

Reduce your energy costs in utilities

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



Working together to save energy and cut costs

Boost your competitiveness by reducing energy consumption

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



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More information about our energy solutions







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 Henriët / 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 / 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, e.g. 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.

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- Compressed air ▶ Page 20
- Heating ▶ Page 26
- Cooling ▶ Page 32
- Industrial gases ▶ Page 38

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

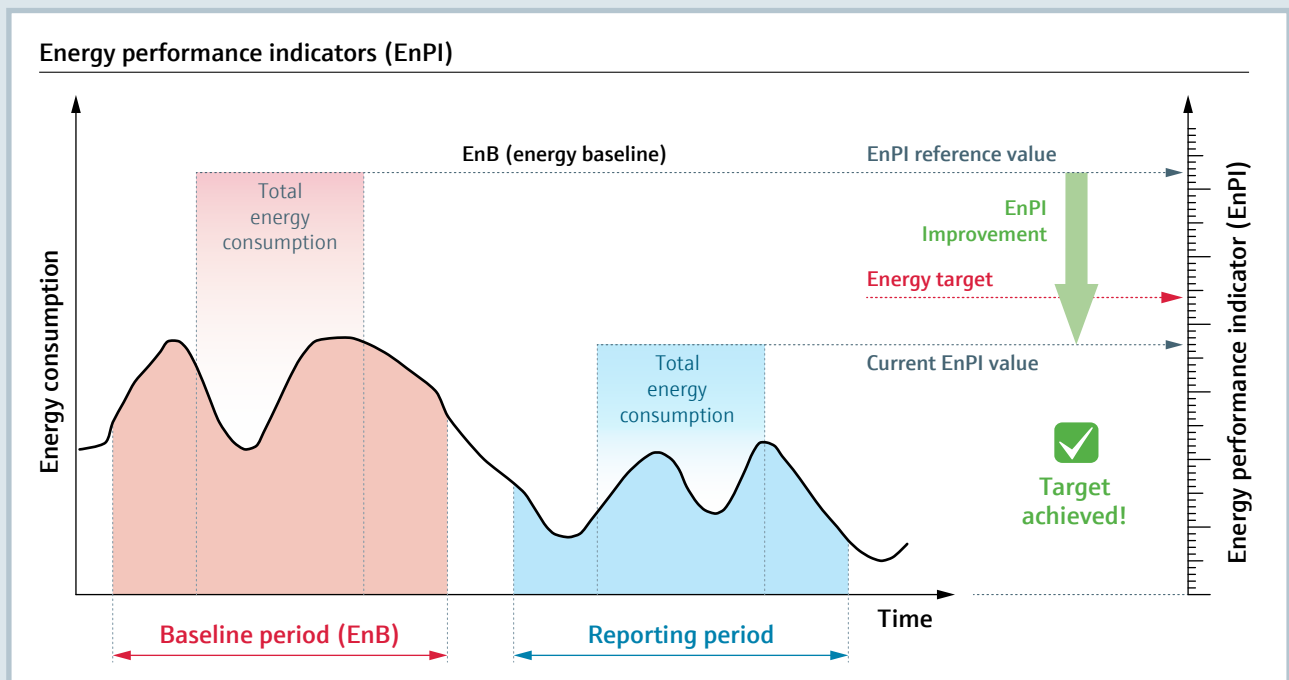
and improvement measures initiated. This can be for a process, a plant, a building or an entire factory complex (► Page 6).

! 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.

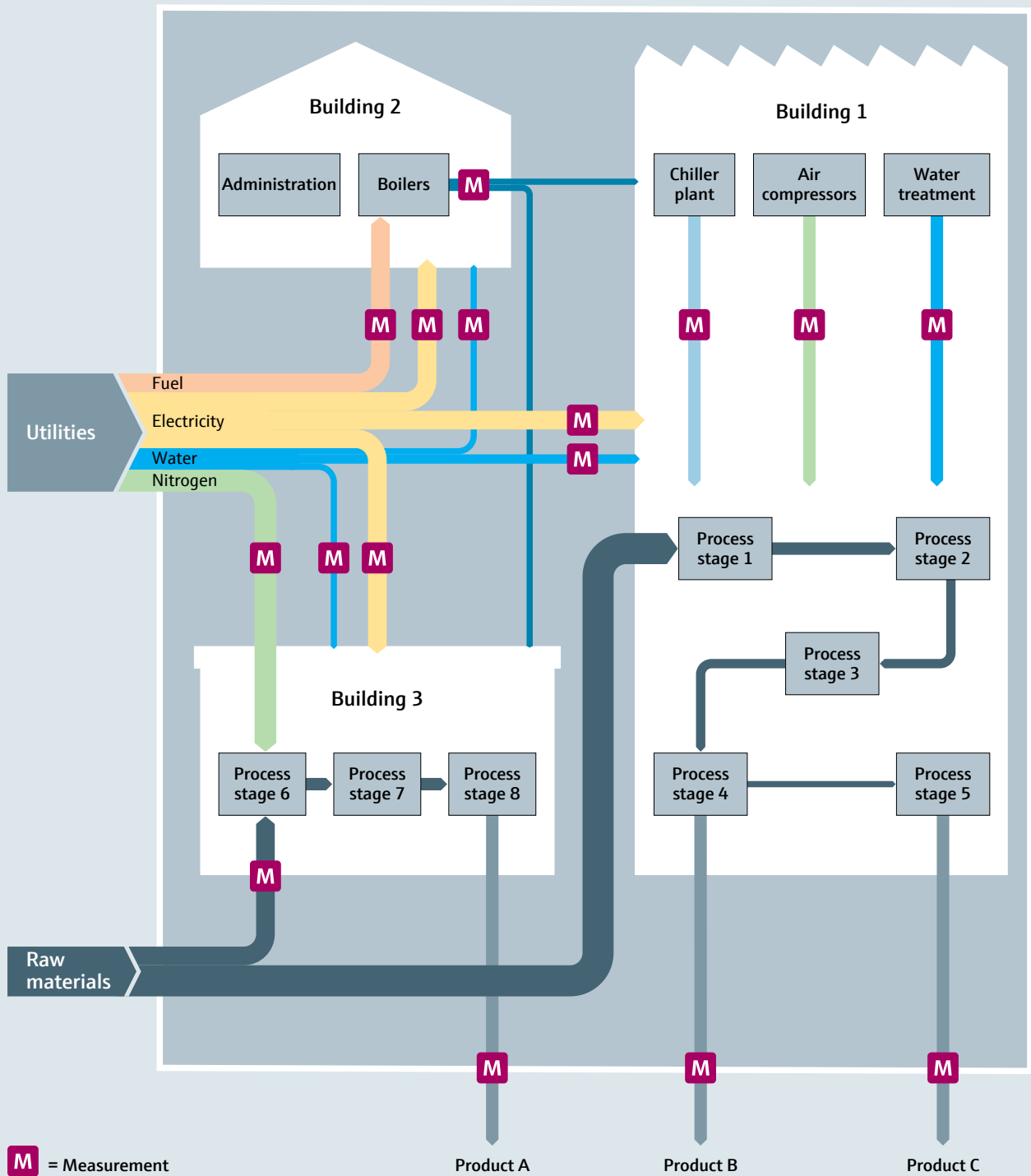
! The comparison of performance indicators is considered the most important control instrument in an energy management system. For lasting energy optimization, a more in-depth analysis of the measured data is therefore indispensable, such as in the form of absolute values, limit values, time frames or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



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/Nm³], 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 e.g. 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 e-mail or server

Deviation analysis

- Trigger warning messages via e-mail
- Set limit values
- Prioritize warning messages

Simulation/calculation

- Calculate characteristic values using mathematical functions

Energy analysis



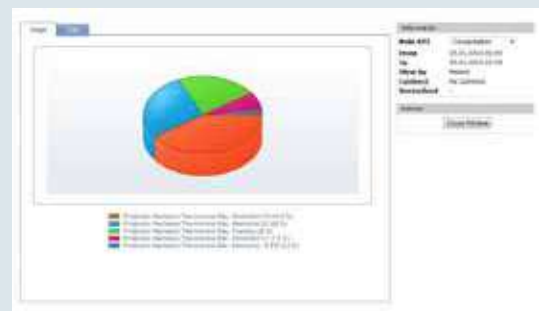
Monitor specific energy consumption



Create reports



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



Break down energy consumption by cost center

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.

Industry 4.0 / Industrial Internet of Things

Industry 4.0 and IIoT (Industrial Internet of Things) offer 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

PROFI
BUS

EtherNet/IP



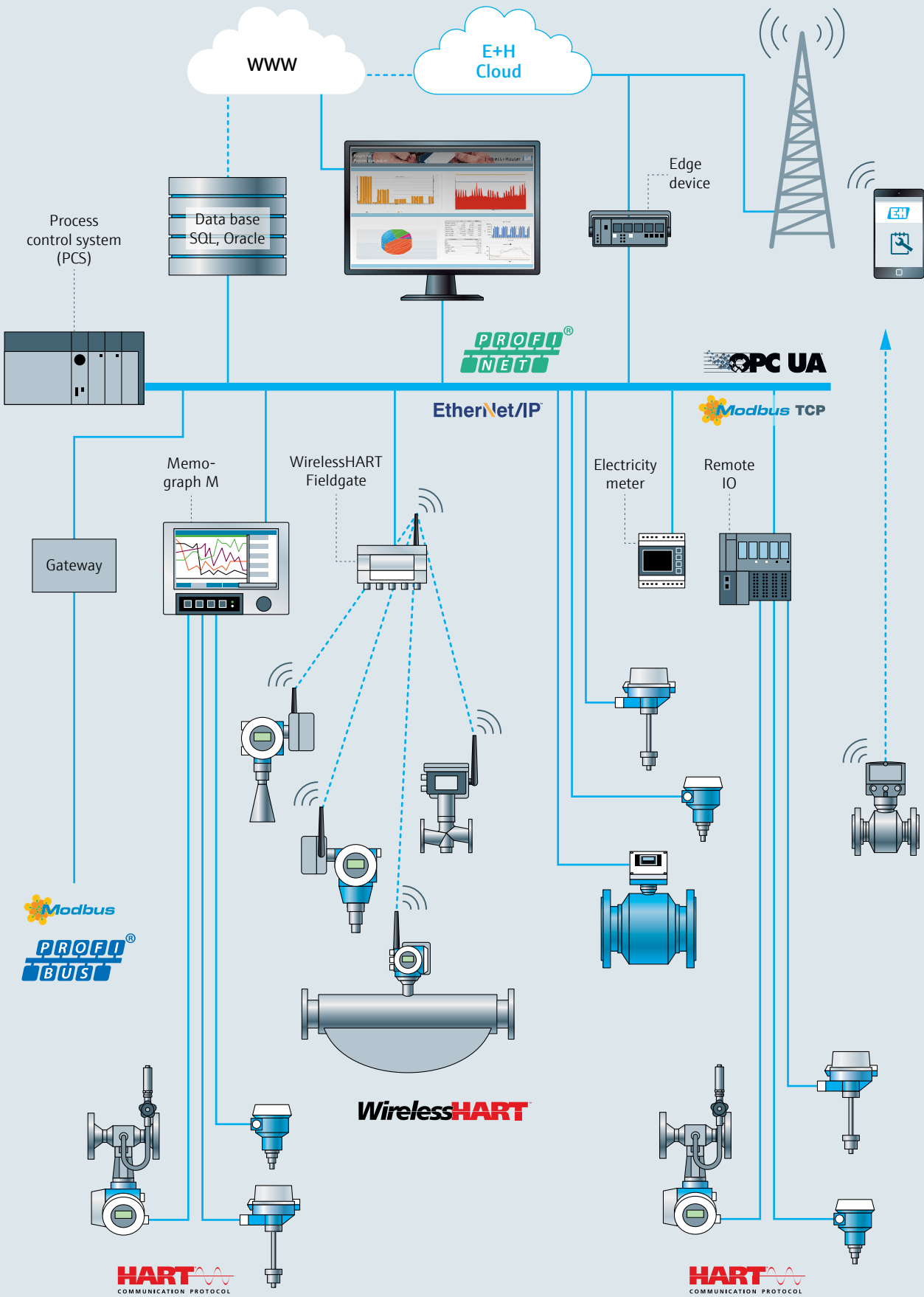
OPC UA

Modbus

PROFI
NET



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)
- Calculate the gains from energy optimizations

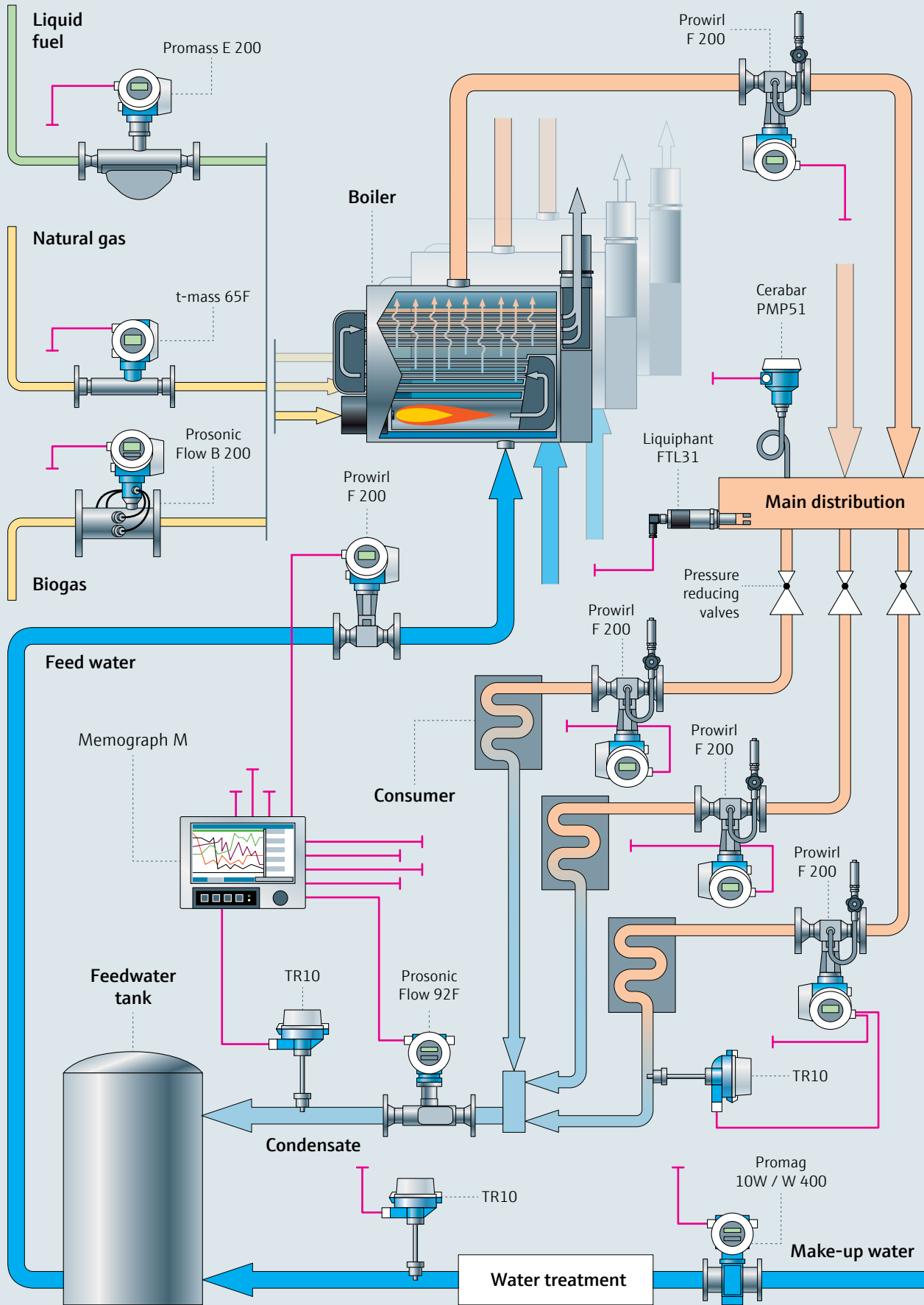


Savings made easy

- 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

Steam generation and distribution



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 (3/8 to 40")
- Recognized and standardized technology since 1929 (ISO 5167)
- External pressure and temperature compensation required



Pressure measurement Cerabar PMP51

- 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 ($\pm 0.15\%$ or $\pm 0.075\%$)

Fuel consumption measurement



Flow measurement (natural gas) t-mass 65F/65I (thermal)

- For mass and corrected volume measurement of gaseous fuels
- Negligible pressure loss
- High turndown (up to 100:1)
- Flanged (65F) or insertion version (65I)

i 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 oil) Promass E 200 (Coriolis)

- For mass and volume measurement of liquid fuels
- With highly accurate, direct density measurement
- High measuring accuracy ($\pm 0.25\%$) and turndown (over 1000:1)

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

Measurement of condensate, fresh water and feed water



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
- Robust design: over 400 000 installations worldwide



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

- For cost-effective volume measurement of make-up water with sufficient conductivity ($>50 \mu\text{S}/\text{cm}$)
- No pressure loss
- High measuring accuracy ($\pm 0.5\%$)
- Very high turndown (1000:1)



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 $200 \text{ }^\circ\text{C}$ ($392 \text{ }^\circ\text{F}$)
- 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 TR10 / TR15 (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 and evaluation



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

i 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 from 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 from 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.

- i** 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!

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).

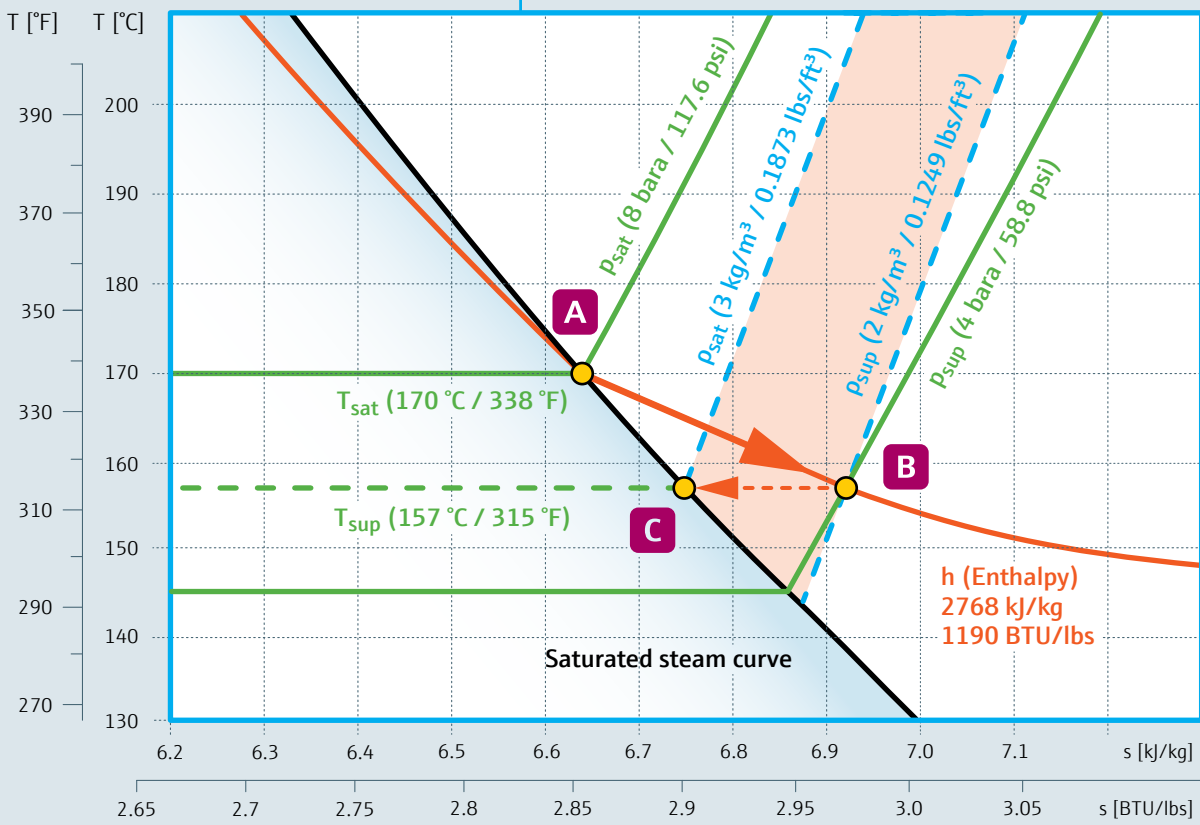
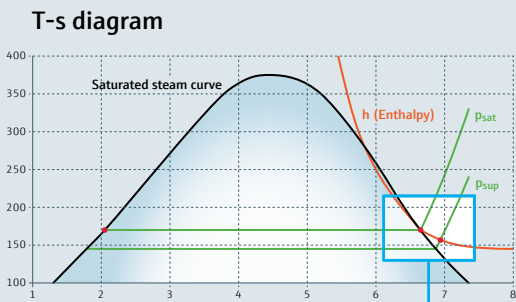
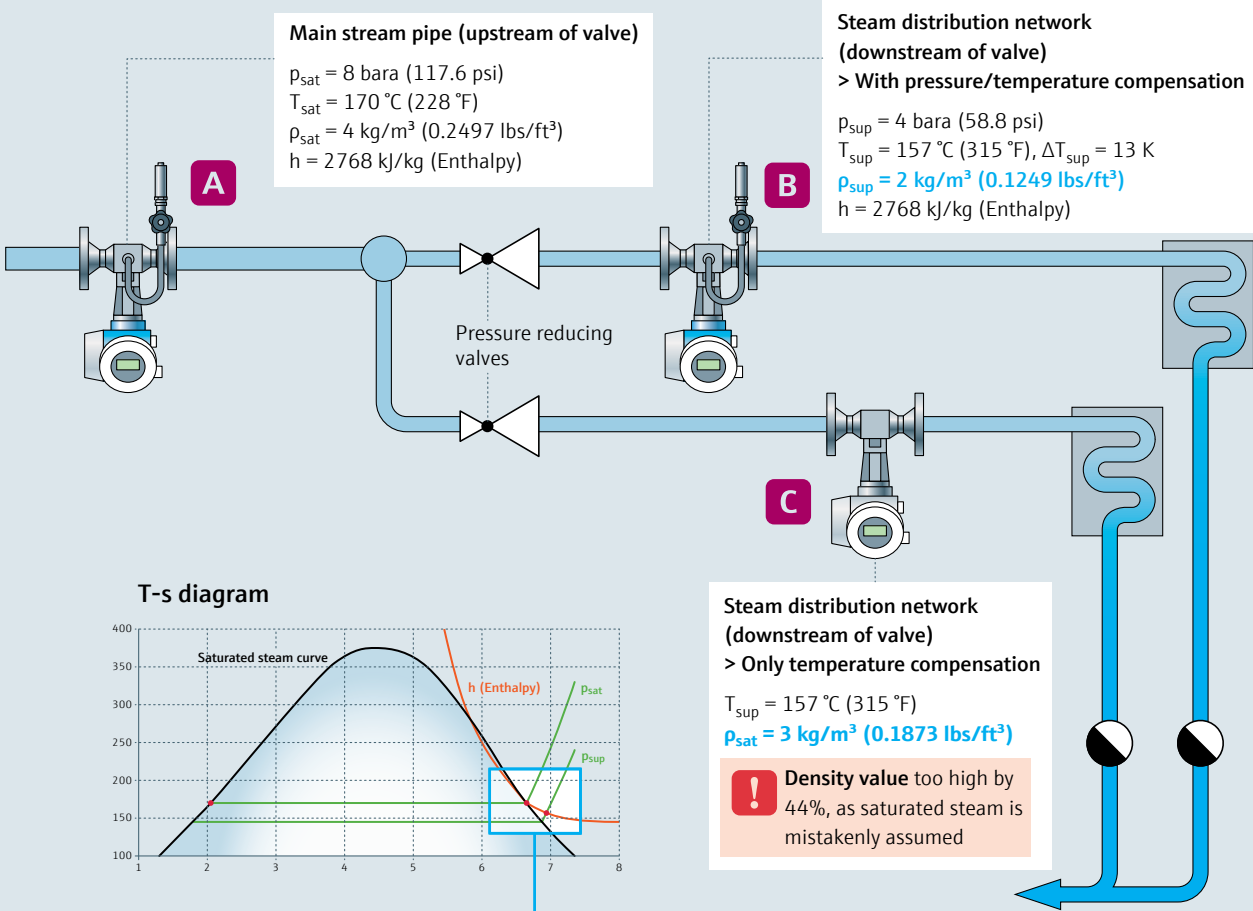


Steam quality measurement with Prowirl 200



Prowirl 200 with integrated temperature and pressure measurement

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





Reliable water quality in steam circuits

Minimize corrosion and deposit buildup with our SWAS solution

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, the need to replace entire plant parts, or lost production due to plant downtime. Our product range therefore also includes water analysis instruments which you can use to consistently monitor the quality of your feed water, boiler water or condensate.

The SWAS solution (Steam/Water Analysis System)

For industrial steam generators, we've developed "SWAS Compact" – a solution that efficiently monitors the water quality and fits neatly into your system, requiring very little space. It comprises sample preparation, a cation exchanger and a Liquiline transmitter to which the sensors for measuring pH, conductivity and oxygen are connected.

Advantages at a glance:

- SWAS Compact delivers reliable and precise measurement results even with low sample volumes
- It protects boilers, turbines and heat exchangers from corrosion and deposit buildup
- 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
 - Computation of remaining service life of the cation exchanger
 - Automatic system shutdown if probe temperature is too high
 - Monitoring of cation exchanger loading with indication of remaining capacity and temperature



MEMO SENS

Ground-breaking
sensor technology

Memosens digitizes the measured value in the sensor and transmits it to the transmitter via a non-contact, interference-free connection. Since it was launched in 2004, Memosens has become the leading global standard in liquid analysis. A broad portfolio of Memosens products has been improving the safety, efficiency, transparency and quality of processes in all industries ever since.

- 100% reliable: digital data transmission via inductive, corrosion-free bayonet lock
- Easy sensor connection
- Calibration and sensor information saved in the sensor head for predictive maintenance
- "Plug & Play" with pre-calibrated sensors increases process and measurement availability
- International standard

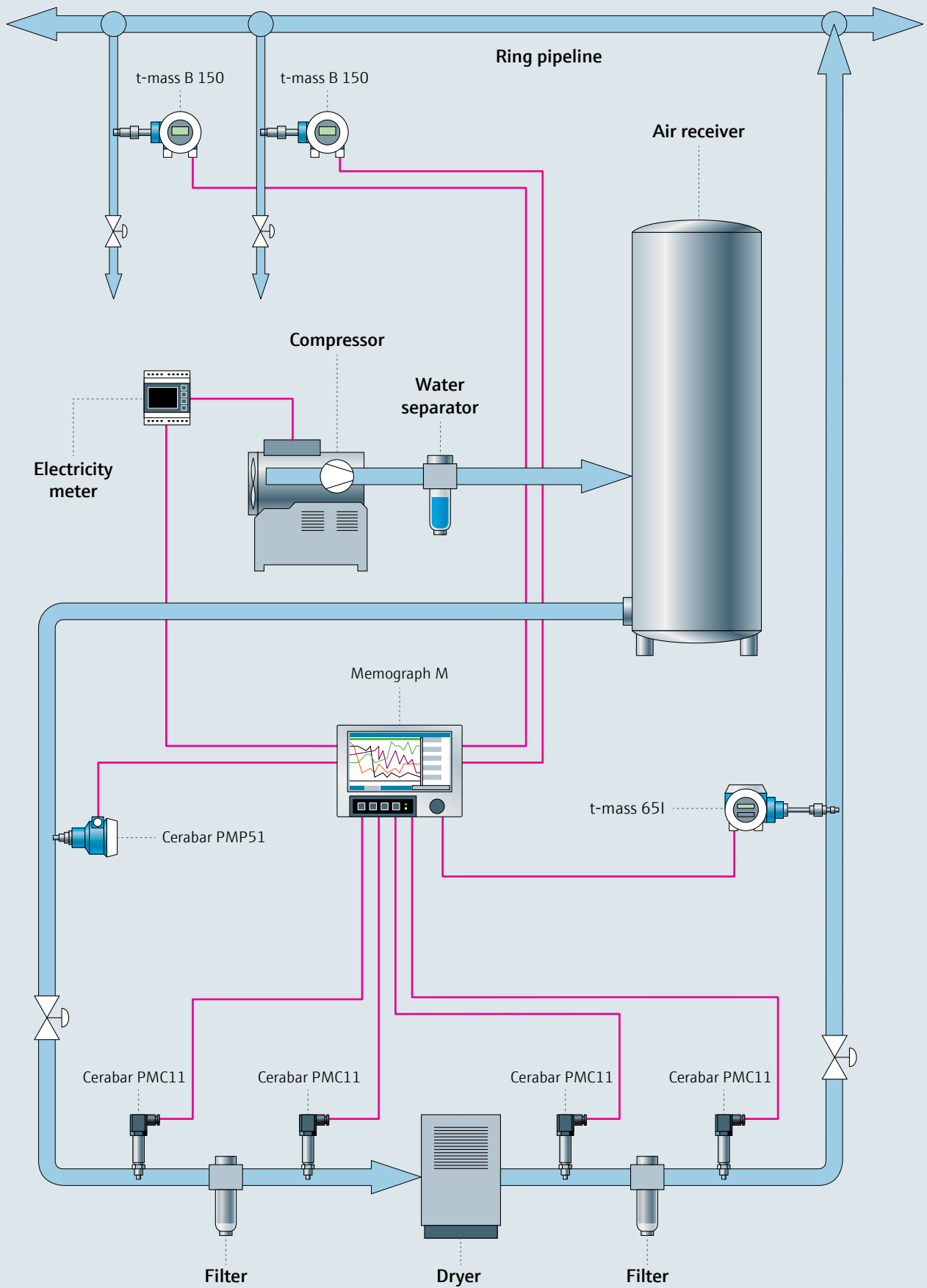




Compressed air



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 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 or humid air)



Flow measurement (dry air) t-mass B 150/65I (thermal)

- Direct measurement in standardized mass or volume flow (Nm^3/h or SCFM)
- Negligible pressure loss compared with mechanical flowmeters
- High turndown (up to 100:1), ideal for identifying leaks
- Low-cost insertion versions (t-mass 65I for main pipes, t-mass B 150 for submetering)



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

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

Pressure measurement (plant pressure, filter monitoring)



Pressure measurement Cerabar PMP51 / 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 and evaluation



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

i 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.





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.



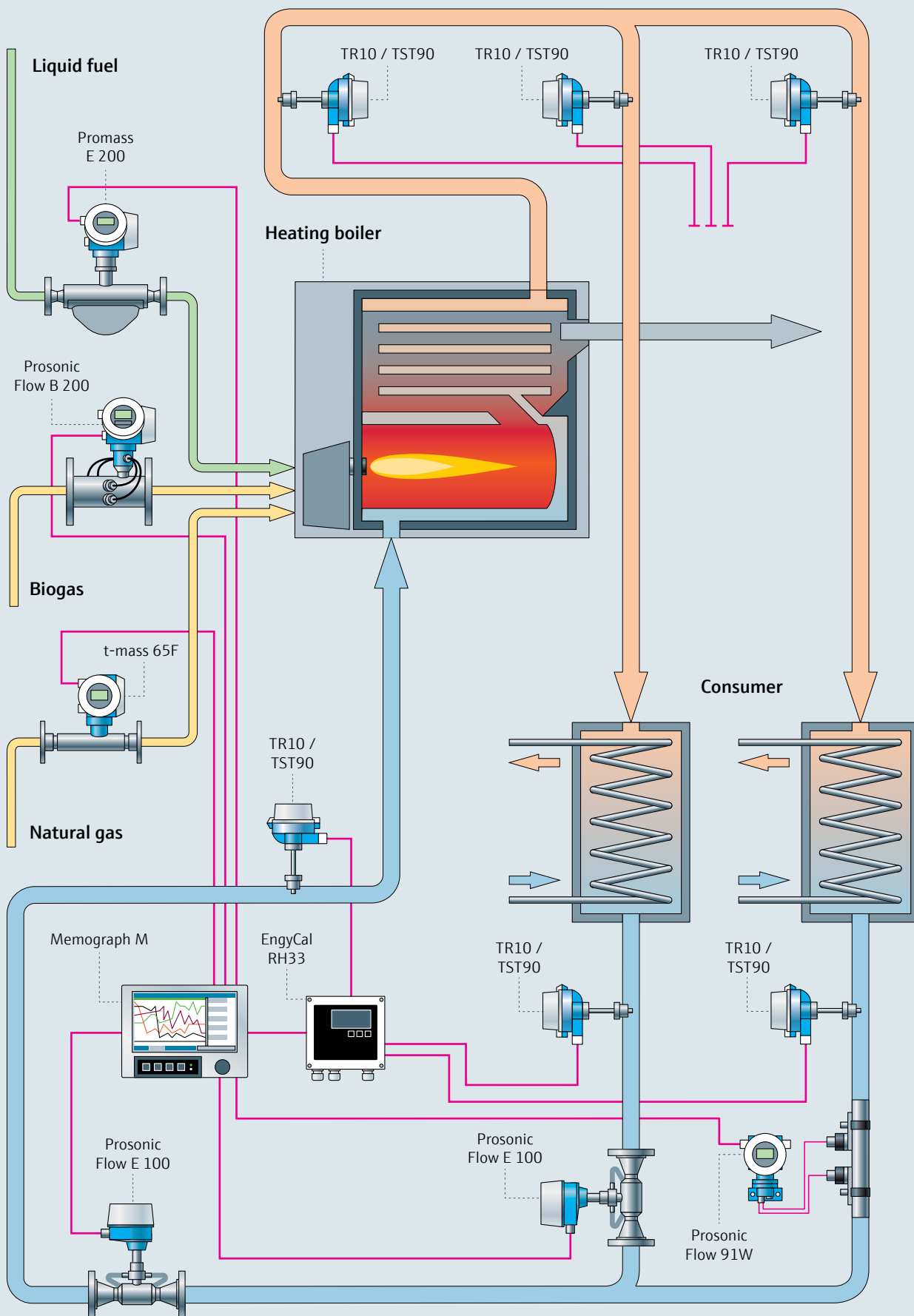
Savings made easy

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

Fuel consumption measurement



Flow measurement (natural gas) t-mass 65F/65I (thermal)

- For measuring the consumption of natural gas (mass flow, corrected volume, power)
- Negligible pressure loss
- High turndown (up to 100:1)
- Flanged (65F) or insertion version (65I)

i 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 oil) Promass E 200 (Coriolis)

- For measuring the consumption (mass flow/volume flow) of liquid fuels
- Direct density measurement
- No straight inlet runs required
- High measuring accuracy ($\pm 0.25\%$) and turndown (over 1000:1)
- Measurement is independent of viscosity

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

Energy flow measurement (feed/return line)



Flow measurement Prosonic Flow 91W / E 100 (ultrasonic)

- For volume measurement of hot water – independent of conductivity
- Measurement immune to magnetite deposits
- Clamp-on sensor (91W):
 - Non-intrusive measuring technology
 - For temporary measurement without opening the pipe
 - No pressure loss
- In-line sensor (E 100):
 - High accuracy ($\pm 0.07\%$ o.f.s. to 0.5% o.r.) thanks to traceable factory calibration
 - Integrated temperature measurement
 - Short inlet runs

Temperature measurement TR10

- For temperature differential measurement (delta heat) in feed and return line (suitable for custody transfer)
- Fast response time due to tapered end
- High accuracy ($\pm 0.025\text{ }^\circ\text{C}$ / $\pm 0.045\text{ }^\circ\text{F}$) thanks to electronically matched (calibrated) sensors

Data logging and evaluation



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-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
- 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 TR10 temperature sensor (Callendar-Van-Dusen coefficient)

i By monitoring parameters such as the fuel quantity, combustion air, combustion gas temperature or the thermal energy transfer rate, it is possible to assess a wide range of parameters in a heating system, e.g. boiler efficiency, pump efficiency, specific energy consumption, degree of waste heat recovery or the performance of heat exchangers. Energy balances can also be created with the measuring instruments.

Our solution package (D9E) for your heating system

Endress+Hauser offers customers a cost-effective solution for the measurement of flow, temperature and energy in heat exchanger systems. This package

consists of an energy computer (EngyCal RH33), two RTD assemblies (TR10) and a flowmeter (Prosonic Flow E Heat).

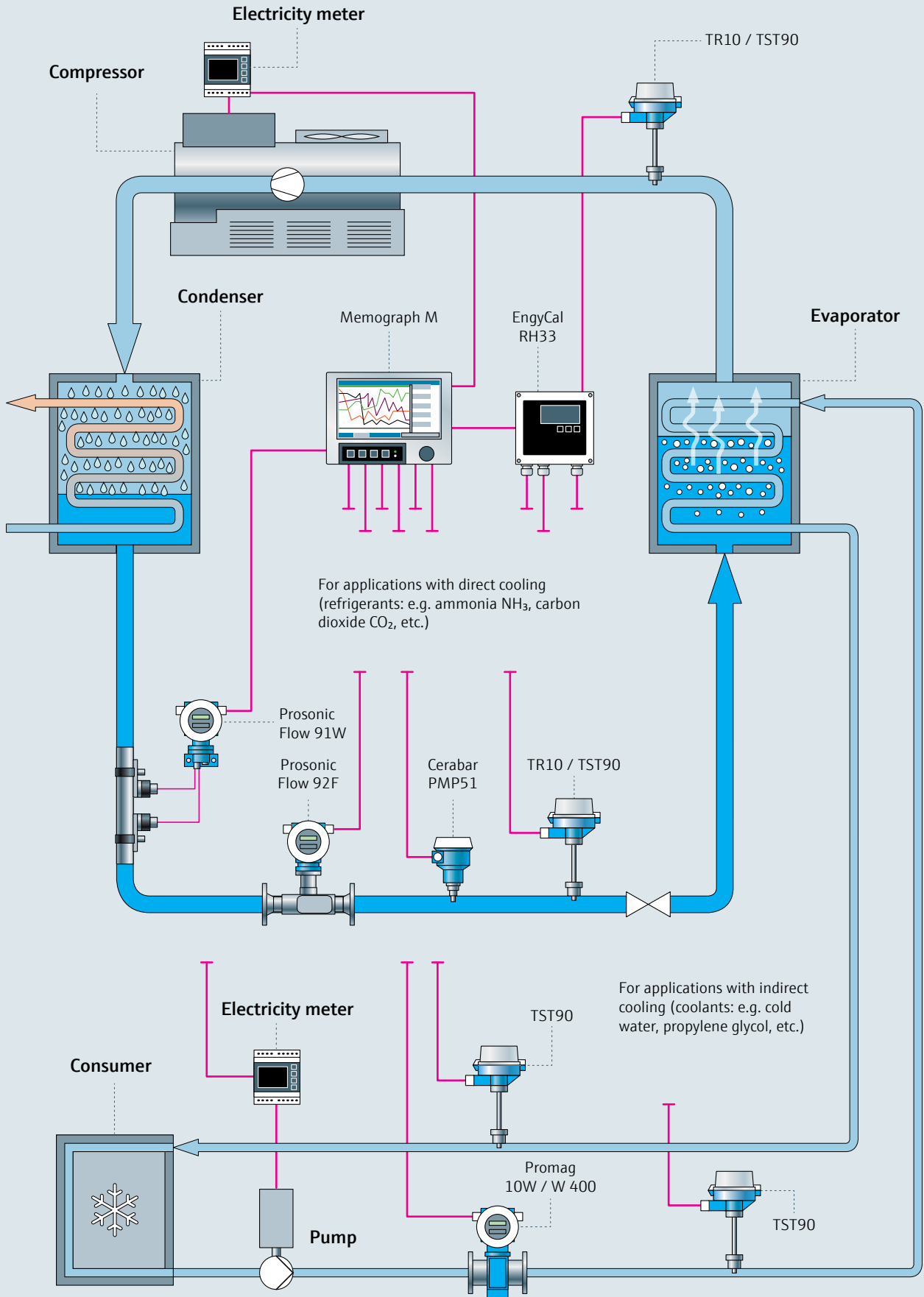




Cooling



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 buildup in tanks and pipes
- Analyze process variables (e.g. density) to detect coolant aging early on

Cooling – Measuring instruments

Flow measurement (refrigerants and coolants)



Flow measurement (refrigerants)

Prosonic Flow 91W/92F (ultrasonic)

- For volume measurement of liquids – independent of conductivity
- No pressure loss
- Clamp-on sensor (91W):
 - Non-intrusive measuring technology
 - For temporary measurement from outside without opening the pipe
- In-line sensor (92F):
 - High accuracy (± 0.3 to 0.5%) thanks to traceable factory calibration
 - Short inlet runs



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 10W (electromagnetic)

- For volume measurement of cold water, propylene glycol or conductive liquids ($> 50 \mu\text{S}/\text{cm}$)
- No pressure loss
- Very high turndown up to 1000:1
- High measuring accuracy ($\pm 0.5\%$)



Flow measurement (coolants)

Picomag (electromagnetic)

- For volume measurement and monitoring of industrial water, cooling water or warm water ($> 20 \mu\text{S}/\text{cm}$) 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 ($\pm 0.07\%$ o.f.s. to $\pm 0.5\%$ o.r.)
- “E Heat” sensor suitable for custody transfer

i For cooling systems with direct cooling (NH_3 , 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 and temperature measurement



Pressure measurement Cerabar PMP51

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



Temperature measurement TST90/TR10

- For temperature differential measurement (feed/return line)
- Fast response time due to tapered end
- High accuracy ($\pm 0.025\text{ }^{\circ}\text{C}$ / $\pm 0.045\text{ }^{\circ}\text{F}$) thanks to electronically matched (calibrated) sensors

Data logging and evaluation



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 TR10 temperature sensor (Callendar-Van-Dusen coefficient)
- System-compatible: supports common fieldbuses like Ethernet TCP/IP, Modbus RTV/TCP, M-Bus

Our solution package (D5W) for your cooling system

Endress+Hauser offers customers a cost-effective solution package for the measurement of flow, temperature and energy in heat exchanger systems. This package consists of an energy computer (EngyCal RH33), two RTD assemblies (TR10) and a flowmeter (Promag 10W).





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's 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:

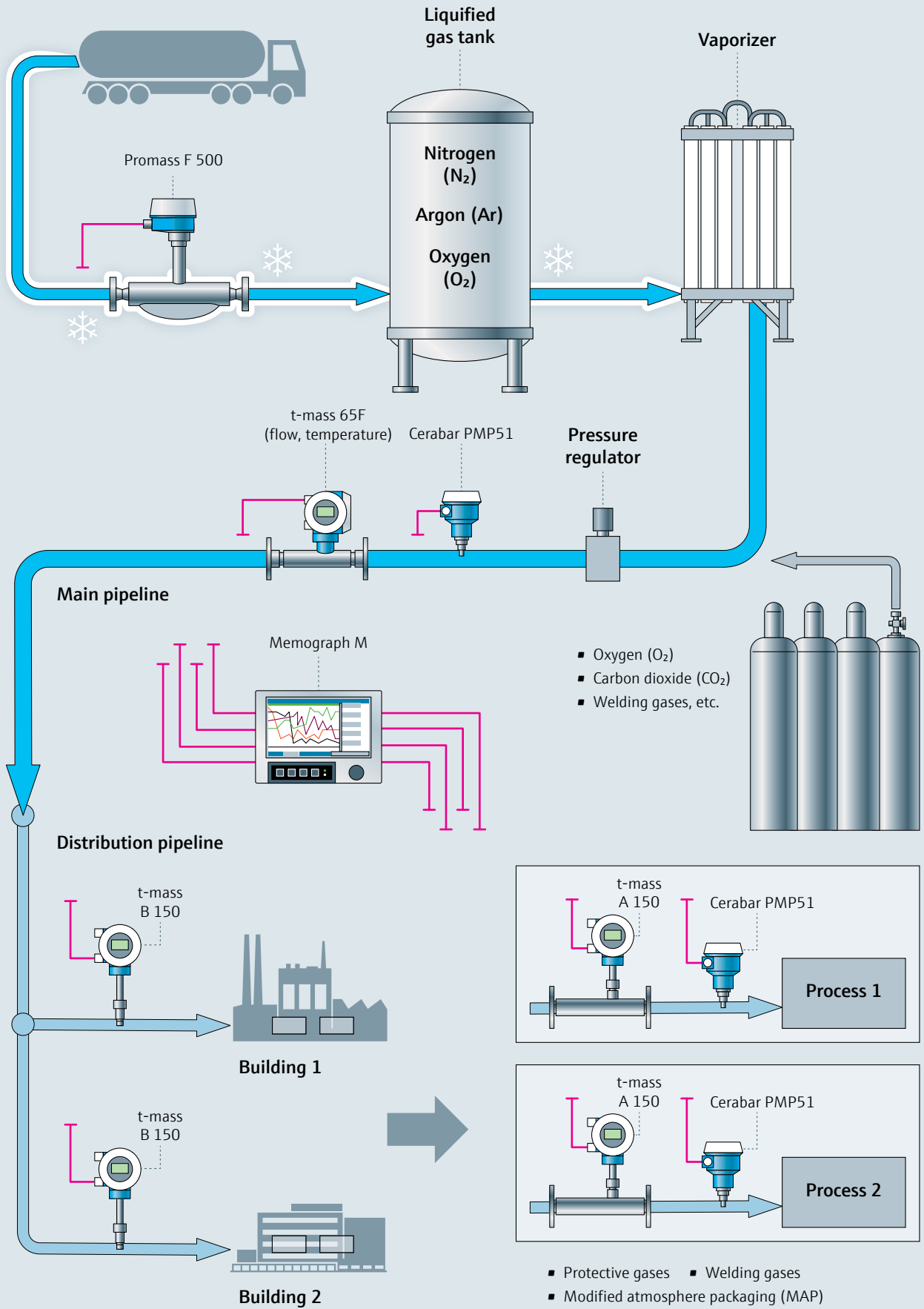
- Quick overview of all gas flows in the various units (building, floor, process, etc.)
- Correct and consistent cost accounting for all consumers
- Reliable identification of leaks, parasitic loads and areas with unusually high consumption peaks

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 of industrial gases



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 (N₂), 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 65F (thermal)

- For direct mass/corrected volume measurement of industrial gases
- Multivariable: additional output of process temperature
- Negligible pressure loss compared with mechanical flowmeters
- High turndown (up to 100:1), ideal for identifying leaks
- No moving parts



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 (Nm³/h or SCFM)
- High long-term stability: no zero point drift, "lifetime" calibration factor
- Negligible pressure loss

Pressure and temperature measurement



Pressure measurement Cerabar PMP51

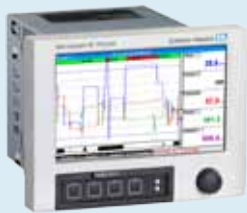
- For monitoring the system pressure and therefore the availability of an industrial gas
- Robust, can sustain vacuum and pressure shock (ceramic)
- Highly accurate



Temperature measurement TR10

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

Data logging and evaluation



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

i 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.



Energy management at Endress+Hauser

A case study – optimizing cooling/heating systems

Global warming, CO₂ 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 many new Endress+Hauser buildings around the world in recent years all meet strict energy efficiency standards.

Case study – Endress+Hauser Flowtec AG (Reinach, Switzerland)

In 2015, our competence center for flow – Endress+Hauser Flowtec AG – opened a new 25 000 m² office and production center. Even though the building was constructed to the latest energy standards, specific Endress+Hauser instruments first were installed before it was possible to obtain more detailed information on the energy flows in the cooling and heating system, and make additional energy optimizations based on the findings (► Pages 46–47).





2015



Energy management certification of Endress+Hauser Flowtec AG (Reinach, Switzerland) according to ISO 50001

2015 - June



New cooling/heating system in the new building is put into operation

2015 - August



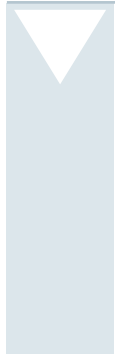
- **Problem:** The warm water system in the new building is designed for a maximum temperature of 45 °C (113 °F). However, water with a temperature of over 60 °C (140 °F) is sometimes required.
- **Solution:** Installation of a decentralized heat pump boiler for the temporary production of warm water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

2015 - November



- **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.**

2016 - February



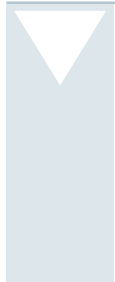
- **Problem:** Even though the hot water storage tank (3) of the pellet heating system (4) is full and heated, the system often signals “empty” (cold). This triggers the gas-powered district heating system (5) to make up for the supposed heating shortfall. Reason: The only temperature sensor in the storage 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.**

2017 - June



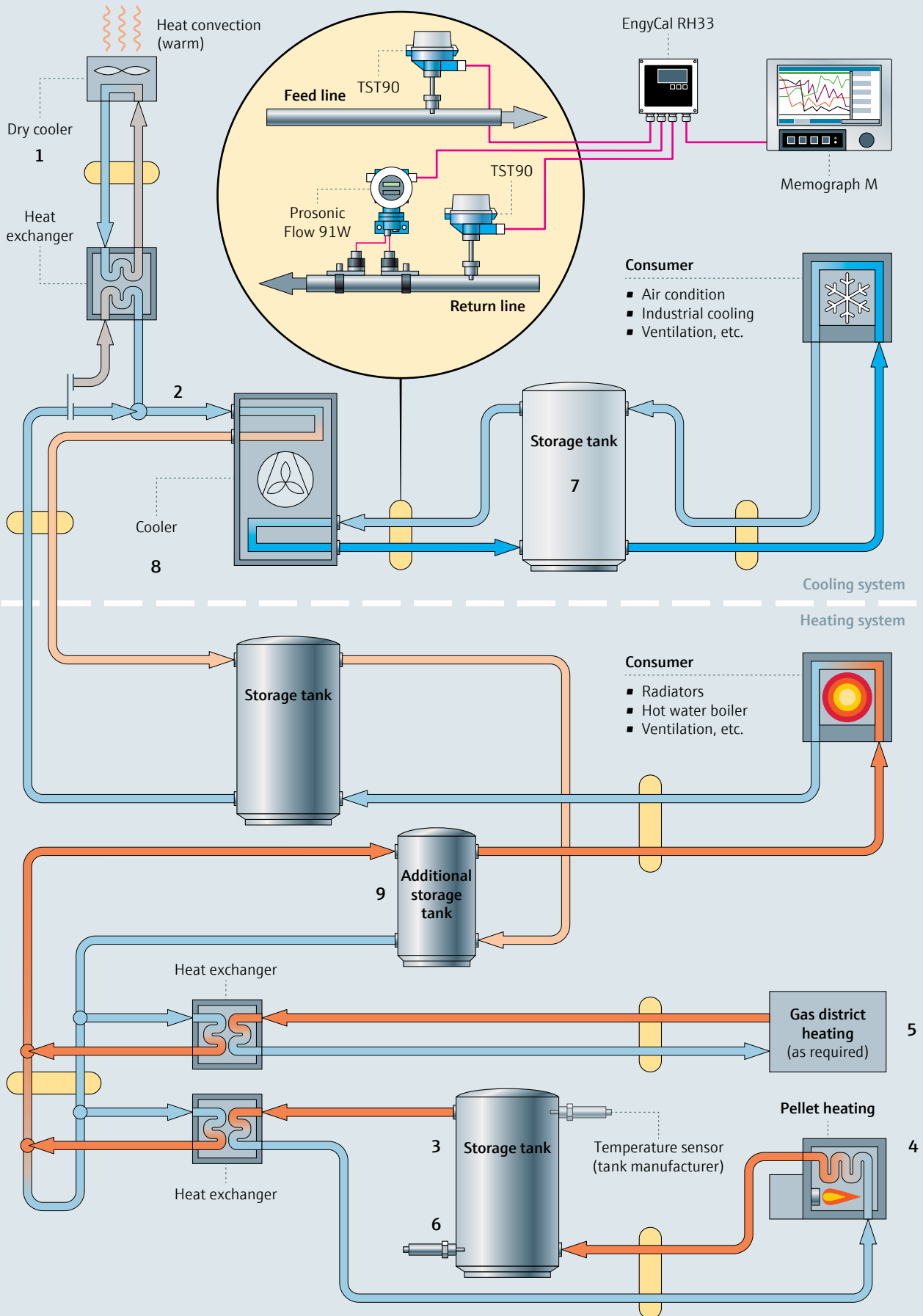
- **Problem:** Feedback signals from the cold water storage tank (7) cause the cooling unit (8) to constantly switch on and off.
- **Solution:** The cooling unit is now controlled via the building control system according to current needs.
- **Result:** **Cooling unit works continuously, resulting in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

2017 - October



- **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 Flowtec





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 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 works 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 – unique worldwide Verification function for maximum plant availability

Heartbeat Technology developed by Endress+Hauser is a one-of-a-kind diagnostics, verification and monitoring function for the optimized monitoring of process-critical instruments and processes. The benefits are clear: reduced testing effort, less downtime, and optimized maintenance. Thanks to Heartbeat Technology, obligations to demonstrate compliance with ISO 9001 and ISO 50001 can be easily met, wherever and whenever you want:

- Fully integrated testing and verification functions – available for flow, level, pressure, temperature and analytical devices
- Compliance with legal requirements
- Permanent instrument and process diagnostics for reduced maintenance and targeted remedial action
- Metrologically traceable device verification (TÜV-certified):
 - Can be performed any time without interrupting the process
 - Results can be archived and retrieved for quality audits
 - Enables longer calibration intervals

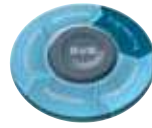
Always at your side worldwide

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 measurement 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
- 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



W@M Life Cycle Management

Data on sensors and actuators is generated constantly when sizing and procuring components, during installation and commissioning, and ultimately during the operation and maintenance of your plants. With W@M Life Cycle Management, you can access this information worldwide – wherever and whenever you want. The benefits for you are higher process reliability and product quality around the clock, and fast access to targeted information for service technicians in the event of a malfunction or during maintenance.

W@M Life Cycle Management ...

- is an open information system based on intranet and internet technology.
- brings together Endress+Hauser software, products and services.
- ensures the global availability of equipment and plant data.
- puts an end to time-consuming searches for device information in data archives.





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





i 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 120 per year? And that 50 to 80 leaks of this size incur annual additional costs of between EUR 6000 and 9500?
- 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%?

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