51 · 11/2026

tec news

HARTING'S Technology Magazine



OFF? NO WAY!

THE ELECTRIC FUTURE IS ALWAYS ON …

Availability is becoming the currency of the electric future: What does this mean for systems, storage and control?

SMART ALWAYS ON? NOT AT ALL COSTS

Dr. Hans Krattenmacher, SEW-EURODRIVE

"NO TRANSITION WITHOUT TRANSMISSION"

Pascal Daleiden, Hitachi Energy

"WE SAVE MONEY BY GOING ELECTRIC"

Dr. Tim Meyer, E3Punkt



editorial

ELECTRIFICATION –
AND NOW WHAT'S NEXT?

Dear readers,

Electrification has long been a reality: in industry, mobility and transportation, energy and infrastructure. So the crucial question is **no longer why, but how** we should take electrification forward and what implications this will have, both technically and structurally.

Electrical systems are always available in our day and age. **"Switch off, power down" is a thing of the past.** Modern assets must remain accessible throughout their entire lifecycle – for monitoring, updates and optimisation. Their digital representation is the foundation for this, namely the digital twin. Without electricity, there are no digital twins.

Electricity must be **generated, distributed, stored and managed intelligently** – across all sectors and in a reliable manner – and within and throughout heterogeneous system landscapes. A wide variety of assets, their digital representations and the overarching IT infrastructures are communicating constantly. **The resulting heterogeneity represents the actual challenge.**

Electrification almost never takes place on greenfield sites. Far more, it is a brownfield issue that has been developing and evolving for 100 years – building on existing networks, facilities, systems and infrastructure. **Automation and digitalisation, combined with artificial intelligence, is what makes this complexity manageable.**

Electrical systems extending across all sectors are the focus of this issue. Energy requirements, charging and supply models, connectivity, and the question of how electrification works across different sectors. From industrial facilities and plants all the way through to the robotics of tomorrow.

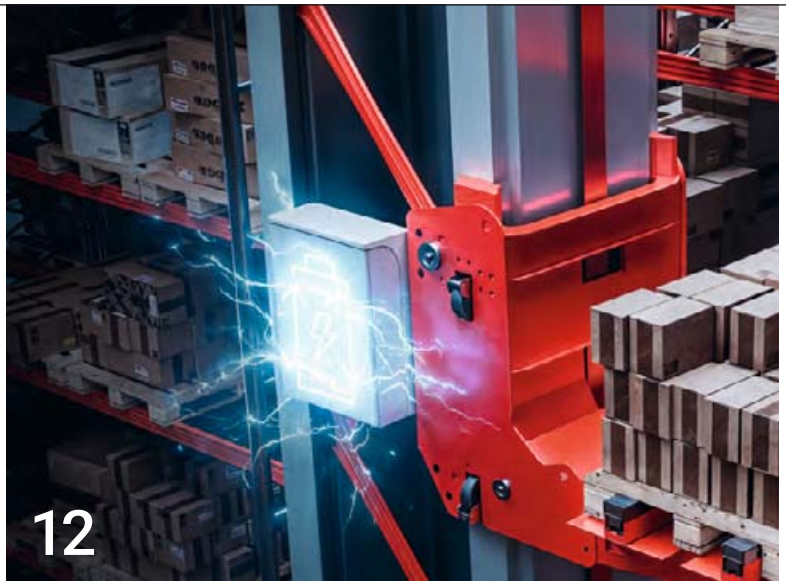
Here's wishing you enjoyable reading,



Christian Gysin
Chief Technology Officer,
HARTING Technology Group

tec news
The technology magazine from
HARTING
Pushing Performance
Since 1945





Taking electrification a step further:
Embedding intelligence in the flow of energy

Does smart mean always on? Not at all costs
Interview with Dr. Hans Krattenmacher, Managing Director Corporate Innovation Mechatronics at SEW-EURODRIVE

Issue 51 I Cover story:

OFF? NO WAY!
THE ELECTRIC FUTURE IS ALWAYS ON …

future technologies

SUPERCHARGING THE FUTURE 6
Global electrification in figures

Does smart mean always on? Not at all costs 12
Interview with Dr. Hans Krattenmacher, Managing Director Corporate Innovation Mechatronics at SEW-EURODRIVE

Bidirectional energy 20
Generate and store electricity with Reverion's reversible fuel cell

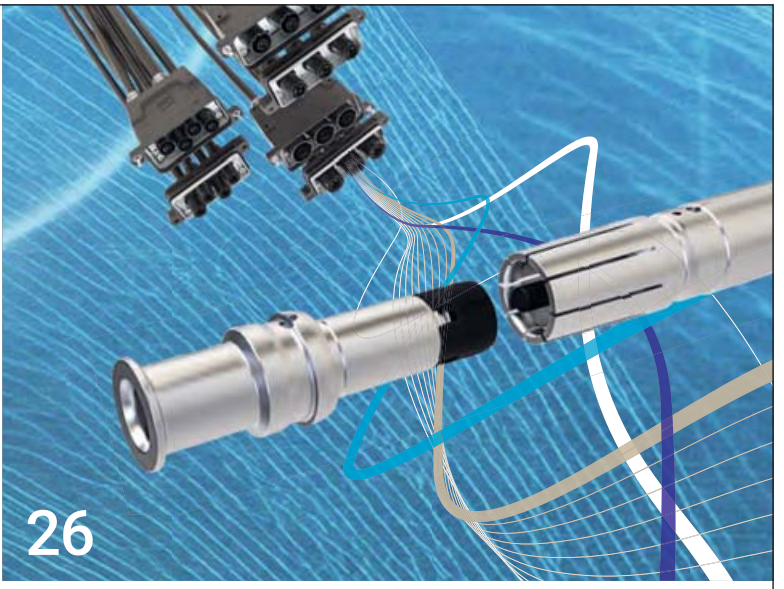
"No transition without transmission" 22
Pascal Daleiden, CEO of Hitachi Energy for Germany, Austria, Slovenia and Switzerland, in an interview

Digital twin: The foundation for seamless end-to-end value creation 28
Enabler for automated engineering and data-driven AI processes

From electrical drives to smart energy systems 32
Battery trains and digitalisation are transforming rail transport. How Stadler is rethinking electrification.







"No transition without transmission"

Pascal Daleiden, CEO of Hitachi Energy for Germany, Austria, Slovenia and Switzerland, in an interview

Double Contact Technology boosts high-current connector performance

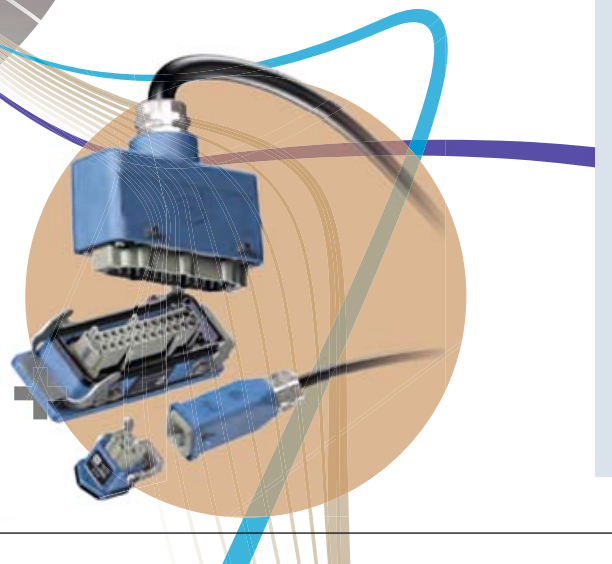
Electrification is continuously driving power requirements in industry and mobility forward

A worthwhile connection: the tec.news world on the web

Delve deeper into topics with articles, multimedia content and lots of inspiration: visit us online too.

HARTING.com/ tecnews





strategy

Taking electrification a step further: 8

Embedding intelligence in the flow of energy

More than just technology 16

Electrification in the context of interconnected energy systems

future trends

Electrification becomes a system task 18

How energy generation, digitalisation and system integration are converging

"We're saving money through electrification" 34

Dr. Tim Meyer in an interview

Bringing intelligence down to the field level 36

Why electric mobility only reaches its full potential through data, communication and flexibility

customer benefits

Double Contact Technology boosts high-current connector performance 26

Electrification is continuously driving up performance requirements in industry and mobility

Packing more power in the same space 30

The new Han® Size 4 meets the growing connector demand of electrification

Configurators: for every application the right connector 38

HARTING's digital tools lead quickly and reliably to the right solution

Han-Modular® 400A Module 39

High current and data transfer in one interface

SUPERCHARGING THE FUTURE: GLOBAL ELECTRIFI-CATION IN FIGURES

Electrification has reached a historic turning point. While global demand for electricity, driven by AI, e-mobility and growing emerging economies, is rising rapidly, renewable energy sources are already overtaking fossil fuel-based electricity generation involving coal.

But green energy alone will not suffice: In order to integrate the increase in energy from wind and solar safely into the grids, storage capacities must be massively expanded.

We highlight key facts about global electrification, broken down into three dimensions: Generation, storage and consumption.

Sources and data:
International Energy Agency (IEA), weforum.org

PRODUCE

A historic turning point in the electricity mix: The tremendous growth in renewables is overtaking fossil fuels and is systematically pushing back global coal-fired power generation for the first time in years.

10,808 TWh **10,858 TWh**

Renewables are catching up: In 2025, global electricity generation from renewable energy sources was, for the first time, virtually on a par with the output from coal-fired power stations.

+29%

Solar power is breaking all the records: Photovoltaics recorded the largest increase ever recorded in electricity generation in 2025, with a rise of 600 TWh (55 per cent of which was in China alone).

-0,5%

Coal is on the decline: Global coal-fired power generation was down by 0.5 per cent in 2025. For the first time in 50 years, the leading coal-producing nations, China and India, are both recording declines.

30%

Europe as a pioneer: In the EU, solarand wind power accounted for 30 per cent of the total in 2025, thereby exceeding the share of fossil fuels for the first time.

STORAGE

Batteries are the bottleneck in the energy supply: Unless global storage capacity increases sixfold by 2030, the boom in renewables cannot be integrated into the grids.

6 × 1.500 Gigawatt

3 ×

A massive need for expansion: In order to meet the Paris climate target (1.5 °C) and triple the share of renewable energy, global energy storage capacity must be ramped up sixfold to 1,500 gigawatts (GW) by 2030.

> 90 % Battery capacities = approx. 750 GWh 2023

Electric cars as mobile buffer storage: Over 90 per cent of the battery capacity produced globally in 2023 was for vehicles (approx. 750 GWh). By 2030, it could be sufficient to use just 5 per cent of the world's electric car batteries for smart charging and discharging (Vehicle-to-Grid) in order to provide 600 GW of flexible capacity.

Technical pace: From a purely structural point of view, battery storage facilities can be built at almost any location in just a few months. However, in order to bring this tremendous pace to the roads, approval processes and grid connections would need to be speeded up.

CONSUMPTION

The world has entered the age of electricity: Demand for electricity is growing more than twice as fast as overall energy demand. Driven by e-mobility, AI and the huge demand from emerging markets.

+38 %

+17 %

USA: 50 %

Data centres as growth drivers: Electric cars (+38 per cent) and data centres (+17 per cent) are experiencing the most rapid growth. In the USA, the AI/data centre sector is already responsible for 50 per cent of the total growth in electricity demand.

-20 % CO_2 1.000 TWh 2 ×

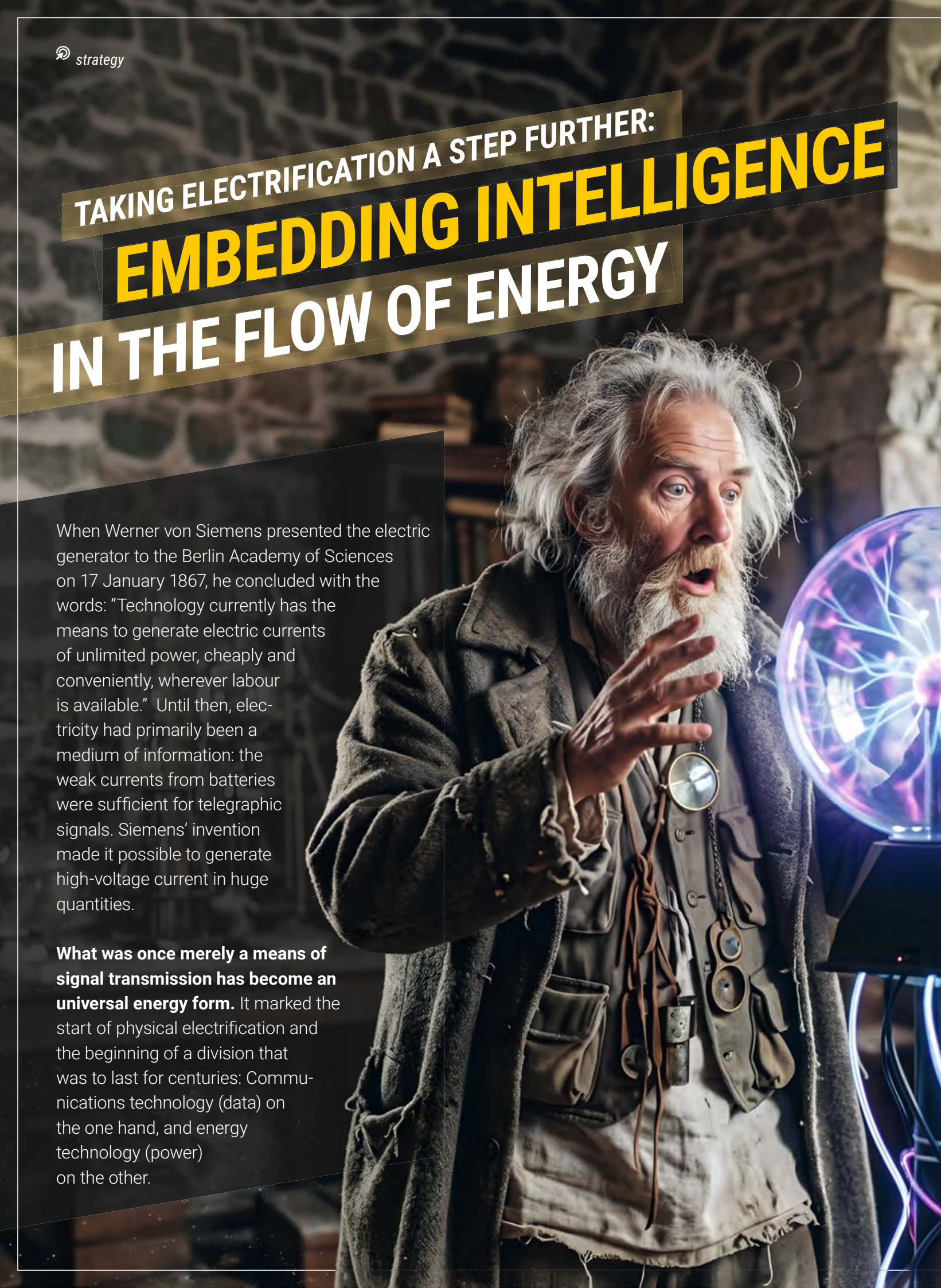
The AI paradox: While artificial intelligence helps to reduce emissions by up to 20 per cent, it is a major devourer of energy itself. By 2026, electricity consumption by data centres and cryptocurrencies could double to over 1,000 TWh.

Emerging and developing countries +70 %

India USA China

Demand shifting eastwards: By the year 2050, 70 per cent of the additional electricity demand will arise in emerging and developing countries. By then, India alone will rise to become the world's third-largest electricity consumer.

TAKING ELECTRIFICATION A STEP FURTHER: EMBEDDING INTELLIGENCE IN THE FLOW OF ENERGY



When Werner von Siemens presented the electric generator to the Berlin Academy of Sciences on 17 January 1867, he concluded with the words: "Technology currently has the means to generate electric currents of unlimited power, cheaply and conveniently, wherever labour is available." Until then, electricity had primarily been a medium of information: the weak currents from batteries were sufficient for telegraphic signals. Siemens' invention made it possible to generate high-voltage current in huge quantities.

What was once merely a means of signal transmission has become an universal energy form. It marked the start of physical electrification and the beginning of a division that was to last for centuries: Communications technology (data) on the one hand, and energy technology (power) on the other.

*Werner von Siemens: On the conversion of mechanical energy into electrical energy without the use of permanent magnets. 1867. p. 58.

Available online at:

Today, more than 150 years later, electrification is taken for granted, as a matter of course; electrical energy is ubiquitous, and its generation and consumption must be kept in balance. This is precisely where the next challenge arises, because the world of electricity – where one entity generates power and many consume energy – has long since come to an end.

How do we manage this gigantic, decentralised force? When millions of machines and energy networks are constantly interating, the physical supply alone is no longer sufficient. The flow of energy must become intelligent. This is where the historical division ends: Communication technology and energy technology are converging. Power and data are becoming indivisible.

Systems rather than sectors: Energy needs connection

This ongoing convergence of energy and data forms the foundation of the All-Electric Society. And that is by no means just a futuristic dream anymore: Whether in the electrified rail sector, in mechanical engineering or on ships fitted with container-sized battery storage systems – the transformation is well under way.

Electrification, however, does not realise its full potential as an isolated factor, but rather as part of a "triangle of impact" alongside digitalisation and automation. Only in this way can fluctuating renewable feed-in be actively balanced by controllable consumers and storage systems. Viewed in this context, sector coupling is less of a technical hurdle than a mental barrier. From a digital perspective, these sectors have long been interconnected; what actually separates them are entrenched ways of thinking. Consequently, genuine sector coupling begins with breaking down these mental silos. In straight forward practical terms, the aim is to integrate individual machines from different sectors. This is how new value is created. Take, for example, a scenario when consumer drones are used in conjunction with energy infrastructure control systems for precision fertilisation in agriculture – which is the result of such integration.

elec-trickery: When electricity starts thinking

Within this triangle, artificial intelligence equips the systems with a new capability. Automation has made processes manageable, digitalisation has made them visible. **And now, AI is making them truly manageable for the first time.**

Catweazle, the wizard from the 1970s cult series, reverently referred to electricity as "elec-trickery", and the trick wasn't the electric light itself but the switching on of the electric light – that was the trick.

In the age of AI, the word takes on a new meaning: Electricity is flowing, but in future it will be AI that helps ensure it is available in the right place and at the right time. While a smart electricity meter knows the price, only a machine-learning system can independently decide when it is cheaper to charge the home battery or to let the electric car feed electricity back into the grid.

››



From a digital perspective, these sectors have long been interconnected; what actually separates them are entrenched ways of thinking.

Energy and data are increasingly complementing each other to form a holistic physical infrastructure.

Brownfield: The reality of the evolved world

The world is always a brownfield; a greenfield is a chimera, because everything takes time, and in every development process, a greenfield inevitably becomes a brownfield. This diversity is also the result of an infrastructure that has developed over more than 100 years. **Electrification is always carried out on brownfield sites,** ensuring that new technologies can be successfully integrated without jeopardising ongoing operations.

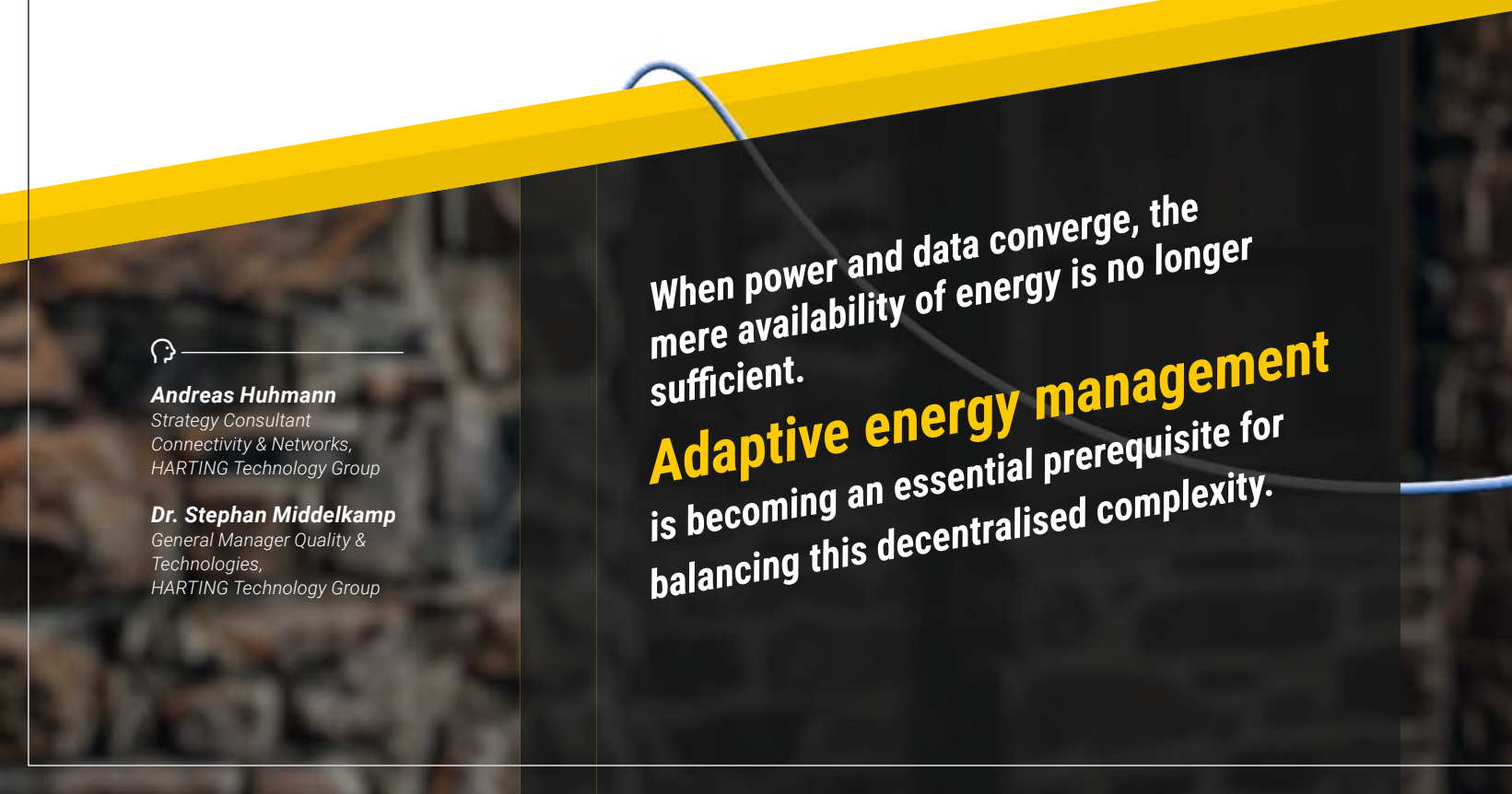
Here the digital twin is proving to be a crucial tool. Through digitalisation, it enables the physical asset to be automated by way of its digital replica. While AI is increasingly translating between different communication protocols, the connectivity itself must be firmly in place.

At the data level, additional structuring is called for: As Andreas Wedel demonstrates in this issue, the digital twin is becoming the central data anchor throughout an asset's entire life cycle. So here addressing the "triad" of the All-Electric Society, namely electrification, digitalisation and automation.

At the same time, the focus is shifting to a system's life cycle. In future, electrical systems must feature modular design, be repairable and expandable. The digital twin makes it possible to replace individual faulty components in a targeted manner, rather than replacing entire systems. **Modularity opens up opportunities.** As Prof. Dr.-Ing. Eva Schwenzfeier-Hellkamp demonstrates, the circular economy is also becoming increasingly imperative in this context. This trend is also reflected in the energy supply: Centralised generation is giving way to local microgrids. Businesses are becoming producers, consumers and storage providers. **In order to ensure the stability of these local systems, highly flexible storage solutions are required:** As Reverion explains in this issue of our magazine, reversible energy systems can convert electricity into gas, thereby helping to bridge local periods of low wind and low sunlight.

Two currents, one cable: Connectivity as a cross-functional role

Whether in a local microgrid or when exchanging data for the digital twin: **As electrification and digitalisation are merging and meshing, energy and data are increasingly complementing one another to form a holistic physical infrastructure.** What was once conceived as separate must grow together.



When power and data converge, the mere availability of energy is no longer sufficient.

Adaptive energy management is becoming an essential prerequisite for balancing this decentralised complexity.

Andreas Huhmann
Strategy Consultant Connectivity & Networks, HARTING Technology Group

Dr. Stephan Middelkamp
General Manager Quality & Technologies, HARTING Technology Group

In this way, connectivity is emerging as a cross-sectoral function. The very same connector that is fitted in a machine today may well end up in a data centre tomorrow – while remaining unchanged in its core function of reliable transmission. **That is why, today, connectivity must be conceived in both a smaller and a larger context at the same time. Smaller, more compact as an integrated, invisible function. Larger, as a critical infrastructure component that communicates and becomes part of the ecosystem.**

Connecting and disconnecting at the same time: In the apparent contradiction lies the strength of the connector, which is becoming increasingly essential as modularisation advances.

This marks the beginning of a fundamental change. While Werner von Siemens's aim in 1867 was simply to unleash and harness currents of "unlimited strength" in the first place, the task today is to channel these energies in a targeted manner. As power and data become increasingly interwoven, the mere availability of energy is no longer sufficient. **Adaptive energy management is becoming an essential prerequisite for balancing this decentralised complexity.** And what is more, modern electrical sytems must be considered over their entire life cycle. In the following pages, Prof. Dr.-Ing. Eva Schwenzfeier-Hellkamp explains exactly how these technological requirements give rise to a holistic, system-level task scope and challenge.

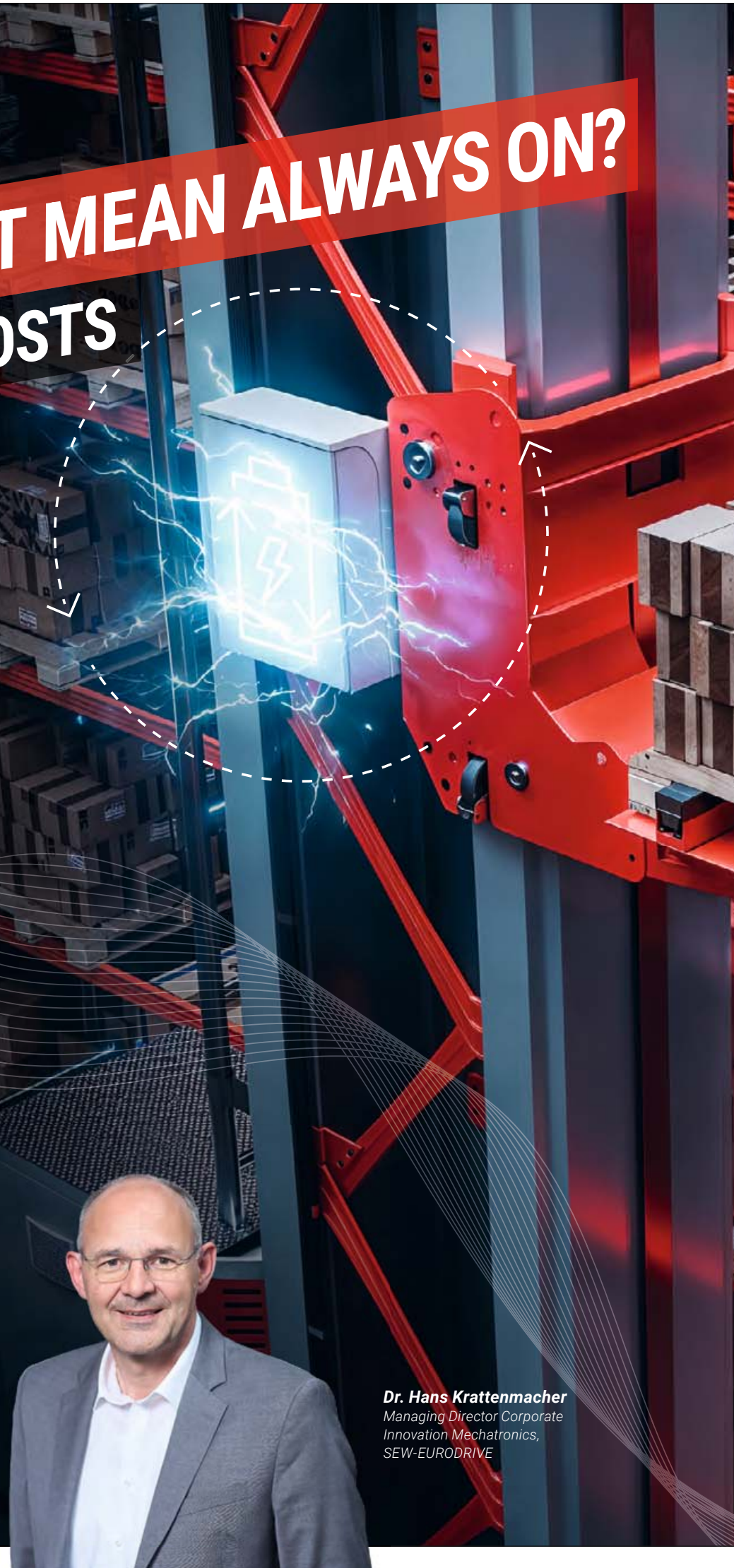
One thing, however, remains constant: the detachable connection.



DOES SMART MEAN ALWAYS ON? NOT AT ALL COSTS

Whether it's battery storage or local buffers: When large volumes of electrical energy need to be transmitted, stored and retrieved within the shortest possible time, absolutely reliable and compact connection technology is mission critically essential. As we have seen, the demands placed on such interfaces are trending upwards rapidly. Secure connections, however, are only the first step. When we look directly into the production halls, the crucial question is: How can machines with extreme peak loads be integrated into existing factories without exceeding the specified grid connection capacity?

Against this backdrop, we spoke to Dr. Hans Krattenmacher, Managing Director of Corporate Innovation Mechatronics at SEW-EURODRIVE, about the fascination of Maxwell's equations, the need for local energy storage within machines, and the question as to why an unreflected "Always On" approach in industry is decidedly not intelligent enough.



Dr. Hans Krattenmacher
Managing Director Corporate Innovation Mechatronics, SEW-EURODRIVE



tec.news: Dr. Krattenmacher, in the cult series Catweazle from the 1970s, a medieval magician regards electricity as magic and calls it "Elec-trickery". When we look at modern machines today: What role does this "magic" play in your professional life today?
Dr. Hans Krattenmacher: As an electrical engineer, this question is quite easy for me to answer: I studied electrical engineering out of genuine conviction. **To me, electrical energy is one of the most versatile forms of energy that exists. They can be converted into mechanical energy, used for communication, or incorporated into electronic circuits.** To many people, it may still seem like a form of black magic, but for me, its fascination lies in the elegance of Maxwell's equations. Although I've been working at SEW-EURODRIVE for 26 years now, I still remember a T-shirt from my student days very well. It read: "And God said …", alongside which were the Maxwell equations, and below them it read: "… and there was light." That sums up my view of electrical engineering very aptly.

Has your understanding of electrification changed significantly over the more than 25 years you have now been with SEW-EURODRIVE?
Perhaps less than one might expect. If, like me, you grew up with electrical engineering, the vision of an electrified world was already part of your university studies. It is more the perspective on implementation that has changed meanwhile: **In the past, electrification was a technical objective, while today, thanks to renewable energy, it is the key to genuine sustainability and independence. My fundamental conviction has therefore remained the same: As soon as we are able to generate and store electricity sustainably, it will be superior to any other form of energy thanks to its tremendous efficiency.** An internal combustion engine loses an incredible amount of energy before any mechanical power actually reaches the shaft, whereas electricity, on the other hand, can be converted with virtually no loss.

That is the physical aspect. But if we look beyond the narrow confines of energy supply alone: What does consistent and comprehensive electrification mean for our society?
Here, we are dealing with the issue of sovereignty. For me, comprehensive electrification means independence. If we generate renewable energy locally, we as a society will become independent of resources from geopolitically sensitive regions. We are electrifying transport, industry and shipping not only because it is cleaner, but also because the energy supply forms the foundation of our entire economic structure. **Controlling the energy supply means controlling a society's capability to act.** We certainly won't be able to replace everything with electricity, but we will be able to replace a great deal.

If we look at the second major megatrend: Is digitalisation even possible without concurrent electrification?
No, because digitalisation requires electrical energy. Just think of networks and data centres. When we factor in artificial intelligence, the connection becomes even clearer: The energy requirements of the major AI providers are massive; we are talking about figures on the scale of entire power stations. The benefits of digitalisation will only be realised in the long term if the necessary energy is also generated sustainably and we use it smartly and efficiently.

Controlling the energy supply means controlling a society's capability to act.

››



The All-Electric Society is often described in terms of the triad of electrification, digitalisation and automation. We've already talked about the first two, so how do you see automation, as the third building block, fitting into this picture?
Automation is ultimately powered by electricity. For us, as a manufacturer of gear motors, this is naturally a key consideration. To put it somewhat casually: This industrial form of electrification is our bread and butter, for electrical energy is the lifeblood of automation. I need this energy to control actuators, read sensor data and run digital services. Without electricity, automation is simply impossible. When designing a system, I need to know straight away how I can efficiently supply and control the energy required for the system. It is only through digitalisation that we can achieve the intelligence required for this kind of management. That is why, for me, these three concepts are not separate developments, but rather form an inseparable whole.

In industry today the "Always On" concept is often bandied about: Plants must no longer be shut down. What does this mean for you from a technical point of view?
In factory automation, we always have been "always on" so to speak, at the 24-volt level. But I take a far more differentiated view on this issue. I don't think it makes sense to leave everything switched on all the time as a matter of principle. My philosophy is: Only keep on what is actually necessary. So I leave switched on precisely what I need to be able to restart a machine or cell in a controlled manner within the desired time frame. If you consistently leave everything set to "always on", you'll often be surprised at just how high the standby losses are in a factory where production does not happen to be ongoing. Simply leaving everything switched on isn't clever enough. Instead, we should talk about a "Smart Always On".

How exactly is SEW-EURODRIVE addressing these rising demands for intelligent energy management in actual concrete terms?
We manufacture electric motors, gearboxes and frequency converters. Every day, we work on converting electrical energy into kinetic energy with the least losses possible. What makes it special today, however, is the system surrounding it. We first began looking into supercapacitors – known as "supercaps" – back in 2008. **Our guiding principle is: The application itself must be designed to be energy-efficient.** This resulted in the development of our "Power and Energy Solutions System". We store energy exactly where it is needed: right at the machine.

Simply leaving everything switched on is not intelligent enough. We should rather speak of a "Smart Always On."

Could you give us a specific practical example of this?
Imagine a high-bay warehouse. Many of our customers require extremely high acceleration performance in operating such applications. When a stacker crane starts up, it causes a massive load spike in the mains supply. Traditionally, the entire infrastructure – that is, cables, fuses and connections – was designed to cope with this brief moment of peak load. Our system buffers this: From the network's viewpoint, we behave almost like a constant ohmic load. In some applications, we are able to reduce the peak power drawn from the mains by a factor of 20, so instead of drawing 60 kilowatts from the grid, we now only need 3 kilowatts. We supply the remaining peak energy required for acceleration locally from our supercapacitor storage systems.



How do you recharge these local batteries?
This is where the circle of energy efficiency is closed. When the vertical axis of the storage and retrieval machine moves downwards or a drive applies the brakes, energy is released. We do not simply feed this braking energy back into the public grid, and from the viewpoint of grid stability, that would often not be helpful at all. Instead, we store it in the DC intermediate circuit in the supercapacitors and use it a few seconds later for the next acceleration manoeuvre.

What other benefits – perhaps not quite so obvious – does this system offer users?
Interestingly, a side effect has actually turned into one of our key selling points. As part of our energy management system, we have not only integrated the 400-volt drive level but also the 24-volt power supply for the control systems. If the power supply fails, the machine does not simply come to a sudden halt, and the brakes do not engage uncontrollably. Instead, we tap the energy from our local storage systems, continue to supply the 24-volt system and move the system in a controlled manner to a safe parking position. This prevents damage to machinery, which can easily run to tens of thousands of euros.

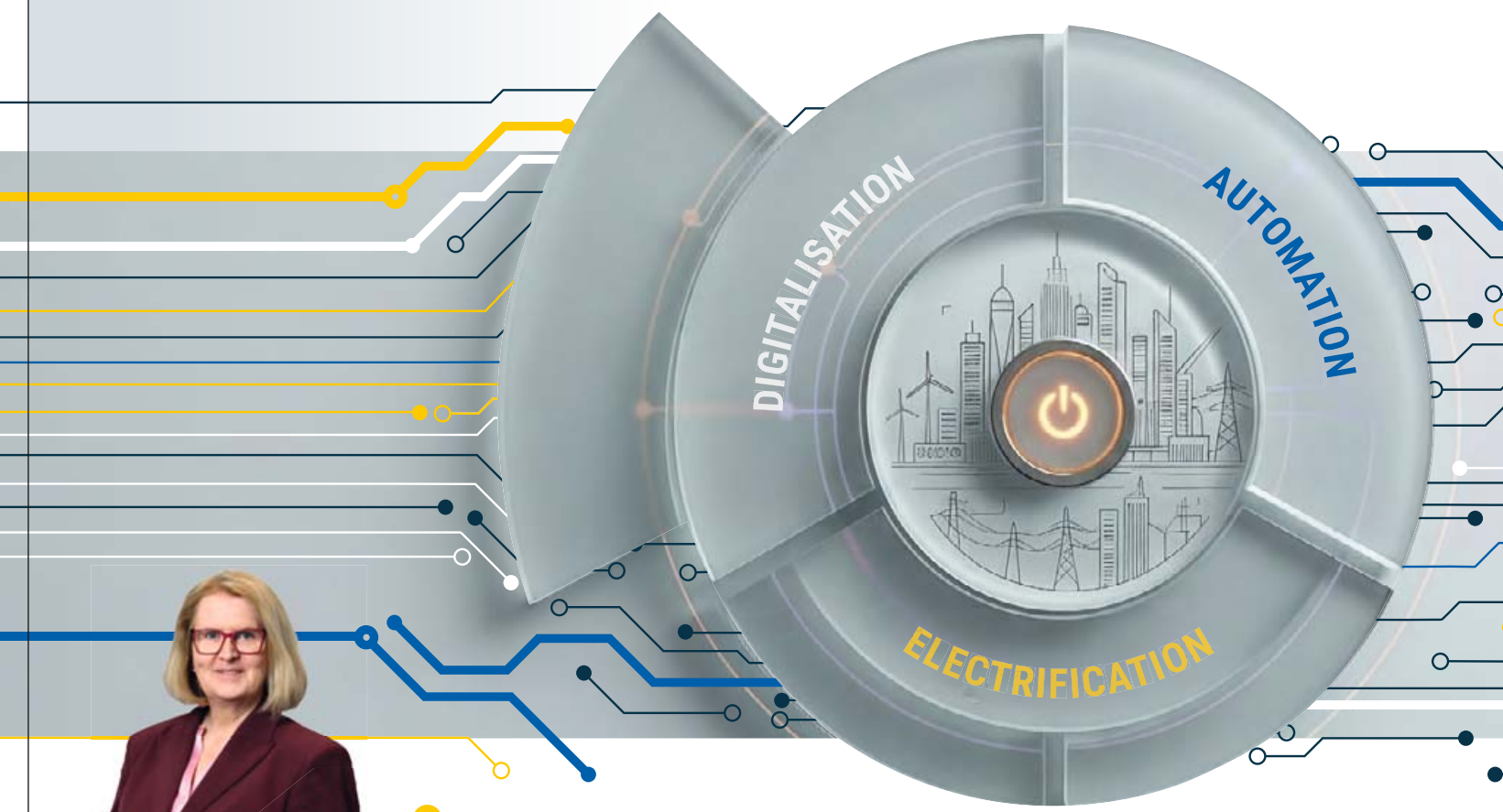
That also solves problems with retrofitting in existing halls – the classic "brownfield" sites – doesn't it?
Absolutely, given that electrification in industry almost never takes place on a greenfield site. In brownfield developments, the building's connected load is usually strictly defined. If you have a connected load of 300 kW, then you have 300 kW – even if you want to set up a new production line. **By reducing peak loads, we enable our customers to expand their facilities in the first place, without having to install new, expensive grid connections. Electrical energy can also be transmitted contact-free in the brownfield system.** With inductive charging systems, such as the ones we are offering for rail-guided systems or automated guided vehicles, wear-prone trailing cables are also eliminated from the factory.

In concluding, here's a question about the sector: Electrification and connectivity are closely linked when it comes to energy and data. What are the resulting demands and requirements in terms of interfaces and connectors?
The key requirement is standardisation. It is actually astonishing that, even today, we still do not have a standardised connector system in many parts of the world, but continue to need numerous adaptors instead. The EU's decision to mandate USB-C as the standard interface is a good example of the right approach. It's sustainable and simple. That is exactly where we need to be with industrial interfaces. This applies to physical connectors as well as to data interfaces, such as the Asset Administration Shell.

AI

If we are serious about the vision of the All-Electric Society and want to leverage agent-based systems and artificial intelligence, systems must be able to connect and understand each other automatically. There is then no way around open, standardised interfaces.

MORE THAN JUST TECHNOLOGY: ELECTRIFICATION IN THE CONTEXT OF INTERCONNECTED ENERGY SYSTEMS



Prof. Dr.-Ing. Eva Schwenzfeier-Hellkamp
is a professor at Bielefeld University of Applied Sciences

and heads up the Renewable Energy degree programme as well as the Institute for Technical Energy Systems (ITES). She is a professor at the NRW Doctoral College and is authorised to supervise doctoral students. In addition, she is involved in various advisory boards and committees, including the City of Bielefeld's Climate Advisory Board and the Association of German Engineers (VDI). Her specialist background is in electrical engineering.

At the start of my career, I saw electrification as an individual, single problem that could be solved through technical means. Today, I perceive it as part of a comprehensive transformation of energy systems that merges and melds technical, economic and social aspects.

Electrification will only unleash and realise its full potential when combined with heat supply, energy storage and digital and automated control systems. Accordingly, a systemic approach is what is called for.

The interplay between electrification, digitalisation and automation

Electrification, digitalisation and automation are the key building blocks of modern energy systems. Electrification provides the

Systems should be modular in design, repairable and expandable.

physical foundation, digitalisation renders conditions and processes transparent, while automation enables them to be controlled in a targeted manner.

However, not every form of digitalisation is appropriate and expedient. It is crucial to limit data-driven processes to what is technically and economically necessary, in order to avoid unnecessary complexity arising.

"Always-on" as a new demand made on energy systems

A significant shift is evident in energy consumption patterns. Systems are increasingly operating continuously and must therefore function reliably at all times. Consequently, the energy supply becomes a permanent background function.

This development gives rise to increased demands on:

- Reliability
- Resilience
- Continuous operability

Energy infrastructures must remain stable and responsive – also under variable conditions.

A focus on the life cycle rather than operational optimisation

For me, taking a holistic view of the entire life cycle of technical systems is key. In addition to operation, the phases of use, maintenance, adaptation and decommissioning must also be taken into account right from the development stage.

This gives rise to clear requirements: **Systems should be modular in design, repairable and expandable.** Interchangeable components extend service life and facilitate technical developments. At the same time, the recycling of materials is becoming increasingly significant in the context of the circular economy. This not only promotes sustainability but also reduces dependencies within global supply chains.

The integration of new technologies into existing infrastructures

The transformation of energy systems is taking place predominantly in existing buildings. Existing facilities and networks must be modernised incrementally, in stages without disrupting day-to-day operations.

Different stages of technological development call for flexible integration strategies. In addition, organisational changes are needed, such as greater agility and stronger interdisciplinary collaboration.

Standardisation as a prerequisite for scalability

I perceive considerable scope for improvement, particularly when it comes to interfaces and connectivity. The high degree of variability makes integration, maintenance and further developments all the more difficult.

Greater standardisation can reduce complexity and promote cross-organisational solutions. Cooperation can be particularly beneficial when it comes to material cycles and recycling concepts.

Actual needs come before technology

Technical excellence alone does not determine the success of a solution. Systems must meet specific requirements and take actual needs into account.

Too many features or a premature market launch can undermine acceptance and cost-efficiency, which is why it is essential to focus consistently on application scenarios and future requirements.

Timeframes for implementation

Implementation will take place incrementally, in stages. Initial solutions are already emerging, but widespread systemic scaling is expected in the medium to long term. Key drivers include regulatory requirements, ever rising demands for resource efficiency and increasing pressure to ensure sustainability.

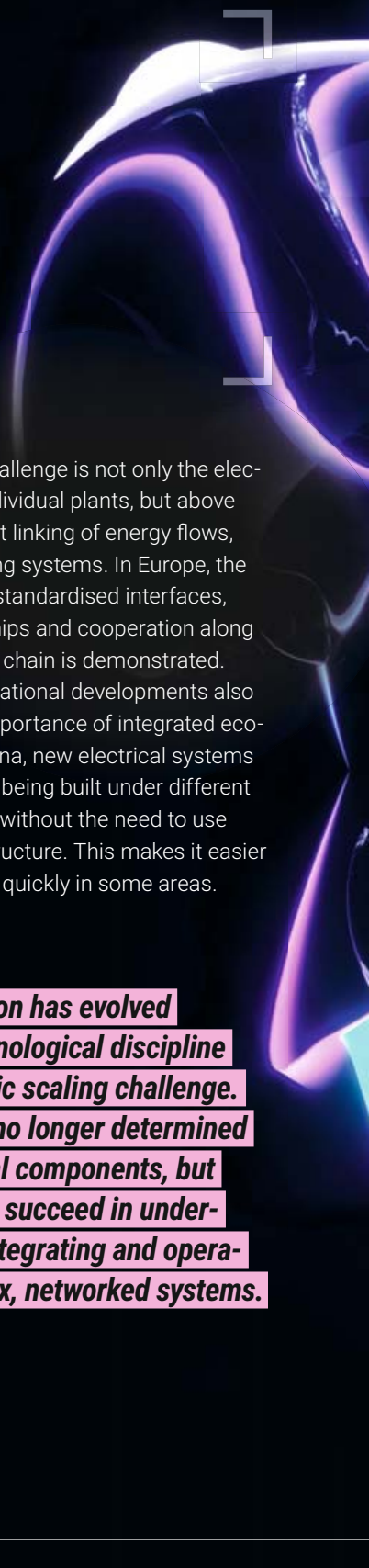
Summary

Electrification is now a systemic challenge. What matters here is not the maximum of technological capabilities, but robust, adaptable and resource-efficient integrated overall systems.

The character of electrification has changed fundamentally. Instead of individual technologies, the focus is now on the question of how complex, networked energy systems can be designed. Where in the past the choice of the right technology was crucial, today it is all about system integration. Energy generation, storage and use are growing together – as are industrial processes and entire value chains. ***Electrification no longer only affects individual plants, but entire ecosystems:*** *from production to logistics to infrastructure.*

ELECTRIFICATION BECOMES A SYSTEM TASK

WORK IN PROGRESS...



No electrification without digitalisation

Today, electrification only works in conjunction with digitalization and automation. Data is becoming the central control variable. **Networked systems, digital twins and automated processes make the necessary transparency and flexibility possible.** In networked and complex applicatons – such as mines, ports or logistics systems – electrical systems can hardly be operated without digital infrastructure. The consequence: Electrification is no longer just a question of energy, but always also a question of data, communication and software, which often has a significant impact on the business models for those involved.

Complexity as a new reality

At the same time, complexity is increasing, especially in existing industrial structures. Electrification usually takes place in the so-called brownfield: new technologies have to be integrated into existing systems. The path therefore leads through step-by-step transformation with clear roadmaps and scalable solutions. **The structure of the energy supply is also changing.** Instead of centralised generation, decentralised systems up to local microgrids are increasingly emerging. Production and consumption are moving closer together, and companies are becoming energy producers and users at the same time. This creates a new understanding of "always on": energy is available but must be actively controlled, optimised and balanced with demand.

Integration becomes key

As system complexity grows, new requirements come into focus:

- Integration instead of isolated solutions
- Standardised interfaces
- Cooperation along the value chain

Electrification is therefore increasingly becoming a joint task of industry, technology providers and infrastructure operators.

Practical examples show the challenge

A project from Scandinavia shows how complex this task already is: There, a steel mill is being converted from coal-based processes to electric arc furnaces. At the same time, port facilities, truck traffic, charging infrastructure and local power grids must be integrated into the new energy system. The challenge is not only the electrification of individual plants, but above all the intelligent linking of energy flows, data and existing systems. In Europe, the importance of standardised interfaces, close partnerships and cooperation along the entire value chain is demonstrated. However, international developments also illustrate the importance of integrated ecosystems. In China, new electrical systems are sometimes being built under different conditions and without the need to use existing infrastructure. This makes it easier to implement it quickly in some areas.

Conclusion

Electrification has evolved from a technological discipline to a systemic scaling challenge. Success is no longer determined by individual components, but by well they succeed in understanding, integrating and operating complex, networked systems.

About The Electrification Hub

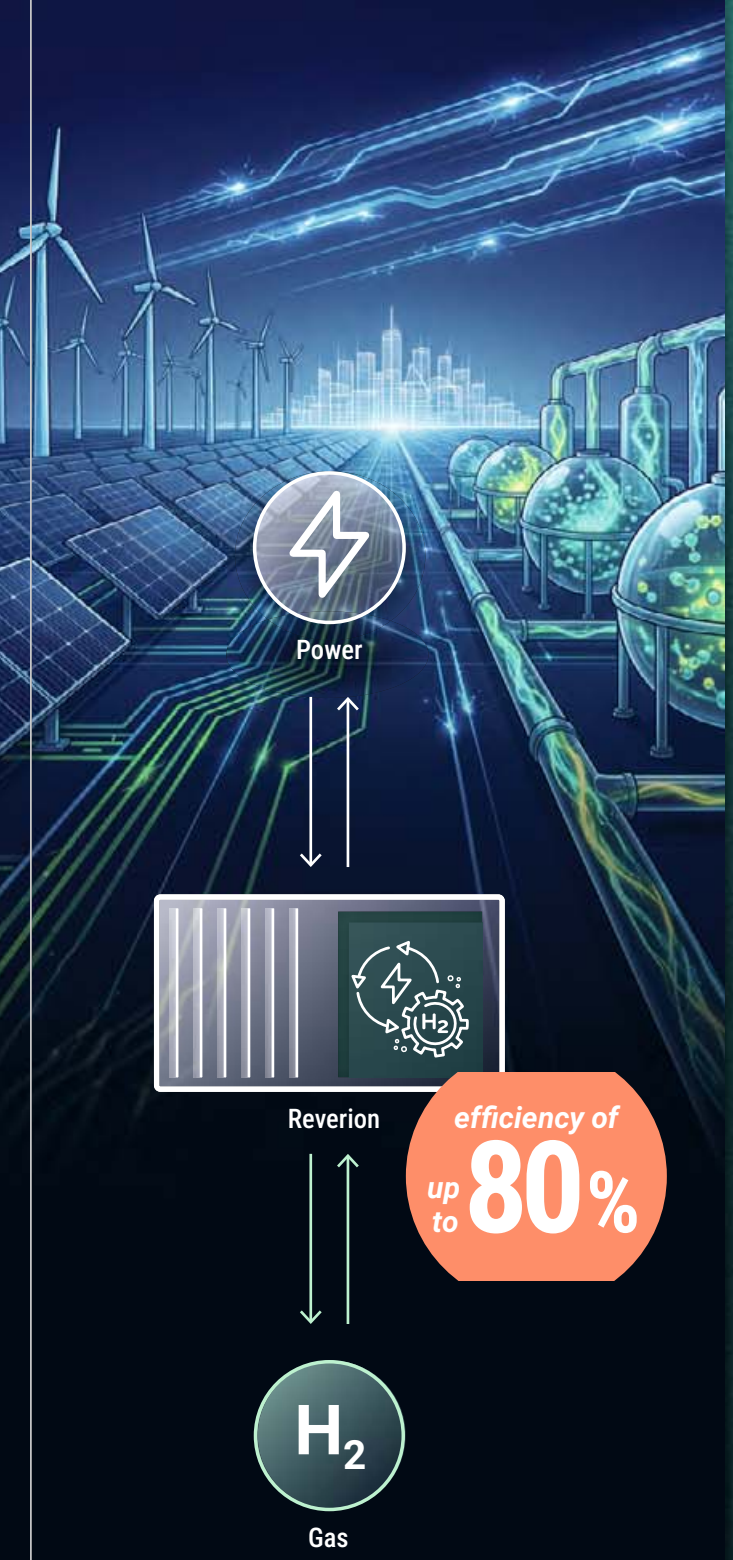
The Electrification Hub, based in Sweden, connects companies, research and public actors to drive the electrification of industry and mobility. The hub is industry-driven and combines scientific research with industrial practice.

The focus is on the integration of complex energy and mobility systems along the entire value chain – with the aim of putting innovations into practice more quickly, accelerating the transition to sustainable electrification.



Mikael Hjorth
Head of the Electrification Hub

BIDIRECTIONAL ENERGY



At Reverion, when we talk about electrification, we no longer mean just the generation of electricity. For us, it's about flexibilising the use of energy, providing power when it's needed, and storing it when there's a surplus. Because that is precisely one of the major challenges today: Renewable energy sources such as wind and solar power are increasingly supplying large amounts of electricity, but not on a constant basis, however.

Keeping energy flowing

In our day-to-day work, we are constantly confronted with this field of tension. With increasing frequency we are encountering situations in which more energy is generated than the grid can handle. At the same time, there are periods in which power is lacking. This is precisely where our systems come in. **Our technology – reversible fuel cell systems – can do both: Generating electricity and storing energy,** thereby transforming a conventional power station into a flexible energy converter.

In practical terms, this means:
- We generate electricity from gas, such as hydrogen or biogas.
- Or we can convert surplus electricity into gas, thereby storing the energy for later use.

Our systems achieve electrical efficiency of up to 80 per cent – and in both directions. For us, gas is therefore no longer a conventional fuel, but a flexible form of energy storage.

More than just a power station

At first glance, our solution can be described as a highly efficient power station. On closer inspection, however, a significantly broader range of functions emerges.

Our systems do not operate in just one direction. They respond dynamically to what is currently happening in the energy system, which makes them fundamentally different from conventional systems.

HARTING technology integrated into Reverion systems

HARTING connectors reliably transmit power, data and signals in Reverion systems. Modular and robust components allow for flexible integration into the system. To this end, Reverion relies on, among other things, Han® HPR hoods/housings as well as Han Modular® inserts.



A coal-fired power station is either running or standing still. **Our systems, on the other hand, are always "on" and responding:** They continuously analyse whether energy is required or should be stored, and adjust operations accordingly. We regard this as representing a new dimension of electrification.

Digitalisation is essential

What is often underestimated in this regard is the fact that this flexibility would not be possible without digitalisation.

For our system to work expediently and effectively, it needs real-time data. We need to know:
- Where is electricity needed?
- When is there an abundance of energy?
- How are supply and demand developing and changing?

It is only with this information that our system can make the right decision. Electrons and data streams are inextricably linked.

Why storage is crucial

A key advantage of our approach lies in the storage duration. Batteries are ideal for smoothing out short-term fluctuations – typically over a few hours. Our technology, however, extends much further than that. **We can store energy for days, weeks or even longer, provided that suitable gas storage facilities are available.** By way of a connection point to the gas network, the storage options are virtually unlimited. This opens up entirely new possibilities for bridging periods of low generation or offsetting seasonal fluctuations.

A building block for the future of energy supply

We do not perceive our systems as the sole solution, but rather as a building block in a larger energy system.

It is particularly in regions with a high share of renewable energy that our approach can make a genuine, substantial difference:
- Surplus energy is stored and is not lost
- Bottlenecks are dealt with flexibly
- The burdens on the networks are eased

And this should be achieved as decentralised as possible, close to where energy is generated and consumed.

From the idea to actual practice

At the moment, we are still working in relatively small power classes and gaining experience in the field. Our systems are modular in design and can be combined – an important step towards catering for larger applications in the future.

We are not only developing technology but also gaining an understanding of how future energy systems could work.

A recent project at HARTING in Espelkamp demonstrates that the technology is already being put into practice. A Reverion plant is part of the energy system there and helps the company to use renewable energy more flexibly and, over the long term, to store it in the form of green hydrogen.

Networking as the key

As the scale trends upwards, so does the importance of an issue that is part of our daily lives, namely connectivity: Our systems rely on being able to communicate reliably with their environment, whether this entails local energy systems, storage facilities or higher-level markets. Only if this communication functions reliably will dynamic operations succeed. That is why interfaces, data transmission and robust connections play a pivotal role in our development.

Reverion

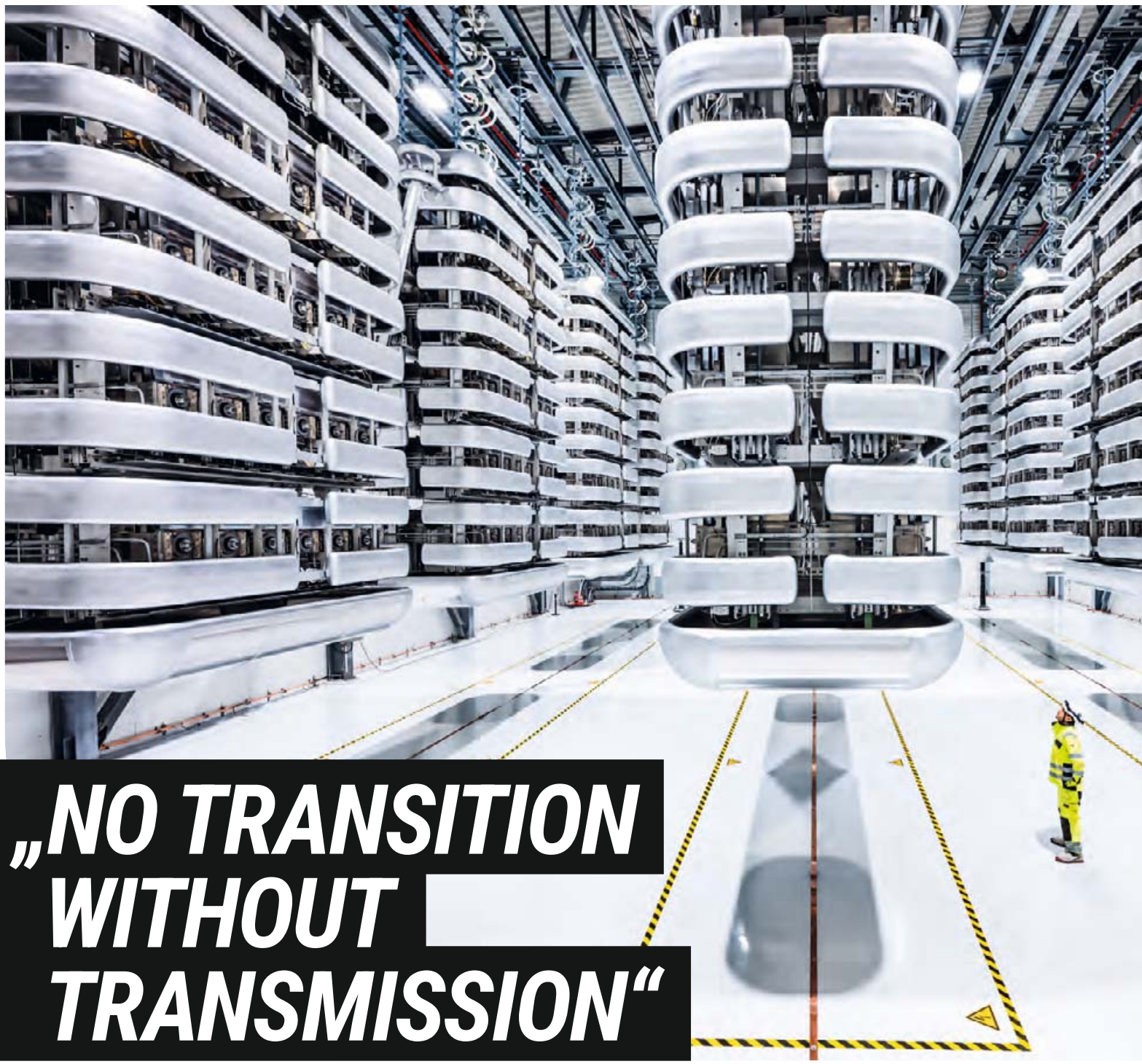
develops highly efficient energy systems based on fuel cells that are capable of generating and storing electricity and converting it into hydrogen as required. The systems achieve efficiency levels of up to 80 per cent. Based in Eresing, near Munich, the company employs around 200 members of staff.







Maximilian Schmitt
Head of Sales & Marketing, Reverion



„NO TRANSITION WITHOUT TRANSMISSION“

Smart grids as the transmission driving the All-Electric Society

Flexibility and decentralised storage are decisive pieces of the jigsaw puzzle when it comes to the future of electrical energy. A coherent overall picture, however, can only emerge if the macro level also plays along: We need a smart grid that is capable of safely accommodating these dynamic feed-ins, controlling load flows and transmitting energy over long distances. Hitachi Energy is convinced that without the expansion of these transmission grids, the entire transition will come to a standstill.



View into the valve hall of a converter station for high-voltage direct current transmission.

Picture: Hitachi Energy

For this issue of tec.news, we spoke to Pascal Daleiden, CEO of Hitachi Energy Germany AG and the company's head of operations for Germany, Austria, Switzerland and Slovenia, about the hidden magic of complex infrastructures, the dynamic, rapid transformation driven by AI data centres, and his view on why electrification, digitalisation and automation must inextricably mesh and merge to create a resilient overall system.

tec.news: Mr. Daleiden, in the 1970s cult series Catweazle, a medieval magician marvels at the modern world and views humanity's control over electricity as veritable magic. He calls it 'Elec-trickery'. When we look at modern energy systems today: What role does this 'Elec-trickery' play in your professional life?

Pascal Daleiden: Although I must admit that I'm not familiar with the series itself, the term fits impeccably. For me, 'Elec-trickery' stands for all those highly complex technical processes that take place behind the scenes and which the general public is often completely unaware of. **The generation, transmission and distribution of electricity are constantly interlinked to ensure that industry, infrastructure and private households are supplied with a reliable supply of electricity at virtually all times.** What is particularly fascinating is just how fundamentally this system has changed. In the past, the energy supply was organised centrally, with a single power station supplying an entire region. Nowadays, we are increasingly generating electricity locally by way of renewable energy sources. As a result, electricity must be transmitted over much greater distances and managed with considerably greater flexibility. So today, the real magic is in managing a tremendously complex, decentralised and dynamic energy system in such a way that supply security, efficiency and resilience are all guaranteed over the long term.



Pascal Daleiden
CEO of Hitachi Energy Germany AG and the company's head of operations for Germany, Austria, Slovenia and Switzerland

Doesn't that also mean that electrification and digitalisation actually go hand in hand these days?

I definitely agree, from my point of view, there are hardly any electrification measures left that do not also involve digitalisation. Systems and products are becoming increasingly intelligent due to the fact that they are being equipped with sensors, interfaces and communication capabilities. This applies to heat pumps in buildings just as much as it does to the huge transformers in the electricity grid. The data generated in this process helps, for example, with the implementation of predictive maintenance,

››

The energy and industrial transition can only succeed if the expansion of the grid proceeds at a high level and on a continuous basis.

improved capacity utilisation and more precise control functionalities. **In future, a decentralised and volatile energy system can only be operated in a stable and efficient manner with the aid of digital technology and semi-automated control mechanisms. The complexity of this task would otherwise be simply unmanageable.**

Which specific drivers of electrification do you currently experience most strongly in your working environment?

The industrial arena is a huge driving force, which is transforming its energy-intensive processes. The electrification of blast furnaces in the steel industry, or local hydrogen generation are specific examples in this context. Projects of this kind require extremely high performing and well-integrated electrical systems. Data centres and artificial intelligence are further drivers of growth. These applications create tremendous additional demands for a fail-safe infrastructure. After all, we mustn't forget: While traditional data centres represent a relatively constant load on the grids, the new AI data centres are highly volatile consumers. This presents new challenges for power quality and system stability. **That is why we at Hitachi Energy say: "No transition without transmission".**

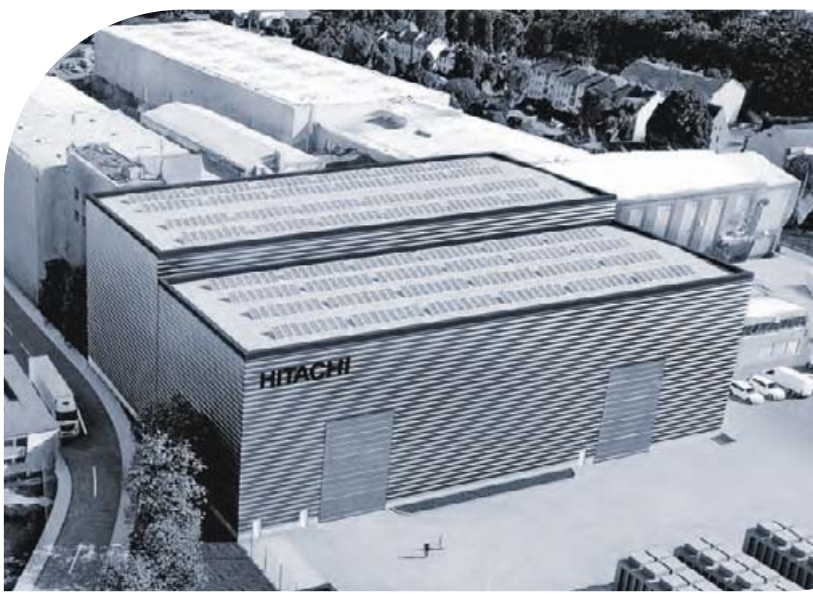
The energy and industrial transition can only succeed if the expansion of the grid proceeds at a high level and on a continuous basis. We must not put the brakes on and leave the next generation with the burden of having to catch up.

You've just mentioned system stability. How exactly does automation come into play here, alongside digitalisation?

All three areas – electrification, digitalisation and automation – can only realise their full potential when working together. With the phasing out of conventional power stations, meaning gas, coal and nuclear power, we are losing our large-scale power generators. Thanks to their physical inertia, their rotating masses have so far dampened fluctuations in the grid and provided reactive power, which is essential for voltage stability in the grid. Renewable energy plants, such as wind and solar, feed their electricity into the grid by way of power electronics – they have none of these rotating mechanical components at all. That is why we now have to maintain this grid stability artificially. Manual grid control by human operators, however, is no longer sufficient to enable a response to grid changes within milliseconds in future. We need automation and AI that can anticipate problems and suggest specific solutions to control centre staff. Moreover, we are also introducing new automated equipment into the network.

Which equipment are you referring to specifically?

I am thinking, for example, of so-called Enhanced STATCOM systems. These are advanced, leading edge compensation systems which supply reactive power and – when fitted with supercapacitors – can even provide active power for short periods to stabilise



Hitachi Energy is investing in the expansion of the manufacturing capacities of the power transformer factory in Bad Honnef.

the grid. Another key component is high-voltage direct current transmission – HVDC for short – which is used, for example, on the major north-south transmission lines in Germany or in interconnectors. Power electronics play a vital role here. Semiconductors and power electronics are the foundation that makes so much of what we see in network automation possible in the first place. This ranges from the converters in the power lines, to railway technology and all the way through to the charging infrastructure for electric cars.

In industry today, the term 'always on' is often encountered. The systems are always accessible and on standby. What does this mean for the electricity grid, and how do you deal with the existing structures into which you need to integrate new solutions?

Within the context of the electricity grid, 'always on' quite simply means constant availability. It's not a case of 'flip the switch and the power goes off'. Systems designed primarily to provide redundancy and resilience are always running or on standby. In actual practice, electrification rarely takes place on a proverbial greenfield site. In existing substations – classic brownfield sites – space is extremely limited and at a premium, meaning that **we need to fit more power into the same space.** The switch from traditional air-insulated switchgear to gas-insulated switchgear is one technological solution to this very space problem – and are considerably more compact. This means that valuable space suddenly becomes available on the existing site, allowing, for example, a second substation to be built right next to the existing substation in order to meet the increased power demand.

Are we currently lacking technical solutions or organisational framework conditions enabling us to keep the pace with electrification?

Technically speaking, most solutions are already in place or at an advanced stage of development. There are no technical reasons why electrification should not be driven forward at the necessary pace. The greatest challenges are actually encountered in the organisational and regulatory areas. Approval procedures and onerous regulatory conditions can delay projects. Although there have been some noticeable improvements recently thanks to the laws of acceleration, we still need to adapt the regulatory framework even more closely to the new challenges, such as system stability. Companies like ours need certainty when it comes to long-term planning. We are investing 9 billion US dollars globally in building up capacities, expanding our plants and recruiting staff. For all this to happen, the right general framework conditions must be in place.

In concluding, let's take a look at the hardware level: Electrification and connectivity are closely linked – both in terms of energy and data. What demands and requirements does this place on interfaces and connectors?

Interoperability is the absolute key requirement, closely followed by cybersecurity. In an increasingly interconnected energy system, components and interfaces must communicate with one another with total reliability. Take large HVDC systems with multiple terminals: When we connect cables and converters from different manufacturers here, we must carry out extremely thorough testing in advance to ensure that they are interoperable and operate safely. There have long been established standards for this in industry, and in the field of high-voltage grids, manufacturers' groups are working intensively on these issues within interoperability committees. More data and reliable connectivity help us to understand the network better and operate it in a more resilient manner. **That is why, for me, connectivity is not just a matter of technical interfaces, but a crucial enabler for stable, future-proof electricity grids.**



Connectivity isa crucial enabler for stable, future-proof electricity grids.

customer benefits

The need for performance gains is one of the key challenges that ongoing electrification is presenting. Across industry, energy infrastructure and mobility, connectivity requirements are increasing continuously as existing systems become ever more powerful. With Han® HC Double Contact Technology (DCT), HARTING is responding to this trend and expanding its range of solutions for high-current applications.

Double Contact Technology boosts

HIGH-CURRENT CONNECTOR PERFORMANCE



Enhanced safety thanks to touch-safe contacts on both sides

- > simple and safe installation
- > high flexibility
- > high safety

Norbert Weiß
Teamleader Marketing Service, HARTING Technology Group



20 %

higher current-carrying capacity compared with conventional HC contacts

HARTING offers proven, exceptionally robust solutions for transmitting such high currents: the HC-Modular 250, 350 and 650 series, which are used primarily in rail vehicles and outdoor applications. To meet the demand for higher current-carrying capacity, the company has revised its existing portfolio. The result is a new range of connectors featuring Han® HC Double Contact Technology. They offer higher performance, minimal contact resistance, improved thermal management and convenient, simple and safe installation.

The improved current-carrying capacity is achieved through a larger contact area. In the new design, the current is transmitted via two parallel paths: an internal pin in the socket contact and a surrounding tab that engages with the mating pin contact. Laboratory tests have confirmed the higher current-carrying capacity: the DCT CU 18, DCT CU 22 and DCT CU 30 contacts – named after their diameters – conduct up to 20% more current than the previous standard solutions.

Convenient, simple handling

Handling is safer because the DCT series provides touch protection on both sides of the connection, for both male and female contacts (previously, only the female side was touch-safe). Installers are also well aware that thicker cables are more difficult to install. HARTING's developers have therefore further optimised the assembly process. **The new contacts are easier to handle thanks to their rotatable design.** They click securely into the insulator and can then rotate freely within it. This rotational movement reliably compensates for mechanical tensile loads in the cable, facilitating installation by a considerable measure.

Fewer, lighter variants

The existing HC-Modular portfolio includes 44 different retaining plates and five installation methods. By contrast, the DCT contacts now use a standardised assembly method. The holding frames vary only in terms of size and the number of contacts, while the cut-outs for the insulators are identical throughout. **Disassembly is also simplified: the retaining plate can be unlocked by twisting, and the insulator can then be pulled out of the sheet metal without resistance.**

Product Manager Maik Iphöfer highlights the potential weight and space savings offered by switching to the new contact series: "The new performance classes provide a wider range of current ratings, allowing customers to select the right contact for their application instead of choosing an unnecessarily oversized solution."

Current-carrying capacity Han® HC DCT CU

DCT CU 30	***up to 660 A***
DCT CU 22	***up to 420 A***
DCT CU 18	***up to 300 A***

Benefits:

- **Up to 20% higher current-carrying capacity** ompared with conventional HC contacts
- **Quick and easy installation** thanks to an efficient coding system, rotatable contacts and fewer frame components
- **Enhanced safety** thanks to touch-safe contacts on both sides
- **High flexibility** thanks to the modular design: suitable for high-current applications across a range of industries

Conclusion:

Applications with high power requirements can use cable assemblies equipped with the new HARTING Double Contact Technology to handle higher currents of up to 660 A per contact, while also reducing the work involved in installation and disassembly for maintenance.

DIGITAL TWIN: THE FOUNDATION FOR SEAMLESS END-TO-END VALUE CREATION

Electrification is now taken for granted and forms the foundation of modern industrial applications. The focus is increasingly shifting to the question as to how this foundation can be designed efficiently – with one topic in particular taking centre stage: the digital twin.

Andreas Wedel
Director Digitalisation, Data & AI, HARTING Technology Group



The convergence of energy and data

The clear distinction between power supply and data transmission is being increasingly relegated to the past. Modern applications combine both levels in integrated systems. In this way, **electrification is becoming an implicit given and a fundamental prerequisite for digital processes.**

Digitalisation as essential precondition

At the same time, one thing is clear: **Without digitalisation, electrification can no longer be implemented in a sustainable manner today.** Digital twins, standardised data models and digital product passports are essential for the efficient planning, documentation and traceable long-term operation of electrical systems.

This is particularly crucial in the industrial arena: Planning, implementation and operation often take place in separate physical and organisational settings.

The digital product passport creates a shared database covering the entire life cycle.

The product passport as a data anchor

The digital product passport serves as a structured repository of information for components and systems. It provides machine-readable data that can be readily integrated into engineering tools, platforms and applications.

This positions it as a key component for:
- end-to-end processes
- workflows that can be automated
- consistent data availability

Automation and AI as driving forces

As digitalisation advances, working practices and routines in engineering are also undergoing change. In future, systems will autonomously generate suggestions for components based on existing data. This process not only incorporates information from the digital product passport, but also contextual knowledge about processes, applications and regulatory requirements – as encountered in different countries, for example.

Manual examination is being replaced by automated processes:
- Analysing requirements
- Linking product and application data
- Taking regulatory requirements into account
- Suggesting suitable products

The digital product passport provides the necessary structured information for this and serves as the central knowledge base for data-driven and AI-supported engineering processes.

Always-on and new requirements

At the same time, the demands placed on the availability of data and systems are trending upwards. Globally networked applications, simulations and AI-supported processes all require access to up-to-date information at all times.

Consequently, product data must also be available “always on”, not only for people but increasingly for automated systems as well.

Outlook

The technological foundations have already been put down. The first applications are now available, particularly in the engineering sector. Over the next three to five years, AI-assisted product selection and data-driven processes are likely to become widely established across the board.

The digital product passport is evolving from a “nice-to-have” to a key enabler – acting as a link between the physical and digital worlds.

In spite of all the ongoing automation, people remain a crucial factor. Although the digital product passport is designed for automated processing, human experience, specialist knowledge and judgement cannot be fully automated. Consequently, HARTING provides information in both human-readable and machine-readable formats and uses its digital tools to combine the strengths of humans and machines.

customer benefits



Electrification is transforming entire industries and sectors across the board. New drive systems, smart sensors, power electronics and digital systems are driving the demand for energy and data transmission ever upwards. Electrification must be viewed holistically: Wherever electricity flows, connections will be needed. **And as electrification trends upwards, so do the demands for connectivity.** Connectors must therefore not only transmit more power but also provide the appropriate interfaces for future applications. The challenge here is packing in ever-higher performance and connectivity where space remains at a premium.

PACKING MORE POWER IN THE SAME SPACE

Han® 4B: Higher energy density for mechanical engineering and robotics

Every additional electrical function needs an interface. Consequently, wherever greater electrification advances, more connectors will be called for. The available installation space, however, is not expanding at the same rate. This is exactly where the new Han® size 4 comes in. HARTING is incorporating the intermediate size into the Han® HPR, Han® B and Han-Eco® series. With current-carrying capacities of up to 70 A, it matches the performance of larger standard models, while saving on valuable installation space at the same time.



20 % smaller!
Comparison plastic housing Han-Eco® 6 vs. Han-Eco® 4

Mechanical engineering and robotics necessitate ever-higher power densities.

Size 4 bridges the gap between Han® 3A and Han® 6B, combining high current-carrying capacity with compact dimensions.

When comparing the housing dimensions, the advantages for machine manufacturers are readily evident: the Han® 4B standard surface-mounted housing requires 13 per cent less base area space than the next largest housing, the Han® 6B.



This allows more connectors to be fitted within the same space on the control cabinet panel.

With a current-carrying capacity of up to 70 A, this intermediate size meets the mounting power requirements of modern machines while also freeing up space, for example, for data transmission, storage elements or cooling and ventilation components.

Han-Eco® 4: Sustainable and flexible

The Han-Eco® Mod.4 range of plastic housings forms the basis for the lightest Han® connectors, designed for current-carrying capacities of up to 70 A. **This is opening up new possibilities for data centres, energy infrastructure and industrial applications.** A Han-Eco® Mod.4 – complete with hood and bulkhead mounted housing – requires 20 per cent less installation space than its size 6 counterpart.

This creates space for data transmission, cooling or other electrical functions. At the same time, the modular design (Han-Eco® + Han-Modular®) allows for flexible combinations of power, signal and data transmission.

Han® 4 HPR: Less space, lower weight

For applications in the energy and transport sectors, the key criteria are ruggedness, weight and installation space. The Han® 4 HPR size takes up half the space on the mounting wall compared with the Han® 6 HPR. Compared with the equivalent solution from the Han® HPR Compact series, this achieves installation space savings of 40 percent.

Han® 4 HPR offers weight-saving benefits: The Han® 6 HPR connector weighs a total of 530 g, including the hood (M25, straight cable entry), the bulkhead mounted housing, the screw lock and the Han-Modular® articulated frame.

In the same configuration, the Han® 4 HPR weighs in at just under 270 g. This is enabled, among other things, by opting for a plastic mounting frame instead of a metal one. It is important to note that the lighter version also meets the stringent requirements for robustness and protection class in accordance with IP68/IP69 – and is certified to IEC 45545 and UL1977.

Summary

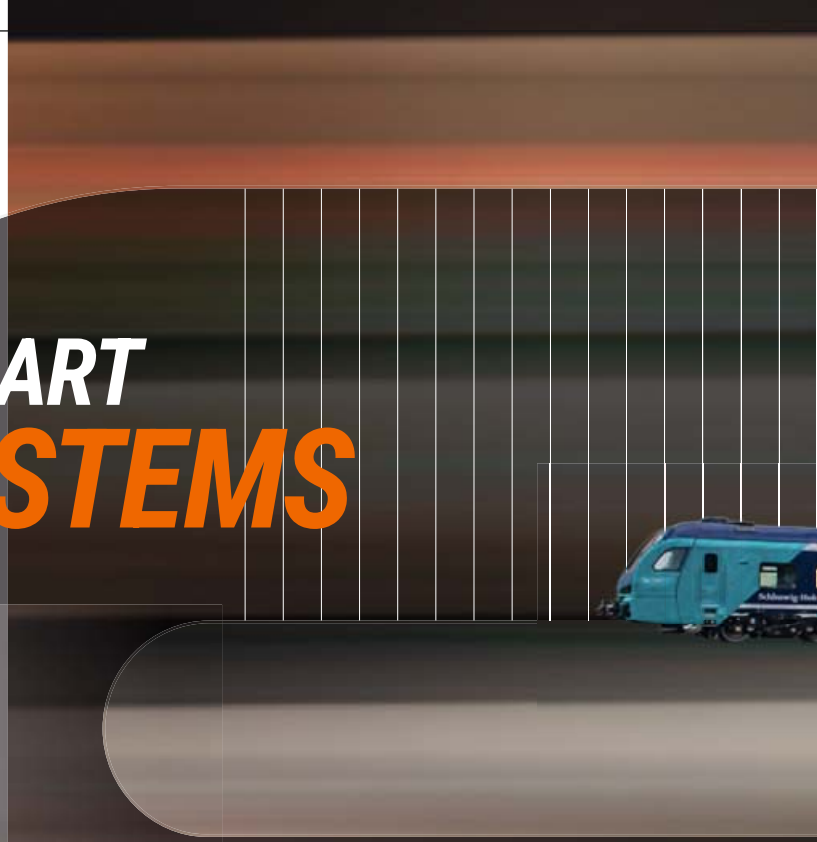
Not every application fits within existing grid sizes. By introducing size 4, HARTING is now closing this gap and expanding its range of connectors for electrification to cover important application areas.

At the same time, the solution takes the increasing energy density of modern applications into account and significantly boosts performance per unit of installation space.

Norbert Weiß
Teamleader Marketing Service, HARTING Technology Group

FROM ELECTRICAL DRIVES TO SMART ENERGY SYSTEMS

Why the next stage of electrification will rely on batteries, data and networking



Railways have always been pioneers in the field of electrification. Decades ago, electric drives became the norm as they were more efficient, more powerful and more cost efficient.

The first stage: Electrification for technical reasons

If you look at the history of railways, the reasons why quickly become clear. Electric drives offer high power density, enable the recovery of braking energy and cause less wear than many conventional drive systems. At the same time, they are quieter, more comfortable and more cost efficient to operate.

From a technical and economic point of view, there are many arguments favouring electric propulsion. That is why, initially, the electrification of rail transport was primarily a matter of efficiency and performance, rather than a climate policy decision.

Batteries are closing the remaining gaps

Today, we are in the midst of the next stage in the development of electrification. **Although many railway lines are electrified, there are still gaps in the overhead line network in numerous regions.**

Modern battery technologies are opening up new possibilities in this area. Non-electrified sections of track are short in comparison to the daily mileage and can therefore be covered with the assistance of relatively small batteries. The train can then draw power from the overhead line again. **This makes it possible to significantly reduce dependence on fossil fuels without having to build costly infrastructure everywhere.** At the same time, new economic opportunities are emerging for operators and other public authorities.

About Stadler

Stadler has been manufacturing trains for over 80 years. The provider of mobility solutions in the fields of rail vehicle manufacturing, maintenance and signalling technology is headquartered in Bussnang, in eastern Switzerland. More than 17,000 employees are active across 8 production and 6 engineering sites, as well as at over 95 service centres, of which around 6,000 are based in Switzerland. Stadler ranks as the world's leading manufacturer of vehicles with alternative drive systems (hydrogen and battery) as well as rack-and-pinion railway vehicles. Keenly aware of its social responsibility towards sustainable mobility the company is committed to producing innovative, sustainable and durable quality products.



Johannes Wilhelmer
Leader Green Technology, Stadler



Picture: NAH.SH/Manuel Weber

Modern electrification is not possible without data

This development, however, is also changing the role of electrification itself – which is no longer limited solely to powering vehicles.

The more strongly batteries and energy storage systems are integrated into operations, the more important data, connectivity and digital control systems will become.

In my view, electrification is now almost inconceivable without digitalisation. Sensors, data interfaces and automated control loops have long featured as an integral part of modern railway systems. We derive the greatest benefit when vehicles, infrastructure and operations are not viewed in isolation, but as an integrated system instead.

From individual vehicles to smart fleets

This shift is particularly evident in battery-electric fleets. Operators need to plan charging times, energy availability and vehicle rotas considerably more precisely than before.

That is why digital solutions for energy management and fleet optimisation are becoming increasingly imperative. **The intelligent analysis of vehicle data increases availability, reduces maintenance costs as well as optimising energy consumption.**

As a result, rail vehicle manufacturing continues to develop: Alongside the vehicle itself, digital services and smart software solutions are becoming integral parts of the overall system.

Trains will become part of the energy system

The next step extends even further than that. In future, battery-powered trains would not only consume energy but also become an active part of a smart energy grid.

A parked train could be recharging power or also supply it again if required. In such a scenario the battery would therefore take on additional tasks and do far more than simply powering the vehicle.

In my opinion, that is precisely the next stage of electrification:
What once began with electric propulsion is now evolving into a smart, connected system encompassing vehicles, batteries, data and energy flows.

Consequently, the future of mobility will not be determined by rail alone, but increasingly by the intelligent combination of electrification and digitalisation.

Why the electricity grid is emerging as a key factor in the success of the energy transition

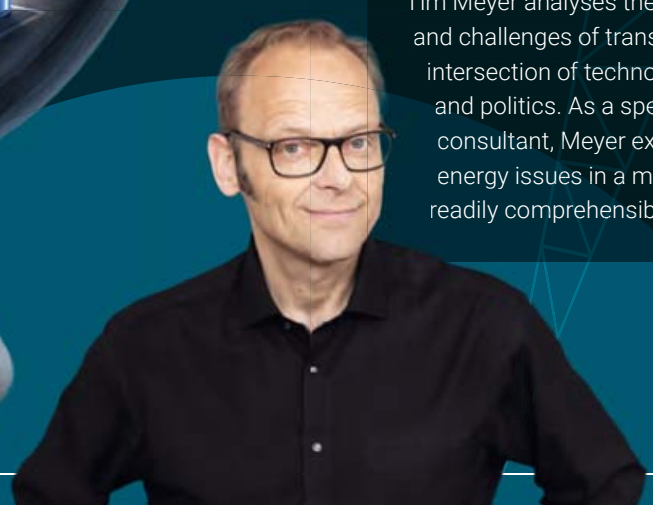
"WE'RE SAVING MONEY THROUGH ELECTRIFICATION"

The electrification of industry, transport and heating ranks as an essential key to a sustainable and competitive economy. While there is frequent discussion of renewable energy, battery storage and electric mobility, however, one key success factor often remains in the background: the electricity grid.

For Dr. Tim Meyer, one thing is certain:

The future of electrification will be decided on the grid.





Dr. Tim Meyer
is an energy expert, author and consultant with more than 25 years of experience in the energy sector.

A doctor of electrical engineering, he focuses primarily on electrification, energy markets and grid infrastructure. Tim Meyer analyses the opportunities and challenges of transformation at the intersection of technology, business and politics. As a speaker, author and consultant, Meyer explains complex energy issues in a manner that is readily comprehensible and practical.

tec.news: Dr Meyer, how has your understanding of electrification changed over the past few years?
Dr. Tim Meyer: In the past, the main focus was on making renewable energy more affordable and integrating it into the grid. Today, electrification encompasses a great deal more: Heating, transport and mobility, industrial processes and new business models. Their impact now extends deep into almost every area of life and the economy.

What role do digitalisation and automation play in this context?
A decisively crucial role. **Electrification cannot work in the long term without digitalisation.** It is only through digital transparency that we can see how heavily networks are being utilised, where bottlenecks occur and what capacity is available. Building on this, processes can be automated and optimised. That is why I like to say: **The digitalisation of energy systems is the big sister of electrification.**

People talking about electrification should, above all, be talking about grids – why is this the case?
Because it is the actual and genuine key to the electrification of the future. It is not the energy producers, consumers or storage facilities alone that determine success, but the grid that connects them all. The grid transmits energy, provides flexibility and is what makes the economic optimisation of the entire system possible in the first place.

The importance of this aspect is often underestimated.
Absolutely. The network is often seen as a cost factor. In fact, however, it is an innovation platform – comparable to the internet or the mobile network. Only a high-performance infrastructure will enable new business models, digital services and industrial applications. **Without modern grids, electrification becomes a bottleneck.**

Germany is generally regarded as lagging behind when it comes to the digitalisation of its electricity grids. Are we holding ourselves back by dragging our heels?
Unfortunately, yes. Other European countries are significantly further ahead, for example when it comes to smart meters or digital grid processes – and in addition, we are burdened with a highly fragmented network landscape. There are over 850 distribution system operators, each with their own technical specifications, software systems and business processes. This makes many things unnecessarily complicated, slow and costly.

Protagonists wishing to speed up electrification must, above all, modernise the grid infrastructure.

Innovation instead of more copper

Here is a salient example of the potential of smart grids: By using a medium-voltage regulator from Hitachi Energy, a grid operator was able to integrate around 260 per cent more photovoltaic power into its grid – without putting down any additional cables. As this aptly demonstrates, more copper is not always the answer. Digitalisation and modern network technology often suffice to make much better use of existing infrastructure.

USA: Networks as a marketplace

In the United States, electricity prices and grid capacity are optimised jointly by way of market design. Local price signals indicate where energy is available and where shortages arise. This is an example of how digitalisation and market mechanisms can help to utilise electricity grids more efficiently and manage investments in a more targeted manner.

It is often claimed that the necessary expansion of the grid will make the energy supply of the future extremely expensive.
Quite the opposite is true. Admittedly, the absolute costs will rise because we need more infrastructure. At the same time, however, the grids will be carrying significantly more electricity than they do today, which will reduce the unit cost per kilowatt-hour.

Or to put it another way: **We will save money by way of electrification.** The more we electrify transport, mobility, heating and industry, the better the grids are utilised – the more cost-efficient they will become as a result.

What needs to happen now?
We need expansion, digitalisation and standardisation all at the same time. The technologies are available, as is the expertise within the electrical and software industries. We now need a reliable regulatory framework and financial incentives for the modernisation of the networks. **Protagonists wishing to speed up electrification must, above all, modernise the grid infrastructure.**

In your view, what is the most important lesson that policymakers, the business arena and society at large must now take on board?
Electrification is no longer a vision of the future, but an economic reality. If it is to realise its full potential, we must view the electricity grid as the central infrastructure of the electrical age. **The success of electrification is not primarily determined in the power stations – but in the grids.**

BRINGING INTELLIGENCE DOWN TO THE FIELD LEVEL

Why electric mobility can only unleash its fullest potential through data, communication and flexibility



Nowadays, electrification means far more than simply supplying devices with electricity. For a long time, electrical energy flowed in only one direction: from power stations to consumers. Electric mobility is now ushering in a significantly more complex system. Vehicles are becoming mobile energy storage units that can not only charge but, in future, will also feed electricity back into the grid.



Dr. Anica Mertins
Manager Charging Infrastructure Technology & Energy Systems, National Coordination Centre for Charging Infrastructure

This change is particularly evident in bidirectional charging. In this scenario, an electric car is no longer used solely for transport, but can store surplus solar power, supply households or help to stabilise the energy system. This opens up new opportunities for consumers as well as for grid operators.

Electrification needs digitalisation

Electrical energy alone, however, is not enough for all this to work. **Modern electrification is virtually inconceivable without digitalisation. Vehicles, wall boxes, energy management systems and electricity grids must continuously exchange information** – providing information on charge levels, available power, electricity prices and grid capacity. The more intelligent applications become, the more important data and standardised communication interfaces will be.

The aim is clear: Energy should be used when it is available and can be put to expedient and meaningful use. Instead of charging vehicles automatically in the early evening, when many people are returning home at the same time, charging can be postponed until times when solar or wind power generation is abundant. This unburdens the grids and improves the integration of renewable energy.

At the same time, new requirements are arising. Uniform standards are required to ensure that different vehicles, wall boxes and energy management systems work together reliably – considering that interoperable solutions are still lacking in many areas. Many systems currently only function within closed, proprietary ecosystems. **For widespread market launches, devices from a wide range of manufacturers must be compatible and must speak the same language.**

Data as the key to smart grids

In this context, the availability of data also plays a crucial role. **When it comes to**

Examples of bidirectional charging scenarios

Within the customer's installation (V2H, 'behind-the-meter')

controlled charging

PV electricity consumption with a smart wallbox (increasing self-consumption of PV electricity)

Using a smart wallbox to source electricity from the grid (tariff-optimised charging)

Lower electricity costs thanks to controllable consumption devices (tariff-optimised charging)

bidirectional charging

Power supply for domestic/portable devices (emergency power, portable power bank)

Use of PV electricity with temporary storage in the vehicle (increasing own-consumption of PV electricity)

Use of PV and grid electricity with on-board storage (increasing own-consumption of PV and tariff-optimised charging)

Outside the customer's premises (V2G, 'in-front-of-the-meter')

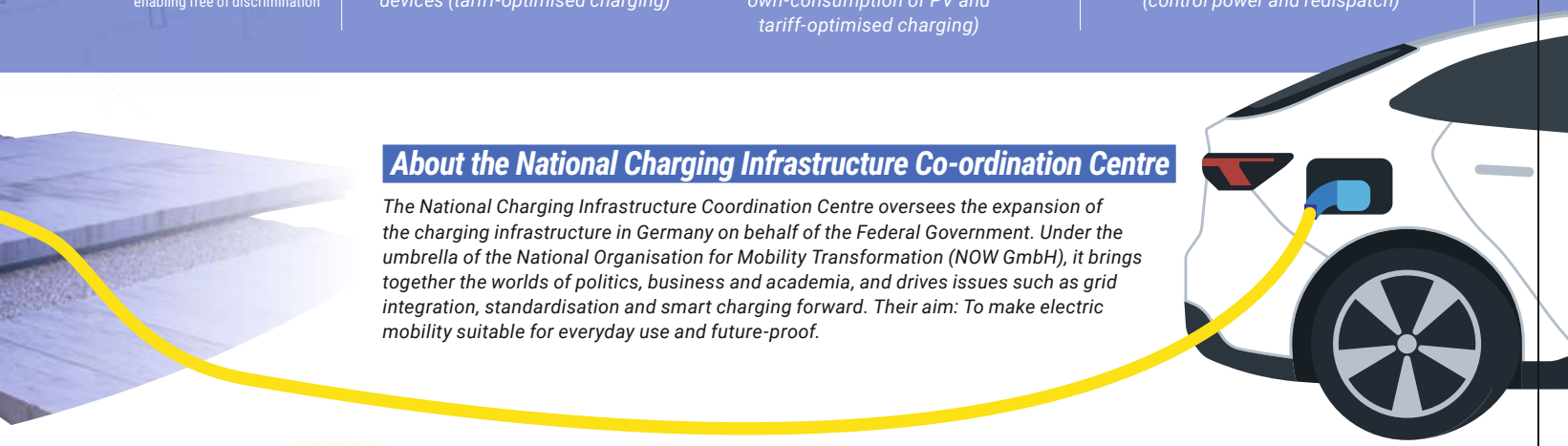
bidirectional charging into the grid

PV electricity trading on intraday/day-ahead markets (electricity price arbitrage)

Electricity trading on the exchange in intraday/day-ahead markets (electricity price arbitrage)

Electricity supply for system services provided by network operators (control power and redispatch)

Source:
National Charging Infrastructure Coordination Centre, NOW GmbH [ed.], (2024): Position paper on bidirectional charging enabling free of discrimination



About the National Charging Infrastructure Co-ordination Centre

The National Charging Infrastructure Coordination Centre oversees the expansion of the charging infrastructure in Germany on behalf of the Federal Government. Under the umbrella of the National Organisation for Mobility Transformation (NOW GmbH), it brings together the worlds of politics, business and academia, and drives issues such as grid integration, standardisation and smart charging forward. Their aim: To make electric mobility suitable for everyday use and future-proof.

Over the long term, no one will need to decide manually when a vehicle is to be charged or can be uncharged.

developing smart energy systems real-time information is absolutely essential. Only then can charging processes be automated and grid capacity utilised efficiently. Consequently, the key question is increasingly no longer whether sufficient electrical energy is available, but rather how generation, storage and consumption can be intelligently linked.

"Always on" – but energy-efficient at the same time

Moreover, there is another notable misunderstanding: "Always on" does not necessarily mean high energy consumption. Thanks to modern communication protocols, vehicles and charging infrastructures can be put into an energy-efficient sleep mode and reactivated only when necessary. Systems remain accessible without having to operate at full capacity all the time.

All of this should remain as invisible as possible to users. Over the long term, no one will need to decide manually when a vehicle is to be charged or can be uncharged. The systems carry out these tasks automatically – taking costs, available energy and grid requirements into account. One thing is particularly important here: The vehicle will be ready whenever it is needed.

In this way, electrification is evolving from a technical discipline into a systemic task, while energy, data, communications and automation are converging. **It is only through their interaction that individual components will become intelligent energy systems –opening up new opportunities for sustainable and resilient energy supply scenarios.**

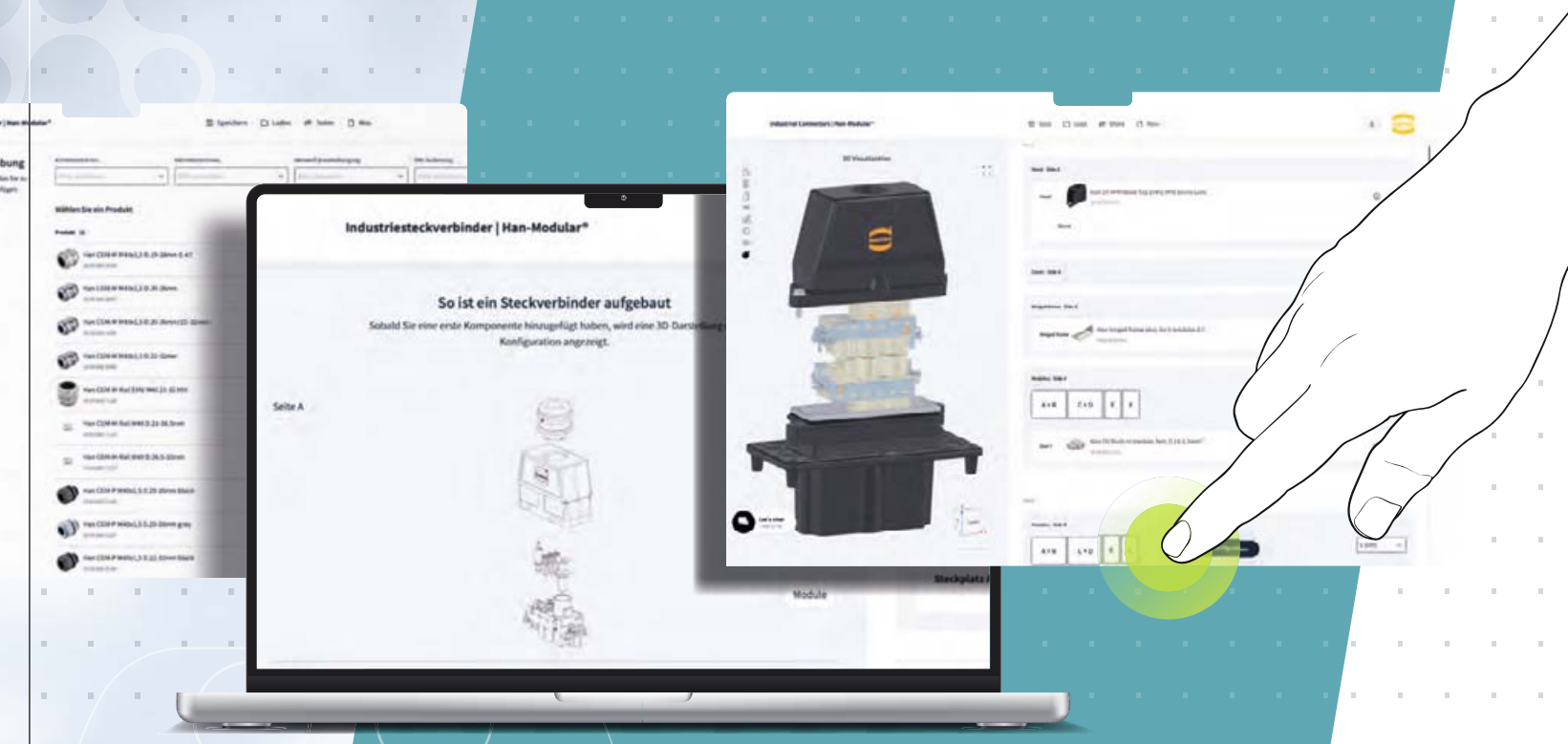
customer benefits

CONFIGURATORS: FOR EVERY APPLICATION THE RIGHT CONNECTOR

HARTING's digital tools guide users quickly and accurately to the right connectors – from applications with high data rates all the way through to high-current connectors.

The selection process is guided. Users specify their electrical requirements, the number of slots, the housing type, the size, the series, and the type of protection and locking mechanism. The software then recommends suitable combinations and automatically excludes unsuitable selections. This always results in a technically expedient and sound product recommendation.

There are separate configurators for monoblock connectors, Han-Modular® connectors and high-current connectors. Once a module has been selected for a slot in the module frame, the Modular Configurator immediately suggests suitable mating partners for the other side of the connector. This ensures that the pin and socket contact are a perfect match right from the start. Customisation features are also taken into account: Users can fit cable entries according to their own specifications in terms of number and diameter, drill custom holes and apply laser markings to the objects. ***The Solution Wizard offers a guided connector selection process and an initial suggestion for a possible interface.***



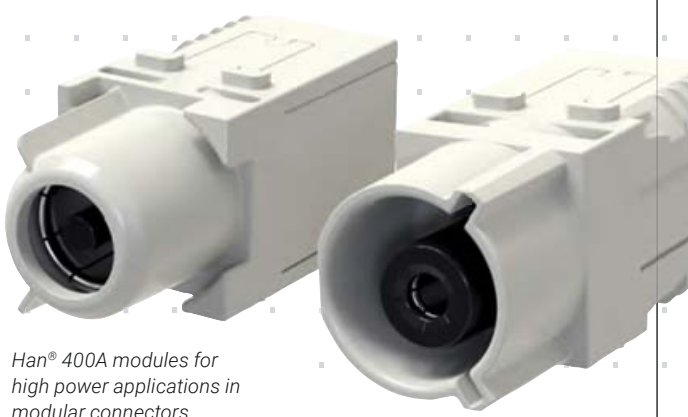
Configure it yourself, entirely according to your requirements: Industrial Han® Connector Configurator

HAN-MODULAR® 400A MODULE: HIGH-CURRENT AND DATA TRANSFER IN A SINGLE INTERFACE

In energy storage systems, the trend is towards ever-higher currents and larger conductor cross-sections. The Han-Modular® 400A module supplies power to applications in battery-powered trains with power requirements of up to 1500 V/400 A. Conductors with cross-sections of up to 185 mm² can be connected. The contacts can carry both direct current and alternating current. They comply with protection class IP20 and are designed to be touch safe, meaning that there is no risk of electric shocks for operators, for example, when connecting batteries.

As a system encompassing over 200 different connectors, the Han-Modular® portfolio offers a wide variety of possible combinations.

As a system encompassing over 200 different connectors, the Han-Modular® range offers a wide variety of possible combinations. In addition to the 400 A power module, further modules can be accommodated in a holding frame: This not only allows the power, but also the necessary data – for example, for temperature monitoring of battery storage cells – to be transmitted. This opens up an extensive range of potential applications, as in data centres, for example.



Han® 400A modules for high power applications in modular connectors

publication details

Published by:
HARTING Stiftung & Co. KG, Margrit Harting,
P.O. Box 11 33, D-32325 Espelkamp,
Phone: +49 5772 47-0, Fax +49 5772 47-400,
Internet: www.HARTING.com

Responsible for the content:
Dr. rer. nat. Stephan Middelkamp,
Andreas Huhmann

Editor Vogel: Sebastian Human

Editorial team HARTING: Volker Uphoff,
Norbert Weiß, Andreas Wedel

Responsible in the sense of the Press Law:
Christian Gysin, Julian Fieres

Overall coordination:
Lars Kühme, +49 5772 47-9982

Design and layout:
trio-group I.AM communication & marketing GmbH,
www.trio-group.de

MIX
Paper | Supporting responsible forestry
FSC® C023618

Production and printing: Meinders & Elstermann GmbH & Co. KG, Belm

Complete reprints and excerpts of contributions are subject to approval in writing by the Editor. All product designations used are trademarks or product names belonging to HARTING Stiftung & Co. KG or other companies.

Despite careful editing it is not possible to completely rule out printing errors or changes to product specifications at short notice. For this reason HARTING Stiftung & Co. KG is only bound by the details in the appropriate catalogue. Printed by an environmentally friendly method on paper bleached entirely without chlorine and with a high proportion of recycled paper.

© 11/2026, HARTING Stiftung & Co. KG, Espelkamp. All rights reserved.

pictures

P. 1: Getty Images 528412509 / 2278846973, Magnific | P. 2: HARTING, Magnific, Getty Images 1594795238 | P. 4/5: Magnific, HARTING, Getty Images 1362788811 / 2233827796 / 173553965 / 2147572771 / 2279893310 / 187433894, Hitachi Energy | P. 6/7: Magnific, Getty Images 1479935086 / 624496774 / 624494608 / 1302936686 / 2253248294 / 2178345065 | P. 8/9: Magnific | P. 10/11: Magnific, HARTING | P. 12/13: Magnific, Dr. Hans Krattenmacher / SEW Eurodrive, Getty Images 2255198864 / 1362788811 / 2233827796 | P. 14/15: Magnific, Getty Images 2255198864 / 1813860881 / 2232527732 / 2269479967 / 1362788811 | P. 16/17: Prof. Dr.-Ing. Eva Schwenzfeier-Hellkamp /Hochschule Bielefeld, Getty Images 1167786035, Magnific | P. 18/19: Shutterstock 2616045613, Getty Images 2246003613, Mikael Hjorth /Electrification Hub Sweden, HARTING | P. 20/21: Maximilian Schmitt /Reverion, HARTING, Getty Images 1465224168 / 2147572771, Magnific | P. 22–25: Pascal Daleiden /Hitachi Energy | P. 26/27: HARTING, Getty Images 173553965 / 646262136 | P. 28/29: Getty Images 2279893310, HARTING, Magnific | P. 30/31: HARTING, Magnific | P. 32/33: Johannes Wilhelmer/Stadler, Manuel Weber /NAH.SH, Getty Images 187433894 | P. 34/35: Magnific, Dr. Tim Meyer, Getty Images 187433894 | P. 36/37: Dr. Anica Mertins /Nationale Leitstelle Ladeinfrastruktur, Getty Images 1473297684 / 1159772967 / 1370725472, Shutterstock 2800350645, NOW GmbH, ADAC | P. 38/39: Shutterstock 145410097 / 2840500661, Getty Images 2225537703, HARTING | P. 40: HARTING

DISCOVER

FUTURE-PROOF CONNECTIVITY

HARTING

Pushing Performance
Since 1945



FUTURE-ORIENTED SOLUTIONS

Design your systems sustainably with connectivity for electrification, digitalisation and automation.

www.HARTING.com

Discover now!