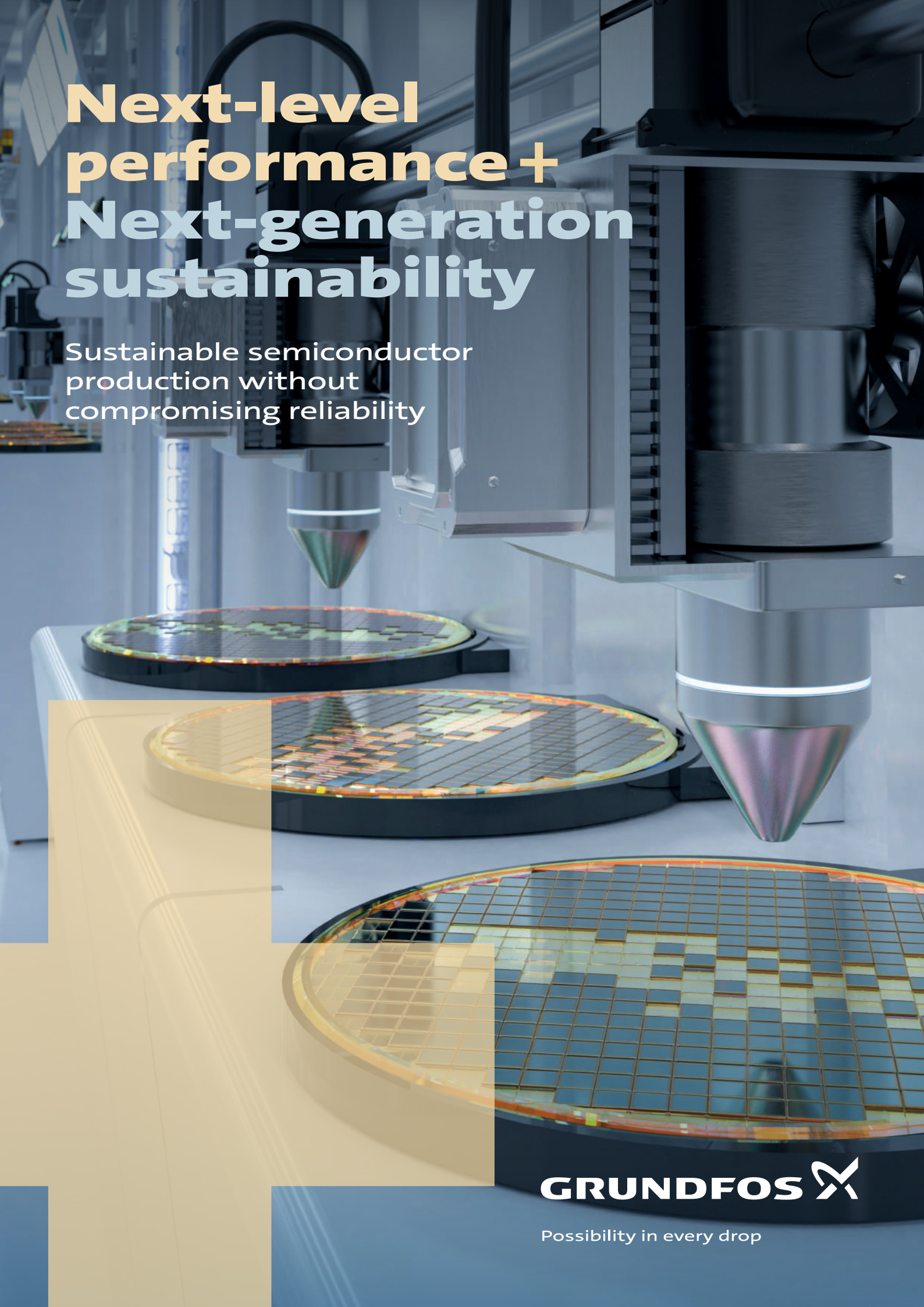


Next-level performance + Next-generation sustainability

Sustainable semiconductor production without compromising reliability

GRUNDFOS

Possibility in every drop

Achieve maximum performance. And step towards a more sustainable future.

The electronics industry is growing rapidly, putting semiconductor manufacturers and fab operators under increasing pressure to match this growth – in the most sustainable ways possible. But maximising sustainable production means meeting local and international climate targets. And you cannot achieve this with oversized, energy intensive pumps that often damage pump systems and generate significant amounts of wastewater. Grundfos helps you meet these challenges with configurable intelligent pump systems, each tailored to reducing your water and energy output whilst maintaining complete production reliability and performance.

Dedicated to developing reliable, more sustainable solutions globally

Semiconductor manufacturers and fab operators face complex challenges. More so with increasing concerns over supply chain security, and forecasts predicting semiconductor demand could double by 2030. Improving production efficiency and securing sustainable processes to meet this demand is essential.

As a reliable and leading full-line supplier with complete global supply chain control, we believe our long-standing expertise and intelligent end-to-end solutions can address your most difficult challenges – all whilst ensuring next level performance and next generation sustainability at every level.

Reliable production and uptime

Maximised production efficiency is essential to semiconductor manufacturing. Our intelligent pump technology integrates remote system control and monitoring solutions to minimise unplanned downtime, even across sensitive factory processes.

Further, our high-quality component materials are robust, long-lasting and capable of handling significant amounts of water, increasing overall equipment effectiveness (OEE) and reducing the risk of costly component or pump failure.

Water efficiency & management

We lower water usage in production, increase water reuse, improve wastewater handling, and maintain a stable water supply in a world of increasing water scarcity. By incorporating our intelligent pump systems into water reuse and recycling strategies, you can meet Minimal Liquid Discharge (MLD) and Zero Liquid Discharge (ZLD) targets.

Climate targets & compliance

Meeting and navigating complex climate targets are a challenge for semiconductor manufacturers. Our intelligent solutions integrate algorithms to accurately control, monitor and document your energy, water and chemical consumption at every stage of your production. Precise documentation, standards and certificates ensure regulatory and legislative compliance, lowering the risk of unnecessary financial penalties.

Global supply & service accessibility

As a global and leading supplier, you can access our entire product portfolio and range of services anywhere in the world. We pre-configure, customise and tailor each intelligent solution to meet your exact requirements at the operational and regulatory levels. And our dedicated team will support your entire transition to intelligent pumps, from consultation to post-installation.

Building a more sustainable future

Water has the power to change the world. We pioneer advanced solutions to resolve the world's water and climate challenges, improving the quality of life for people worldwide. Through system innovations and energy optimisation strategies, we promise to respect, protect and advance the global flow of water – now and into the future.

Better water management and a more sustainable supply chain

We do not underestimate the impact we have as a business. That's why we continuously work to minimise our environmental footprint through the development of energy-efficient water solutions. By reducing our footprint, we commit to:

- Responsibly measuring, managing and reducing our water withdrawal
- Efficiently reducing energy consumption through business operations
- Enabling a green supply chain that's focused on purchasing, logistics and packaging

Leading the way

We took bold steps and made significant progress in our sustainability ambitions by establishing future-looking net-zero and 2030 science-based targets.

The Science-Based Targets initiative recognises and validates these targets. And as the first water solutions manufacturer to join this initiative, we build them on a commitment to energy conservation, demonstrating leadership in addressing climate change across our operations and supply chain.

What drive us is our purpose

We take our responsibility seriously and commit to promoting greater respect and understanding of water around the world. We protect water by minimising waste, inefficiency, shortage, discomfort and inaccessibility wherever the flow of water is

needed. And we advance the flow of water through water system innovations as well as energy optimisations, with a focus on sustaining water´s flow now – and into the future.

Our long-term net zero commitments include:

- A 25% supply chain emissions reduction and a 50% operational emissions reduction by 2030.
- A minimum of 90% operational and supply chain emissions reduction by 2050.

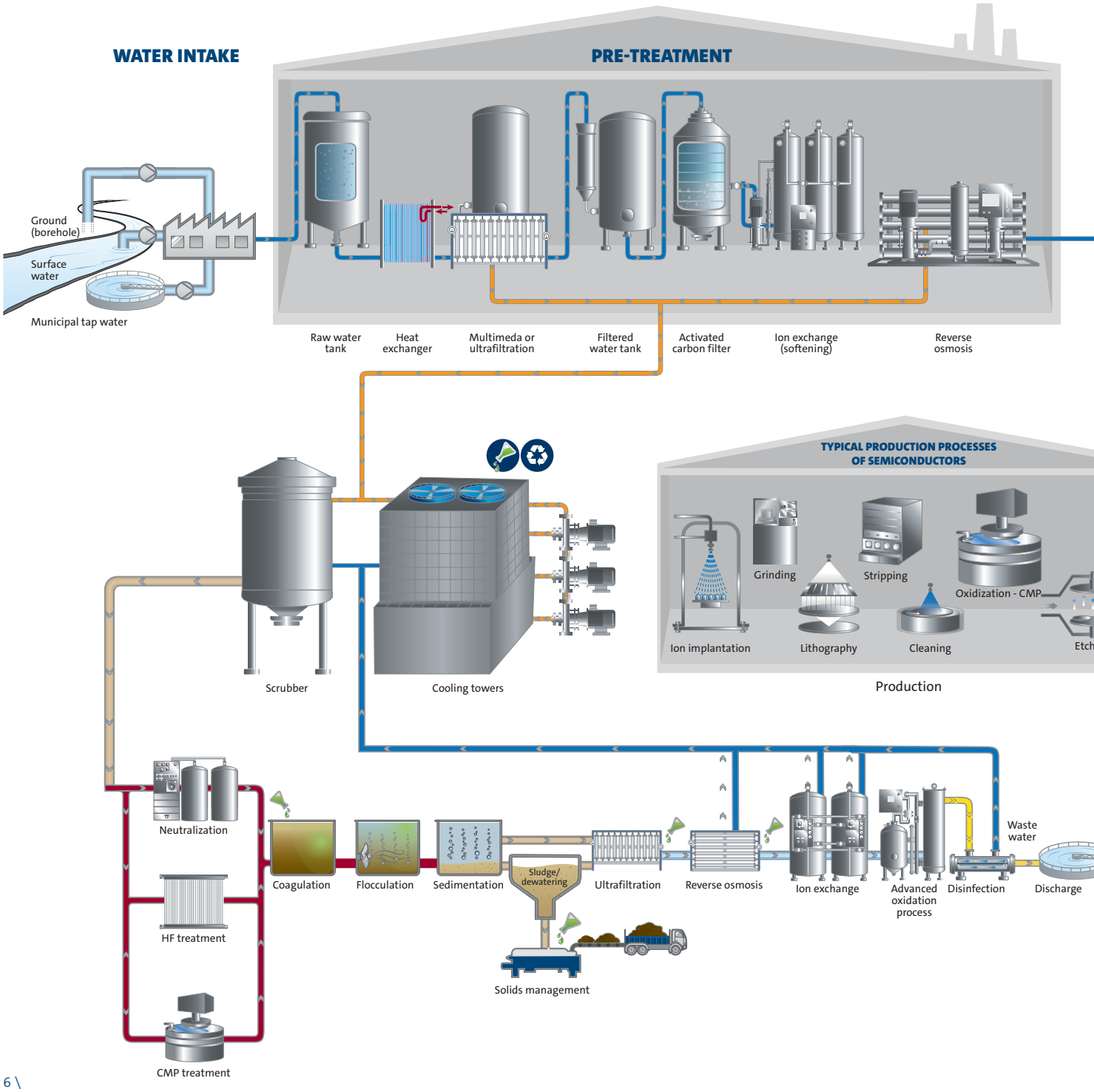
Our first-hand experience in setting and achieving climate targets are the guiding principles when offering customers our CO_2 reduction solutions.

SCIENCE BASED TARGETS
DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

Net zero approval from SBTi

The Science Based Targets initiative (SBTi) drives ambitious climate action in the private sector by enabling organisations to set science-based emissions reduction targets. Science-based targets provide companies with a clearly defined path to reduce emissions in line with the Paris Agreement goals. More than 4,000 businesses around the world are already working with the Science Based Targets initiative (SBTi).
We are the first Water Solution Company in the world to receive Net Zero approval from SBTi including our 2030 near term target.

We understand the flow of water for key applications in semiconductor manufacturing processes



Our expertise enables us to resolve key issues in especially the following application areas:

Water intake:

- Pre-treatment and make-up water
- Ultra-pure water (UPW) feed and transfer
- Customised pumps that comply with stringent water purity requirements

Cooling:

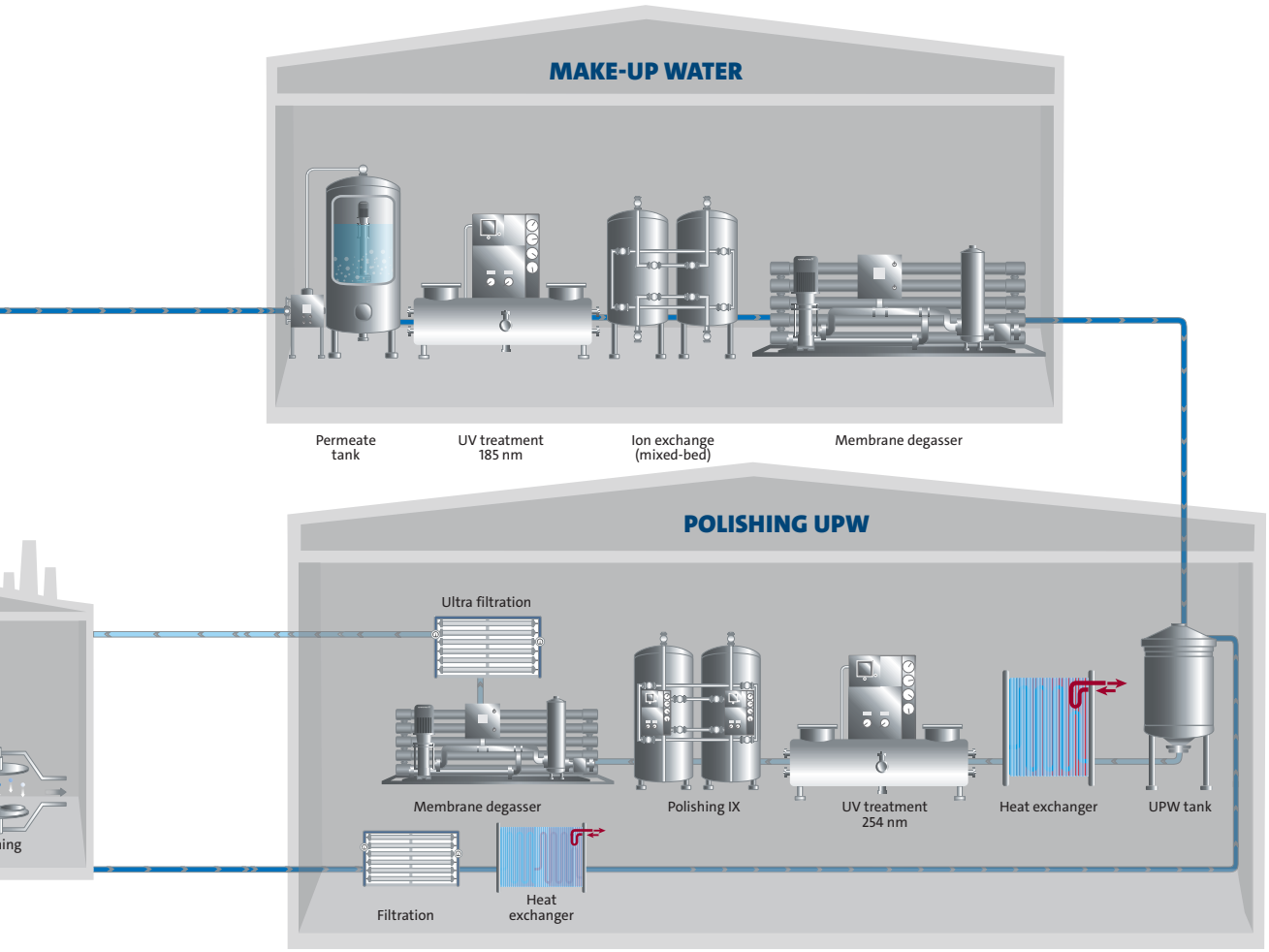
Intelligent and high efficiency solutions for substantial water and energy savings

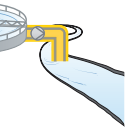
Wastewater treatment and water reuse:

Intelligent pumps for decentralised integration and control of membrane filtration and reverse osmosis systems

Service offerings:

Control and monitoring, optimised processes, greater energy efficiency and improved asset reliability





Explore our full package of offerings for key industrial applications

The Industry Portfolio Catalogue provides a complete country-specific overview of the equipment and services available for each of our 22 key industrial applications. Scan the QR code for a convenient dive into all our solutions categorised by industry.

Get the Industry Catalogue

MEMBRANE FILTRATION

Intelligent pumps for smart control of membrane systems

The steady growth of filtration systems is one of the major trends in industrial water treatment and semiconductor facilities is not an exception, with the need for ultra-pure water. As a state-of-the-art technology that's widely used, membrane systems also offer high potential for operational optimisation and cost reduction.

Grundfos has a wide range of solutions that supports membrane systems' optimisation with intelligent components and algorithms to reduce operational cost, increasing the flexibility, while reducing the complexity of integration. Grundfos pumps together with Grundfos sensors provide the functionalities of membrane system control without the need for external PLC/HMI control.

System builds and integration costs can be optimised, especially for small membrane filtration systems such as ultrafiltration (UF), microfiltration (MF), nanofiltration (NF) and Reverse Osmosis (RO). Grundfos CRE and NBE E-pumps and DDA digital dosing pumps integrated with Grundfos sensors for pressure, flow and quality provide important process control in system operations.

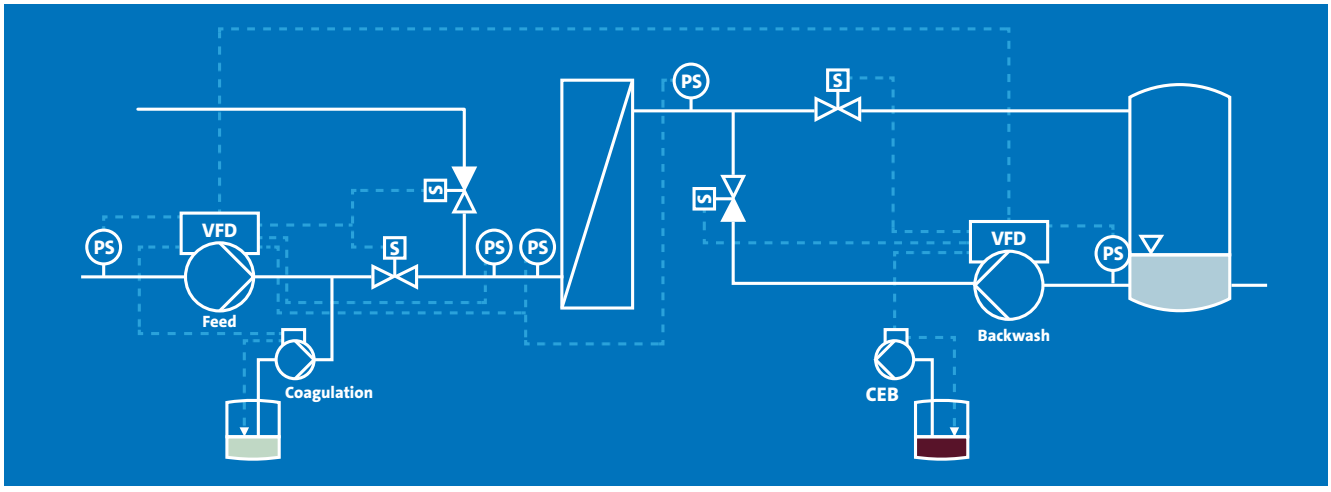
What does a decentralised membrane filtration system look like?

Control functions are distributed in all components and interact directly with each other, with pre-defined functionalities embedded in the intelligent pumps. Constant system permeate throughput can be achieved, regardless of fouling of membranes, and backwash or forward flushes can be triggered dynamically based on differential pressure across the membrane when needed. Other factors such as temperature or dosage of chemicals can also be considered for better performance and for protecting the integrity of the membrane.

Examples of process controls in membrane filtration system are:

- Feed pressure and flow control
- Backwash flow and time control
- CIP (clean-in-place) control
- Permeate level control
- Permeate production control
- Chemical dosing control in feed and backwash
- System monitoring for flow, pressure, water and chemical level, for example
- Other customisable process controls are available

An example of the integration and control of a decentralised ultrafiltration with Grundfos iSOLUTIONS. E-Pump recommendations for the system are either NBE, NKE or CRE with a DDA dosing pump with flow sensor (FS) and pressure sensor (PS).



INDUSTRIAL COOLING

Pump control improves operations and reduces water loss

The highly controlled cleanrooms in the semiconductor industry create requirements out of the ordinary to the pumps providing cooling with very little room to differ from the settings. Additionally, there are several processes within the semiconductor industry that require very heavy control of the cooling process to keep the temperature constantly on the set-point.

Today, 70% of all existing variable speed solutions are operating at factory settings, meaning they are not optimised for pump operation, wasting costly and valuable resources. With Grundfos iSOLUTIONS it is possible to optimise the cooling system, take full control and achieve the benefits of the intelligent solutions:

- Improve operational efficiency
- Achieve greater OPEX savings
- Reduce water loss by up to 20%

Reduce energy consumption by up to 60%

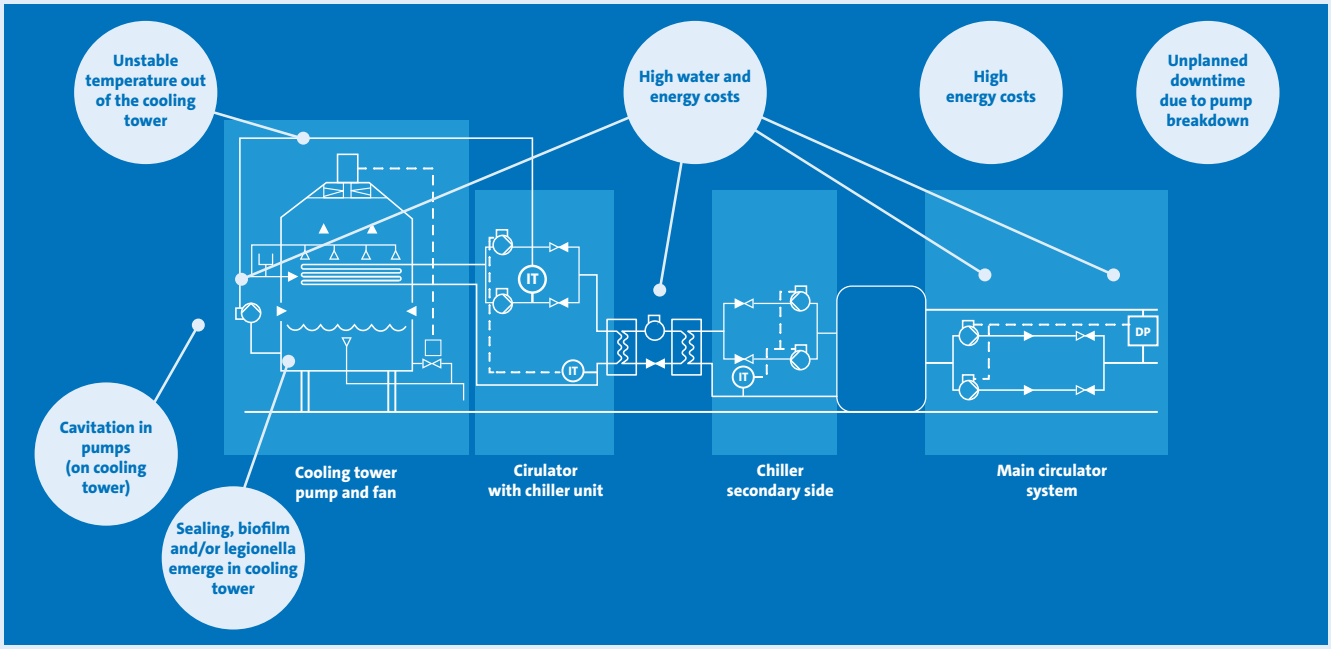
Grundfos can help optimise a cooling system by installing the right sized pumps, as well as installing sensors that provide feedback to the pumps. When the pressure/temperature changes in any relevant part of the system, the speed of the pumps are automatically adjusted to fit demand. This eliminates the need for valves and removes the energy lost from those.

Additionally, the same can be done for the fan in the cooling tower, so it will automatically switch on and off accordingly to the need. Not only does it result in a reduction in the energy needed, but it will also reduce the evaporation from the cooling tower, lowering the water consumption and risk for scaling, biofilm and/or legionella emerge in the cooling tower.

Grundfos iSOLUTIONS provides:

- Autonomously optimise system performance: Reacting to system performance data, adjusting to demands
- Complete system overview and control: Integrated user interface for pumps and components, controlled remotely
- Improved reliability: Reduced downtime and maintenance cost
- Customer specific digital offerings: Tailored to requirements out of the box

Industrial Cooling: Common issues



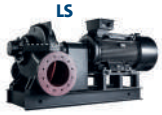
Sustainable and efficient water solutions for semiconductors manufacturing processes

Grundfos delivers end-to-end the pumps and equipment for building sustainable and efficient solutions for the following applications in semiconductor manufacturing.

Water intake & feed

Ground water | Surface water | Tap water

Split-case pumps
LS



End-suction pumps
NB(E)/NK(E)

Multistage pumps
CR(E)

Submersible pumps
SP

Booster systems
Hydro MPC

Water treatment

Water analyzer
DID

Dosing pumps & DID
SMART Digital, DME, DMX, DMH

Multistage pumps
CR(E)

End-suction pumps
NB(E)/NK(E)

End-suction pumps
CM(E)

High-pressure pumps
BM/BMS

Wastewater treatment

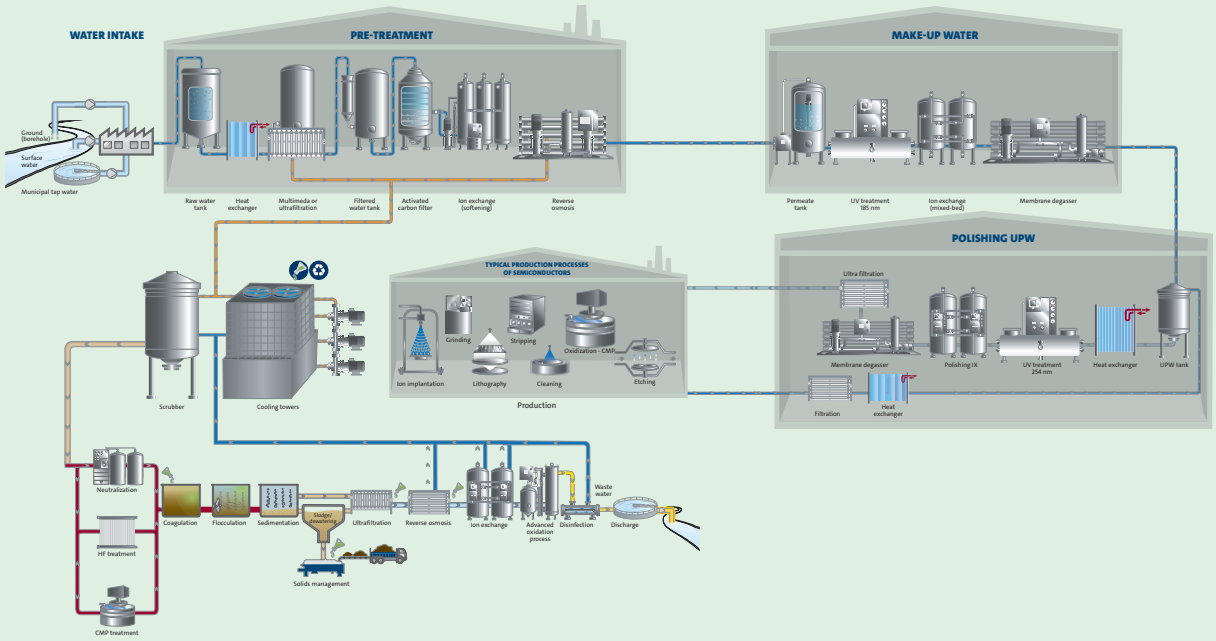
Multistage pumps
CR(E)

Dosing pumps & DID
SMART Digital, DME, DMX, DMH

Wastewater pumps
S/SE/SL

Dosing skids
DTS/DDS/ Accessories

Polymer preparation
POLYDOS



Water reuse

- Dosing pumps & DID **SMART Digital, DME, DMX, DMH**
- End-suction pumps **NB(E)/NK(E)**
- Dosing skids **DTS/DDS/ Accessories**
- Multistage pumps **CR(E)**
- End-suction pumps **CM(E)**
- High-pressure pumps **BM/BMS**
- Disinfection **Oxiperm Pro**

Temperature control

Ground water	Surface water	Tap water

- End-suction pumps **NB(E)/NK(E)**
- Multistage pumps **CR(E)**
- Booster systems **Hydro MPC**
- Circulator Pumps **MAGNA**
- Disinfection **Oxiperm Pro**
- Singlestage pumps **TP(E)**
- Multistage pumps **MTRE/MTHE**
- End-suction pumps **CM(E)**
- Dosing pumps & DID **SMART Digital, DME, DMX, DMH**

Controls and drivers

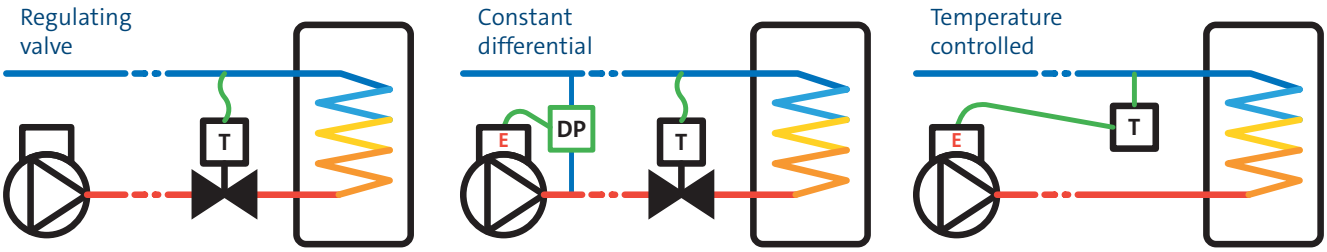
- External variable frequency drivers **CUE**
- Integrated motor variable frequency drive **MGE**
- Grundfos remote management **CIM/CIU**
- Level control **LC 231, LC241**
- Multi-pump control **CU 362**
- **Direct sensor** Differential pressure sensor/flow sensors Pressure sensors/ temperature

E-PUMPS

Taking efficiency to new levels

To achieve the most efficient solutions, it is necessary to not only look at the pump efficiency, but the total efficiency of the whole system. Grundfos E-pumps achieve this with intelligence built into the motor.

Learn more about our CME range with MGE motors



DP: Differential pressure sensor, T: Temperature sensor

Grundfos was among the first to launch an IE5-rated motor, the MGE, for our pumps. The MGE motor provides our customers with the highest efficiency. The MGE motor comes with an integrated frequency drive, a large variety of application control modes and are used as motor for several Grundfos pumps such as the vertical, multistage centrifugal CRE pump, our single-stage in-line centrifugal TPE pumps and our horizontal end-suction NBE/NKE and CME pumps.

Intelligent temperature control provides the best efficiency

Utilising the intelligence in our E-pumps can improve energy efficiency even further and achieve constant temperature in a system using either a regulating valve, a differential pressure sensor, or direct temperature control.

The illustration shows three ways to achieve temperature control in a pump system.

- The first case with the regulating valve requires the biggest pump as it needs to overcome not only the pressure loss in the heat exchanger but also in the control valve. Furthermore, the pump is always running at full speed.
- In the second case, with the differential pressure (dP) sensor, the solution requires the same size pump as before, but the energy consumption is reduced because the speed of the pump is adjusted to keep a constant dP over the control valve. The CAPEX of the solution will be more expensive than the first solution, but the life cycle cost will be much lower.
- The last solution with the direct temperature control is the one we recommend. It will have the lowest CAPEX and life cycle cost, as the pump can be down sized as it no longer needs to overcome the pressure loss in the control valve. Even with different load profiles the direct temperature control solution will always provide the highest energy savings.

CR MULTISTAGE PUMPS

Recognised reliability, efficiency and adaptability

The Grundfos CR is the world's number one inline vertical multistage centrifugal pump, has the broadest range available, and through our modular approach, we can create a solution to cover practically any non-standard situation. The CR delivers the exact pressure required, maintaining stability in operations with no downtime.

The CRNE pump variant for ultra-pure water applications

The solution can be delivered electropolished, cleaned and dried – and offer special options to meet internal standards:

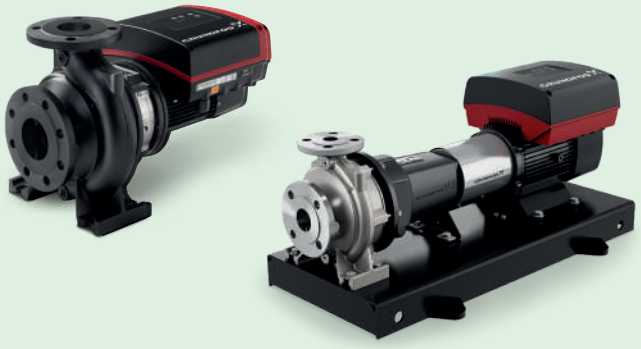
- All stainless-steel components are at least 1.4401
- Washing processes are finished with a de-ionized water wash
- HUQE or HUUE shaft-seal for conductivity of water that's less than 2µS/cm to avoid electro-corrosion
- Can be delivered with an electropolished pump report and a PWIS-free certificate

Learn more about Grundfos CRNE

NBE/NBGE/NKE/NKGE END-SUCTION PUMPS

Optimised perfection

Grundfos offers an almost limitless range of close-coupled (NBE/NBGE) and long-coupled (NKE/NKGE) end-suction pumps. Their robustness and ability to be configured and optimised for seamless operation make them ideal for use in virtually all applications. Backed by comprehensive pump know-how and carefully selected materials, the Grundfos end-suction range is renowned for its outstanding reliability



Learn more about Grundfos NBE/NBGE

Learn more about Grundfos NKE/NKGE

SMART DIGITAL DOSING™

Precision control and monitoring of chemical dosing

Accurate and reliable chemical dosing is essential for chemical treatment of wastewater, so it can be discharged or reused while meeting regulations. Grundfos dosing pumps provide several features to enable precision in chemical dosing. Traditional dosing pumps regulate the dosed quantity by adjusting stroke length and/or frequency. However, reducing the stroke length adversely affects dosing accuracy. In cases where the dosing pump cannot operate at 100% stroke length, valves will suffer from reduced performance leading to inefficient dosing.

SMART Digital Dosing™ offers a clear advantage. By using a stepper motor, the volume dosed is altered by the discharge stroke speed while continuously utilising 100% of the stroke length. This results in optimum dosing accuracy. The pumps also have a high resolution for operating setpoints, so that the exact dosing setpoint required by the process is found. This results in treatment efficiency as well as reduced chemical consumption.

Grundfos dosing pumps provide several connectivity options required for monitoring, control and communication, especially for integration in digital platforms and ecosystems. For example, this can be for relaying operational status and alarms, external controls and communicating with other components in a turnkey system.

Measurement of chemical dosing flow is quite challenging due its aggressive impact towards flow meters. Integrated flow measurement functionality in Grundfos smart dosing pumps monitors the real time dosing flow without a need of external flow measurements.

Dosing Tank Stations

Dosing Tank Stations provide the best economic efficiency when adding liquids such as coagulants, disinfectants or neutralising agents to a process in a precise and controlled way. Intended for storing and dosing liquid chemicals, many different configurations can be selected and applied flexibly to fulfil various dosing tasks.

Built-in alarms

- Overpressure
- Damaged outlet line
- Air in the dosing chamber
- Cavitation
- Inlet valve leakage
- Outlet valve leakage

Real process value measurements:

- Pressure monitoring
- Flow measurement

DDA SMART DIGITAL

Diaphragm dosing pump for complex and demanding applications

The top-of-the-line DDA pump is designed as the perfect solution for complex and demanding applications. The control variants offer a range of intelligent options, including selective fault diagnosis, built-in pressure monitoring, integrated flow measurement and AutoFlowAdapt, which allows for the setpoint to remain constant even when discharge conditions, such as pressure, change. This ensures the desired amount of chemical is consistently added to the process.

Continuous monitoring of pressure and dosing flow allows the pump to detect any dosing failure or accident in the dosing lines, for example chemical leakage, blockage in the discharge line, air bubble intrusion in suction side, and more. Necessary action is then taken, including alarms. Such functionalities are essential, especially from chemical health and safety perspectives.

Learn more about Grundfos DDA

The DDA range offers performance up to 52.8 gph (200 l/h) and is the ideal solution to deliver high flows accurately. A wide variety of pump materials are available, allowing dosing of aggressive chemicals.

DOSING SKIDS

Complete factory-built and tested dosing systems

Pre-engineered dosing skids consist of a closed or open cabinet, dosing pumps, pipes and accessories which are required for chemical dosing are also available. Complete dosing systems allow the optimisation of the build and installation cost as well as addressing safety issues. Customisation of dosing skids is also available to meet specific needs on-site.

Learn more about our Dosing systems

CONTROL MPC

Complete control cabinet solution for operating up to six pumps

Grundfos CUE is a complete range of external frequency converters designed for speed control. A solution with a built-in CUE is the Grundfos Control MPC, which has a complete control cabinet with a built-in CU 352 multi-pump control unit, main switch, contactors, IO 351 modules, cabling and more. The Control MPC controls and monitors up to six identical speed-controlled pumps connected in parallel, is supplied with all necessary components, and contains application-optimised software. The solution helps ensure the most energy-efficient operation of up to six pumps in heating, cooling or water transfer applications and also features a wide range of languages.

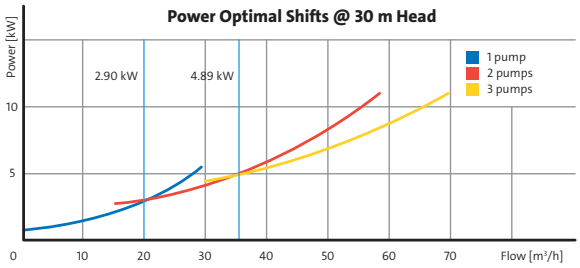
Learn more about our Control solutions

HYDRO MPC BOOSTER SYSTEM

Pumps and intelligent control in perfect interaction

Semiconductor sites are large production facilities where water is often transported a long way. The Hydro MPC Booster System is a fully integrated packaged system that brings the latest technology at the highest quality to the market and keeps the right number of pumps running to ensure optimal efficiency.

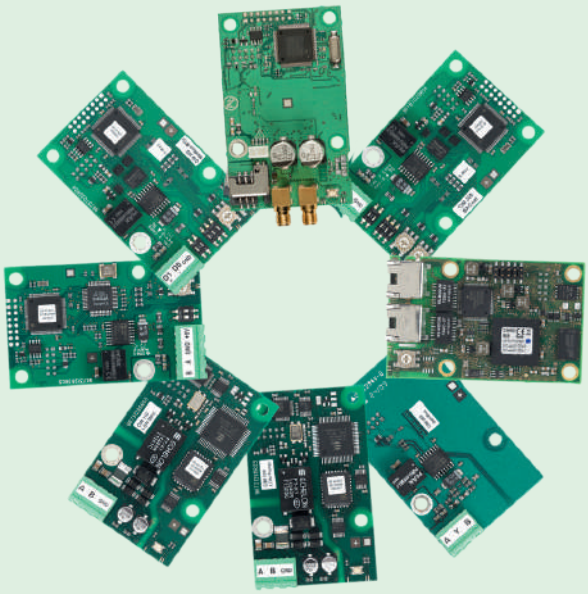
The CU352 MPC controller can handle even the most difficult boosting applications with ease and accuracy, where the algorithm after a short parameterisation phase will be able to determine if a pump cut-in/cut-out will result in less or more power consumption, which can result in up to a 33% reduction in energy use. With standard speed control, the system runs with one pump until it reaches 98% of its maximum speed before it cuts in with an additional pump.



Learn more about Hydro MPC

COMMUNICATION AND CONNECTIVITY

Monitor, diagnose and optimise pump systems



Why use CIM/CIU connectivity interfaces?

- Pumps and controllers have better reliability with reduced downtime, due to monitoring and control functionality on a PLC, BMS/SCADA system
- The operational cost of pumps can be lowered by reducing setpoints to match precise system needs via remote control
- Enable predictive maintenance and fast reaction time on process changes and exceptions
- One solution for all products with a modular design prepared for future needs, offering complete process monitoring and control
- Easy to install and commission, as Grundfos delivers the required support files and functional profile manuals

Avoiding pump breakdown is critical. The typical problem with pumping infrastructure on bigger sites is that so much activity takes place, making it difficult to gain an overview. Without an overview, it is difficult to operate the pumps and ensure that the various loops are working as efficiently as possible. Furthermore, fault-finding at breakdowns becomes very complicated. For complete control of pump systems, the Grundfos fieldbus concept is the right solution.

The innovative Communication Interface Module (CIM) and the Communication Interface Unit (CIU) are a series of connectivity interfaces that enable data communication via open and interoperable networks.

Grundfos connectivity interfaces are compatible with Modbus RTU, Modbus TCP, BACnet MS/TP, BACnet IP, PROFIBUS DP, PROFINET IO and EtherNet/IP communication protocols.

They offer ease of installation and commissioning, user-friendliness and great value for money in the long term. The modules are based on standard functional profiles for an easy integration into the network and easy understanding of data points, showing alarms, energy consumption, operating mode status, look at trend curves, event logs and much more.

Visit our EICA selection tool

GRUNDFOS SERVICE OFFERINGS

Optimise processes, energy efficiency and asset reliability

Through our many and varied interactions and discussions with industrial customers and end-users, the Grundfos Aftermarket team has identified the three most common customer pain points:

- **Process Optimisation** How to configure manufacturing and utility systems in the most efficient and effective way?
- **Energy Efficiency** How to manage the ongoing costs of production and utility services with ever-increasing energy rates and ageing equipment?
- **Asset Reliability** How to optimise system uptime in a critical production/manufacturing environment?

To assist in addressing these pain points a suite of Aftermarket Service Offerings has been developed that address the associated challenges and risks. Grundfos is already working with industrial customers to create the most robust, efficient and reliable pump asset-based systems available to them.

Service Agreements	Operation Services	Repair Services	Optimisation Services
All-In-Maintenance	Installation	Repair	Training
Customised Service Agreement	Commissioning	Spare Parts	Energy Check
Standard Service Agreement	Laser Alignment		Energy Audit
Energy Earnings	Inspection		Predictive Maintenance
	Extended Warranty		

Grundfos Optimisation Services

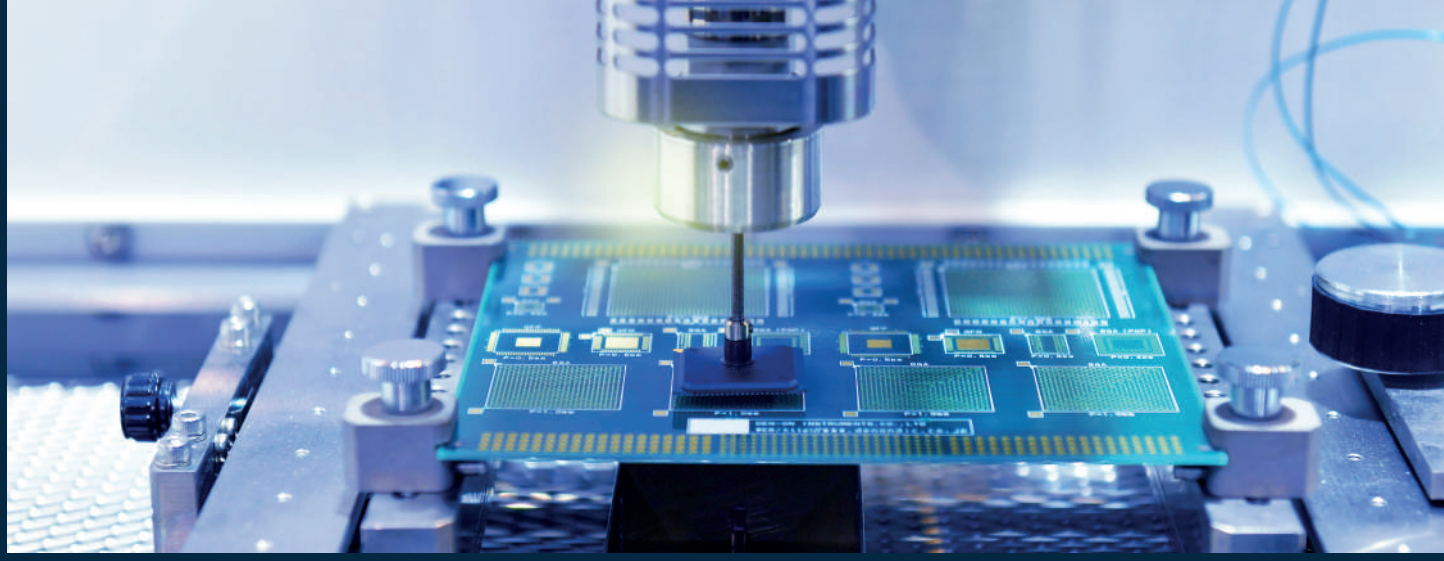
To address the global challenge of energy availability and consumption, Grundfos has put together a range of Grundfos Energy Optimisation offerings. Grundfos Technicians inspect, review and monitor the current pump asset systems in real time, take the data and enter these into a specifically designed algorithmic tool that identifies the potential pump asset energy savings.

This enables Grundfos to generate a proposal/ recommendation on how to upgrade and optimise the existing system to new and more modern technology and application design. Another positive here is the energy monitoring tools used are non-invasive and can be connected without interrupting the system operation.

Grundfos Service Agreements

In addition to our focus on addressing climate challenges, Grundfos has also a suite of Service agreements available. From a basic level service, to customised agreements and the top level All-In-Maintenance agreement, we provide our customers with confidence that their pump assets are maintained at fixed terms and price.

The benefits are optimised system uptime, increased asset lifetime and greater confidence about the operational reliability.



CASE

Grundfos helps a semiconductor company keep pressure stable in process cooling water

When a semiconductor company had to equip its new production facility with a pumping system for process cooling water, it turned to Grundfos and the new CRN 185 pump to maintain the completely stable pressure and temperature required.

Cooling systems for equipment that produce microchips must maintain a stable operating pressure and temperature. The collaboration began several years ago, when the stability of the operating conditions of the cooling systems began to become more important every day.

From simple pump selection initially to identify the correct product, to energy audit in the recent past, Grundfos and the company have established a high level of cooperation, which will see the future installation of another 20 CRN 185 pumps.

The outcome was improved efficiency when compared with the previous installation. Reliability is also better and with greater control temperature is kept stable in all silicon processes.

CASE

Water treatment made more energy efficient and less complex with decentralised controls

Industrial Water Equipment Ltd (IWE) customers depend on a reliable, guaranteed source of purified water. This makes the Reverse Osmosis (RO) systems essential for IWE's business.

Grundfos supplied a CRIE pump, a SMART Digital DDA, Direct Sensors™, remote monitoring and other components to gain intelligence and easy integration. The Grundfos components reduce system complexity and physical footprint, while the CRIE pumps can run at variable speed to massively reduce the pumps' energy rating.

By upgrading their systems, they achieved 70% energy savings, reduced footprint and chemical savings, thereby lowering the emissions during waste water treatment. Lastly, with Grundfos supplying all components IWE benefited from a less complex supply chain with Grundfos as the full-service supplier.

About Grundfos

Grundfos is a global water solutions company and one of the leading pump manufacturers in the market. We pioneer solutions to the world's water and climate challenges and improve quality of life for people.

- 1945: when it all started
- #1 pump manufacturer in the world
- 100+ companies worldwide
- 16+ million units produced per year
- 20,000 employees
- EUR 3.9 billion net turnover in 2021

Every day, year after year, we put water to work for industry. Moving, treating, reusing and saving water. Developing solutions to drive sustainability and efficiency. Changing the world one industrial process at a time – for people, business and the planet.

Grundfos. Possibility in every drop

Please contact your local Grundfos representative for further information, or write to semiconductor@grundfos.com

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