CWIEME
BERLIN

Electrical engineering's green revolution

Sustainable practices in electrical engineering

Chris Lee – Portfolio Director (HYVE Group):
The electrical engineering industry is undergoing a significant transformation, driven by the urgent need for sustainable practices and the global push towards Net Zero emissions by 2050. As we navigate this pivotal moment, it is more important than ever to understand the challenges and opportunities that lie ahead.

With rising energy prices, stringent regulatory requirements and increasing consumer demand for transparency, the industry faces substantial hurdles. Yet, these challenges also present unparalleled opportunities for innovation and growth.

Engineers are at the forefront of designing systems that reduce waste, optimise energy use and incorporate renewable energy solutions. The insights provided in this report aim to equip professionals with the knowledge and strategies needed to drive sustainable practices within their organisations.

By exploring cutting-edge technologies and sustainable design principles, this report offers a comprehensive overview of how electrical engineering can contribute to a greener future. We invite you to read on and discover the transformative impact that sustainable engineering practices can have on our industry, and the planet.

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NO COPPER, NO NET ZERO

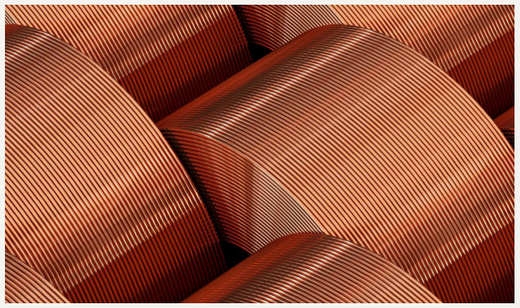
The role of nature's greenest metal in the energy transition

Achieving Net Zero by 2050 essentially means completely phasing out fossil fuels in under 30 years. We can't do that without copper, say Bruno De Wachter and Fernando Nuño, representatives of the International Copper Association and members of the advisory board of CWIEME Berlin. Here they discuss the challenges facing our relationship with this ancient metal.

Our history with copper

Humanity's history with copper goes back around 10,000 years. Neolithic peoples first used native copper in tools, weapons and decorative items, and smelting of copper kicked off the Bronze Age about 5,000 years ago. The Romans mainly sourced it from Cyprus, calling it aes cyprium, 'metal of Cyprus'. This subsequently became cuprum, the origin of the English word copper.

In Roman times, copper was predominately used in the empire's coins and to make brass for specialised uses like ornaments and some aspects of plumbing and architecture. Today however, more than two thirds (70 per cent) of modern copper production is earmarked for electrical applications. Copper is involved at every stage of the electricity system: generating it, transferring it, and using it.



Why copper?

On the journey to Net Zero, electricity is our main tool, and the backbone of our electrical system is copper.

Copper is the second most conductive known metal after silver, and more conductive than gold, but the scarcity and price of these two precious metals make them unsuitable for the millions of tonnes required for a global energy network. Copper's physical properties, such as its ductility and resistance to corrosion make it ideal for countless components like cables, connectors, and coils. Finally, it's the 25th most abundant element in Earth's crust and it can be recycled without any significant loss of quality.

Copper's unique properties solidify its position as the essential material for electrification, the energy transfer system that underpins humanity's path to Net Zero.

More power, faster

As electrical infrastructure develops and standards of living improve around the world, we'll naturally need more megawatts of power to meet demand.

But a side effect of the green energy transition is that each megawatt of electricity end use will be more copper intensive than fossil fuel alternatives.

The main reason is that renewable electricity generation is much more dispersed than conventional thermal generation from fossil fuels, making it more material intensive. For example, each wind turbine of 1 to 5 MW has its own generator, while a coal fired thermal power plant has one generator of typically 400 MW. A more dispersed generation also means that the grid for transferring electricity from where it's made to where it's needed must expand.

In addition, generating electricity from sustainable sources is often weather-dependent.

While coal can burn nearly 24/7, wind power needs a consistent breeze and solar power only works during the daytime. To compensate for natural low-output periods, we'll need extra production capability and storage to keep up with demand, meaning more copper for renewable energy systems. This is another reason why we need a stronger grid: the better all sites of generation and consumption are interconnected, the easier it becomes to tap the electricity from where it is available at that moment.

Generation is one thing, but Net Zero means decarbonising energy at the other end of the chain too: the end user. Carbon-free end-use energy on the roads, for instance, means more electric vehicles, but each requires 2-3 times more copper than an internal combustion engine powered vehicle.

Clean electricity will be the largest consumer of copper by 2040, but copper is also used for some of the non-electrical systems that aid the transition to Net Zero. For example, as an excellent thermal conductor, copper is often used in heating and cooling systems, such as those found in heat pumps, which are playing a major role in reducing fossil fuel use for heating.

Finally, the quest for energy efficiency itself is copper intensive. According to Joule's law, energy lost as heat in an electrical wire is proportional to resistance and resistance is inversely proportional to wire diameter — so the thicker a copper cable is, the less energy is wasted as heat and therefore the more efficient the system is. This includes the windings of transformers and electric motors. Essentially, the more copper we use in each application, the more energy we save.

Is there enough?

The International Energy Agency has published two scenarios for future copper demand.

The Stated Policies Scenario (STEPS) is based on what governments have already pledged to do, and the more aggressive Sustainable Development Scenario (SDS) is based on reaching Net Zero by 2050. Both scenarios see annual copper demand increasing to 40 Mt by mid-century (from around 26 Mt nowadays), either in 2050 for STEPS or 2040 for SDS.

Does Earth has enough copper to meet our requirements?

Considering these lofty figures, it is natural to wonder whether Earth has enough copper to meet our requirements. The short answer is yes. Enough resources exist to support the energy transition and meet society's needs. The question is whether we can extract that copper quickly enough to align with STEPS or SDS.

Primary copper production currently sits at 22 million tonnes (Mt) annually. Together with 4 Mt of recycled copper, this meets current demand of 26 Mt. Demand has grown by about 3.3 per cent per year for over a century, doubling about every 30 years. In the past, the drivers for copper demand were population growth, electrification deployment and electricity usage. Today, it is the green energy transition and improving global standards of living. **At present, we have about 41 years' worth of copper reserves** — copper in the ground at operational mines — and up to 250 years' worth of predicted, but currently unexploited resources. Surprisingly, the number of years' worth of copper reserves has been roughly the same for decades. Just like with oil, the scarcer it becomes, the more effort goes into finding more.

Other materials

It may be possible to reduce our reliance on copper by developing alternatives such as aluminium. Aluminium is about three times lighter than copper, so might be advantageous for use in electricity overhead lines, for example. On the other hand, in space and weight constrained applications, the increased volume of aluminium and surrounding structure required to provide the same functionality as copper makes it unsuitable.

Another area of research is graphene, which is also three times lighter than copper but more than twice as conductive and made from carbon, which is ten times more abundant. It's promising, but the uses of graphene in the electrical industry is a field currently dominated by research and it will likely be decades before graphene becomes a mainstream alternative to copper. If growth continues at historical rates and copper production increases in line, as it has done for over 100 years, there's nothing to be concerned about. Meanwhile, changes in the way we produce copper are being introduced.

Low impact production

It's essential that we maximise copper recycling to keep secondary copper in circulation. Electrical copper's properties, such as purity, favour recycling and doing so is much less impactful than mining. However, current recycling of pre- and post-consumer scrap (10 Mt) provides just a third of today's demand and a fifth of 2040's SDS. Furthermore, post-consumer scrap only becomes available after the lifespan of the equipment has passed, around 30 years for a transformer, for instance.

Green copper

For now, at least, mining existing resources for primary copper is essential. In fact, without mining there can be no Net Zero. While zero impact mining is impossible, mining must be responsible — a careful balance of economic, environmental, political and social challenges.

In some cases, that balance is hard to strike, as evidenced by the closure of one of the world's largest open-pit copper mines in late 2023. In response to nationwide protests ranging from environmental concerns to corruption suspicions, Panama's top court ruled that Canadian miner First Quantum Minerals' contract at Cobre Panama was unconstitutional and forced it to shut down operations at the mine. The site in Donoso employed 7,000 people, accounted for around five percent of Panama's gross domestic product and one per cent of global copper output.

International collaboration and sharing of ideas and expertise at events like CWIEME Berlin, help the industry collaborate and do its part to maximise the benefits of copper use and reduce the environmental impact of copper production.

For example, 0.2 per cent of global carbon emissions come from the production cycle of copper, from mining to refining and production. While this is much less than the emissions copper helps prevent, the members of the International Copper Association have committed to the ambition of reaching Net Zero for Scope 1 and 2 emissions by 2050. Or consider The Copper Mark, an industry-wide standard to encourage the responsible production, sourcing and recycling of copper and other critical metals. Based on 32 indicators, the certification is designed to cover social and environmental themes, from social engagement and prevention of child labour to responsible use of water and management of resources.

Humans have been using copper to make life better for thousands of years and, with the right approach, we can continue using it for thousands more — perhaps its greatest era is still to come.

Q&A

At CWIEME Berlin 2024, Saqib Saeed, Chief Product Officer at PTR Inc spoke with representatives from academia and industry to discuss the need for electrification. The panel explored the challenges posed by these transformations and highlighted strategies for seizing opportunities through collaboration and innovation.

What are the top two challenges that you think our industry is facing today?

Frédéric Beghain, General Manager, Region 9, Europe and World Chapter EASA (Electrical Apparatus Service Association Inc): The two main challenges right now are centred around people and training. We have a lot of business and we could do so much more, but we are limited by the number of people.

Our industry is becoming increasingly sophisticated with the advent of new technologies. It is crucial to ensure that our workforce is properly trained to deliver these advanced services effectively. This need spans all levels. It's not just about engineers.

At this stage, this shortage is a significant threat. If we fail to address these issues, the gap will inevitably need to be filled, possibly by alternative solutions. For instance, artificial intelligence presents a major opportunity for us to enhance service delivery.

The average age of people working in our industry is currently between 47 and 50 years, which is quite concerning. This issue affects the entire industry, not just the service sector and requires a global approach.

Moreover, the electrification rate currently represents only 20-25 per cent of the energy mix. By 2050, this is expected to rise to 50-60 per cent. It took us 100 years to reach 25 per cent and now we are tasked with doubling that in just 20 years. This is a significant shift and underscores the immense opportunities within our industry.

Saqib Saeed: People often only understand the importance of these issues when they become critical. We saw this with the transformer shortage in the US. The lack of available transformers led to delays in numerous projects. With advancements in the data centre industry, there's now growing concern about energy and transformer availability. Statements from companies like Meta and Tesla highlight that while computational power may not be an issue, energy supply and transformers are becoming critical constraints. This urgency underscores the importance of transformers in keeping everything operational.

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Since the future workforce will come from academia, what's your perspective on addressing these challenges?

Dr. Pawel Rozga, Associate Professor, Vice-Director of Development at the Institute of Electrical Power Engineering Lodz University of Technology: From the perspective of academia, we observe the same issue when cooperating with industrial practices and even when seeking new university employees. There's a noticeable shortage of people interested in electrical and mechanical engineering.

Many young people might opt for different paths when they realise the effort needed to become an expert engineer. The challenge is how to demonstrate to them that careers in electrical or mechanical engineering can be fascinating and rewarding. We need to engage with young people at ages 12, 14, or 15 to show them the exciting and fulfilling opportunities that engineering careers can offer.

And when we talk about collaboration between academia and industry, what role do you think this partnership can play?

PR: I consider myself fortunate to have strong co-operation with industrial partners. Our PhD students frequently tackle real problems from the industry, which greatly enhances their learning experience. However, when it comes to undergraduate students aspiring to become engineers, this collaboration needs to be even stronger.

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It's essential to invite industry partners to universities to promote their vision of career development. This serves as a gateway for students to understand the practical applications of their studies and the opportunities available to them. Additionally, engaging industry partners in creating the curriculum for engineering courses would ensure that the education provided is relevant to industry needs.

You also spoke about the lengthy process of changing curriculums. What's the immediate solution to address this problem? Given the fluctuating demand for certain skills, what can we do in the short term to attract engineers to this industry while we work on long-term solutions?

FB: Currently, we're seeing a rise in learning management platforms within our association and across the internet. These platforms are crucial for young engineers, enabling them to continue their self-directed learning while they advance in their careers.

However, one thing that surprises me is the lack of unified effort in our industry to attract more candidates to engineering studies. Despite the potential of platforms like TikTok and other media, which we are now investing in to promote our mission, there remains a need for broader industry collaboration and strategic advertising.

Moving forward, we need a coordinated approach akin to a Marshall Plan to tackle pressing issues like climate change and resource management. This requires consistent focus and strategy, ensuring that investments and efforts are aligned towards meaningful progress rather than sporadic initiatives.

SS: Using a mix of both modern and traditional platforms to broadcast this message ensures broader reach and engagement. It's about showcasing that involvement in this industry isn't just about a job — it's about being part of a historic shift that could reshape the future.

FB: We've recently begun investing in videos and conducting interviews with the younger generation. What we're finding is a stark contrast between managerial perceptions and the actual needs of younger individuals. Taking the time to understand what attracts them and how they prefer to engage with potential employers has been eye-opening.

PR: It's clear that for us to excel, we must unite. This means fostering collaboration across all sectors — academia, industry, utilities and manufacturers. By working together, we can amplify our message and achieve greater strength and impact collectively.

Moving on to the next topic, we need to address the challenges in the supply chain. Recently, we've witnessed significant issues and there are projections suggesting a potential decline in electrification within sectors like transformers and the broader legacy market. How do you foresee these challenges impacting the industry over the next decade?

FB: It's evident that the industry is grappling with significant supply chain challenges, particularly highlighted by last year's copper shortages and price spikes in the US. A key presentation emphasised that while copper itself is available, the bottleneck lies in the lead time required to bring it to market for new projects.

I was pleasantly surprised by an insightful presentation on recycling, which resonates deeply within the repair and maintenance sector I belong to. Many members were unaware of the viable solutions available for reusing copper from motors and reintroducing it into the supply chain.

Logistically, there's also a positive trend towards purchasing second hand motors, driven by the unavailability of new ones due to various factors, such as last year's Suez Canal crisis.

How do regulations impact the overall equation? Do you see them as a challenge?

PR: I believe that regulations present a significant challenge for our field. This challenge extends beyond mere regulatory impact to include its effects on our digital environment and our broader area of concern. It's crucial not only to navigate through these regulations but also to engage with standardisation commissions and the European Union effectively. We must educate people about the importance of these regulations and how they contribute to improving our future quality of life.

Another critical aspect is the impact of regulations and standardisation on the creation of new standards. I believe it's essential to have independent members, such as those from universities or similar institutions not affiliated with manufacturers or utilities, involved in every standardisation commission.

FB: Firstly, I want to emphasise our immersion in the era of data collection. As we accumulate vast amounts of data, it's natural to derive insights and explore the development of standards around this data, particularly concerning the performance of machinery and other systems.

It's essential to recognise that regulations exist because we operate within an industrialised and international business environment. It's beneficial to remind stakeholders of the foundational aspects related to regulations and emphasise their benefits before delving into critiques. The European Union, for instance, aims to foster a unified market of 430 million people where clarity and mutual understanding prevail.

While leveraging support from independent authorities such as universities could enhance understanding and implementation, there's a fundamental positivity in regulations that our industry should increasingly embrace.

SS: There are two distinct perspectives to consider, particularly in the realm of e-mobility. A clear example is the standardisation of charging ports. For years, the existence of competing standards sparked concerns about confusion among installers, consumers and other stakeholders. The lack of a unified standard was seen as potentially detrimental to the industry.

However, this situation also spurred healthy competition. Some argue that it's acceptable to introduce a partially developed product or idea because it allows for iterative development. On the other hand, there's a contrasting viewpoint that insists on the necessity of a well-defined standard from the outset.

In the United States, the recent adoption of the NACS standard (National North American Charging Standard) exemplifies this debate. This transition highlights the evolution and eventual convergence within the industry, despite initial competition and divergence in standards.

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PROPELLING E-MOBILITY FORWARD

For years, the idea of harnessing motorways to power battery electric vehicles (BEVs) through a magnetic field has tantalised researchers. Even as BEV technology advances, the reality remains that EV systems continue to rely on static recharging. Yet, the winds of change are stirring.

Here Nicola Acampora, Head of Sales at Hyve Group, organiser of CWIEME Berlin, the leading event for the electrical engineering community, explores dynamic wireless charging — poised to transform transportation and fast-track the transition to electric mobility.

Electric mobility has been on the rise for years, and the promise of a sustainable, environmentally friendly future hinges on its success. Electric vehicles have made remarkable progress in recent years, but one of the persistent challenges has been the inconvenience and time-consuming nature of recharging.

Traditional charging stations necessitate stopping and waiting, which can be a deterrent to potential EV adopters.

This inconvenience has often been cited as one of the barriers to the mass adoption of electric vehicles. Also cited as a key factor against switching from combustion engines is "range anxiety". Difficulties recharging electric cars meant **more than half (52 per cent) of car owners surveyed by the Opinions and Lifestyle Survey between 22 September and 3 October 2021, were not likely to switch to electric in the next decade, due to a lack of infrastructure, such as charging stations.**

However, dynamic wireless charging technology has emerged as a game-changer in the world of electric mobility. Imagine a world where electric vehicles seamlessly recharge as they cruise down the motorway, with no need to plug in, wait or even slow down. **By embedding copper coils beneath the road surface, we have the potential to eliminate range anxiety** and the need for frequent stops to recharge.

Simple but extremely impactful

The concept behind dynamic wireless charging is remarkably simple but extremely impactful. Electric vehicles would be equipped with receiving coils, and motorways fitted with transmitting coils. As the EV travels over the transmitting coils embedded in the asphalt, a magnetic field is generated, inducing an electric current in the receiving coils on the vehicle.

52%

of car owners were not likely to switch to electric

This current charges the vehicle's batteries while it's in motion, making the entire process seamless and effortless. Not only is this magnetic-resonance-charging technique practical for EV drivers, but it also generates a grid-to-battery efficiency of up to 94 per cent — the same as a wired connection.

One company, Electreon, an Israeli innovator in the field of wireless electric vehicle charging, has begun to put this idea into motion. Electreon started a pilot programme in Gotland, Sweden in December 2020, for its dynamic wireless charging technology. So far, this has proved successful, as the copper embedded under the asphalt managed to power a 40-tonne truck along the test section of the road.

Significantly, this year the company broke the world record for the longest time and distance ever driven by a passenger electric vehicle. **The world record involved a 100-hour non-stop demonstration, during which the vehicle drove 1,942 km as it charged from Electreon's proprietary Wireless Electric Road technology.**

The aim for Electreon is to make EV charging more convenient, especially for public transportation and commercial fleets. The dynamic wireless charging technology eliminates the need for lengthy recharging stops and contributes to cleaner urban air.

While dynamic wireless charging presents an exciting opportunity for electric mobility, challenges remain. Infrastructure development and standardisation are critical hurdles that must be overcome.

The costing of the initial investment is a hinderance, with an estimation of millions of US dollars being needed for a single kilometre of road to be fitted with copper coils. The disruptive nature of the installation of the copper under the road surface would cause many road closures, as well as the maintenance once its installed. On top of this, heavy traffic and extreme weather conditions could affect the durability of the embedded infrastructure leading to maintenance concerns and expenses.

Another potential obstacle is the health and safety aspects of the technology. Some have raised concerns about prolonged exposure to a high electromagnetic field, however, scientific studies have shown no conclusive evidence of this causing any harm.

Nevertheless, with innovation and investment, these hurdles can be addressed, and **we can pave the way for a more sustainable and convenient future.** CWIEME Berlin, which is held at Messe Berlin from May 14-16, 2024, plays a crucial role in fostering discussions, collaborations and innovations in the field of e-mobility. The dynamic wireless charging concept is a testament to the ingenuity of engineers and researchers, and it highlights the potential for groundbreaking advancements in the industry.

No longer a distant dream

As we move forward, we should embrace the promise of dynamic wireless charging with enthusiasm and support further research and development in this area. The vision of electric vehicles charging on the go is no longer a distant dream, it's a reality that's within our grasp. **With dynamic wireless charging, we're not just driving towards a cleaner future, we're accelerating towards a more convenient and sustainable tomorrow.**

To learn more about innovations in the electric vehicle industry
head over to the **CWIEME Berlin website,** where we facilitate a platform for industry experts to share their knowledge and solutions to an international audience.

Q&A

At CWIEME Berlin 2024, a distinguished panel of professionals from diverse backgrounds in geography, sectors, and experience gathered to discuss the pivotal role future engineers can play in shaping a greener world and mitigating greenhouse gas emissions.

The experts shared insights and strategies aimed at empowering the next generation of engineers to drive sustainable innovations and foster environmental stewardship on a global scale.

What are the main technological challenges that you see in the future?

Dr. Carlos Abomailek, Electrification Initiative Program Leader at Syensqo: From my perspective, the primary technological challenges facing us in the future revolve around two key areas. Firstly, achieving clean transportation for both people and goods is critical not only for reducing global carbon emissions but also for creating healthier and more liveable cities worldwide. This goes beyond environmental conservation; it's now a necessity for improving urban quality of life.

Secondly, another significant challenge is leveraging AI systems to boost productivity in a world where populations are declining. AI isn't just about automation; it's about empowering societies to maintain or even enhance their quality of life with fewer people. This technology plays a crucial role in ensuring sustainable economic growth and societal well-being.

Lastly, addressing and reversing environmental pollution remains a vital challenge. This involves developing innovative solutions to clean up and restore our natural environments, ensuring a sustainable future for generations to come.

John Morehead, Principal Consultant at Motion Mechatronics LLC: Most major corporations are planning significant reductions in their carbon footprint over the next 25 years. This shift will impact all of us in our work environments, as we will likely be involved in projects aimed at reducing carbon emissions. It's important for each of us to consider how we can contribute within our organisations by suggesting meaningful changes to help achieve these goals.

This transition presents a tremendous opportunity for the development of innovative technologies and new products geared towards reducing carbon emissions. This emerging market is poised to grow rapidly, offering exciting prospects for those who engage in driving this transformative change.

Therefore, it's crucial for us to actively participate in and contribute to these efforts. By doing so, we can not only align with the evolving priorities of our organisations but also play a significant role in shaping a more sustainable future.

Professor Thomas Norrby, Technical Manager & Senior Specialist - Lubricants and Electrical Industry at Nynas AB: One key piece of advice for both the current and younger generations is to prioritise actionable solutions with high technology-readiness that can be implemented effectively. There are already numerous examples of products with lower carbon footprints that demonstrate the potential for immediate impact. It's crucial to expedite these solutions into the market as quickly as possible.

It's also important to seek scalable solutions that are already operational. While scientific development and innovation are essential, their true impact comes through industrial implementation and scalability. Achieving tangible results requires focusing on solutions that can be scaled effectively and efficiently.

Therefore, if we are serious about achieving meaningful results, the focus must be on implementing scalable solutions now, rather than waiting for hypothetical advancements in the future.

Ahmed Selema PhD, E-Motor Specialist at Ghent University: I believe sustainability presents one of our main challenges today. It goes beyond having clean energy sources to encompass adopting clean and environmentally friendly manufacturing and production techniques. Looking ahead, our focus should be on technologies that minimise material waste and improve the recyclability of materials.

For example, the recyclability of magnets and magnetic materials is crucial. While achieving high recyclability can be time-consuming, it's essential to prioritise materials that can be recycled more effectively compared to others. This approach is pivotal in our efforts to promote sustainability.

Therefore, a significant aspect of addressing sustainability involves not only advancing technologies with reduced environmental impact but also ensuring that materials used in these technologies can be recycled efficiently. This concerted effort will play a vital role in building a more sustainable future.

Prof. Thomas Norrby: Today's reality is that the demand for engineers and scientists is set to soar, driven by urgent challenges across energy, life sciences, biodiversity, food security, IoT, AI, space travel and more. It's a competitive race for talent, compounded by declining populations and student numbers. As an industrialist, it's clear: reaching out to and inspiring students is not just a necessity but an opportunity. If we fail to engage, we risk losing them to others who will shape the future. This is our wake-up call—to show students the transformative impact they can have. Yet, amidst these opportunities lies a profound challenge: the pivotal task of finding and retaining these skilled individuals. Without them, none of our ambitions in technology and sustainability will materialise.

Ahmed Selema: Manufacturability is currently a major challenge, especially as we strive for clean and efficient production processes. 3D printing exemplifies this shift. It's not just about adopting the technology, but mastering its application. At our institute, we leverage its flexibility — both geometrically and in material composition — to innovate beyond traditional materials like copper. By altering chemical compositions, we enhance material mobility and significantly reduce weight. This approach not only minimises material waste but also opens up myriad possibilities for advanced applications.

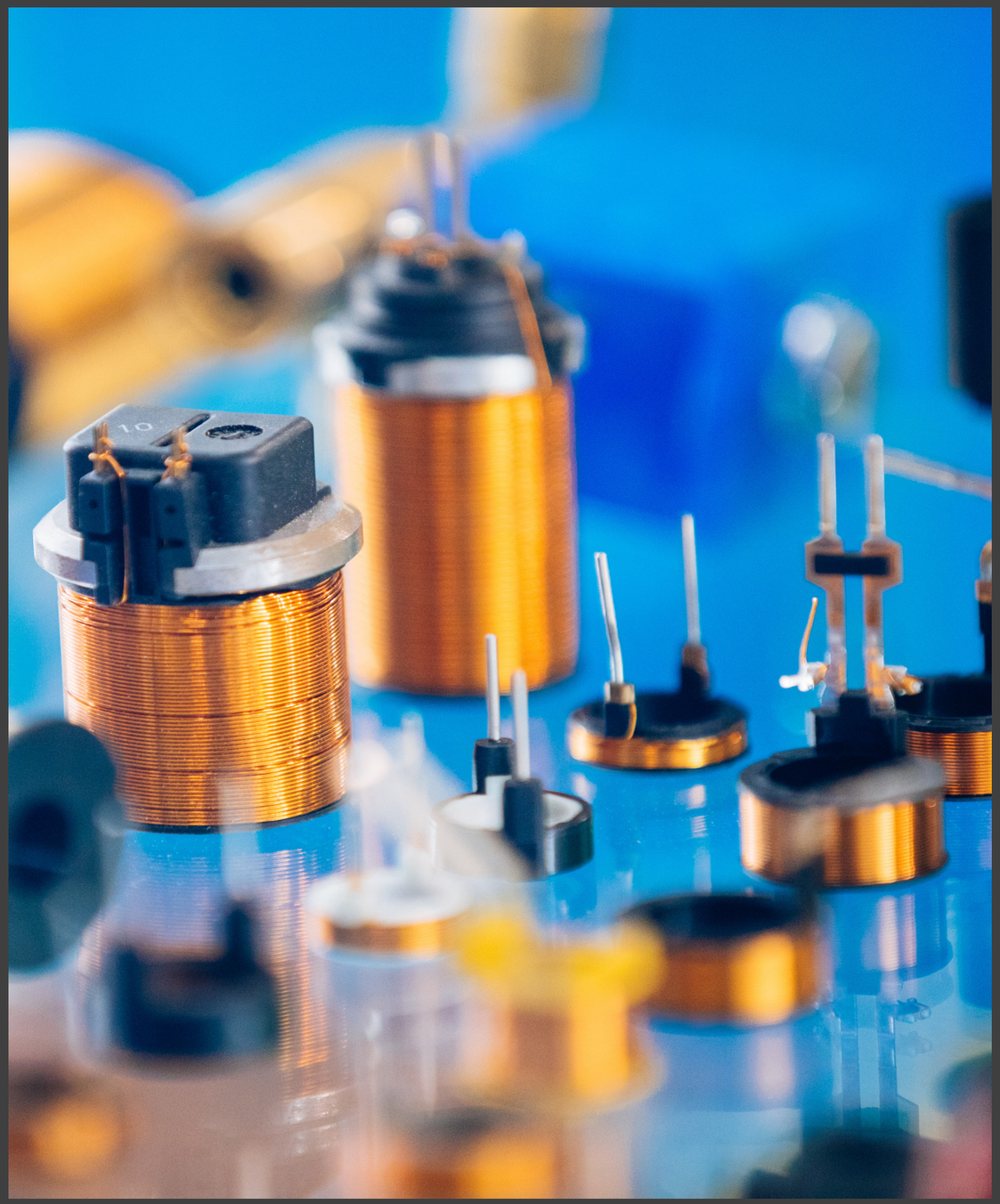
John Morehead: I believe this underscores the engineering challenges awaiting you, particularly in electrical engineering. We must shift towards a circular economy in our products and daily practices, moving away from the throwaway culture that leads to issues like fast fashion waste piling up on beaches. It's essential to focus on designing products for durability, repairability, refurbishment and reuse. These challenges in engineering, especially in electrical engineering, offer significant opportunities to influence the sustainability of our world.

Most of us have experience in research. Would you recommend a young engineer to spend some time doing research in university or research centres?

Prof. Thomas Norrby: I was fortunate to pursue a PhD in chemistry immediately after completing my undergraduate studies. For the younger generation, with potentially longer lifespans and retirement ages extending to around 75, there's ample time ahead. I strongly recommend investing in research and education as they equip you with invaluable tools. My journey started as an organic chemist and within five years, I transitioned into the lubricants industry and eventually became an associate professor in machine engineering specialising in lubrication science. This flexibility was possible because of my scientific training, which emphasises adaptability, as we discussed earlier.

I encourage young engineers to acquire tools that foster flexibility early in your career, akin to an evolutionary force enabling you to navigate diverse paths. Consider pursuing a double major or gaining varied experiences to broaden your perspective. While obtaining a PhD requires dedication and hard work, it demonstrates a crucial ability to commit to and complete significant undertakings.

This perseverance signals to employers that you can see tasks through to completion. It's essential to start something and commit to it for a substantial period, proving your capability not only to yourself but also to the world. Research and education will undoubtedly provide you with lasting value.



Carlos Abomailek: Years ago, I started a PhD in electrical engineering, even though it seemed like an old discipline at the time. It was a personal interest of mine and sometimes you have to pursue things that genuinely excite you, without overthinking the future. I completed my PhD in 2018, right around the time when there was a significant demand for engineers in the field of electromobility. At my company, most of us were not from the automotive sector; we came from various backgrounds like research, induction kitchen design and other design activities. This diverse mix highlighted the evolving landscape of engineering.

I believe anyone starting a PhD today will encounter similar opportunities. It's crucial to follow your passion because, with dedication and experience, opportunities will undoubtedly arise. Personally, I've never regretted pursuing a PhD.

We've shared our experiences, showing that we're just regular people who chose to study engineering and continue exploring throughout our lives. There's no secret formula or extraordinary background — just normal individuals like you. In the next five, ten, or 15 years, many of you will find yourselves in similar positions. It's a perfect time to consider delving into research. With potentially longer careers and lifespans than previous generations, this period offers ample opportunity.

As Thomas mentioned, the skills you develop through research are invaluable. It's not just about the specific research topics but about how you approach and solve problems — skills that will serve you well throughout your career, which will undoubtedly present its own set of challenges and opportunities. Now it's up to you to make your mark.

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What do you think the most important technology is and will be on our path to net zero?

Christina Losifidou: One of the critical technologies in our journey toward achieving net zero is ensuring that the grid is prepared to seamlessly integrate renewable resources. The development of grid infrastructure capable of efficiently accommodating and leveraging renewable energy sources will be pivotal in the transition toward a more sustainable and environmentally friendly energy system. This technology will play a vital role in realizing our net zero emissions objectives by facilitating the effective and widespread adoption of renewable energy.

Chris Gerber : Various industries and sectors will view this question, within their industrial ambit and respond differently. Industrial sectors differ. Depending on what product they manufacture and the significant importance of their product in the end product supply chain the answer may also further differ. Yash HighVoltage manufactures high voltage bushings. It is a leading player. The bushing industry is an industry that rapidly embraces the transfer from old to new technology. In the past Oil Impregnated (OIP) bushings had been the preferred high voltage bushing product in electrical generation, transmission and distribution infrastructure. There is a current shift, certainly in the developed world, driven by sustainability and a circular economy, to move into Resin Impregnated (RIP) bushings.

Caro Roeffen : So far the rising star in all markets is clearly the electric motor, powered by batteries or fuel cells. However, some needs are still met best with combustions engines. Each powertrain technology has advantages and disadvantages, and the specific use case determines the best option. Taking a technology-neutral approach to decarbonisation allows the industry to continue to innovate, offering customers a range of solutions to meet their needs best. This approach is key to achieve climate targets. Whether it is modern internal combustion engines, e-fuels, hybridization or electrification including fuel cells.

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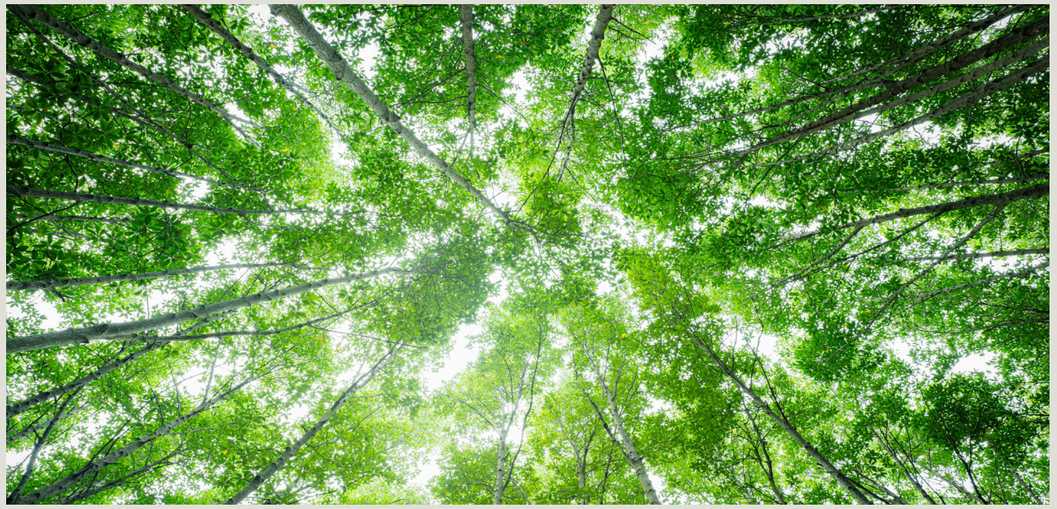
What is the main hurdle to reach this goal?

Oliver Florek: EC technology combines controllability, low noise, low power consumption, .. but is more expensive. A lot of companies are not willing the switch because of the higher price. Higher price means approx.. 30% compared to old motor designs.

Oliver Florek: In the transformer market, all solutions are very conservative and not state-of-the-art anymore. The engineers are not experienced with EC technology and concerns are high, because they must modify a system which they used for many, many years.



Christina Losifidou: A significant obstacle in achieving this goal is the requirement for substantial time, substantial investments, and, most importantly, partnerships across the entire value chain.

Chris Gerber: The current hurdle in terms of RIP bushings would appear to be supply chain related. Largely attributed to production capacity constraints within the bushing industry, resulting in long lead times, driving product availability limitations and bottlenecks resulting in an increase in product price. This constraint is currently impacting on the move towards and the roll out of sustainable carbon neutral electrical infrastructure required to ensure carbon neutrality and the e mobility. In contrast, the perceived older, but equally efficient technology ensures shorter lead times and better pricing with an equally impressive and sustainable life span of 15-20 years depending on operating conditions.

Caro Roeffen: Climate action is not just something that applies to the actual use of a technology, but from well to wheel. Therefore it is at least as important to consider what happens between well and tank. Optimizing engines will not be enough. The focus should not only be on the defossilisation itself, but also on the energy source. The fundamental premise of CO_2-free technology is energy production from renewable sources. For example, driving around without consuming energy will remain in the realm of fantasy, like the idea of a perpetual motion machine. Driving around without emitting CO_2 on the other hand, is within the realms of possibility.

How do CWIEME's values support you in attaining this goal?

Oliver Florek: We can explain and show EC Technology on fans and blowers to customers.

Christina Losifidou: CWIEME's values support me in attaining this goal by integrating sustainability into our supply chain. The transformer supply chain significantly contributes to greenhouse gas emissions, and CWIEME brings together the supplier base and provides a platform for collaborative discussions to drive decarbonization efforts forward. CWIEME's emphasis on innovation, collaboration, and sustainability is aligned with the imperative to develop and implement the grid infrastructure necessary for the integration of renewable resources and the attainment of net zero emissions.

Chris Gerber: CWIEME serves a broad supplier and end user base across multiple industries and sectors. The bushing industry forms part of the transformer supply chain. If one agrees that CWIEME supports the values of carbon neutrality and its transition, sustainability, and a circular economy, and aims to promote and create a platform for like-minded companies and industries then it is easy to answer. It is this platform that appeals to Yash HighVoltage, in not only tracking new technologies, but also show casing their sustainable and world class renowned and appreciated high voltage condenser bushing products manufactured to both IEEE and IEC standards.

Caro Roeffen: CWIEME offers a meeting spot for the whole world to come together and find the partners, suppliers and customers to create and market electric motor products. Selecting the right suppliers and developing the right product for the right application in the most climate-neutral way is key.

WATT'S NEXT?

The electric motor industry stands at the cusp of a revolution, with technological advancements poised to redefine efficiency and functionality in radical ways.

From the whir of household appliances to the humming engines propelling electric vehicles (EVs), electric motors are an integral part of our daily lives. Here, John Morehead, principle consultant at Motion Mechatronics and advisory board member at CWIEME Berlin, explores the significant trends that are not only reshaping the automotive industry, but are also forging an environmentally sustainable path forward.

For the past decade, the EV market has been on the rise

Statistics show that by the end of 2024, over **25 per cent of all new passenger car registrations will be electric,** and sales figures tell a similarly electrifying story — the global EV market, valued at £291.5 billion in 2023, is projected to more than double to £714.9 billion by 2030.

While this exponential growth is certainly noteworthy, I believe we're merely in the initial chapter of the EV revolution. With continued government incentives fuelling consumer adoption and advancements in electric motors promising both longer ranges and lower costs, the following trends are poised to accelerate significantly in the coming years.

Navigating rare earth magnet dependency

Rare earth magnets have long been a staple in electric vehicles, occupying a substantial 80 per cent market share. These magnets, typically made from neodymium (NdFeB) and other rare earth elements, reside within the motor, and create the rotating magnetic field that drives the car. Their strength allows for compact and efficient motors, maximising battery range and vehicle performance. However, the reliance on rare earth elements presents a challenge. Currently, these rare earth elements are sourced from a single country, and concerns have been raised about the sustainability and environmental issues stemming from mining and processing this element, as well as supply chain security.

Despite these challenges, researchers and companies worldwide are actively trialling rare earth-free alternatives. Take Niron Magnetics as an example, who are manufacturing Iron Nitride-based, "clean earth" magnets. Iron nitride boasts significant environmental benefits — iron and nitrogen are readily available elements, unlike neodymium, which relies on potentially harmful mining practices. Additionally, iron nitride's lower cost can translate to more affordable EVs and offer better temperature stability — a crucial factor for performance and longevity.

From stators to batteries

Less well-known but equally promising is niobium, a metallic element making significant strides in the EV industry. Unlike traditional motor stators made from silicon steel, niobium has the potential to be transformed into nanocrystalline soft magnetic materials. These advanced materials boast superior magnetic properties, leading to significantly reduced eddy current losses within the stator.

Early research suggests its unique properties could pave the way for the development of next-generation battery materials, potentially leading to batteries with higher capacity and longer lifespans.

In axial flux motors — a design gaining traction for its compactness and efficiency —niobium-based stators could potentially improve overall motor efficiency, translating to a longer driving range on a single charge. Companies like CBMM and WEG are at the forefront of this exciting development, pioneering the use of niobium in motor construction. The partnership's experimental validation tests proves the benefit: nanocrystalline material containing niobium slashed motor total losses by an impressive 53 per cent. This translates to a significant 6.7 percentage point increase in efficiency compared to the same project built with traditional silicon steel.

Their efforts hold the promise of not only more efficient motors, but also potentially lighter ones due to niobium's lower density compared to silicon steel.

The positive impact of niobium research may even extend beyond motors. Early research suggests its unique properties could pave the way for the development of next-generation battery materials, potentially leading to batteries with higher capacity and longer lifespans.

The industrial potential of 3D printing is shaking up the traditional method of motor stator production, where thin steel sheets are meticulously stacked and laminated. This innovative approach promises a new era of manufacturing efficiency and design flexibility.

Unlike the limitations of traditional methods, 3D printing offers the ability to create complex internal geometries within the stator core. This opens doors for optimising magnetic flux paths, potentially leading to significant improvements in motor performance and efficiency. Furthermore, 3D printing allows for creating intricate stator configurations not possible with laminations for potentially enhanced performance or efficiency.

However, the benefits extend beyond the final product. 3D printing offers a more streamlined production process compared to traditional methods, potentially reducing waste and production time. This flexibility could revolutionise the entire supply chain, enabling on-demand manufacturing and localised production closer to assembly facilities.

The algorithmic advantage

The integration of deep learning and AI into the design process development marks a significant shift in how motors are developed and optimised. Traditionally, motor design relied on engineers balancing various factors like efficiency, power output and size constraints.

However, AI has introduced a powerful new partner to the equation. By harnessing the capabilities of AI algorithms, manufacturers can now analyse vast amounts of data related to motor performance, thus allowing AI to identify complex relationships and patterns that might elude human engineers.

However, the impact of AI on motor design goes beyond mere analysis. By leveraging its processing power, AI can act as a virtual design assistant by optimising motor configurations for specific applications. This translates to the creation of EV motors with unparalleled levels of efficiency, power output and performance. Imagine motors tailor-made for a specific driving style or vehicle type, maximising both range and power delivery — the possibilities are vast. Furthermore, AI can continuously learn and improve its design capabilities with each iteration.

The rise of the machines

Robots and other automated systems are rapidly replacing manual tasks, ushering in a new era of efficiency and reliability. Studies by the International Federation of Robotics (IFR) show a 11 per cent average annual growth rate in industrial robots installed globally between 2015 and 2021.

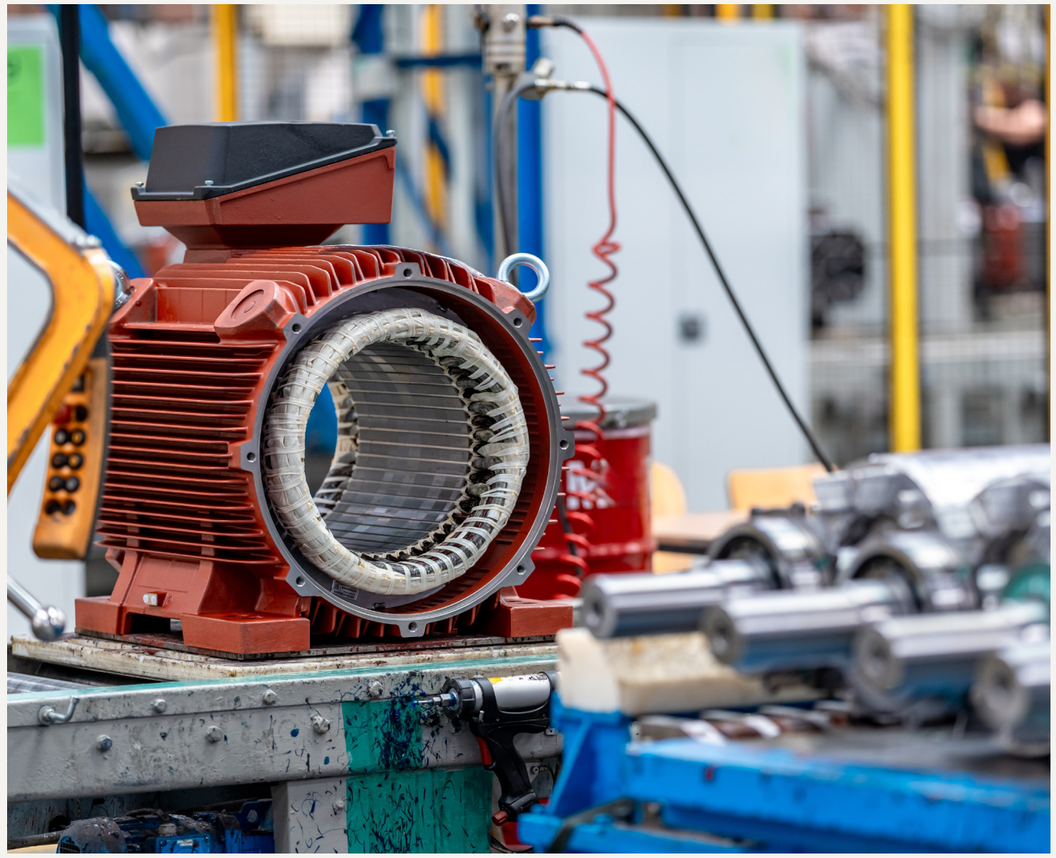
This trend is only going to continue, particularly within the EV motor industry.

Automation offers several key advantages. Robots can handle repetitive tasks with unmatched precision, minimising human error and ensuring consistent quality in motor component fabrication — a McKinsey report estimates that automation can potentially reduce defect rates by up to 90 per cent, leading to a significant improvement in motor reliability. Furthermore, automation allows for faster production cycles, enabling manufacturers to meet the ever-increasing demand for electric motors driven by the growth of the EV market.

A future electrified

Taken together, these emerging trends – from groundbreaking magnet materials to the intelligent power of AI and the precision of automation – paint a transformative picture for the electric motor industry. This confluence of innovation signifies a powerful shift towards a future characterised by three pillars: increased efficiency, unwavering sustainability, and relentless innovation.

Taken together, these emerging trends – from groundbreaking magnet materials to the intelligent power of AI and the precision of automation – paint a transformative picture for the electric motor industry. This confluence of innovation signifies a powerful shift towards a future characterised by three pillars: increased efficiency, unwavering sustainability, and relentless innovation. For industry leaders and stakeholders, the path forward demands a collective embrace of these advancements. By pushing the boundaries of what's possible, we can ensure the electric motor industry remains on a progressive trajectory, paving the way for a more sustainable and electrifying future of e-mobility.



To learn more about innovations in the electric motor industry
head over to the **CWIEME Berlin website**, where we facilitate a platform for industry experts to share their knowledge and solutions to an international audience.

Q&A

Highlights from the women in engineering panel at CWIEME Berlin 2024

The electrical manufacturing industry is dynamic and has experienced wide disruption and progression over the last decade. Rising global trade disputes and geopolitical tensions are increasing costs and cutting margins. At the same time, the regulation forcing decarbonisation is disrupting existing business models and demanding immediate capital investment.

Why are you passionate about empowering women?

Irem Unlu Demir, Head of Power, Global Key Accounts, Shell:
Turkey has a very patriarchal culture, and the field I chose was heavily dominated by men, so I began my career as part of a minority. However, it wasn't just gender that posed challenges — age and educational background were significant hurdles as well. In my education, I was taught not to speak up, question or challenge, because my teachers were considered the ultimate authorities. This background made it difficult to challenge superiors in the workplace.

My first job was at a company in Istanbul, the largest privately owned company in Turkey at the time. Despite its size, it was steeped in local cultural norms. No women held senior leadership roles and the company chairman only communicated with people one level below him.

This changed when I joined Shell in 2002. The cultural shift was immense, moving from a local company to a multinational corporation with a strong focus on diversity and inclusion. To my surprise, in my first week at Shell I was asked to present at an event in Italy in front of nearly 200 colleagues. I remember terrible stage fright, but the support from the audience was overwhelming.

In 2003, shortly after joining Shell, I was appointed as the crude oil trader for the North Sea in London. This was a significant risk for the company, as I had no prior experience working abroad. Yet, they trusted my performance, which underscores the importance of taking risks and trusting employees.

After my assignment in London, I returned to Turkey and became the supply director for Shell subsidiaries there. Over 90 per cent of my team and peers were male. During my tenure, I transformed the team to be 50 per cent female, inspiring other subsidiaries to follow suit.

Organisations like Shell, which truly walk the talk and make diversity and inclusion more than just concepts, take real steps towards change. As individuals, sharing our experiences is crucial. If I can help accelerate any woman's career, support them with coping strategies for their struggles, or positively impact their lives, it makes me a happier, more content person.

Have you ever experienced a challenge with a person in leadership who has not valued diversity and inclusion?

Javiera McGuiggan, Assistant Vice President, Global Business Leader, Cargill BioIndustrial – Power Systems: Sadly, yes, but I'm passionate about sharing this message because it's important to understand that these issues still exist. Even at my level as a global director of a very successful business, I had a boss who wanted to control every aspect of my work. He insisted on reviewing every email and forbade me from speaking to his colleagues without his approval. He wanted to be the sole messenger, which went beyond micromanagement — it was complete control.

This experience taught me that assuming we've made progress simply because women hold certain positions is a mistake. It's easy to tick the box and say, "We have X percent of women" or "We have women in leadership." However, if you place such controlling leaders on top, you undermine the essence of diversity.

> Diversity aims to bring different voices and opinions to the table. If women aren't given the authority to make decisions or have a fair say, the purpose of diversity is nullified.
>
> **JAVIERA MCGUIGGAN**

For a time, I felt like I was just there to check a box, and my voice wasn't truly heard. I received many comments that highlighted how much support we still need, especially from allies who can call regressive behaviour out. Comments about my style being "too much" or me being "too loud" or "unpredictable" were common. But I never acted unpredictably or against the rules; it was just a perception of being uncontrollable.

Another example was when I organised activities for Latino employees in the diversity group. I was warned not to do too good a job, as it might lead to more responsibilities and distract from my "real" job. This highlights the risk of superficial diversity initiatives — ticking the box without truly committing to change.

Today, I feel Cargill provides a great environment. However, it only takes one person to silence you and undo the progress, so this issue isn't over.

How can mentorship help boost diversity?

Georges Houtappel, Executive Vice President, Global Head of Automotive Business, Syensqo: I firmly believe that both allyship and mentorship are crucial in an organisation. It's essential to have male executives actively supporting the development of women. While many male colleagues claim to support this, I believe that active mentorship is the additional step needed.

Often, female candidates hesitate to apply for certain positions because they feel underqualified. I learned a small trick from my own mentor that can help get more women into roles that are right for them. It involves keeping a list of female colleagues on the last page of my notebook.

In leadership meetings, when discussing critical positions that are opening, I refer to this list and highlight potential female candidates. Then I encourage potential candidates to put themselves forward for positions they might not have thought of applying to otherwise.

For example, one of my mentees last year was about to start maternity leave and had been offered a promotion. She initially gave several reasons why she couldn't take the offer, even though she was interested. Her hesitation stemmed from the fear of leaving her comfortable environment and managing a new job while simultaneously becoming a mother.

At that moment, the company's role wasn't to offer her a comfortable position, but to make any position she held more comfortable. She ultimately accepted the promotion, and I worked with her manager to ensure she had the necessary parental leave. Her manager also agreed to cover part of her job, allowing her to start part-time and gradually ramp up.

These are instances where male executives need to take an active role. Without such efforts, these advancements don't happen naturally.

> One key area of recruiting allies is communication. We need to talk about these issues and give visibility to the women already in the industry.
>
> **STEFANIE KLEIN**

Why did you start WoMen4Metals and what does allyship mean to you?

Stefanie Klein, Initiative Lead, WoMen4Metals: We always felt the need to change the gender balance in our company because it seemed quite different from society. The metal industry, as you can imagine, is very male dominated.

In the beginning, we worked on this initiative in our private time. We set a vision and some goals. Two years ago, we had the opportunity to present our initiative to our CEO. At that time, our board consisted of three slightly older white men, and we were unsure how they would react. Fortunately, our CEO immediately supported us, he became our sponsor and encouraged us to make the initiative big and impactful for the entire industry.

One key area of recruiting allies is communication. We need to talk about these issues and give visibility to the women already in the industry. Women attract other women, so it's important to showcase female faces in our industry. If women only see men in pictures, they won't consider applying because they'll think it's not their place.

At the same time, we need to make women feel welcome in the workplace. For example, by providing appropriate work clothes, sanitary facilities and toilets that aren't used as storage rooms. Even just avoiding scheduling important meetings after 5 PM helps accommodate mothers with other duties.

Allyship from men is also incredibly important because addressing this issue shouldn't fall solely on women. Men can play a significant role in supporting us. For example, at one of the first meetings of WoMen4Metals, our CEO gave a presentation to an audience of 50 women. He said, "Oh my, now I completely understand how you feel and what it's like working in this industry." He wanted change, and to get men involved in this initiative. That support, his allyship, was invaluable.

We also went to the factories and production facilities and spoke directly with our male colleagues. We explained the constant challenges women face, as early as their apprenticeships, where they are repeatedly told that women shouldn't work in this industry. It's tough for young women, and they need to be incredibly strong to persevere. During these conversations, we saw men in senior positions with tears in their eyes, because they were thinking of their own daughters facing the same challenges.

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TRANSFORMING SUSTAINABILITY

Consider electrical transformers when decarbonising the grid

Each year, the world uses enough electricity to turn Lake Erie into a hot tub for a day, around 23,000 TWh. Most of this power flows through transformers, so they're a crucial part of our road to net zero, says Christina Iosifidou, head of sustainability, grid technologies at Siemens Energy and advisory board member for electrical engineering trade show, CWIEME Berlin.

According to the European Commission, 93 TWh of electricity is wasted annually in Europe due to transformer losses. That's more electricity than all the renewable sources in the UK produced in 2023 and about three per cent of all the energy generated across Europe.

Transformer losses, though usually only one or two per cent of the load, add up over the transformer's expected 35-year operation phase and represent more than 95 per cent of its total carbon footprint. Manufacturing the transformer in the first place, delivery and installation make up the other five per cent.

Naturally, improving transformer efficiency continues to be a topic for constant research and development and is in the DNA of any transformer manufacturer. The numbers have improved over time and the European Commission's Ecodesign Directive now demands minimum transformer efficiencies of up to 99.77 per cent. Efficient transformers are more expensive, though, and efficiency also often comes at a cost to compactness.

You are what you eat

Eventually, we'll meet the boundaries of physics — some energy will always be lost to things like hysteresis, eddy currents and Joule heating. Because most of a transformer's carbon footprint comes from these unavoidable losses, a transformer can only truly be green when the electricity it's fed is green.

While renewable electricity is freely available in some geographies, the origin of the electricity a transformer receives is out of our hands as OEMs. It's up to governments to facilitate the extensive development required to make green electricity the norm.

What can OEMs do?

One way manufacturers can reduce a transformer's carbon footprint is to decarbonise the production process as much as possible. For example, a major portion of emissions from a transformer factory comes from drying and oven processes.

Traditionally, the ovens are heated using fossil fuels, so electrifying them and feeding them 100 per cent renewable electricity would significantly reduce carbon emissions. Indeed, all four ovens in one of Siemens Energy's factory at Nürnberg are now electric and run on renewable power. However, just like with electric vehicles, making the switch before sufficient green electricity is available at a facility negates any reduction in emissions.

Using sustainably sourced materials wherever possible is another way to decarbonise supply chains. In fact, more than 90 per cent of manufacturing emissions comes from raw materials and, of that, around 85 per cent comes from copper and steel. Switching to green steel and using responsibly sourced copper can make a big difference, but doing this might be harder in some geographies or developing countries due to the significant investment required. For example, converting one out of four coal-fired blast furnaces to hydrogen-fired cost thyssenkrupp around 2 billion euros.

All this points to why we need to plan for a transition period which includes and involves the entire value chain. It's important because manufacturers, large OEMs especially, have the power to shape the industry by demanding responsibly produced materials from suppliers.

That's where events like CWIEME Berlin can help. Getting everyone under one roof makes it possible to discuss critical topics like these. Through international collaboration and the exchange of ideas across the whole value chain, we can continue making progress towards net zero. Once we get there, let's all go to Lake Erie to celebrate.

If you want to ensure you keep up to date with all the latest news, opinion focussed content and case studies from **CWIEME Berlin**, visit the company's website

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