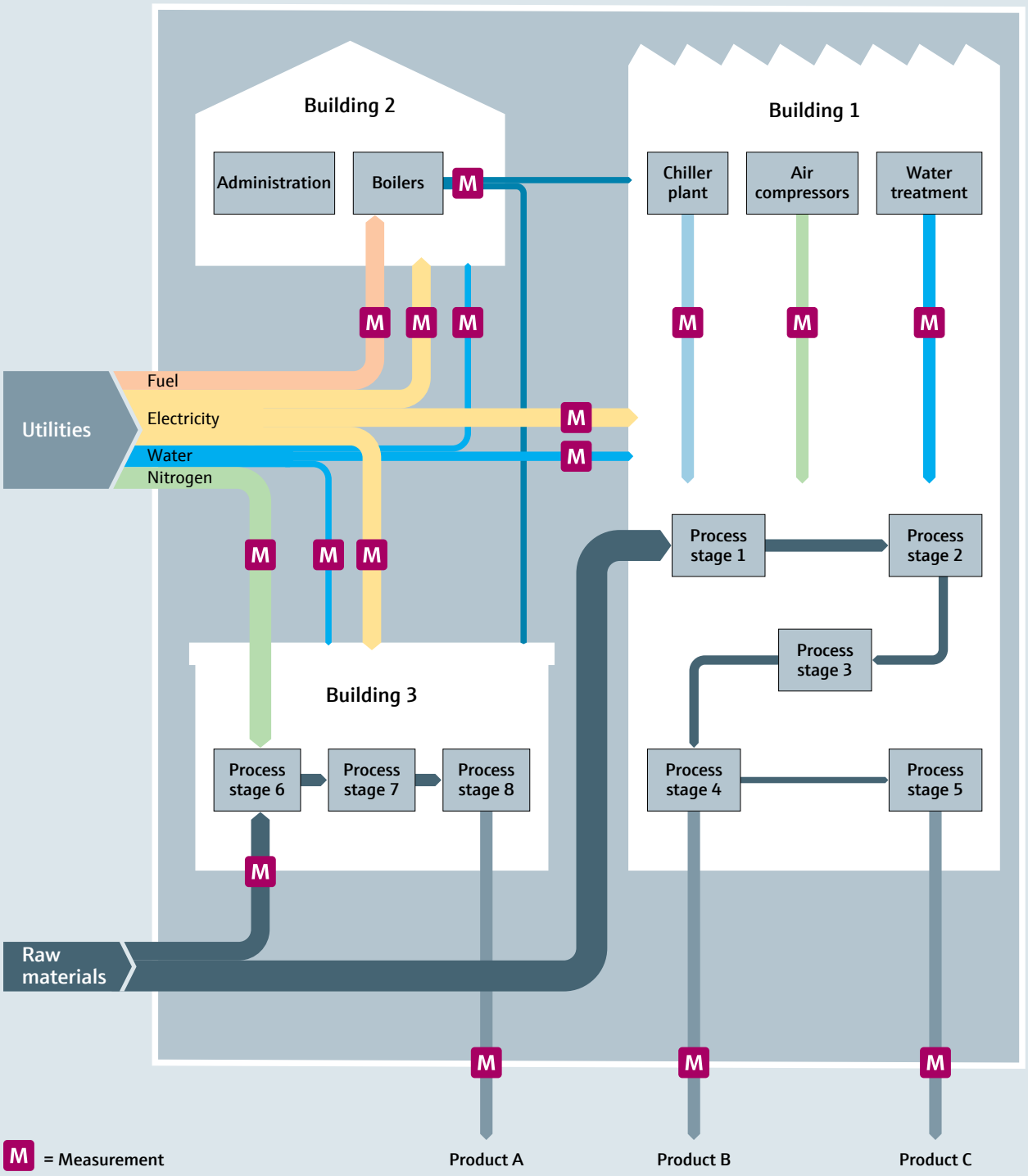
Energy performance indicators (EnPI)



Examples of performance indicators

- Total primary energy consumption [MWh/year]
- Improvement in energy intensity for the baseline year [%]
- Adjustment for primary energy demand [MWh/year]
- Energy savings for the current year [MWh/year]
- Energy savings since the baseline year [MWh/year]
- Improvement in energy intensity for the current year [%]
- Total consumed primary energy [MJ/year]
- Electricity, water or fuel consumption (total values, peak loads, etc.)
- Specific energy consumption, i.e. energy consumption per quantity of produced medium: compressed air [kWh/Nm^3], steam [MJ/t], hot water [kW/kg]
- Efficiency of steam boilers [%]

Energy and utility flows across functional areas



Procedure for measuring material and energy flows as the basis for sustainable energy management

1. Define the desired "functional area" (e.g., factory complex, building, floor, manufacturing department, process)
2. Measure/Evaluate **(M)** the actual material and energy flows (raw materials, fuel, water, electricity, steam, compressed air, etc.)
3. Analyze the values measured (data basis)
4. Create energy performance indicators (EnPI)
5. Define energy optimization measures (using the energy baseline)
6. Control and monitor efficiency improvements achieved

Record – Evaluate – Economize

Software for a 360° view of your data

Merely installing meters, for example for flow, temperature or pressure, is not enough to save energy, but it is the basis for efficient energy management according to ISO 50001. Visualization of the measured values and energy data is the real key to detailed evaluation that complies with the ISO 50006 standard.

The energy monitoring software programs on the market today permit access to the entire monitoring system in a plant via an intranet or the internet. In addition, this software can be used to analyze measurement data and create energy reports. State-of-the-art energy monitoring software offers users the following:

- Fully web-based software solution
- Worldwide or local usage via intranet or internet
- Simple operation and easy-to-use interface with drop-down menus
- Automatic data import from data loggers, SCADA systems, production systems or building management systems
- Simple integration into any existing operating data recording system
- Modular software design, customization possible at all times

Energy analysis
- Monitoring of energy consumption
- Efficiency assessment
- Target/Actual comparison of energy data
- Identification of peak values

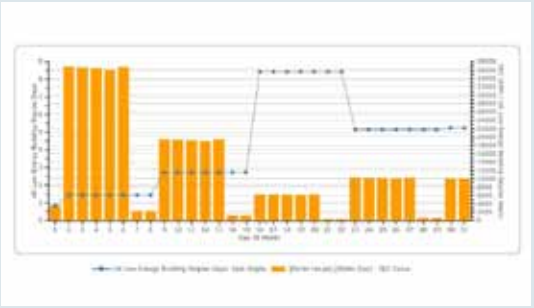
Cost analysis
- Create diagrams and displays
- Create and monitor budget plans
- Compare costs
- Calculate profitability (ROI, Return on Investment)

Reporting
- Tailor-made reports via SSRS (SQL Server Reporting Services)
- Generate cumulative curves or comparative displays
- Automatic sending of energy reports (PDF files) via email or server

Deviation analysis
- Trigger warning messages via email
- Set limit values
- Prioritize warning messages
- Continuous monitoring of (steam) quality

Simulation/calculation
- Calculate characteristic values using mathematical functions

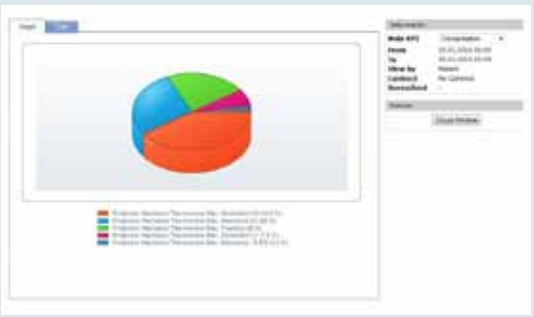
Energy analysis



Monitor specific energy consumption

Create reports

Track consumption profiles of a measuring point over various days of the week



Break down energy consumption by cost centers

Seamless system integration for greater transparency

Turnkey solutions for smart energy monitoring

Every day, energy monitoring generates thousands of measured values that have to be transmitted to the process control system where they are visualized and evaluated using special software. Endress+Hauser's open energy management system has all the hardware and software components you need for this task. Measured values can be queried and imported automatically at user-defined intervals – e.g., from measuring instruments for flow, pressure, temperature or level, or from electricity and gas meters, data loggers, energy computers and recorders.

Endress+Hauser also develops individual digitization solutions tailored to our customers' needs and incorporates them into their IT landscape. Furthermore, for hard-to-access measuring points we also offer solutions for wireless data transmission, including data transfer to databases in the cloud. Cloud-to-cloud solutions with other vendors can also be implemented on request.

Industrial Internet of Things

The IIoT (Industrial Internet of Things) offers undeniable potential and advantages, thus becoming increasingly important in a wide variety of industries and applications in the future. This is also true for energy monitoring: predictive maintenance, asset information management, and quick and easy device configuration are just some examples of the opportunities digitization presents for business enterprises.

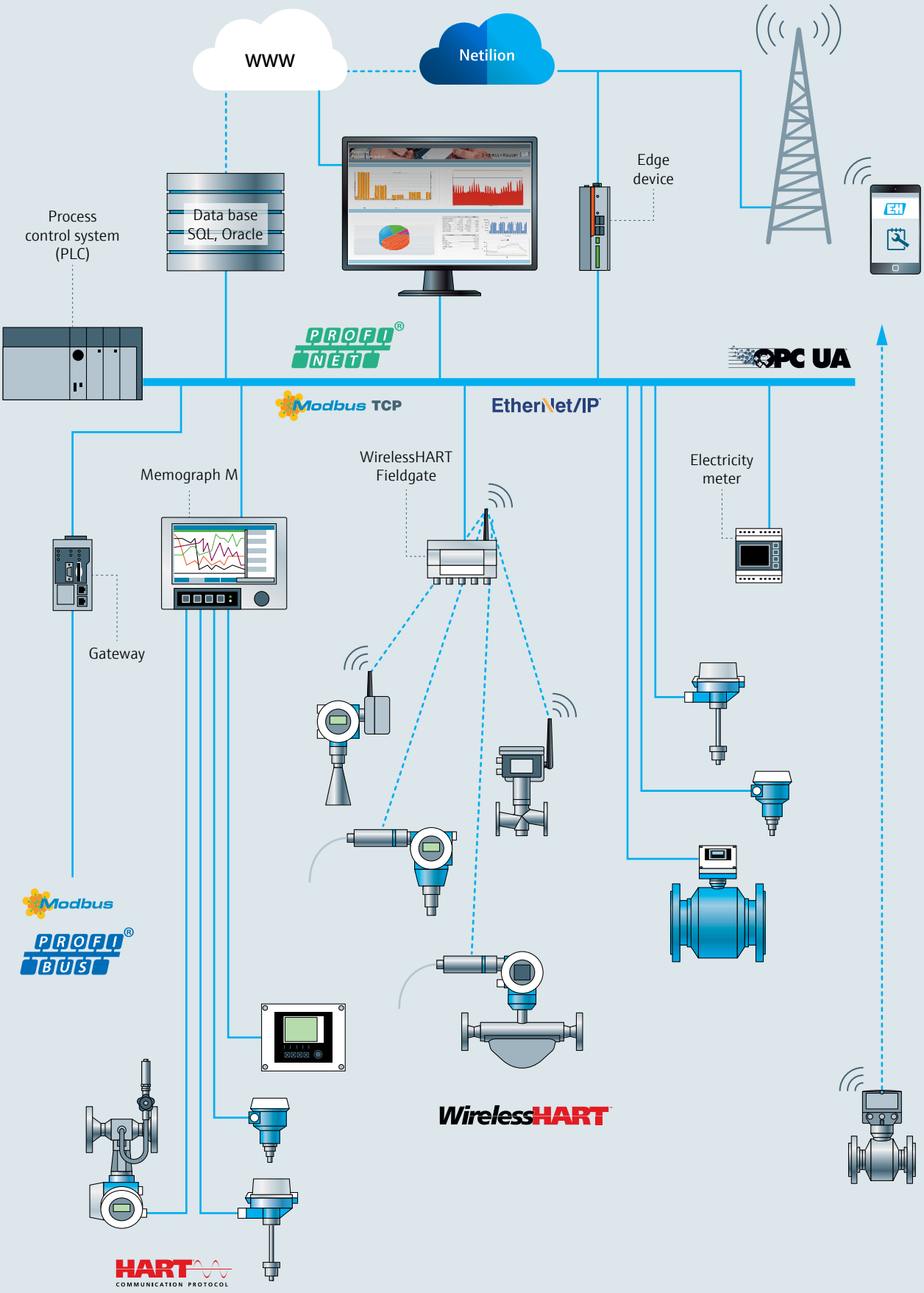
Fieldbus technology
More value through more information

Modern multivariable instruments like those from Endress+Hauser deliver a wealth of information on process-related parameters. Digital signal transmission by fieldbus, however, enables process data to be transferred and utilized along with device parameters. For measuring operation, the benefits are:

- Easy servicing and predictive maintenance thanks to advanced diagnostics
- More efficient process management and high product quality
- Optimized plant availability owing to reduced downtimes
- Maximum process safety

HART COMMUNICATION PROTOCOL
PROFIBUS
EtherNet/IP
Modbus TCP
OPC UA
WirelessHART
Modbus
PROFINET

System integration with Endress+Hauser field measuring devices



Steam

Steam systems

Monitoring steam boiler efficiency – Minimizing fuel consumption

For heating or for power generation in turbines, for sterilization or for cleaning purposes – in many industries steam is used on a grand scale. It is therefore not surprising that in industry a massive 40% of fossil fuels are used for steam generation in boilers. The judicious use of fuels such as oil or natural gas is just one of the aims in energy management. These days, steam management covers a whole lot more than checking water level, conductivity, pH value, temperature and pressure in the boiler.

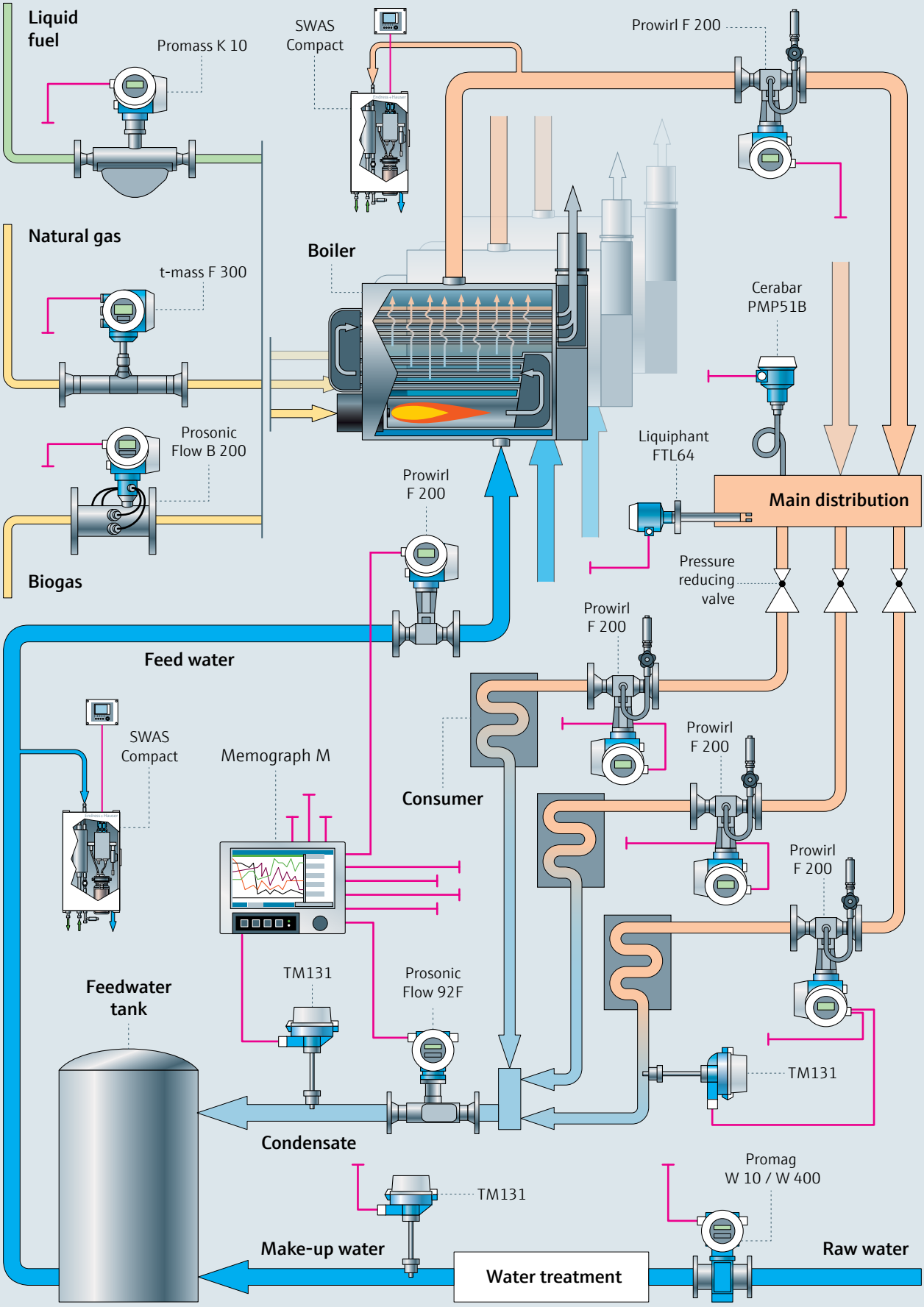
Steam systems offer numerous options for saving, re-using and reclaiming energy, whether in generation, distribution, billing or in boiler efficiency. Endress+Hauser can provide all the measuring instruments required to realize potential improvement optimally, including instruments for comprehensive water analysis (▸ page 18):

- Monitor specific energy consumption and boiler efficiency
- Share generation costs among multiple cost centers
- Identify and monitor target values based on historic data
- Uncover leaks at valve bodies, connections, pressure regulators, pipe connections and defective steam traps
- Measure steam quality directly in the pipe (wet steam, saturated steam, superheated steam) for the optimization of the fuel to steam efficiency and for the prevention of damage
- Calculate the gains from energy optimizations

Savings made easy

- Minimize leaks
- Insulate steam pipes sufficiently
- Shut down line sections not in use
- Reduce condensate loss
- Service boilers regularly (e.g., remove deposit buildup)
- Check performance indicators (e.g., boiler efficiency)

Energy management in steam systems



Steam – Measuring instruments

Flow measurement (steam quantity and quality)
Prowirl F 200 (vortex meter)

- Multivariable vortex meter (incl. flow computer) for direct mass and volume measurement of saturated or superheated steam with best-in-class accuracy
- Optionally available with integrated pressure and temperature measurement for the calculation of delta heat and energy flow
- Maximum accuracy thanks to "PremiumCal" calibration

Unique worldwide: steam quality measurement (dryness fraction)
▸ page 16

Flow measurement (steam quantity)
Differential pressure flow measurement

- For mass and volume measurement of saturated or superheated steam
- Nominal diameters: DN 10 to 1000 (⅜ to 40")
- Recognized and standardized technology since 1929 (ISO 5167)
- External pressure and temperature compensation required

Pressure measurement
Cerabar PMP51B

- For reliable monitoring of steam pressure at the boiler outlet or in the main steam line
- Can sustain high temperatures and vibration
- Fitted with shutoff valve and siphon (accessories)
- High accuracy (standard 0.075%, platinum up to 0.055%)

Flow measurement (fuel consumption measurement – natural gas)
t-mass F 300 (thermal)

- For mass and corrected volume measurement of gaseous fuels
- Negligible pressure loss
- High turndown (≥100:1)
- Direct mass flow measurement without external pressure and temperature compensation
- Reverse flow detection and drift-free
- Flanged version (F) available with integrated flow conditioner for shortest inlet runs, or insertion version (I) for larger pipelines (>DN 80/3")

We recommend Prosonic Flow B 200 for the measurement of biogas. This ultrasonic flowmeter also enables the measurement of the methane fraction and the calorific value of biogas.

Flow measurement (fuel consumption measurement – fuel oil)
Promass K 10 (Coriolis)

- For mass and volume measurement of liquid fuels
- With highly accurate, direct density measurement
- High measuring accuracy: ±0.5% (option ±0.15%)

Alternatively, Promass E/F 200 is equipped with the same electronics platform as Prowirl F 200, which is used in steam operation.

Flow measurement (feed water)
Prowirl F 200 (vortex meter)

- For volume, energy and mass measurement of feed water
- Optionally available with integrated temperature measurement for the calculation of delta heat and energy flow, optional pressure measurement
- Robust design: over 500 000 installations worldwide

Flow measurement (make-up water)
Promag W 10 (electromagnetic)

- For cost-effective volume measurement of make-up water with sufficient conductivity (>50 µS/cm)
- No pressure loss
- High measuring accuracy (±0.5%)
- Very high turndown (1000:1)
- Integrated conductivity measurement for additional safety

Flow measurement (condensate)
Prosonic Flow 92F (ultrasonic)

- For volume measurement of hot condensate – independent of electrical conductivity and low flow rate
- Suitable for use up to 200 °C (392 °F)
- Immune to magnetite deposits
- No pressure loss – low risk of flashing
- Also available as clamp-on version for measurement from outside without opening the pipe

Temperature measurement
TM131 / TM151 (butt-weld version)

- For temperature measurement of make-up water, condensate and feed water to determine the energy content
- Fast response time due to tapered end

Data logging/evaluation
Memograph M RSG45

- For the visualization and recording of performance data and consumption data
- For calculating the thermal energy content and aggregate energy flows from the measured values for flow, temperature and/or pressure
- Calculation standard according to IAPWS-IF97/ASME

Fuel consumption is measured to determine the boiler efficiency and the (carbon dioxide) emissions produced. To calculate the efficiency of a boiler, the thermal energy content of the feed water must be taken into account by measuring the temperature and flow. Furthermore, the thermal energy content of the condensate return lines and the added water is needed to calculate the total efficiency of the boiler system.

Unparalleled steam quality measurement with Proline Prowirl 200

For maximum safety and energy efficiency

As a multivariable vortex meter, Proline Prowirl 200 offers everything you need in a single product: simultaneous measurement of mass flow, corrected volume flow, energy flow, temperature, and also of process pressure. No matter how much your process variables fluctuate, Prowirl enables highly accurate measurements and comprehensive energy management even for compressible fluids like steam or gas.

Example 1 – Steam density measurement upstream/ downstream of pressure reducing valves (see figure)

The density of the supplied steam plays a central role in correct cost allocation. Pressure reducing valves between the main pipe (A) and the final consumers regulate the steam to the required pressure level. However, due to pressure reduction, the steam downstream of the pressure reducing valve (B) is superheated and no longer saturated. Vortex meters that only use temperature compensation (C) assume that the steam in such situations is saturated both upstream and downstream of the pressure reducing valve. This assumption produces incorrect steam density values, which can deviate from the true value by more than 100% in extreme scenarios, and therefore also result in incorrect cost accounting.

- With the optional pressure measurement, Proline Prowirl 200 can also directly measure the degree of superheating of superheated steam, and display a warning message if necessary.
- With the Applicator selection and sizing tool from Endress+Hauser, users can also simulate and calculate different steam states.

Example 2 – Wet steam measurement for maximum safety and energy transmission

Poor insulation, faulty steam traps and variations in pressure and temperature occasionally result in the condensation of steam in the pipe, causing wet steam to form. The consequences are often serious: poor energy transmission efficiency and dangerous plug flow water hammers or condensation-induced water hammers. Proline Prowirl 200 is the first vortex meter worldwide that allows users to monitor the steam quality directly in the pipe:

- Measurement of the dryness fraction (80 to 100%) and the steam type (wet steam, saturated steam, superheated steam)
- Alarm signal if steam content drops below predefined limit (80 to 100%)
- Direct mass measurement of steam and condensate

If the steam quality is only 90%, for instance, conventional vortex meters and orifice plates produce an additional measured error of 5%. Only Prowirl F 200 can fully compensate such errors!

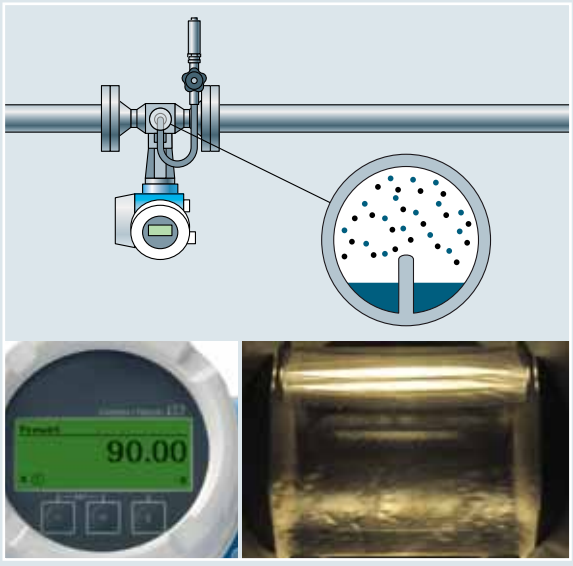
Steam quality measurement with Prowirl 200

Prowirl 200 with integrated temperature and pressure measurement

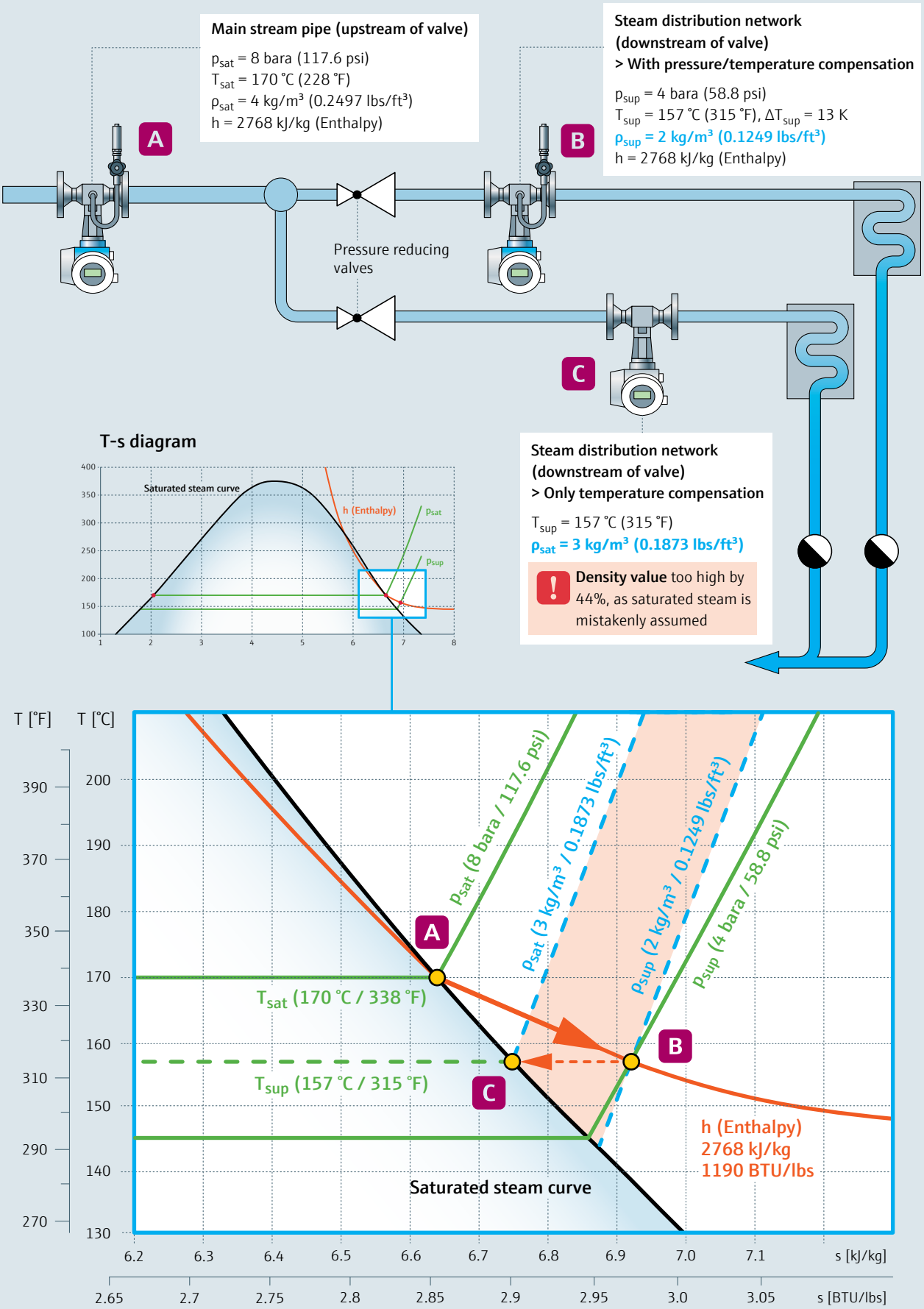
Measuring wet steam – here's how!

Wet steam results from the condensation of steam. The condensate first flows down to the pipe floor and then "creeps" up along the pipe wall. This effect influences the measuring signal of the Prowirl vortex meter. The quality of the steam can be determined from this, and both the mass flow and the energy content of the steam can be corrected accordingly.

Example: If steam has a dryness fraction of 90%, it is wet steam, consisting of 90% saturated steam and 10% condensate (water).



Pressure and temperature compensation with Prowirl F/R/O 200



Reliable water quality in steam circuits

Minimize corrosion and deposit build-up with our SWAS solutions

The quality of water is a matter of central importance in water and steam circuits. Water of insufficient purity can cause corrosion or fouling in steam boilers and pipes. This often results in expensive repairs or production losses due to plant downtime. Our product range includes water analysis instruments which you can use to consistently monitor the quality of your feed water, boiler water or condensate. Besides measuring instruments, we supply complete solutions for all steam analysis tasks from sample preparation to analysis.

The SWAS solutions (Steam/Water Analysis System)
With our modular SWAS solutions, we can deliver customized solutions that are optimized for your requirements. Especially for industrial steam generators, we have developed “SWAS Compact” – a solution that efficiently monitors the water quality and fits neatly into your system, requiring very little space. It includes sample preparation, a flow assembly with optional cation exchanger for measuring pH, conductivity and oxygen as well as the Liquiline multiparameter transmitter.

Advantages at a glance

- Suitable analysis solutions even for the highest steam parameters with more than 600 °C (1112 ° F) and 300 bar (4351 psi)
- Extensive SWAS portfolio with numerous sensors, analyzers and fittings
- Various cation exchanger types including electrodeionization (EDI) cation exchanger for maintenance-free operation without resin consumption
- Easily integrated into existing water and steam circuits thanks to its compact design and turnkey delivery
- Multifunctional Liquiline transmitter:
  - Up to 8 sensors can be connected
  - Integrated pH value calculation using differential conductivity
  - Automatic system shutdown if probe temperature is too high

MEMOSENS

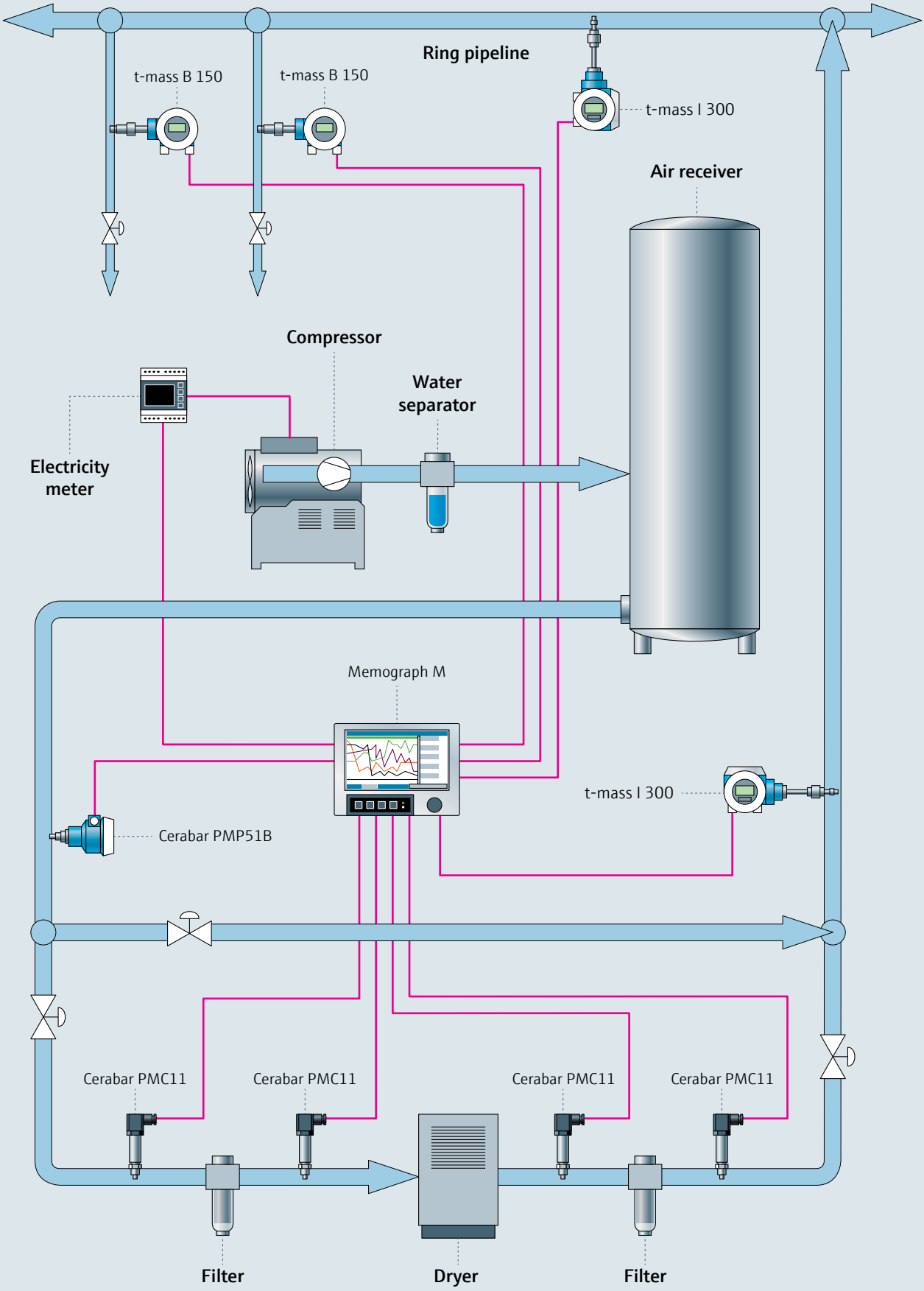
The new ground-breaking sensor technology

Memosens technology has revolutionized liquid analysis technology. It converts the measured value to a digital signal and transfers it inductively to the transmitter, eliminating the problems associated with moisture. With signal alarms in the event of transmission disruption, Memosens offers safe data transfer for increased availability of the measuring point and trouble-free processes. With Memosens 2.0, measuring points become completely future-proof and ready for IIoT.

- Connected: Memosens 2.0 offers extended storage of calibration, sensor and process data. It facilitates better trend identification, a more precise process management and provides a future-proof basis for predictive maintenance and IIoT services.
- Seamless integration: Memosens 2.0 and Liquiline offer numerous protocols, interfaces and bus communication for fast integration into existing infrastructures and plant asset management.
- Simple: Calibration under favorable lab conditions, lockable bayonet connector and true plug & play make sensor handling a breeze.

Compressed air

Energy management in compressed air systems



Compressed air systems

Active reduction of energy loss and leakage

Up to 10% of electricity consumption in industry – equivalent to the output from 75 large nuclear power stations – is used to generate compressed air using compressors. Up to 95% is lost as unproductive waste heat in the process. And up to 30% of the compressed air generated "disappears" due to leakages in the supply network. Experience has shown that by implementing appropriate measures, this proportion can be reduced by up to 10%, thus reducing power consumption. In large-scale systems this can quickly equate to ten thousands or up to hundred thousands of euros per year.
Financial losses due to inefficient compressed air systems nevertheless continue to be underestimated, ignored or simply accepted as a given. It doesn't have to be like that! With Endress+Hauser's energy management solutions, you can reliably identify weaknesses and savings potential in your compressed air system, and permanently monitor the specific energy consumption of compressors (kWh/Nm³), for example.

Savings made easy

Waste heat, pressure losses, excess system pressure – all this also contributes to compressors being regarded as power guzzlers. Reduce your energy consumption by:

- Minimizing leaks (less pressure loss)
- Monitoring filters (less pressure loss)
- Taking in air for compressors at the coldest point (improved performance)
- Utilizing waste compressor heat (process air)
- Keeping system pressure low
- Shutting down compressors during unproductive times
- Checking the efficiency of a compressor (corrected volume flow vs. power consumption)

Compressed air – Measuring instruments

Flow measurement (dry air)
t-mass I 300/500 (thermal)

- Direct measurement in standardized mass or volume flow (Nm^3/h or SCFM)
- Negligible pressure loss compared with mechanical flowmeters
- High turndown (≥100:1), ideal for identifying leaks
- Low-cost insertion versions (t-mass I 300 for main pipes, t-mass B 150 for submetering)
- Bidirectional versions, e.g., for ring pipelines
- Detection of excess moisture (condensate) and pulsating flow using Heartbeat Technology

Flow measurement (non-dry/non-filtered air)
Prowirl F/R 200 (vortex meter)

- Direct output of standardized mass flow or corrected volume flow (Nm^3/h or SCFM)
- High long-term stability: no zero point drift, "lifetime" calibration factor
- Optional version with integrated diameter reduction by 1 or 2 line sizes with the same installation length
- Negligible pressure loss
- With integrated pressure and temperature measurement (optional) for the calculation of mass flow/volume flow

Pressure measurement (plant pressure, filter monitoring)
Cerabar PMP51B / PMC11

- For reliable monitoring of the specific power consumption (kWh/Nm^3) depending on the pressure entering the system
- Monitoring of the pressure delivered by the system as well as monitoring the filters upstream/downstream from the dryer (differential pressure)

Data logging/evaluation
Memograph M RSG45

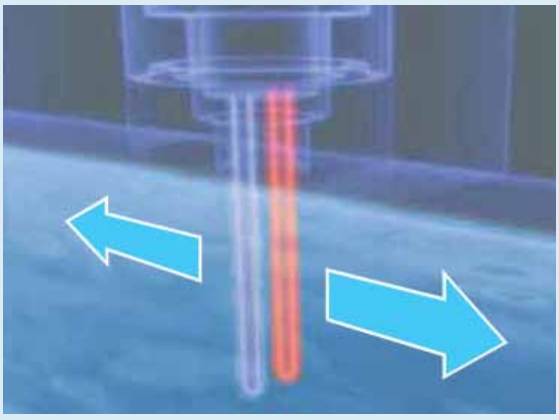
- For precise monitoring of plants and distribution networks
- Customized overview of the installation
- Visualization and logging of performance data (e.g., specific energy consumption)
- Alarm management
- Communication gateway

In large-scale installations, by measuring the flow of air at the system outlet, it is possible to monitor the total production as well as the consumption of each individual station. The quality of the air will determine whether a thermal flowmeter or a vortex meter should be used. The most important parameters for monitoring compressors are the specific energy consumption (kWh/Nm^3), the monitoring of free air delivery (FAD), and leak monitoring in compressed air systems.

Bidirectional measurement and reverse flow detection

Proline t-mass F/I, the reliable all-rounder for pure gases and gas mixtures, convinces with numerous alarm functions as well as bidirectional measurement and reverse flow detection:

- Mass flow can be measured and totalized in both flow directions, this ensures optimal balancing
- For backward flowing gas streams, an alarm message is generated thanks to the reverse flow detection
- Same measuring accuracy of ±1% o.r. in both directions



Heating

Heating systems

Lower your heating costs with efficient energy management

A great number of different industry-specific heating processes and technologies are available on the market. That's why customized approaches and specific measured values are needed to assess their performance and improve their output. Energy loss is typically high in boilers and furnaces, owing to inefficient combustion, incorrect operation or poor maintenance and servicing. Measuring the level of efficiency is therefore the easiest way to gauge losses and take remedial action. By monitoring fuel consumption, combustion air, flue gas temperature or the transmission rate of thermal energy, it is possible to get a clear picture of the efficiency of heat generation:

- Identify and quantify energy loss, such as no-load or partial-load operation of the burner
- Assess and optimize degree of boiler efficiency and consumption
- Minimize maintenance costs and downtimes
- Quantify improvement measures such as the pre-heating of combustion air, etc.

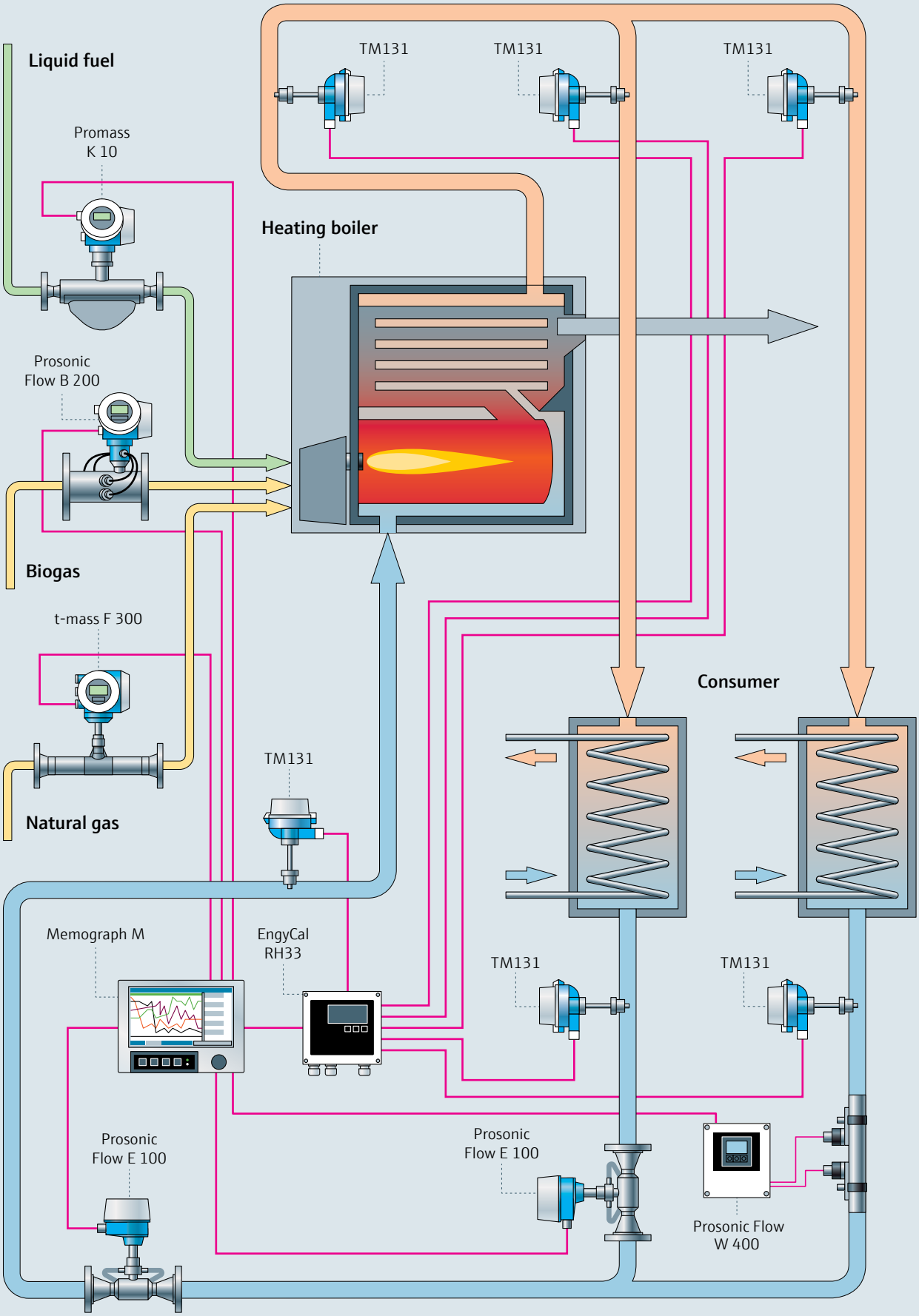
The definition of energy performance indicators (▸ page 5) is key for businesses to correctly assess the efficiency of a heating system. For example, it almost always makes sense to use the waste heat from office buildings or a production facility. Depending on the building and the business, an investment in a heat recovery system pays off in just a few years.

Savings made easy

Suitable measures implemented in heating systems can cut energy consumption by up to 55%:

- Insulate pipe network
- Insulate buildings and production machines
- Minimize leaks
- Recover heat from cooling systems, waste air and production processes, e.g., for the generation of hot water (summer) or for heating (winter)
  Case study ▸ page 46
- Reduce inlet temperature according to actual heating needs
- Plan sufficiently large buffer systems for heat storage
- Use energy-efficient technologies such as condensing boilers or combined heat and power generation
- Optimize burner control and system temperatures

Energy management in heating systems



Heating – Measuring instruments

Flow measurement (fuel consumption measurement – natural gas)
t-mass F/I 300/500 (thermal)

- For measuring the consumption of natural gas (mass flow, corrected volume flow, energy flow)
- Negligible pressure loss
- High turndown (up to 100:1)
- Flanged version (F) with integrated flow conditioner for shortest inlet runs, or insertion version (I) for larger pipelines (> DN 80/3")
- Bidirectional version for detection of reverse flow

We recommend Prosonic Flow B 200 for the measurement of biogas. This ultrasonic flowmeter also enables the measurement of the methane fraction and the calorific value of biogas.

Flow measurement (fuel consumption measurement – fuel oil)
Promass K 10 (Coriolis)

- For measuring the consumption (mass flow/volume flow) of liquid fuels
- Direct density measurement
- No straight inlet runs required
- Very high measuring accuracy (±0.5%, option: ±0.15%) and turndown (over 1000:1)
- Measurement is independent of viscosity

Promass I 300 enables permanent in-line viscosity measurement to control the optimum combustion of fuels.

Flow measurement (energy flow measurement – feed/return line)
Prosonic Flow W 400/E 100 (ultrasonic)

- For volume measurement of hot water – independent of conductivity
- Measurement immune to magnetite deposits
- Clamp-on sensor (W 400):
  - Non-intrusive measuring technology
  - For temporary measurement without opening the pipe
  - No pressure loss
- In-line sensor (E 100):
  - High accuracy (±0.07% o.f.s. to 0.5% o.r.) thanks to traceable factory calibration
  - Integrated temperature measurement
  - Short inlet runs

Temperature measurement (energy flow measurement – feed/return line)
TM131

- For temperature differential measurement (delta heat) in feed and return line (suitable for custody transfer)
- Fast response time due to tapered end
- High accuracy (±0.025 °C / ±0.045 °F) thanks to electronically matched (calibrated) sensors

Data logging/evaluation
Memograph M RSG45

- Flexible, high-performance system for the visualization, storage, organization and analysis of process values (e.g., boiler efficiency)
- System capability: supports common fieldbus systems like Modbus, PROFIBUS DP, PROFINET or EtherNet/IP
- Integrated web server: remote access to device operation and visualization for lower maintenance costs
- Stainless steel front with touch control

Energy computer
EngyCal RH33

- Certified BTU meter suitable for custody transfer measurement
- Wide range of calculation functions: e.g., power, volume, density, enthalpy, enthalpy differential, mass, temperature differential, energy, deficits or total amounts
- For maximum accuracy when processing the values measured with the TM131 temperature sensor (Callendar-Van-Dusen coefficient)

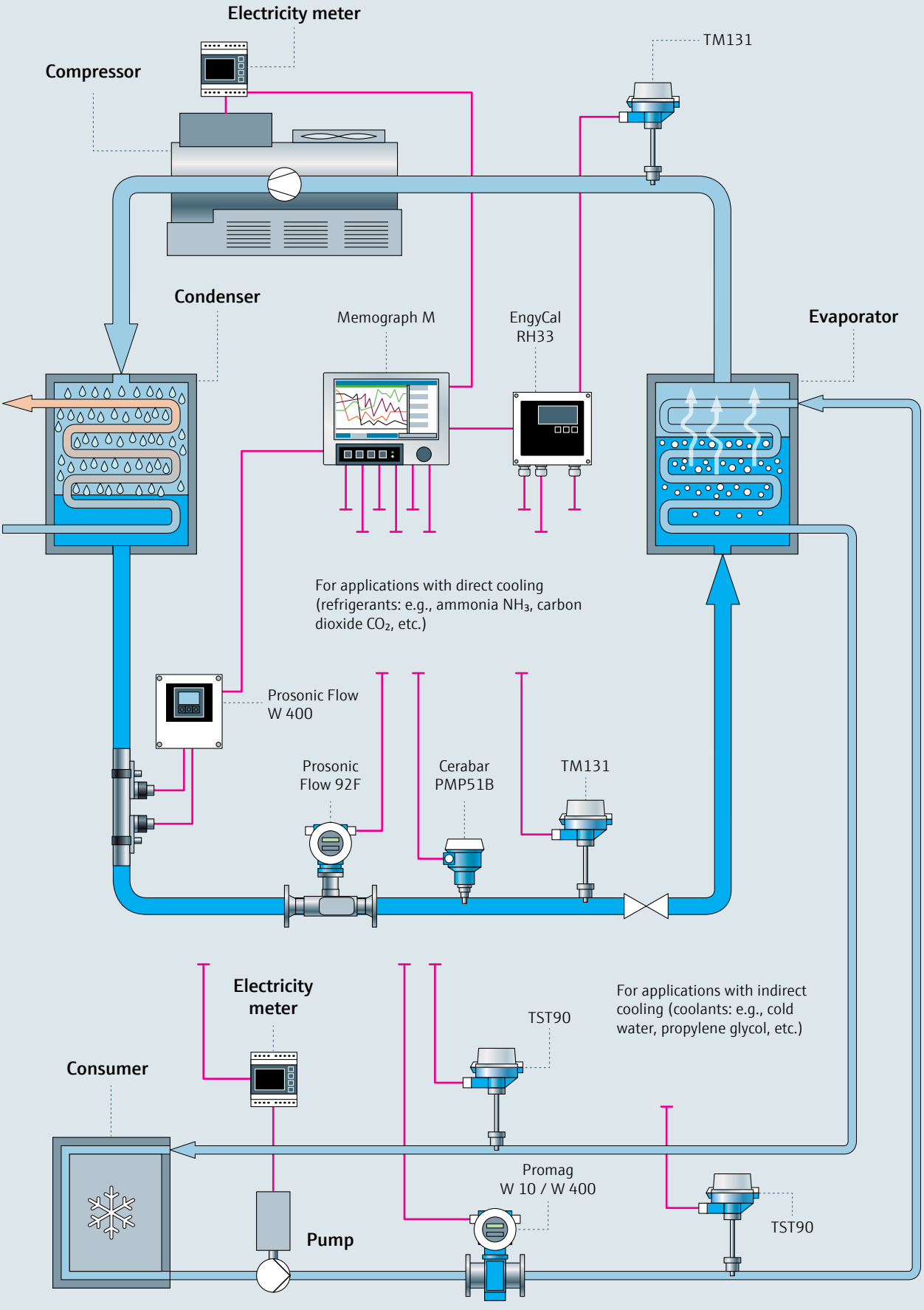
FlowDC function – constantly high performance

The innovative FlowDC function guarantees consistent (specified) measuring performance even downstream of turbulence-generating fittings:

- Massive reduction of required inlet run from the usual min. 15 × DN down to just 2 × DN
- Ideal for installation after single/double pipe bends (in/out of plane), pipe reducers or pipe expanders
- Maximum flexibility when planning process facilities where space for piping is at a minimum
- Simple retrofitting of measuring points with almost no limitations

Cooling

Energy management in cooling systems



Cooling systems

Cool – but not too cool

In many industries, the production of cooling energy makes up a large chunk of total energy costs, accounting for roughly 10% of electricity consumption in all industries. Even a minor reduction in energy consumption can deliver significant cost savings.

The complexity of new buildings, stricter laws and regulations, as well as changing requirements for heating and cooling needs (such as in production facilities) pose major challenges for planners and building developers. An efficient cooling system, however, requires more than just efficient components. More than anything, it depends on the system configuration and operation. As cooling systems are often developed to customers' specific requirements, an individual analysis of the supply and demand is needed to identify the ideal operating point. Therefore, electricity (watt) meters are not enough to monitor total energy demand reliably.

The definition of system-specific energy performance indicators (▸ page 5) – such as energy consumption per production unit or per square meter and year – is key for businesses to correctly gauge the efficiency of a cooling system and its energy consumption. Endress+Hauser's smart energy solutions allow you to optimize your production processes and ensure the energy-efficient operation of your cooling systems.

Savings made easy

Regular maintenance ensures that cooling systems work efficiently. You can also implement the following measures to increase the efficiency of your system:

- Insulate pipe network
- Make use of waste heat (heat recovery)
- Minimize leaks
- Avoid deposit build-up in tanks and pipes
- Analyze process variables (e.g., density) to detect coolant aging early on

Cooling – Measuring instruments

Flow measurement (refrigerants)
Prosonic Flow W 400/92F (ultrasonic)

- For volume measurement of liquids – independent of conductivity
- No pressure loss
- Clamp-on sensor (W 400):
  - Non-intrusive measuring technology
  - For measurement from outside without opening the pipeline, with shortest inlet runs (2× DN)
- In-line sensor (92F):
  - High accuracy (±0.3 to 0.5%) thanks to traceable factory calibration
  - Short inlet runs (min. 5× DN)

Flow measurement (refrigerants)
Prowirl F 200 (vortex meter)

- For volume measurement of liquids and gases
- Guaranteed long-term stability: no zero point drift, lifetime calibration factor
- Negligible pressure loss
- Very robust: not affected by pressure shock and vibration

Flow measurement (coolants)
Promag W 10 (electromagnetic)

- For volume measurement of cold water, propylene glycol or conductive liquids (>50 µS/cm)
- Integrated monitoring of conductivity for additional safety
- Very high turndown (up to 1000:1)
- High measuring accuracy (±0.5%)

Flow measurement (coolants)
Picomag (electromagnetic)

- For volume measurement and monitoring of industrial water, cooling water or warm water (>20 µS/cm) up to DN 50 (2")
- Simultaneous measurement of flow, temperature and conductivity
- Compact, pocket-sized format for space-saving installation
- Wireless and secure access to all device data via Bluetooth and SmartBlue App (range: 10 m)

Flow measurement (coolants)
Prosonic Flow E 100/E Heat (ultrasonic)

- For volume measurement of cold water
- High turndown (over 200:1)
- High measuring accuracy (±0.07% o.f.s. to ±0.5% o.r.)
- "E Heat" sensor suitable for custody transfer

For cooling systems with direct cooling (ammonia NH_3, carbon dioxide CO_2, etc.), pressure, temperature, electrical power and flow must be measured to calculate the cooling capacity or the energy efficiency ratio (ERR) of an installation. The same applies for other performance indicators such as the coefficient of performance (COP) of heat pumps, machines, installations and specific energy consumption.

Pressure measurement
Cerabar PMP51B

- For pressure measurement of refrigerants and coolants
- Robust, can sustain pressure shock and corrosion (ceramic)

Temperature measurement
TM131

- For temperature differential measurement (feed/return line)
- Fast response time
- High accuracy (±0.025 °C / ±0.045 °F) thanks to electronically matched (calibrated) sensors

Data logging/evaluation
Memograph M RSG45

- Flexible, high-performance system for the visualization, storage, organization and analysis of process values
- System-compatible: supports common fieldbuses like Modbus, PROFIBUS DP, PROFINET, EtherNet/IP
- Integrated web server: remote access to device operation and visualization for lower maintenance costs
- Stainless steel front with touch control

Energy computer
EngyCal RH33

- Certified BTU meter suitable for custody transfer measurement
- Wide range of calculation functions: e.g., power, volume, density, mass, temperature differential (delta heat) or energy
- For maximum accuracy when processing the values measured with the TM131 temperature sensor (Callendar-Van-Dusen coefficient)
- System-compatible: supports common fieldbuses like Ethernet TCP/IP, Modbus RTV/TCP, M-Bus

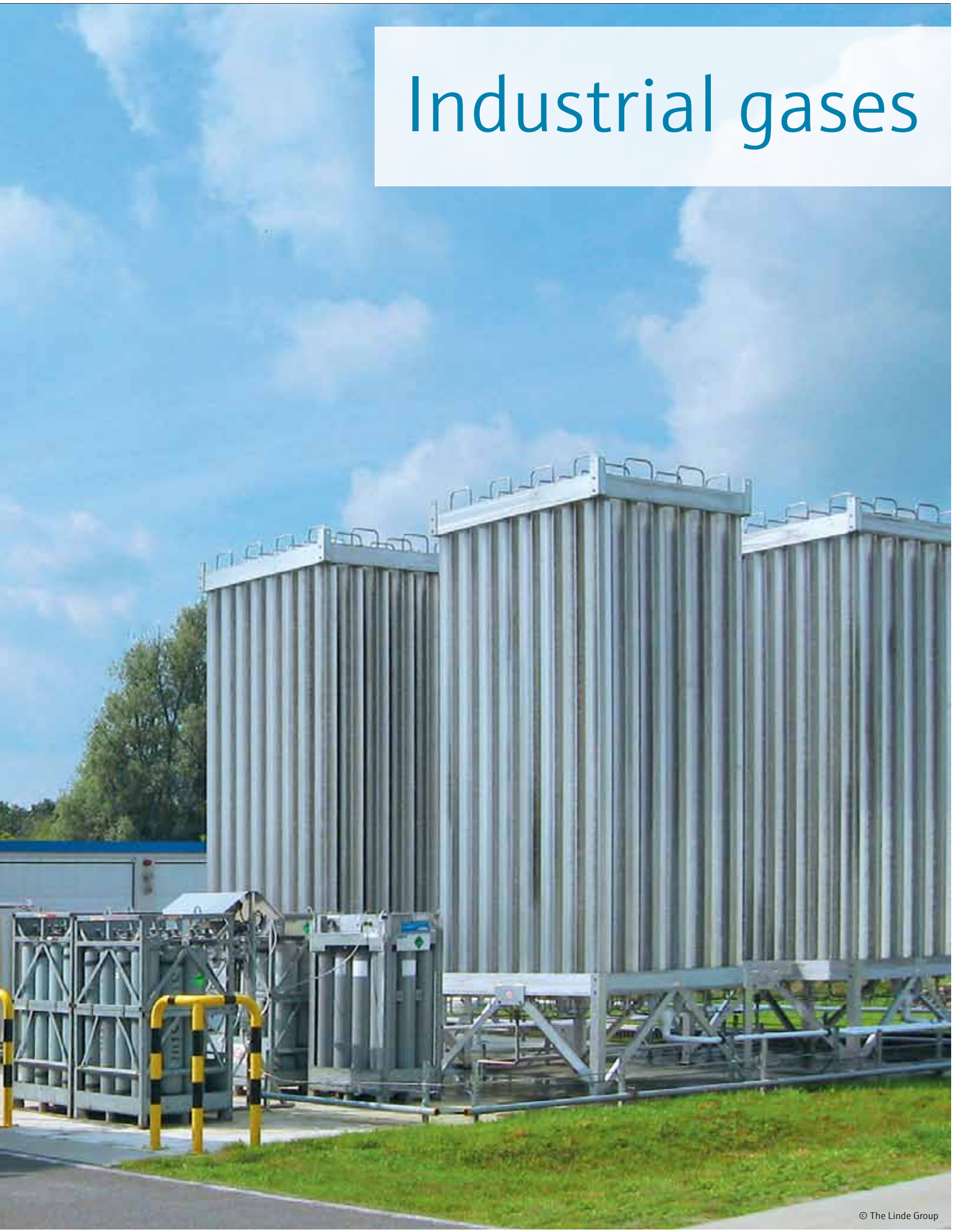
"0 x DN full bore" – without inlet runs and without pressure loss

Promag W 10 flowmeters enable measurements with high accuracy (±0.5%) even directly downstream of pipe bends thanks to the option "0 x DN full bore":

- For installation in space-restricted areas, no inlet and outlet runs required
- Swirl downstream of obstacles such as pipe bends, insertion devices, build-up on the pipe wall, protruding seals or different inside diameters are no problem for high measuring accuracy
- No pressure loss due to the design without constriction
- "0 x DN full bore" was tested by an external and independent testing laboratory (NEL) and the specified measurement deviation was confirmed

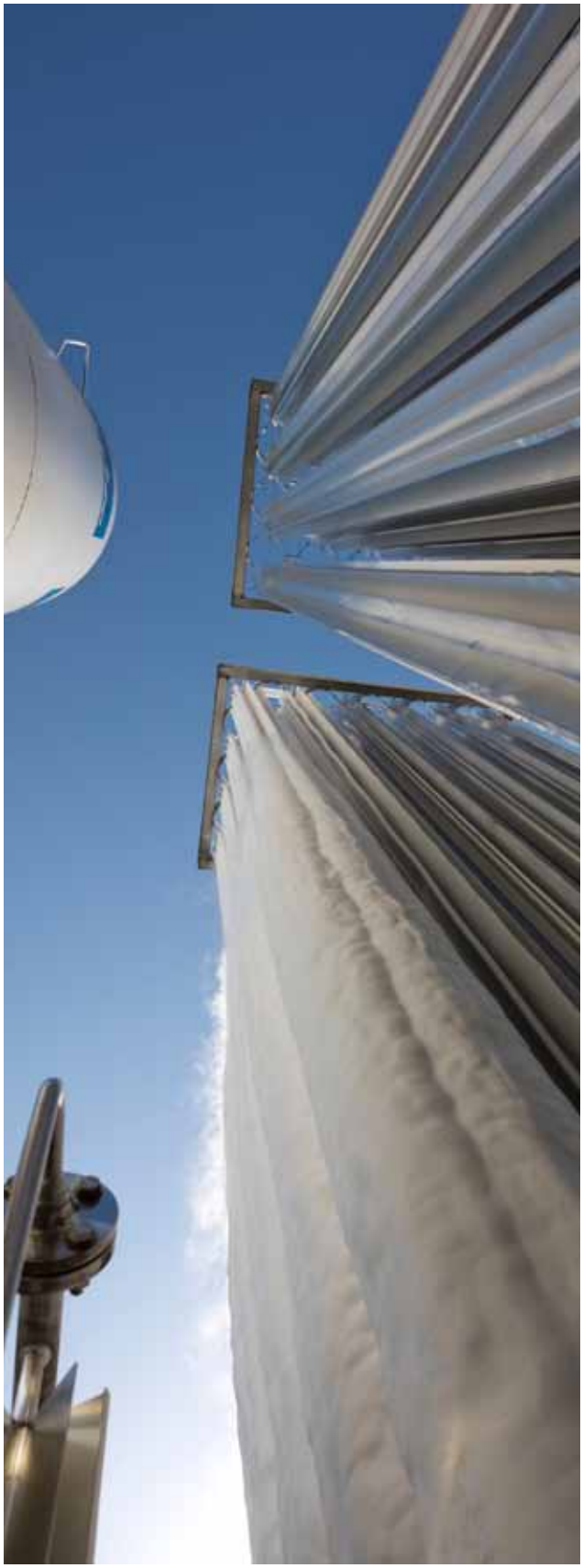

THE LINDE GROUP
Linde
Linde
MAN
22
2187
TS MT 327

Industrial gases



Industrial gas plants

Submetering for efficient savings and accurate billing



Utilities in the process industry use vast quantities of nitrogen (N_2), carbon dioxide (CO_2), oxygen (O_2), argon (Ar) and many other industrial gases as welding gases, shielding gases (soldering) or for modified atmosphere packaging (MAP) in the food industry. It is just as important to avoid energy loss and leaks here as it is in the fields of production, heating, ventilation and air conditioning, and to ensure detailed and correct cost accounting if multiple consumers are involved.

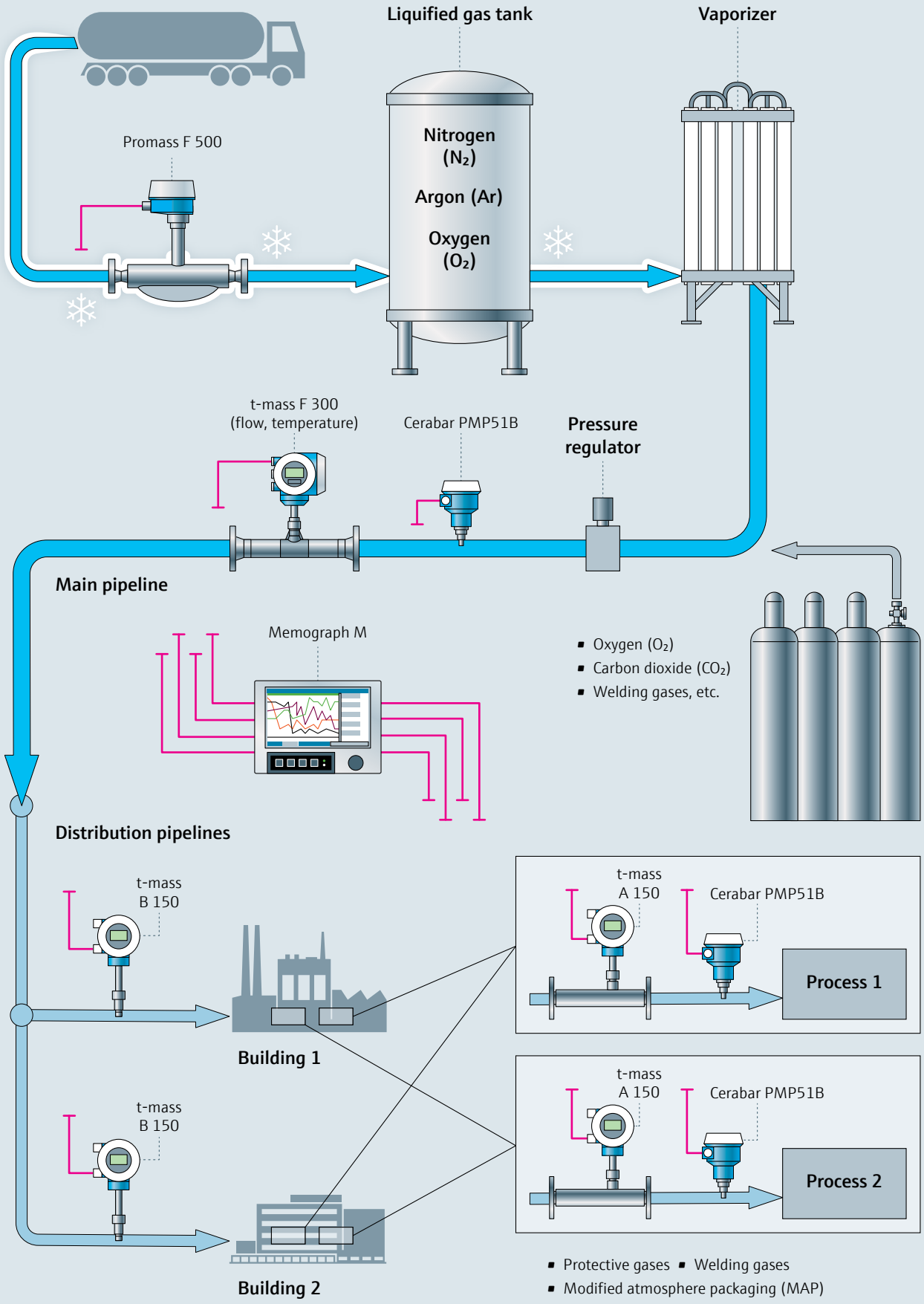
This calls for more than simply measuring the total consumption of an industrial gas, however. For gases to be monitored efficiently, the measurement of flow in the distribution lines or directly at the consumer is key. Thermal flowmeters have proven to be particularly effective submeters, enabling the detailed allocation of costs to individual buildings, floors, departments, production processes or other units. The use of submeters is an integral component of a comprehensive energy management system according to ISO 50001 and pays off in multiple ways:

- Quick overview of all gas flows in the various units (building, floor, process, etc.)
- Correct and consistent cost accounting for all consumers
- Reliable identification of leaks, parasitic loads and areas with unusually high consumption peaks

Savings made easy

- Minimize leaks
- Monitor filters
- Avoid carry-over of liquefied gas into the main pipelines

Energy management in industrial gas systems



Industrial gases – Measuring instruments

Flow measurement (cryogenic fluids)
Promass F 500 (Coriolis)

- For highly accurate measurement of mass flow, density and volume flow of cryogenic liquefied gases such as nitrogen (N_2), argon (Ar) or liquefied natural gas
- Applicable down to −196 °C (−321 °F)
- No straight inlet runs required
- Suitable for custody transfer

Flow measurement (dry gases in main pipelines)
t-mass F 300/500 (thermal)

- For direct mass/corrected volume measurement of industrial gases
- Reduced inlet runs thanks to optionally integrated flow conditioner
- Detection of reverse flow / bidirectional flow measurement
- Negligible pressure drop and high turndown (≥100:1), ideal for identifying leaks
- Detection of excess moisture (condensate) and pulsating flow using Heartbeat Technology

Flow measurement (dry gases in distribution pipelines)
t-mass A 150/B 150 (thermal)

- For direct mass/corrected volume measurement of industrial gases without pressure or temperature compensation
- Negligible pressure loss compared with mechanical flowmeters
- High turndown (up to 100:1), ideal for identifying leaks
- No moving parts
- Low-cost insertion version (t-mass B 150) or in-line version (t-mass A 150)

Flow measurement (wet gases)
Prowirl F 200 (vortex meter)

- With integrated (optional) pressure and temperature measurement for the direct measurement and calculation of mass flow and corrected volume flow (Nm^3/h or SCFM)
- High long-term stability: no zero point drift, "lifetime" calibration factor
- Negligible pressure loss

Pressure measurement
Cerabar PMP51B

- For monitoring the system pressure and therefore the availability of an industrial gas
- Robust, can sustain vacuum and pressure shock (ceramic)
- Highly accurate (standard to 0.075%, platinum up to 0.055%)

Temperature measurement
TM131

- For reliable temperature monitoring (e.g., if liquefied gas from the vaporizer enters the main pipeline)
- Fast response time
- High accuracy (±0.025 °C / ±0.045 °F) thanks to electronically matched (calibrated) sensors

Data logging/evaluation
Memograph M RSG45

- Flexible, high-performance system for the visualization, storage, organization and analysis of process values
- System-compatible: supports common fieldbus systems like Modbus, PROFIBUS DP, PROFINET or EtherNet/IP
- Integrated web server: remote access to device operation and visualization for lower maintenance costs

When purchasing or filling tanks with cryogenic liquefied gases, the difference in accuracy between mechanical meters and modern Coriolis flowmeters corresponds to a volume of liquefied gas that's worth a considerable amount of money. Submeters are a worthwhile investment for several reasons – not only to identify leaks but also to ensure correct cost accounting for the consumers.
When measuring oxygen in steel pipes, it is important to ensure that the pipes – as well as the measuring instruments – are degreased using special cleaning measures and that maximum flow velocities are not exceeded.

Detect residual moisture or residual CO_2 with gas analyzers

The J22 Gas Analyzer uses patented tunable diode laser absorption spectroscopy (TDLAS) technology to detect residual moisture or CO_2 in industrial gases.

The benefits:

- Online real-time measurement of H_2O in hydrocarbon gas streams
- Featuring the reliable diagnostic capabilities of Heartbeat Technology
- Seamless integration into any plant management system
- Advanced diagnostics and superior measurement algorithms
- Preventing corrosion in pipelines, minimizing the risk of explosion hazard and no more hydrate formation

For electrolyzers, contained residual oxygen can also be determined by means of the compact oxygen analyzer Oxy5500.

Energy management at Endress+Hauser

A case study – optimizing cooling/heating systems

Global warming, CO_2 emissions reduction, and a trend towards increasing energy prices are issues no plant operator can ignore, and Endress+Hauser is no exception. That's why we analyze our energy and resource consumption according to ISO 50001 in all our production centers worldwide, in order to identify potential savings, optimize processes and cut costs. The numerous new buildings opened by our sales companies around the world over the past few years all meet strict energy efficiency standards.

Case study – Endress+Hauser Flow (Reinach, Switzerland)
In 2015, our product center for flow measuring technology – Endress+Hauser Flow – opened a new 25 000 m^2 office and production center. Although the building was constructed in accordance with the latest energy regulations at that time, it was not until Endress+Hauser measuring instruments were installed that it was possible to record the energy flows in the cooling/heating system in more detail and to implement additional energy optimizations on this basis (▸ pages 46–47).

Consistent energy management saves costs and preserves the environment: Greenhouse gas emissions at Endress+Hauser Flow have been reduced by a total of 33 percent over the past five years. By the year 2030, the CO_2 emissions at the Reinach site are to be reduced to zero.

Continuous improvement process

After obtaining the energy management certification of Endress+Hauser Flow (Reinach, Switzerland) in accordance with ISO 50001, the cooling/heating system in the building described was commissioned in 2015. One focus of ISO 50001 is on the continuous improvement process; accordingly, numerous measures for energy optimization have been implemented.

Optimized warm water system

- **Problem:** The warm water system in the new building is designed for a maximum temperature of 45 °C (113 °F). However, water with a temperature of over 60 °C (140 °F) is sometimes required.
- **Solution:** Installation of a decentralized heat pump boiler for the temporary production of warm water (>60 °C).
- **Result:** **Power consumption reduced by 31 500 kWh/year (compared with power consumption with constant provision of warm water > 60 °C).**

Improved waste heat recovery

- **Problem:** Waste heat recovery in the cooling system is not working as it should. Too much waste heat is entering the atmosphere via the dry cooler (1) and leaving the building unused.
- **Solution:** Installation of a frequency converter (2) for optimum control of the heat recovery pump.
- **Result:** **Additional waste heat recovery of approx. 300 000 kWh/year.**

Gas-powered district heating system only in emergencies

- **Problem:** Even though the hot water storage tank (3) of the pellet heating system (4) is full and heated, the system often signals “empty” (cold). This triggers the gas-powered district heating system (5) to make up for the supposed heating shortfall. Reason: The only temperature sensor in the storage tank was located too high up and therefore did not return a representative temperature value for the storage tank. When very large quantities of water were drawn from the storage tank, the temperature at the top of the storage tank dropped and the sensor detected values that were too low (“empty”).
- **Solution:** An additional temperature sensor was installed further down in the tank (6).
- **Result:** **Gas-powered district heating system is not activated unnecessarily. It is now only used in an emergency or for short periods when the demand for heating is very high.**

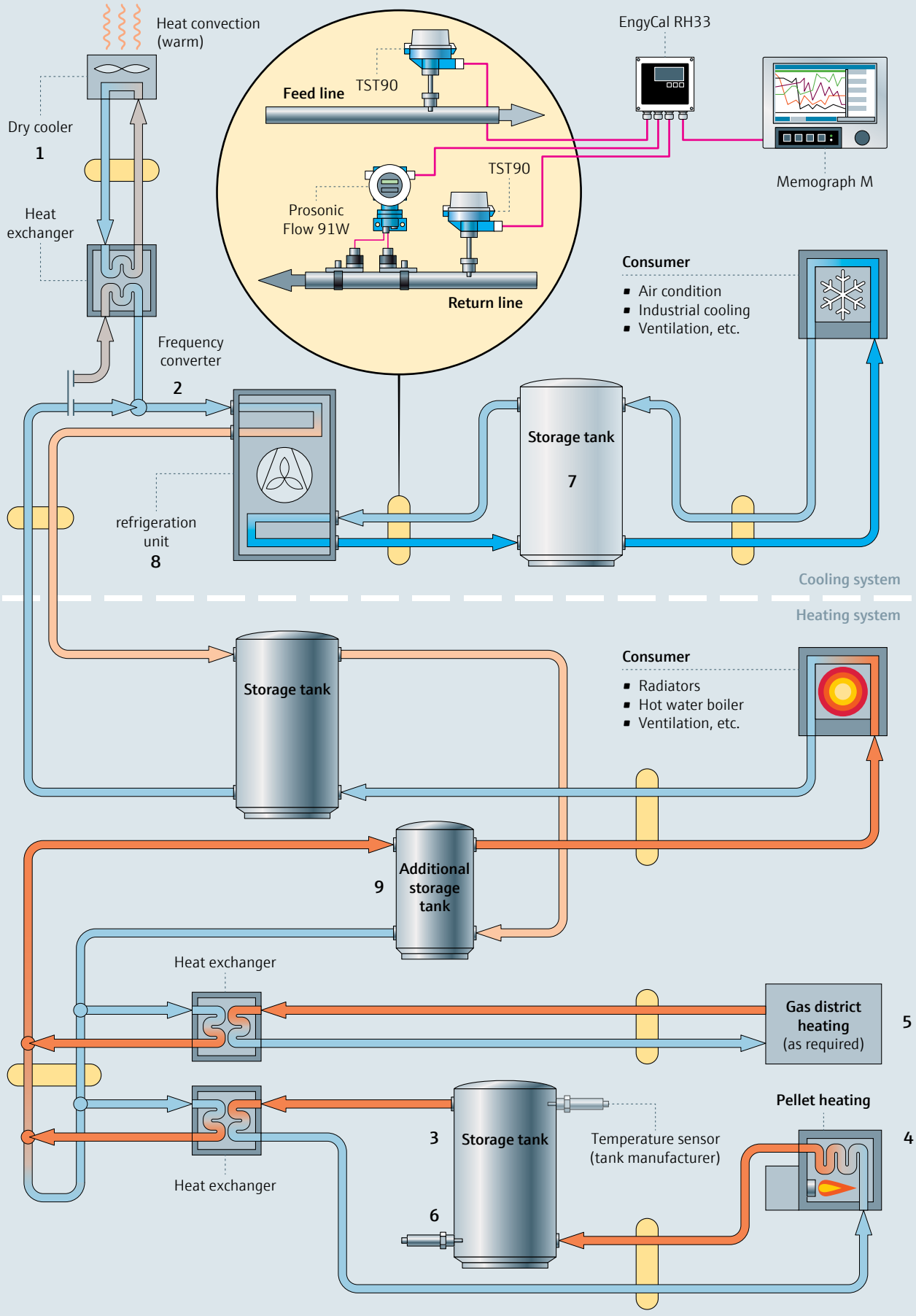
Optimized control of cooling unit

- **Problem:** Feedback signals from the cold water storage tank (7) cause the cooling unit (8) to constantly switch on and off.
- **Solution:** The cooling unit is now controlled via the building control system according to current needs.
- **Result:** **Cooling unit works continuously, resulting in better waste heat recovery.**

Additional heat storage tank

- **Problem:** Despite all the optimization efforts, too much waste heat is still entering the atmosphere and leaving the building unused via the dry cooler (1). The pellet heating system (4) must make up for this lost energy.
- **Solution:** Hydraulic adjustment to the cooling/heating system with the installation of an additional heat storage tank (9) with a capacity of 2000 liters.
- **Result:** **Waste heat recovery increased by 200 000 kWh/year.**

Energy management: Cooling/heating system at Endress+Hauser Flow



High measuring quality worldwide

Thanks to precisely calibrated measuring instruments

Energy performance indicators (EnPI) are only as good as the instruments that produce them. For this reason, ISO 50001 also describes requirements for measuring technology. For example, the measuring instruments used for energy management must be calibrated, and the measured data gathered must demonstrate a minimum degree of accuracy and reproducibility over the longer term. It is precisely in this area where Endress+Hauser has been a leader for decades:

- Every measuring device for flow, pressure, temperature, level or analysis is tested and calibrated according to ISO/IEC 17025 on the most state-of-the-art calibration rigs in the world
- All our calibration rigs are accredited by national authorities and are fully traceable
- We operate more calibration laboratories than any other measuring device manufacturer, and calibrate all device types and brands – in the factory or mobile on site
- Our measuring devices are robust, proven in use and offer long-term stability

Take advantage of our calibration service in over 40 countries:

- Customized advice when planning measuring technology
- Professional calibration according to defined Standard Operating Procedures (SOP)
- Expert service technicians – trained according to Good Manufacturing Practice (GMP)
- Certified and traceable documentation for every calibration ex factory or for verification measurements on site
- Comprehensive calibration and maintenance management (service agreements)

Calibration pays off – an example

- Application: steam generation
- Operating duration: 5000 hours/year
- Temperature error: 2 °C (3.6 °F) (sensor not calibrated)
- Incorrect measurement: 30 kg steam/hour
- **Annual deficit: 150 t steam**

More information about our calibration service

Heartbeat Technology

Taking the pulse of your measurement

Heartbeat Technology provides you with in-depth device and process insights to increase your plant performance and reduce operating and maintenance costs. This technology is integrated into numerous Endress+Hauser measuring devices and consists of three functions:

Heartbeat Diagnostics – Permanent process and device diagnostics

- Increased measuring reliability and safety thanks to continuously best-in-class diagnostic coverage (up to 97%) and device development according to IEC 61508
- Immediate indication of device failures or processes being run out of device specifications
- Standardized diagnostic messages with clear text instructions regarding cause and remedy

Heartbeat Verification – Documented device functionality without process interruption

- Optimized calibration and proof test cycles due to traceable device verification at the push of a button
- Reduced documentation and auditing efforts thanks to comprehensive verification report
- Clear verification result and third-party attested verification concept (according to ISO 9001)

Heartbeat Monitoring – Information for process optimization and predictive maintenance

- Conversion of physical sensor responses into easily understandable process and device insights
- Monitoring of specific device parameters to optimize operations by identifying and, if necessary, correcting deviations in the process
- Maintenance planning and predictive measures for reliable and safe process operation

Always at your side worldwide

Consulting – Maintenance – Solutions

All devices manufactured by Endress+Hauser guarantee high measuring accuracy and operational safety – around the clock and throughout the entire life cycle of your plant. Our sales and customer service centers in over 45 countries ensure that you are always up and running, and that you find the best solutions when it comes to energy management. We are always close at hand, no matter whether you produce in Europe, America, Asia, Africa or Australia.

How Endress+Hauser can help you

- First-class field measuring technology for all process variables (flow, pressure, temperature, level, analysis, recording, etc.)
- Planning and delivery of all common control, visualization and process control systems
- Planning and advice from consultants, engineers and expert technicians on site
- Professional management of national and international projects
- Consulting, design, engineering and customer inspections
- Installation, commissioning and configuration
- Inspection and maintenance (maintenance contracts)
- On-site calibration, control measurements
- Repair service, spare parts, conversion kits
- Individual maintenance concepts (Installed Base Audit Software)
- Training courses and qualifications
- Worldwide service

Installed Base Audit

Installed Base Audit is a service for auditing and analyzing the instrument base installed in processes. The main aim is to develop fact-based recommendations to create a maintenance schedule that increases plant availability and cuts cost.

- Define the priority focus of maintenance efforts according to available resources and production requirements
- Reduce the complexity of older systems, e.g., older systems may use different brands of equipment and a wide range of measuring instruments
- Identify out-of-date plant documentation that no longer reflects current standards
- Define necessary measures to increase production quality and plant availability
- Meet strictest safety requirements

Did you know ...

- that many countries provide tax incentives for implementing an energy management system according to ISO 50001?
- that targeted measures can lower the energy consumption of a plant typically by 5 to 15%?
- that electricity accounts for 75% of the total operating costs for air compressors?
- that a 1 mm leak in a compressed air pipe can cause additional costs of EUR 240 per year? And that 50 to 80 leaks of this size incur annual additional costs of between EUR 12 000 and 19 000?
- that the energy cost for the generation of compressed air goes up approximately 9% for every unnecessary bar of pressure?
- that a maximum flow velocity of 6 to 10 m/s (20 to 33 ft/s) is recommended for the economic operation of compressed air distribution systems, and a maximum of 25 m/s (82 ft/s) for steam pipes?
- that leaks in old steam or hot water distribution networks can cause additional energy expenditures of up to 50%?

www.addresses.endress.com

Eco-friendly produced and printed
on paper from sustainable forestry.

CP01353S/06/EN/02.23

Endress+Hauser

People for Process Automation