



**cetop**

*The Voice of the European  
Fluid Power Industry*

**European Fluid Power –  
Efficient, Sustainable  
and Digitised**

## Fluid Power – Innovative and Multifunctional

Fluid power – hydraulics and pneumatics – transmits force and power for drive, control, and motion functions. It uses the physical characteristics of a fluid such as oil, synthetic fluids, water, and air, to transmit force and power. We come across it in all aspects of our daily lives. Hardly any product is developed without the use of fluid power, and barely a machine or aircraft moves without it.

Hydraulics and pneumatics manufacturers are suppliers for the entire manufacturing industry. They are technological pioneers for innovative solutions in

- mobile machinery
- machine tools
- food processing and packaging machinery
- environmental technology
- semiconductor manufacturing
- automotive engineering
- medical technology
- and many others

Energy and resource efficiency, sustainability, climate protection, etc., are essential topics for a good and healthy future for all of us. Fluid power companies contribute to this with innovative developments involving the latest materials and state-of-the-art electronics as well as digital solutions.

The close link to science is essential. Together with academic partners, the European fluid power industry designs efficient technologies for the future. The technical advantages of both hydraulics and pneumatics as well as some innovative solutions are presented hereafter.



# Advantages of Hydraulics and Pneumatics

## Pro Hydraulics

- high power density
- robustness and overload protection with simple load limitation
- good time response due to low inertia
- small installation space and flexible assembly
- long life-time
- low life-cycle-costs (cost advantage with many axes due to shared hydraulic power supply unit, very cost-effective in load holding operation)
- peak load coverage via storage technology
- good lubrication and corrosion protection by means of an operating medium (integrated cooling)
- high starting torques with hydrostatic transmissions

## Pro Pneumatics

- robustness and overload capacity
- simple design and lightweight construction by use of aluminium and plastics
- low investment costs
- high specific power density
- constant peak load
- resilience in cases where maximum power rating is exceeded (service robots)
- low energy consumption in long cycles
- small installation space
- application in hazardous areas





**Dr. Marcus Fischer**  
**COO, ARGO-HYTOS Group**  
**Switzerland**

**“We create a competitive advantage for our customers in energy efficiency, smart products, assistance systems and condition monitoring.”**

## **Saving energy and resources through optimized filtration**

Developing sustainable products is our obligation towards future generations. Energy losses and waste of resources can be avoided on all parts of hydraulic circuits. ARGO-HYTOS has reached a new technological benchmark by reducing pressure losses up to 30% with its latest generation of multi-layer filter elements EXAPOR®MAX3. Increased dirt holding capacity prolongs operating time of the filter element and saves resources.

Special simulation tools predict the oil contamination level in different areas of a hydraulic circuit. The most effective filtration setup for the circuit to achieve the necessary cleanliness level and protection of sensitive components can be defined. Operating lifetime of various filter elements in a system and the maintenance intervals can be effectively synchronized.

Simulation can also be used to optimize the design of hydraulic tanks. In combination with the AirEX air separation module the air content is reduced up to 70% faster compared to conventional return-filters and allows a tank size reduction of up to 30%. This again saves resources, machine weight and costs.

Competence and an innovative product portfolio contribute to the reduction of waste and energy losses.



*Increased machine availability, longer maintenance intervals and lower operating costs - always on the safe side with EXAPOR®MAX 3 filter elements from ARGO-HYTOS.*





**Iñaki Goitia**  
**Product Manager, Bosch Rexroth**  
**Spain**

**“CytroBox in the automotive industry.  
Energy efficiency thanks to connected  
hydraulics.”**

At Bosch Rexroth, we are committed to creating technological innovations that help to drastically reduce CO<sub>2</sub> emissions in the pursuit of sustainability. This common goal has led us to develop and implement a revolutionary concept in the world of hydraulics in recent years: ENERGY-ON-DEMAND.

The concept of supplying hydraulic energy on demand is a revolutionary technology that clashes head-on with conventional hydraulic power unit, which is still in use in most industries nowadays. The technology developed for this purpose is called SYTRONIX (Smart interplay of Hydraulics and Electronixs) and reduces electricity consumption by up to 80% compared to a conventional system.

This technology is the starting point for complete solutions called CytroX family (CytroBox, CytroPac, CytroForce, CytroMotion). Together with a differential design, these devices make up the new generation of hydraulic power units and actuators. Their advantages do not end with a substantial improvement in energy efficiency but have other great advantages that make them unique: sound levels below 75dB, small footprint, 75% reduction in the use of hydraulic oil, integrated sensors, connectivity Multi-Ethernet to superior controls, and integrated IoT service. CytroConnect Solutions ensure higher availability.





**Dr. Steffen Haack**  
**CEO, Bosch Rexroth**  
**Germany**

**“Shifting complexity from the hardware to the software makes machines even more flexible and productive.”**

New powertrain technologies and concepts, such as variable-speed electric drives, are diversifying the requirements for functions and actuation of hydraulic drives. The requirements for robustness and dynamics are increasing. At the same time, the functions must become ever more flexible.

The eOC technology from Bosch Rexroth is the ideal answer to this because it expands the range of functions and the functions themselves by implementing them not in the hardware but in the software.

This is based on mechatronically optimized hydraulic pumps for the open circuit. eOC ensures the proper control of the necessary setpoint values for torque, pressure or flow in mobile and industrial applications. In combination with the eOC software, characteristics such as dynamics and power control can be set, changed and combined.

The eOC software makes it possible to set various control parameters flexibly during operation. With predefined parameters, the pump behaves optimally as part of the hydraulic system whatever the function is.

The stability of the function in the application is increased. In addition, performance benefits in the component and in the system cluster increase efficiency. Energy recuperation solutions become possible or simplified.



*Electronically controlling hydraulic pumps in open circuits with Rexroth eOC opens up new possibilities for hydraulic drives. Shifting complexity from the hardware to the software makes machines even more flexible and productive.*





**Daniel Waller**  
**CEO, Bucher Hydraulics**  
**Germany**

**“Massive reduction of power consumption and CO<sub>2</sub> emissions with innovative electro-hydraulic linear actuators.”**

### **New electro-hydraulic horizons**

Electro-hydraulics means smart combination of the two technologies to reach highest efficiencies. The advantages of hydraulics (high force, robustness) are combined with those of electric drive technology (efficient, easily controllable).

HELAX (hydraulic electric linear axis based on AX technology), a product of Bucher Hydraulics, offers tremendous opportunities to increase energy efficiency resp. reduce energy losses.

A series of tests conducted at construction machines (e.g. wheel loaders) proved significantly increased net power output combined with a massive reduction in power losses leading to a revolutionary improvement in the drives' carbon footprint. In addition, there is a significant noise reduction.

Extensive tests with this modern linear drive with 50 kW drive power in conjunction with the new HELAX technology showed reduction of the previously common power losses by up to 90%. With an annual operating time of 2000 hours, this can save up to 135t of CO<sub>2</sub>.

This demonstrates the great potential for energy savings available to manufacturers (e.g. construction machinery) to be able to meet future requirements for drive solutions in terms of energy efficiency and reduction of CO<sub>2</sub> emissions.





**Dr. Robert Rahmfeld**  
**Senior Director Engineering Hydrostatics,**  
**Danfoss Power Solutions**  
**Germany**

**“Danfoss is engineering a sustainable tomorrow.”**

## **Sustainable and more efficient driveline solutions: fluid power for electrified construction machines**

It is estimated that, globally, construction machines emit around 400 Mt of CO<sub>2</sub> each year, out of which excavators in particular account for more than 200 Mt of CO<sub>2</sub> emissions annually globally. Therefore, electrifying medium and heavy construction machines is a clear commitment to the environment, as well as an investment into a greener future. But today’s electrified solutions are costly. Focusing on energy efficiency, Danfoss aims to accelerate the transition to electric off-road vehicles, by making them cheaper to own and run than Diesel equivalents.

Fluid power is in fact a key to this effort. By focusing on ultra-efficient hydraulics component technology and novel hydraulics architectures, significant run time improvements are possible. Combining the Danfoss Digital Displacement hydraulics, with leading efficiency in the entire operating range, and Editron electric motors allows useful energy to be recovered and re-used, leading to up to 50% reduction of energy consumed in vehicles, like excavators, which consume vast amounts of energy in use.

By implementing these novel technologies, dramatic reductions in the needed cost of battery packs are possible including the energy needed to charge them. Positive environmental and operating cost impacts are proportional.





**Roberto Gambetta**  
**R&D Manager, Hansa TMP**  
**Italy**

**“A new pump is born in HANSA TMP with a monolithic body.”**

Our technical department headed by Roberto Gambetta, in collaboration with other company departments, during the development of the new TPV 2500, the new axial piston pump for closed loop circuit, decided to project it with a monolithic body and a wide range of controls. For this pump, they studied a new digital control: the automotive control. This kind of control permits to modify the displacement of the pump in function of the variation of the revolutions of the heat engine. The digital dashboard allows programming and visualization of functional parameters when the machine is working.

The monolithic body is available on the single pump and on the compact tandem version.

The reasons for opting for this solution are mainly aimed at efficiency and sustainability without affecting performance.

The pump body, made of cast iron, gives strength and structural solidity to the components. In this way we have deleted some parts most subject to elastic deformation, i.e. the joints. More rigidity combined with the improved collocation of the internal components makes it more efficient in its operating dynamics, guaranteeing overall efficiency of the component and, consequently, lower fuel consumption by the engine on which it will be installed.

This type of design makes the hydrostatic transmission system more sustainable and ‘green’, as the reduction in components translates into lower operating, logistics (transport), processing and production costs.





**Robert Schullan**  
**CEO, HAWE Hydraulik**  
**Germany**

**“HAWE Hydraulik considers not only the manufacturing process, but the entire life cycle of its products and solutions in order to continuously reduce the ecological footprint. This can only be achieved in close cooperation with our customers and our internal and external supply chain. Concrete examples of this can also be found in the HAWE range of products of CETOP valves.”**

Directional seated valves with CETOP connection are an energy-efficient alternative to directional spool valves in many applications. Due to their design principle, directional seated valves offer a high potential for energy savings compared to directional spool valves. So it makes sense to optimize the entire production process of these seated valves accordingly. HAWE Hydraulik uses the GHG protocol for the evaluation of the Product Carbon Footprint (PCF) and currently considers the cycle from the procurement of all materials to delivery to the customer. The high depth of added value in the HAWE production plants, the associated short transport routes plus a product design that generates little material waste in production, contribute positively to this.

A comprehensive consideration and reduction of the PCF also took place during the development of the directional seated valve type ROLV. It is used wherever work functions must be precisely controlled and at the same time maintained over a defined period of time. Due to the leak-free design principle, the switching position can also be held over longer periods of time without further energy supply. Typical application is in machine tools, in processing machines but also in mobile machines. Thanks to the CETOP 3 standard connection pattern, it can also be flexibly combined in valve assemblies to form extensive control blocks. The standardized connection pattern makes it particularly easy to switch from spool valve to seated valves. The seated valve only has to be built on the existing connection pattern. In the HAWE product range you will find many designs and sizes for this modern valve type.





**Dr. Johannes Schmitz**  
**Director R&D, Linde Hydraulics**  
**Germany**

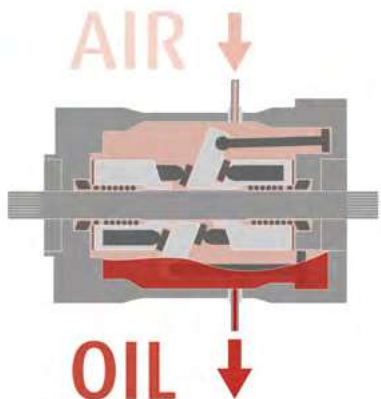
**“The HMV double motor, which operates in dry case conditions, leads to higher efficiency and improved performance, especially in high speed ranges where splash losses have a high impact.”**

The Linde Hydraulics HMV double motor, available in two frame sizes, is designed to cover the entire market of 40kph machines using drive axles such as telehandlers, wheel loaders and dumpers.

This motor design uses two smaller rotating groups in “face-to-face” arrangement within a single housing and just one center swash plate with electro proportional controller. This exclusive design results in balanced internal forces and thus, reduced mechanical friction.

The high efficiency of this axial piston motor is achieved especially by its oil drained housing called “dry case”. This innovative solution significantly eliminates splash losses. The housing is constantly drained by an active suction which removes the oil coming from internal leakages. Linde Hydraulics managed to offer this possibility to the market without limiting the service lifetime in any way.

In combination with the latest closed loop pump design from Linde Hydraulics (CPV) this new compact hydrostatic transmission combines reduced fuel consumption and high tractive force at high-speed operation. Moreover, the replacement of a traditional gear box improves the efficiency at low-speed operation and creates a better driving comfort without gearshift disruptions.





**Damien Marsal**  
**Technical Director, Poclair**  
**France**

**“Our society and civilization are currently facing a significant challenge posed by climate change, and the need for reducing CO<sub>2</sub> emissions is pressing. Every company must play its part, and Poclair is committed to supporting its customers in this task.”**

The key to meeting this challenge lies in the availability and use of energy. As we face potential energy scarcity, the efficient use of energy at every stage of a machine’s lifecycle will be critical. Poclair’s strategy, which is focused on efficient transmission, is fully committed to this goal.

The journey begins with the correct sizing of the transmission. Poclair has developed a complete range of connected services to ensure optimal transmission design for our customers. Moving from a “power-based transmission sizing” to an “energy-based transmission sizing” ensures the best CO<sub>2</sub> emission levels during operation in the case of an ICE machine, or the best autonomy for electro-hydraulic or fully electric machines.

Efficient energy usage can also be found through component optimization. Poclair’s product range includes efficient hydraulic motors and pumps, and we will continue to innovate and develop new technological breakthroughs in the coming years to support the need for greater efficiency. With ongoing electrification, there is an increased focus on this efficiency requirement, and we are also developing a range of efficient electric components, leveraging the expertise of our recently acquired power inverter company, EMSISO. Energy efficiency can also be achieved at the end of a product’s life, thanks to our new remanufacturing program. Our components can be monitored in real-time to anticipate maintenance needs and evaluate remaining useful life. This enables final customers to operate smoothly by upgrading critical components when necessary and continuing critical operations with remanufactured motors that are equivalent to brand new ones.

With our holistic approach, Poclair is dedicated to contributing to a more energy-optimized industry that supports the challenge of reducing CO<sub>2</sub> emissions that we all must face.





**Sergio Assi**  
**Strategic Marketing Manager, Stucchi**  
**Italy**

**“The environmental challenge:  
 quick couplings to prevent leakage.”**

Research and development in the quick coupling industry is advancing beyond functionality and focusing on manufacturing leak-free quick couplers which also minimize impact to the environment.

The flat face coupling system includes a flat face valve, spring mechanism, safety closing system and specific seals in order to minimize, if not completely eliminate, fluid leakage during disconnection. Eliminating the intermediate space between the male and female couplers prevents fluid from gathering in the coupler and leaking into the environment.

Industrial benefits of leak free flat face couplings include:

- Minimize fluid leakages and clean-up efforts – save time and money by not containing and properly disposing of hydraulic fluid
- Increased equipment uptime – prevent unplanned machinery downtime and forced stops due to leaks and insufficient pressure
- Do not contaminate the ground you work on – agricultural processes must preserve the soil and water
- Eliminate external contamination of quick couplers – preventing damage caused by accumulation of pollutants and contaminants
- Improve safety – leak free quick couplers protect workers and machinery operators by preventing injuries and illnesses caused by exposure to contaminants

Leak free flat face couplers are proven to provide these benefits to production performance as well as contribute to environmentally sustainable practices. This is a cause that Stucchi strongly believes in and supports with innovative, efficient hydraulic quick coupling solutions. We are committed to research and development, providing new ideas and first to market products which provide important advantages to our customers.





**Andrea Zorzi**  
**Product Engineering Manager,**  
**UFI Filters Hydraulics**  
**Italy**

**“Even the smallest element of the hydraulic system can significantly improve the equipment efficiency and extend the components life thanks to constant research and the use of innovative media and formulas, specifically engineered for each application and environment requirements.”**

In response to the increasingly demanding market about higher and reliable over time performance, hydraulic filtration experts are asked to identify the best compromise between the interacting key factors pressure drop, filtration efficiency and dirt hold capacity.

To achieve the goal, it is necessary to focus on the research of enhanced filter media and on the study of the best media combination.

UFI Filters Hydraulics, thanks to its 30 years of expertise in filtration solutions, to the synergies with the UFI Innovation Centres and to UFI Group experience in filter media production, released FormulaUFI, 6 different material formulas, engineered to satisfy the most challenging filtration and environment requirements.

The FormulaUFI range covers every kind of media and brings several advantages, including higher filter efficiency, better combination of the filter materials and energetic process optimisation due to lower pressure drop, higher differential pressure stability and enhanced dirt holding capacity over the whole lifetime of the element.



Furthermore, the use of innovative materials specifically designed for each individual application generates extended component life and service intervals, thus reducing labor, material and disposal costs.





**Alexandre Badev**  
**Technical Manager, ARTEMA**  
**France**

### Energy efficient solutions in pneumatic systems

Energy efficiency in pneumatic systems can be assessed by regulating the compressed air flow upstream to each machine, during the production and non production (standby mode) stages.

Indeed, the machines during the non-production phases remain supplied with compressed air at full pressure in order to keep the actuators in « production position ». This case generates losses in terms of compressed air consumption due to internal leakage - likely to be controlled on new machines, but losses are more significant using older machines.

The proposed technical solution by ARTEMA, the Association of French Mechatronics Industries, consists of lowering the pressure automatically during the non-production phase in order to decrease the leakages of a selected machine, part of the pneumatic network. The service pressure is automatically restored as soon as the production stage restarts.

With the collaboration of the ATEE club, which is the Technical Organization for Energy and Environment, and through the establishment of standardized energy saving operation sheets, ARTEMA will contribute to spreading the above described solution among the industries concerned, by creation and delivery (by the Government) of custom fixed value energy saving certificates (CEE).





**Ignacio Paniego Ramón**  
**Product Manager Vacuum Automation,**  
**AR Vacuum Technology**  
**Spain**

**“A pneumatic vacuum generator can be a low consumption device. Efficiency-based design and intelligent control are the key to energy efficiency. Examples: TRIMAX and FAB vacuum generators.”**

The growing demand for suction cup grippers in industrial and collaborative robotics poses new challenges for pneumatic vacuum generators.

With energy saving as its main value, AR Vacuum Technology has launched the TRIMAX and FAB vacuum generators. The compressed air consumption of a vacuum generator is dependent on the suction power of the generator, the design of the internal nozzles, and the running time of the generator in each cycle. TRIMAX and FAB generators use multistage technology that results in an aspirated flow rate up to four times greater than that of an equivalent single-stage generator without increasing the consumption of compressed air. The Energy Saving system is available as standard on all TRIMAX-PROX and FAB generators, allowing the automatic management of the vacuum generator, so it is activated only when necessary. This system is applicable in handling parts without leakage or with a very low leakage.

The Energy Saving system consists of the automatic management of the vacuum generator with the help of the built-in vacuum sensor so that the user programs the vacuum value sufficient to handle the load, including the necessary safety factors. The energy savings from this system can be enormous, with a robotic process for folding 1 mm steel plates, where the vacuum generation is active for only 9.2% of the time with a total consumption per cycle of 5.9 liters, compared to the 65 liters per cycle without the Energy Saving system.





**Andrea Camisani**  
**Chief Technical Officer, Camozzi**  
**Italy**

**“Pneumatics and mechatronics: a marriage that Camozzi develops through interconnected intelligence.”**

In recent years, Camozzi implemented a multi-technological strategy and created a synergy between several technologies.

Pneumatics was the starting point, and in the past years electro-mechanical and proportional technologies were used to expand the concept.

In recent time, mechatronics and digitalization have enabled new features for „traditional“ pneumatic components, particularly sustainability and efficiency.

Camozzi has created a new division to focus on these developments, combining Camozzi Digital and the Mechatronic Application Research Center to form the Camozzi Digital & Mechatronics Society.

By incorporating electronics into components, it is possible to measure parameters directly from the inside, process the data at the edge, and obtain refined data. New machine learning techniques, combined with domain knowledge and multi-physics models, enable the use of low power consumption microcontrollers to monitor components and collect data useful to machines in order to save energy and air.

The new BPA Series pressure multiplier from Camozzi optimises the pneumatic air distribution network while lowering investments and expenses. It adjusts the outlet pressure according to needs, increasing it only when necessary.





**Miguel Calvo**  
Sales Manager Iberia, Emerson  
Spain

**“Energy efficiency and conservation are critical issues in today’s world, as the demand for energy continues to increase.”**

To address this challenge, organizations and individuals are turning to innovative technologies and practices to reduce their energy consumption and carbon footprint. One such area is the use of Internet of Things (IoT) and artificial intelligence (AI) technologies to improve energy efficiency and save energy.

IoT refers to a network of devices connected to the internet that can collect and exchange data. In the context of energy efficiency, IoT-enabled devices can be used to monitor energy consumption in real-time, identify patterns and anomalies, and automate energy-saving actions. For example, in Emerson the Flow Sensor AF2 is used for reducing the waste energy by pressure air and the energy usage based on occupancy and usage patterns.

A typical manufacturing plant loses about 35% of the compressed air it produces to leaks each year. While leaks waste energy, they can also affect machine performance, further increasing energy use, reducing equipment service life and increasing maintenance and downtime. Most manufacturers only check for leaks periodically. The AVENTICS™ Series AF2 Flow Sensor from Emerson continually monitors compressed air in pneumatic systems in real time, helping operators detect and address early-stage leaks and optimize energy use.

Many manufacturers are using the AF2 to meet their sustainability goals through energy consumption monitoring. The AF2 is a plug-and-play solution that easily retrofits on existing equipment and continually measures eight parameters in real time. When it detects a leak, it sends an alert to appropriate personnel. By using the AF2, operators can quickly diagnose and address issues, significantly reducing energy use and improving OEE.



*The AVENTICS Series AF2 Flow Sensor is a proven, plug-and-play solution that helps manufacturers meet their sustainability goals by detecting early-stage compressed air leaks.*





**Christian Österle**  
**Vice President Corporate Communication**  
**and Sustainability, Festo**  
**Germany**

**“In addition to the energy consumption of our components during operation, the Product-Carbon-Footprint from “cradle-to-gate” is a key control variable for the sustainable use of automation components. Festo is working very hard to provide our customers with this Product-Carbon-Footprint (PCF) for all our components, also as part of the digital product passport.”**

What information do our customers need so that they can make an economically and environmentally advantageous decision when selecting automation components? This is an important question for Festo if we want to position ourselves as a sustainable partner for our customers.

The answer is that they need to have transparency on the CO<sub>2</sub> emissions produced when the component was manufactured as well as on the CO<sub>2</sub> emissions produced during operation. Relevant information, including the CO<sub>2</sub> emissions produced during operation, is already provided, for example via our pneumatic sizing tool. In addition, customers need to know the Product-Carbon-Footprint from “cradle-to-gate” (PCF). This is what we are currently focusing on.

We are in the process of determining this PCF for all Festo components in accordance with the Greenhouse Gas Protocol (GHG) and the VDMA guideline „Calculation of the product carbon footprint in mechanical and plant engineering“. In doing so, our approach to determine the PCF is similar to that for our manufacturing costs. We use available information, such as material, mass or production steps and times, and convert these into a PCF using a „CO<sub>2</sub> currency“.

At the moment, we can determine the PCF for individual components on customer request. The roll-out to the entire Festo product catalog is in the planning.





**Corrado Tamiozzo**  
**Chief Engineer, Metal Work**  
**Italy**

**“Pneumatics: synergistic actions to reduce consumption.”**

## **METAL WORK – GREEN DEAL**

Compressed air is used in today’s most industrial applications. It is estimated that, on average, the energy required for the generation of compressed air accounts for around 20% of total industrial consumption. Of this amount, approximately one third could be saved through three types of synergy actions:

- use of suitable products
- component sizing
- measurement of consumption and losses, followed by corrective action.

The choice of quality products, designed to optimise flow and reduce friction, is the first step towards guaranteeing a significant reduction in consumption. Reducing mechanical friction in the products ensures better efficiency and, therefore, better actuator performance for the same amount of energy consumed. Similarly, improving the conditions under which the pneumatic fluid passes through the component parts and hoses by means of CFD analysis reduces pressure drops, leading to better system performance.

In addition, correct component sizing means that energy is not wasted with unnecessary product markups. In order to assist designers in the sizing of component parts, some FEDERTEC companies have developed specific software to help them select each product correctly.

Finally, given that the pneumatic energy is directly proportional to the two main parameters at play, i.e., pressure and flow rate, the use of digital measuring devices, such as pressure switches and flow meters, to be placed at critical points of the system, allows constant and precise monitoring of the consumption trend. This makes it possible to intervene in order to improve the situation, by either adapting existing component parts or intervening in a planned manner.





**Ralf Laber**  
**General Manager, SMC**  
**Germany**

**“Efficient and sustainable use of energy is only successful with a holistic approach - this also applies to tailored solutions.”**

### **Five pillars and one goal: optimal energy efficiency**

Energy is indispensable, but expensive - not only in monetary terms, but also in view of climate change. To enable manufacturing companies to take appropriate measures for a sustainable energy management, we at SMC have developed a holistic concept consisting of five pillars.

First, generation on demand. For example, we are developing components to establish a standard operating pressure of 4 bar.

Second, energy recovery. Among other aspects, our intelligent cylinders save up to 48% energy by triggering the return stroke directly by the exhaust air during each cycle.

Third, by monitoring. We have developed a new air management system that not only comprehensively monitors pressure, temperature, and flow. It also enables condition-based monitoring and predictive maintenance so that, for example, leaks do not go undetected and become „energy guzzlers“. All in all, this leads to a reduction of up to 62% in comparison to the previous compressed air consumption.

The fourth pillar are thoroughly reflected decisions. They are characterized, for example, by the combination of performance and energy efficiency through the selection of a precisely tailored solution for an application.

The fifth and final pillar is efficient thinking. This means looking at the big picture instead of individual measures.





**Prof. Dr.-Ing. Marcus Geimer**  
**Karlsruhe Institute of Technology**  
**Germany**

**“Energy efficient hydraulic systems support local CO<sub>2</sub>-neutral machines.”**

Local CO<sub>2</sub>-neutral machines require battery-electric solutions with highly efficient drives. Unlike liquid fuels, the energy density of batteries is relatively low, so efficient drives can either increase the time to recharge the battery or reduce the size of the battery for a defined task.

A combination of a variable-speed electric motor with a hydraulic constant pump can be used to build an electric-hydraulic flow sharing system with a flow rate adjusted to the demand of the actuators. The losses in this system are significantly lower than those of traditional load-sensing systems as the load-sensing pressure difference can be significantly reduced. At the same time, the response time of the actuators is noticeably reduced, allowing the operator to work very efficiently with the system.

Surveys with machine operators using an internal combustion engine-driven machine with a flow sharing hydraulic system have confirmed the improved operator behaviour. This example shows that hydraulic systems can also lead to a competitive solution in electric mobile working machines.





**Prof. Dr.-Ing. Katharina Schmitz**  
**RWTH Aachen**  
**Germany**

**“Fluid power is a key technology for a sustainable future industry. It is on us, to coordinate our efforts and exploit emerging potentials.”**

### **Carbon Footprint and digital technologies**

Fluid power is an important drive technology which is found in various technical applications. Accordingly, fluid power systems provide a significant lever in reducing energy consumption, and hence greenhouse gas emissions, across several industrial branches. A way of measuring the overall contribution of products to climate change is the calculation of the Carbon Footprint. As our recent studies indicate, the usage phase of fluid power products typically yields a major part of carbon emissions during a product's lifetime. Therefore, the use of energy-efficient components and the implementation of optimized system topologies remain crucial measures to secure a greener future.

Furthermore, the use of digital technologies can help us to achieve the least impact on our environment and promote sustainability. Condition monitoring, in particular, allows operators to permanently track a system's performance. As a result, it helps optimizing energy usage and minimizing waste and thereby reducing carbon emissions. Moreover, by predicting and preventing failures, it can also extend the lifespan of components and reduce the need for frequent replacements, leading to a reduction in the Carbon footprint of the manufacturing and transportation of these components.





**Prof. Dr.-Ing. Tatiana Minav**  
**Tampere University**  
**Finland**

**“Future Off-road machinery must be intelligent and energy-efficient.”**

In order to achieve the Paris objectives to limit global warming to 1.5 degrees Celsius, strict and all-encompassing legislation on reduction of greenhouse gas emissions are required for all economic sectors. However, this legislation is only enforced in a limited number of countries worldwide and often fails to set out concrete and feasible targets and pathways for all economic sectors. One of the sectors that is impacted by this legislation, but not on track to achieve the EU’s climate objectives, concern heavy-duty vehicles. Currently, this sector contributes to 6% of total EU GHG emissions.

That is why new and more ambitious solutions are required and must come from companies and universities. Innovative Hydraulics and Automation (IHA) laboratory in Tampere University concentrates on novel solutions combining fluid power and electrical systems for powertrain and implement systems, where automation brings boost in functional safety, reliability, controllability and energy efficiency. Due to the variety of heavy-duty machinery and their low production volume the research strategy of IHA is made up with the ambition to develop new fluid power automation technology from system level and application specific perspective, which minimizes the environmental impact in all aspects. Future Off-road machinery must be intelligent and energy-efficient.





**Prof. Dr.-Ing. Jürgen Weber**  
**Technische Universität Dresden**  
**Germany**

**“Fluid-mechatronic drive technology is developing into a sustainable and operator-friendly powertrain technology through increased efficiency and connectivity.”**

## Components and systems of tomorrow with the mechatronic approach

Decades of research have made hydraulic and pneumatic drive technology one of THE solutions for machine manufacturers worldwide. In the meantime, technological and physical limits have already been reached. However, in extending the system limits with the mechatronic approach, further potentials can be exploited.

Cross-domain knowledge and simulations, as well as the use of alternative materials, are extending the operating range limits of axial piston pumps [1]. Compact electrohydraulic linear drives allow easy machine integration with high user-friendliness and durability [2, 3]. In pneumatic drive technology, an enormous savings potential of up to 80% of the current energy consumption has been demonstrated, for the exploitation of which various design and monitoring strategies have meanwhile been developed [4]. In particular, by connecting drive technology across machine boundaries and over the entire product life cycle, further benefit can be generated through the automated flow of data. A means of doing this is the concept of the asset administration shell, which is explained for the fluid power sector on the fluidtechnik40.de website.



[1] Horn, Svenja; Ivantysyn, Roman; Weber, Jürgen: Validated efficiency improvements by implementation of structures on the slipper surface of an axial piston pump. In: IEEE GFPS 2022. Naples, 2022

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[3] Michel, Sebastian: Elektrisch-hydrostatische Kompaktantriebe mit Differenzialzylinder für die industrielle Anwendung, Dissertation, TU Dresden, 2021. <https://nbn-resolving.org/urn:nbn:de:bsz:14-qucosa2-762716>

[4] V. Boyko, et al., 'Anwenderorientierter Einsatz von energieeffizienter Antriebstechnik in der Produktion' (EnAP), final report No. 03ET1385A-E, 2021.





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## IMPRINT

Editor: CETOP, Frankfurt/Main, GERMANY, April 2023

Design: Bureau for visual Communication

Dipl.-Des. Rainer E. Rühl, Alsheim, GERMANY

Photo credits:

Cover picture: Matthias Ibeler, RWE, Germany

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