INNOVATIE NU

September 2024

12

Dear reader,

A year ago, I was a key player in the team at FIP-AM@UT who were preparing for the upcoming tasks of having the Advanced Manufacturing Centre finally open and running. Along with this new centre came new opportunities, new lessons to be learned, and new ideas to improve the Dutch manufacturing industry. It was indeed an exciting and fulfilling experience.

With that now behind us, and with an open mindset, I look forward to my new role in InnovatieNU. This has been a path full of learning opportunities and new discoveries since I joined the team as a student only a couple years ago to now taking on the role of co-editor.

In the spirit of change, I invite you to embrace a mindset of exploration, learning, and evolution for the well-being of our environment and our communities from the lens of sustainable manufacturing. It may seem as too complex a challenge, but it is vital to untangle and explore its different aspects.

From a manufacturing perspective there are already multiple efforts made, alternative solutions being explored, and a vast sea of opportunities to bring into your company. From research to market, in the articles that follow you will discover paths for sustainable action in diverse areas of the Dutch manufacturing industry.

Let's embark on this journey together towards discovering the future of sustainable manufacturing in its multiple forms via Industry 4.0, additive manufacturing, smart textiles, alternative sources of energy, sustainable packaging, and much more.

ESTEFANÍA MORÁS JIMÉNEZ

Research Engineer

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UNIVERSITY OF TWENTE. | FRAUNHOFER INNOVATION PLATFORM FOR ADVANCED MANUFACTURING

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CIRCULAR MANUFACTURING SYSTEMS PROGRAM

Twente Board

LEADING THE CHARGE IN SUSTAINABLE BATTERY MANUFACTURING

The Fraunhofer Innovation Platform at the University of Twente (FIP-AM@UT) has been awarded the management of the Circular Manufacturing Systems Program (CMSP), an initiative aiming to significantly improve battery manufacturing by enhancing sustainability, automation, and efficiency.

Advancing Sustainability in Battery Manufacturing

The CMSP is designed to address the urgent need for sustainable practices in the battery manufacturing industry. With a comprehensive approach that covers the entire lifecycle of battery modules and packs, the program aims to enhance circularity in this sector.

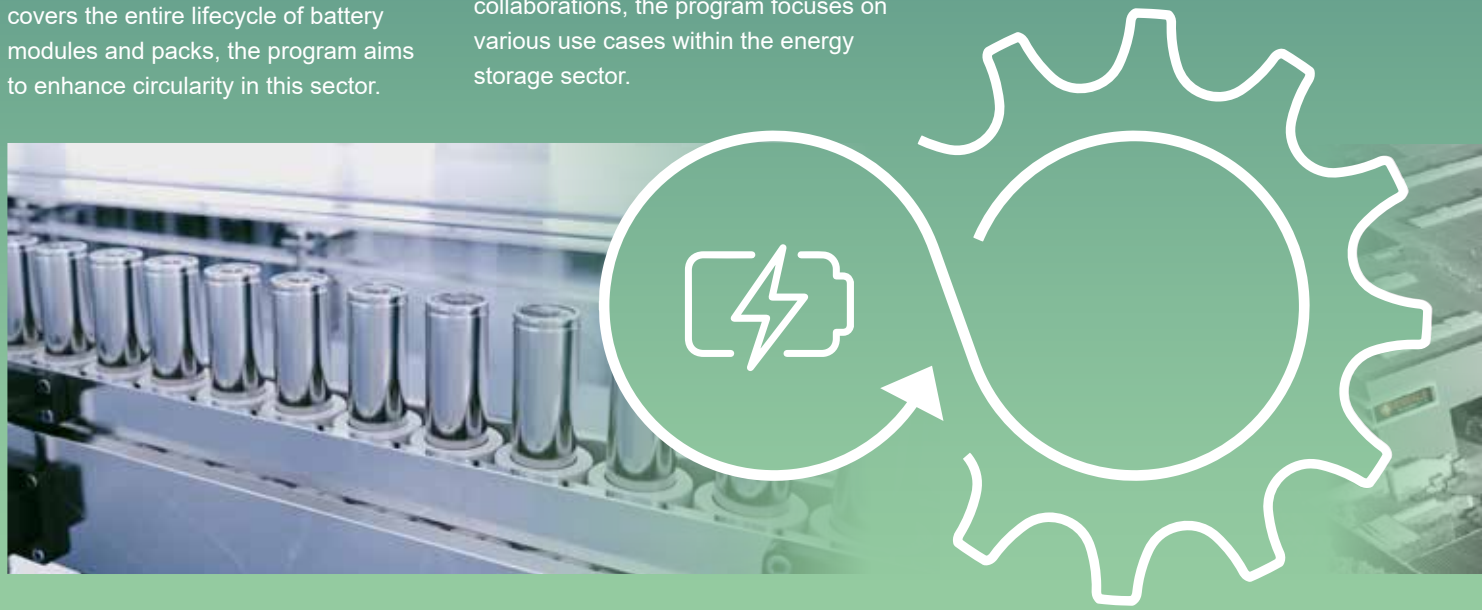
Activities of this initiative are supported by the Advanced Manufacturing Centre (AMC) at the University of Twente, providing state-of-the-art industrial equipment.

Leveraging Strategic Partnerships

Through initiatives supported by the province of Overijssel, Twente Board and projects like Manufacturing NextMaterials (MNM) in the framework of Interreg, the CMSP ensures a cohesive and effective approach to sustainability. Facilitated by a consortium of regional industrial partners, with potential international collaborations, the program focuses on various use cases within the energy storage sector.

Addressing Key Challenges

The CMSP tackles several persistent challenges in battery manufacturing. One significant challenge is designing battery packs that can be easily assembled and disassembled, even when damaged. Additionally, adapting to the evolving conditions and specifications of battery packs poses a significant challenge. The program also aims to maximise the reuse of battery modules in secondary applications, develop reliable health assessment methods for extended battery use, and integrate eco-design principles to mitigate environmental impact.



The main objectives of the CMSP are multifaceted. They include facilitating:

- efficient disassembly and material recovery from spent battery packs,
- innovating methods to adapt manufacturing processes to changing battery specifications,
- and assessing and repurposing battery modules to maximize sustainability and extend their lifecycle.

Furthermore, the program aims to incorporate ***eco-design principles*** to minimize emissions and promote material circularity in battery production.

Use Case Spotlight: Advancing Energy Sustainability through Battery Repurposing

One example of a use case within the program involves **Riwald Recycling**, a division of ArcelorMittal, focusing on battery repurposing to advance energy sustainability.

Riwald Recycling encounters challenges in efficiently managing used lead-acid batteries from energy plants. Their goal is to repurpose these batteries for internal or external uses, such as solar parks. However, current challenges include sorting usable cells, designing a battery pack, and potential grid integration, highlighting the limited knowledge that exists on large-scale lead-acid battery repurposing.

To address these challenges, the program will concentrate on enhancing techniques to transform used batteries into functional battery packs suitable for various applications. This effort aims to promote circularity, alleviate grid congestion issues, and explore diverse industrial and modular uses for the battery packs.

Repurposing waste batteries into functional battery packs will not only contribute to circularity but also help alleviate grid congestion issues. This innovation opens avenues to serve new customer segments such as grid operators and industries requiring sustainable energy solutions. Furthermore, insights gained can foster new business models or even spawn startups, driving regional economic growth and sustainability.

Delivering Impact

The CMSP aims to produce tangible outcomes, including the implementation of a test production environment that showcases advanced battery module production and disposal techniques.

The program also seeks to demonstrate a significant reduction in waste and emissions throughout the battery lifecycle. Organising workshops and training sessions to disseminate best practices is a key component, along with engaging in international events to foster collaboration and share insights. Developing and implementing eco-friendly design and assembly solutions is another crucial objective, as is involving local companies to enhance cooperation and innovation. Creating design guidelines for sustainable battery pack assembly and disassembly is also a major goal.

Knowledge dissemination is a cornerstone of the CMSP. FIP-AM@UT will lead efforts to spread awareness and educate industry stakeholders. This includes maintaining a comprehensive CMSP program page on the FIP-AM@UT website, organising a series of seminars, workshops, and conferences, and utilising social media, press releases, and publications to reach a broader audience.

Looking Ahead

The Circular Manufacturing Systems Program (CMSP) represents a significant step forward in sustainable manufacturing, particularly in the battery sector. By focusing on circularity, automation, and eco-design, the CMSP aims to reduce environmental impact and promote resource conservation. With strategic partnerships and a comprehensive knowledge transfer strategy, the CMSP is set to make a lasting impact on the battery manufacturing industry and broader sustainability efforts. ■

If you would like to know more or are interested in getting involved through a use case or participating in existing ones, please contact FIP-AM@UT.

STRATEGIC RESPONSE TO EU'S NET ZERO PUSH:

A ROADMAP FOR HIGH-TECH MANUFACTURERS

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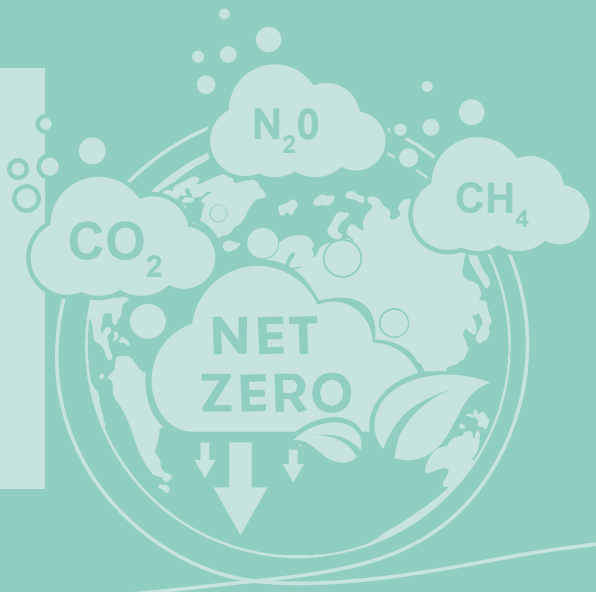
In the dynamic realm of high-tech manufacturing, companies producing industrial products must balance innovation and sustainability. With the European Union (EU) spearheading ambitious net zero commitments, high-tech (and indeed all) manufacturers must strategically align with regulatory mandates while fostering sustainable practices. Understanding the essence of net zero, the increasing pressure on companies to act, and strategic pathways for high-tech manufacturers of industrial products is crucial for navigating this transformative journey.

What is Net Zero?

Net zero represents a milestone for organisations committed to environmental stewardship. It signifies achieving a state where greenhouse gas (GHG) emissions are significantly reduced and any residual emissions are offset through carbon removal techniques. This encompasses emissions not only from internal operations but also throughout the entire value chain, spanning manufacturing processes, supply chain logistics, and product lifecycle management.



The Imperative Intensifies

The urgency behind the net zero agenda is underscored by the escalating impacts of climate change. At the heart of global efforts to address this crisis lies the Paris Agreement, a landmark international treaty adopted in 2015. Signed by 197 nations, including major emitters such as the United States, China, the European Union, and India, it aims to limit global temperature rise to well below 2°C above pre-industrial levels, with a more ambitious target of 1.5°C. This ambitious goal is crucial for safeguarding the planet from the most devastating impacts of climate change, including extreme weather events, sea-level rise, and biodiversity loss.

The Paris Agreement sets specific targets for reducing greenhouse gas emissions, including carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), which are the primary contributors to global warming. By limiting these emissions, it aims to mitigate the adverse effects of climate change and protect the environment for future generations.

Recent breaches of the 1.5°C threshold serve as stark reminders of the urgency to curb emissions. The devastating consequences of climate change are already being felt worldwide. From unprecedented heatwaves and wildfires to destructive hurricanes and floods, the impacts are evident. Swift and decisive action is essential to mitigate these impacts and secure a sustainable future for generations to come.

To meet the goals outlined in the Paris Agreement, drastic reductions in greenhouse gas emissions are necessary. Emissions must be slashed by 45% by 2030, with the ultimate objective of achieving net zero emissions by 2050. This requires a fundamental transformation of our energy systems, industries, and lifestyles, as well as unprecedented cooperation and commitment from governments, businesses, and individuals worldwide.

Stakeholders across the board, including investors, customers, and regulators, are increasingly scrutinizing companies' climate commitments. Supply chain partners are integrating emission reduction targets into procurement strategies, while regulatory frameworks such as the Corporate Sustainability Reporting Directive (CSRD) in the EU are imposing stringent reporting requirements. As the pressure mounts for companies to align with the objectives of the Paris Agreement, those that fail to take meaningful action risk falling behind in an increasingly climate-conscious world.

2024

-45% by 2030

NET ZERO 2050

Crafting a Strategic Response

For high-tech manufacturers of industrial products, navigating the path to net zero requires a comprehensive and proactive approach. Let's envision a scenario of a high-tech manufacturer specializing in a range of industrial products, from parts to advanced finished products.

1 Clean Energy Adoption

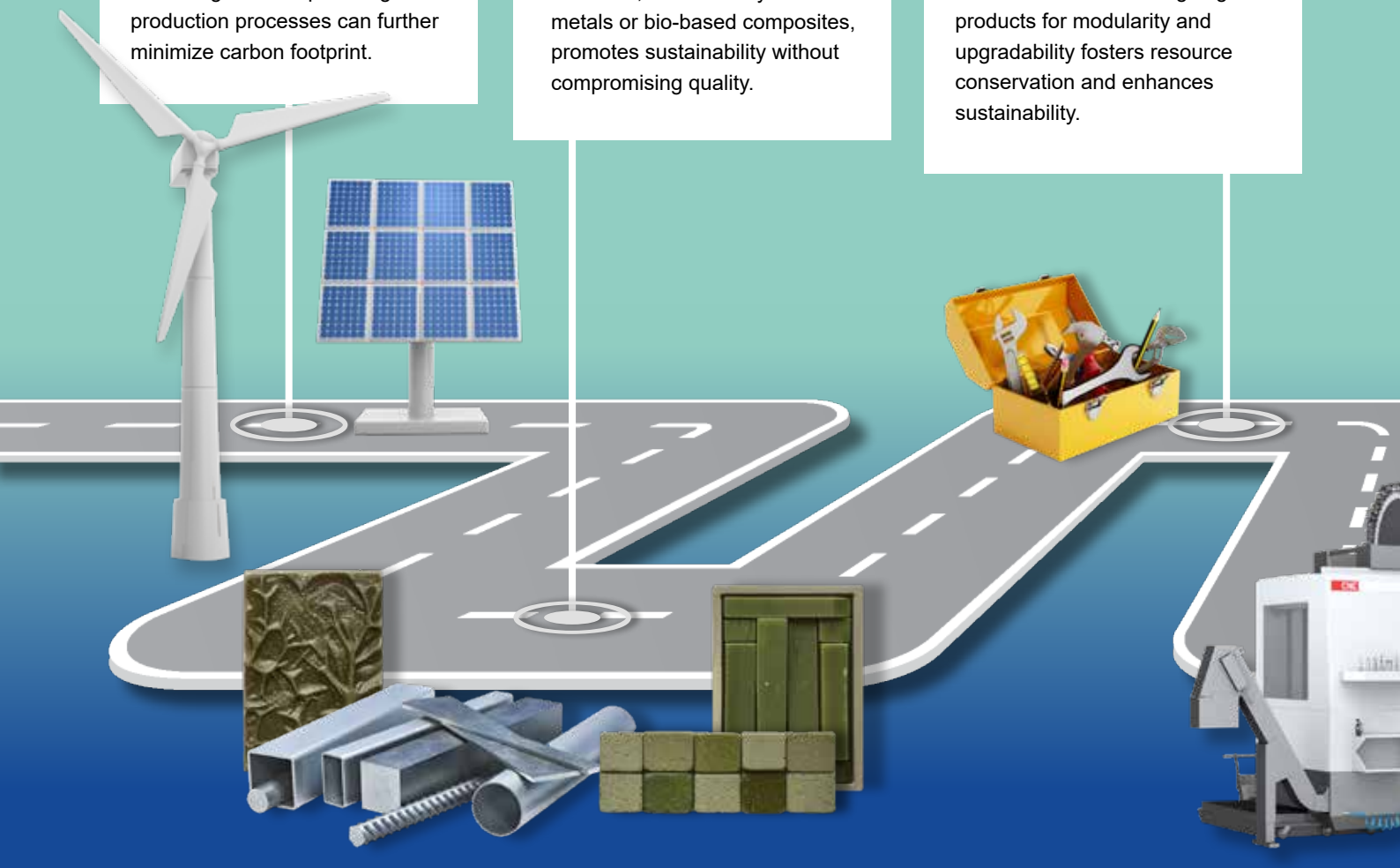
Transitioning to renewable energy sources, such as solar or wind power, for manufacturing facilities is paramount. Implementing energy-efficient technologies and optimizing production processes can further minimize carbon footprint.

2 Sustainable Materials

Embracing eco-friendly materials and manufacturing processes can significantly reduce environmental impact. Exploring alternatives to traditional materials, such as recycled metals or bio-based composites, promotes sustainability without compromising quality.

3 Circular Economy Initiatives

Implementing circular economy principles, such as product refurbishment and remanufacturing programs, can extend product lifespan and reduce waste. Designing products for modularity and upgradability fosters resource conservation and enhances sustainability.



4 Supply Chain Collaboration

Collaborating with suppliers committed to sustainability fosters resilience and transparency throughout the supply chain. Establishing environmental criteria for suppliers and promoting responsible sourcing practices drive positive change across the industry.

5 Carbon Offsetting and Innovation

Investing in carbon offset projects, such as reforestation or carbon capture technologies, can help neutralize residual emissions. Concurrently, fostering innovation in carbon capture and utilization (CCU) technologies contributes to long-term sustainability and resilience.

Embracing the Future

The transition to net zero presents high-tech manufacturers of industrial products with both challenges and opportunities. By embedding sustainability into core business practices, companies can mitigate climate risks, drive innovation, and enhance stakeholder trust. As catalysts for industrial progress, high-tech manufacturers have the potential to lead the charge towards a sustainable future, reshaping industries and redefining corporate responsibility in the 21st century. ■

Greenwashing

ETHICAL MARKETING STRATEGIES FOR **SUSTAINABLE SUCCESS** IN THE NETHERLANDS

In today's environmentally conscious world, consumers are increasingly scrutinizing the sustainability claims of the products they buy. This heightened awareness has given rise to a pervasive and insidious phenomenon known as greenwashing. It's a deceptive marketing practice where companies exploit the growing demand for eco-friendly products by exaggerating or falsely claiming their products or practices to be environmentally responsible. For manufacturers in Europe, particularly in the Netherlands, understanding the depths of greenwashing is paramount. It's not just about navigating consumer preferences; it's about upholding integrity and credibility in an era where environmental stewardship is a non-negotiable expectation.

The economic landscape is shifting, and the imperative for sustainable business practices is no longer merely a moral choice but a strategic necessity to stay relevant to buyers and customers. Furthermore, global regulatory frameworks are evolving rapidly to promote sustainable procedures and practices among suppliers, OEMs, and brand owners. With the EU leading the charge with ambitious targets and initiatives such as the European Green Deal and the proposed European Climate Law, the message is clear: the time to scale up actions to combat climate change and drive innovation is now.

In addition to regulatory advancements, discussions within the EU are underway regarding eco-design principles and the potential mandating of digital product passports. These passports would serve as repositories of critical information about products, components, and materials, facilitating extended product lifetimes and increasing their reuse potential. The EU's proactive stance on supply chain transparency is setting a precedent globally, igniting discussions beyond its borders.

What is Greenwashing?

In the world of sustainability, there's a deceptive tactic lurking known as greenwashing. It operates like a wolf in sheep's clothing, masking unsustainable practices with a veneer of eco-friendliness. This insidious phenomenon manifests in various forms, from misleading labels and ambiguous language to exaggerated assertions of environmental benefits.

The Forms of Greenwashing

1. **Unsupported Claims**: This occurs when sustainability assertions lack substantiated evidence or factual support.
2. **False or Distorted Claims:** Greenwashing extends to claims that are outright untrue or manipulate the actual benefits offered by a product or service.
3. **Ambiguous Claims**: Using vague terms like "greenest" or "cleanest" can create a misleading perception of a company's products or services.
4. **Misleading Labels**: Some companies employ logos or labels resembling recognized sustainability symbols, or they use labels with lax requirements or inadequate independent assessment.
5. **Comparative Deception**: Comparing products or services to others that serve different needs or purposes can mislead consumers.
6. **Confusion of Product and Company Sustainability**: Greenwashing blurs the line between a company's overall sustainability efforts and the sustainability of specific products or services.

Consequences of Greenwashing

Engaging in any of these forms of greenwashing can lead to serious repercussions. Companies may face lawsuits and substantial financial penalties, including fines, investment losses, or product removal from the market. Moreover, the damage to brand reputation can be profound, eroding public trust in the company's products and communications. Once accused of greenwashing, regulatory bodies and industry watchdogs may intensify scrutiny, heightening the risk of fraud investigations.

Understanding and combating greenwashing is crucial for fostering genuine sustainability and preserving consumer trust in the marketplace.

Strategies to Combat Greenwashing

To combat the deceptive practices of greenwashing and uphold integrity in marketing, manufacturers must employ robust strategies rooted in transparency and evidence-based claims. By implementing the following approaches, businesses can navigate the complex terrain of sustainability with authenticity and credibility.

Transparency Reigns: Transparency is the cornerstone of ethical marketing. Be forthright about your products' environmental impact and provide clear, verifiable information about your sustainability initiatives.

Evidence-Based Claims: Avoid empty rhetoric by backing your claims with concrete evidence. Utilize certifications from reputable organizations to validate your commitment to sustainability.

Authentic Imagery: Ensure that visual representations accurately reflect your product's environmental impact. Avoid misleading imagery that may create false perceptions of eco-friendliness.

Educational Outreach: Empower consumers by educating them about sustainability complexities, including product lifecycle, materials used, and efforts towards reducing environmental footprint.

Crafting Reliable Sustainability Claims

In the Netherlands, where environmental consciousness is exceptionally high, making reliable sustainability claims transcends mere marketing; it's about upholding integrity and credibility. Here's how manufacturers can navigate this terrain with integrity:

Regulatory Compliance: Adhere to Dutch and EU regulations on environmental labeling and advertising standards, ensuring alignment with legal requirements.

Certifications and Labels: Obtain recognized certifications such as the EU Ecolabel, Cradle to Cradle, or Fairtrade to bolster the credibility of your sustainability claims.

Life Cycle Assessment (LCA): Conduct comprehensive LCAs to assess the environmental impact of your products thoroughly. Use data-driven insights to communicate transparently with consumers.

Collaborative Engagement: Forge partnerships with environmental organizations, NGOs, or sustainability experts to amplify your sustainability efforts and foster transparency.

> **It operates like a wolf in sheep's clothing, masking unsustainable practices with a veneer of eco-friendliness.**

Forging an Authentic Path to Sustainability

In the pursuit of sustainability, honesty and transparency must underpin every action taken by manufacturers in the Netherlands and across Europe. Greenwashing not only erodes consumer trust but also undermines genuine efforts towards environmental stewardship. By eschewing greenwashing tactics, substantiating claims with evidence, and embracing authentic sustainability practices, manufacturers can not only attract environmentally conscious consumers but also make meaningful contributions to the planet's well-being. Let's elevate sustainability from a mere marketing buzzword to a tangible reality—one rooted in integrity, transparency, and genuine commitment.

GREENING YOUR COMPANY PROCESSES

THE ESSENTIAL ROLE OF LEADERSHIP AND CHANGE MANAGEMENT

Sustainability is one of the top concerns for businesses around the globe. Spanning the dimensions of people, planet, and profit, also known as 'triple bottom line', sustainability covers all main aspects a business should consider in their (future) strategy. Yet, a key consideration regards how businesses contribute to the pro-environmental 'planet' component. In fact, businesses are increasingly forced to consider their detrimental impact on our planet. This is stimulated by European or national governmental regulations, including the European Green Deal and global developments such as the United Nations Sustainable Development Goals. But also customers (B-2-B and B-2-C) increasingly consider a company's pro-environmental performance and image in their decision making. As such, industry needs to seriously think about and act upon 'greening' their operations towards net zero production. This big task leaves a question mark how they will realize those ambitions and manage to transform their organization accordingly.

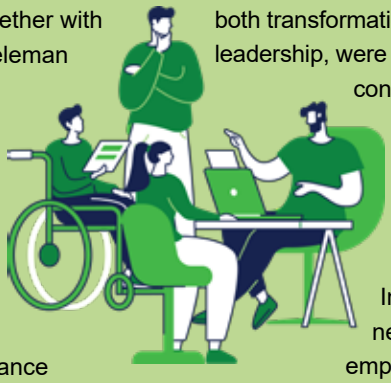
In my research team at the University of Twente, within the department of High-tech Business & Entrepreneurship, we develop insights on how companies can successfully navigate this 'green transformation'. We focus specifically on effective change management and organizational behaviour, including the roles of leaders and employees in the change. Naturally, we also teach those concepts to our students, for instance in the Minor Energy Transition Perspectives[1] for technical Bachelor students, the Leading Systemic Change course as part of the Transdisciplinary Master Insert Shaping Responsible Futures[2], and our Bachelor and Master Honours programmes (Change Leaders[3] and Processes of Change[4]) at the University of Twente. So, what are our latest learnings that could benefit your company facing this major challenge?

Change management for the green transformation

When it comes to large (industry) transformations, people often think about big bang shifts or even inertia because it might be difficult to determine where to start. In fact, we found that complex change is most effectively implemented using a combination of providing clear top-down direction and bottom-up initiatives. For example, in an entirely different context of interdisciplinary process improvement throughout large hospitals, such a combined approach to change led to the most significant performance improvement over time (as reported in the article with my PhD student John van Beers[5]). This means that leaders at all levels need to be involved and follow a clear and focused strategy execution while leaving room for (innovative) frontline contributions. Together one can achieve far more.

Taking it one step further, engaging employees and letting them participate in the (radical) renewal of new work processes and green company policies, has been found to safeguard actual, long-lasting green performance benefits, including carbon footprint reductions, energy conservation, reduced water use, and waste reduction. This promising conclusion is based on a preliminary overview[6] of the literature to date offered by my colleague Annemarie Dedden. Thus, it really pays off to involve your employees in the change process if you want to realize a green transformation in your company.

Yet, the green transformation requires such a different scope and level of change that we must acknowledge that it cannot be realized with internal stakeholders alone. Thus, your company could benefit from taking a so-called 'open strategy' approach when developing your green strategic action plan. This approach engages a wide variety of internal and external stakeholders (such as customers, suppliers, and network partners) into the strategy development process and setting your company's green goals, while at the same time aligning and preparing all stakeholders for the execution that needs to follow. Indeed, a study[7] conducted together with my colleague Henk Doeleman showed that such an open strategy approach is supported by the use of just one A3 page visual strategy map, combined with regular management dialogues about the up-to-date (green) performance figures, and IT-enabled performance data figures. Driving this change and (open) strategy process also requires leaders to properly prepare their employees for the shift in ways of working, behaviours, and even mindset. Our study therefore also highlighted the importance of transformational leadership for strategy implementation.



Leading people in the transformation process

Such transformational leaders, who try to motivate employees through charismatically sharing the bigger vision, certainly contribute to the change. Yet, for a green transformation to succeed this is not the full story. In fact, recently published work [8] with my PhD student Nissa Syifa Puspani shows that, besides a transformational leadership style, leaders also need to be rather instrumental.

In particular, she found that the leaders of family-owned firms that were seriously implementing 'lean and green practices' in their logistics operations, added also 'instrumental leadership' to their behavioural repertoire. For example, they specified the path towards implementing the green ambitions by clarifying the different phases steps in the implementation process, invested time and effort in the right skills training, actively tracked the implementation and intervened if needed, and constantly engaged in dialogues with staff to ensure fast feedback and mutual learning process. We found that the business leaders who embodied the behaviours of both transformational and instrumental leadership, were most successful in convincing and engaging their employees across organizational levels to participate in the green change.

In other words, leaders need to help their employees to adequately balance their efforts between the adoption of visionary innovations in their daily job and small, incremental improvement steps. This also requires leaders to be sensitive to their people's needs throughout the change process. Indeed, my own recent publication[9] highlighted the essential emotional intelligence skills leaders need to show when introducing innovation to the frontline. In fact, a green transformation often goes together with the adoption of smart technologies to reduce carbon footprint, energy use, etcetera. Thus, it is advised to not only map out the different steps in the implementation process, but also consider the impact this change might have on your employees. Do they see it as an opportunity, or as a threat? Does it make their job more interesting or meaningful? How much effort does it take them to make the shift and learn new skills? How can you alleviate the impact the change might have on them?

Conclusion

Hence, to green your company processes, it is strongly advised to:

- ✓ set your company's strategic green goals together with in- and external stakeholders,
- ✓ integrate the execution of a clear top-down direction with bottom-up ideas from employees,
- ✓ develop and train both transformational and instrumental leadership behaviours among your management team, and
- ✓ open up to the socio-emotional needs of employees by tapping into your emotional intelligence.

Considering these powerful leadership and change management practices alongside smart green technological innovations, is likely to contribute to a smoother green transformation. ■

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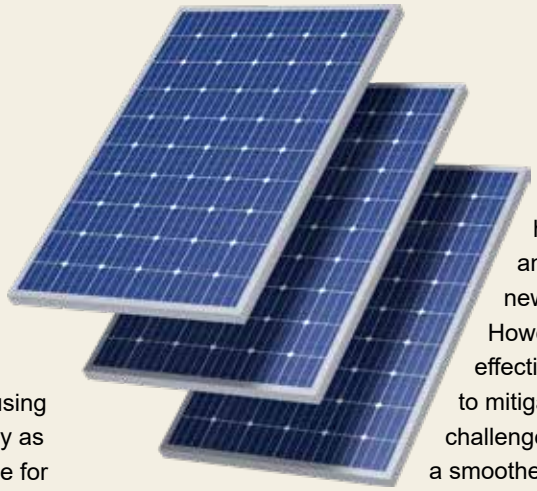
[1] Faculteiten Werken Samen in Nieuwe Minor Energietransitie - U-Today (utoday.nl)
[2] Transdisciplinary Master-Insert | Home | MSc University of Twente (utwente.nl)
[3] Change Leaders | Honours programmes (utwente.nl)
[4] Bachelor Honours programme | Our tracks | Honours programmes (utwente.nl)
[5] Effective Hospital-Wide Lean Implementation: Top-Down, Bottom-Up or Through Co-Creative Role Modeling? | International Journal of Lean Six Sigma
[6] Effectively Changing Intra-organizational Behaviors for Environmental Performance | Academy of Management Proceedings (aom.org)
[7] Leading Open Strategizing Practices for Effective Strategy Implementation | Journal of Strategy and Management
[8] Evolved Leader Behaviours for Adopting Lean and Green in Family Firms: A longitudinal study in Indonesia | Journal of Family Business Management
[9] Social Enablers of Industry 4.0 Technology Adoption: Transformational Leadership and Emotional Intelligence | International Journal of Operations & Production Management

THE ROLE OF RENEWABLE ENERGY IN SUSTAINABLE MANUFACTURING

In the context of the global energy transition and rapidly shifting industrial landscape, sustainable manufacturing represents a pathway toward reducing environmental impact, optimizing resource use, while promoting economic resilience. It not only addresses the urgent need for decreased carbon footprints and environmental degradation but also aligns with growing demand for responsibly made products, offering industries a competitive advantage in a sustainability-conscious market. As defined by the U.S. Environmental Protection Agency, sustainable manufacturing is the practice of producing goods using economically viable methods that minimize negative environmental impacts, conserve energy and resources and prioritize employee, community, and product safety [1].

Recent regulatory initiatives, such as the **"Eco-design for Sustainable Products Regulation"** introduced by the European Commission, are crucial for promoting sustainable manufacturing, enhancing energy efficiency and circularity of products [2]. This regulation sets criteria for products to qualify as sustainable, emphasizing waste prevention, material recovery increase, extended product lifespan, support for the circular economy, utilization of recycled materials and reduced environmental footprint throughout the life cycle of the products [3]. Products, meeting these criteria, can be issued with the **"Digital Product Passport"**, a passport that provides information to consumers regarding the product's sustainability characteristics [2]. The provision of the "Digital Product Passport" can help consumers make informed decisions when buying products but also offer a competitive advantage to a business. By adopting sustainable manufacturing practices, companies can gain significant environmental, economic, and social benefits while contributing to a more sustainable future. The integration of sustainable manufacturing processes is related to lower production costs, increased operational efficiency, improved sales and brand recognition, greater access to financing and capital, resilience to energy price volatility, new business opportunities, as well as lower regulatory compliance costs [1].



A crucial aspect of sustainable manufacturing is **"Environmental Impact"**, which can be achieved through various means such as using renewable energy as the energy source for the production process, with solar energy being the most promising on-site solution. Dutch electricity sector in 2023, emitted 40.16 million metric tons of CO2 equivalent. The share of solar energy in the Dutch electricity mix was 18.03% for the same year while it was accountable for only 2.51% of the total emission [3], primarily associated with the manufacturing process of solar panels. The green electricity generated by large-scale solar photovoltaics systems can be utilized in manufacturing processes, effectively reducing the environmental footprint of the production processes, and subsequently resulting goods. This also contributes to another pillar of sustainable manufacturing which is resource and material efficiency. This principle aims to get the most out of the value of the resources and materials used in the production process while minimizing waste. This approach can preserve critical resources, such as energy, contributing to sustainable development. Moreover, by integrating photovoltaic systems, factories can operate more independently from the grid, mitigating the risk associated with fluctuating energy prices. It also supports the creation of a closed-loop system in manufacturing processes by powering production lines and machinery exclusively with renewable sources.

Integrating renewable energy into manufacturing and broader industrial activities indeed comes with its set of challenges such as intermittency, high initial costs, and the need for new infrastructure. However, there are effective strategies to mitigate these challenges, ensuring a smoother transition and more sustainable outcomes. Energy storage technologies can address reliability and intermittency issues, while government incentives and innovative financing options can alleviate financial burdens. These measures collectively facilitate the adoption of renewable energy, driving forward sustainable manufacturing practices.

A case study illustrating the implementation of sustainable manufacturing practices can be found at the Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente [4]. In this case, a PV system of 36.9 kWp is installed on the roof of the building and the generated electricity is directed towards powering a 3D titanium printer, resulting in a lower carbon footprint and energy costs, not only for the manufacturing phase but also for the resulting products. With the avoided CO2 emissions amounting to 10,599.355kg and the operational cost reduced by approximately 2,500€ over the ten-month operational period of the system, this case study underscores the economic viability and environmental impact of such sustainable systems in the industrial landscape. ■

PV system installed on the roof of Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente.

References:

[1] Sustainable Manufacturing. US EPA. Published July 30, 2015. Accessed April 29, 2024. https://www.epa.gov/sustainability/sustainable-manufacturing#:~:text=Sustainable%20manufacturing%20is%20the%20creation,employee%2C%20community%20and%20product%20safety

[2] Commission welcomes provisional agreement for more sustainable, repairable, and circular products. Press corner - European Commission. Published 2024. Accessed April 29, 2024. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6257

[3] Live 24/7 CO2 emissions of electricity consumption. Electricitymaps.com. Published 2024. Accessed April 29, 2024. https://app.electricitymaps.com/zone/NL

[4] https://fip.utwente.nl/about/amc/

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ADVANCED MANUFACTURING PROGRAM (AMP)

Powered by: **Regio Deal Twente**

The Fraunhofer Innovation Platform for Advanced Manufacturing (FIP-AM), together with the regional government and partners, has developed the Advanced Manufacturing Program (AMP) to create a transition framework to Manufacturing 4.0 and to strengthen the industry in the east of the Netherlands.

The Advanced Manufacturing Program (AMP) provides subsidies through the RegioDeal, supported by the Province of Overijssel and the Dutch State. The aim is to stimulate the rapid development of Twente and other regions in The Netherlands by creating an Advanced Manufacturing hub with an outward-looking, European image.

In this way, the AMP strengthens the reputation and climate of the region. Within the AMP, the Fraunhofer Innovation Platform is developing innovation projects in the field of production technology together with the University of Twente. Each AMP project is built around a solid industrial collaboration. During the project, the companies will have access to relevant knowledge and the latest technological and industrial methodologies. These can be shared with other high-tech manufacturing companies in the region via the hub.

The companies that are members of the AMP can solve their specific technological problems and answer market-oriented questions. This is done by developing and creating demonstrators with direct technological insight. FIP-AM then works through workshops and master classes on the dissemination of this newly acquired knowledge.

The Advanced Manufacturing Program (AMP) is a grant program that helps us businesses support your transformation to Industry 4.0. This is made possible by the RegioDeal, supported by the Province of Overijssel and the Dutch State.

Rijksoverheid

provincie Overijssel

Twente Board

e.rouchou@utwente.nl +31 (0)6 4876 7414 **Elias Rouchou**

THEME 01_

PROJECT PARTNERS WANTED

For research on circular manufacturing

Most manufacturing processes produce waste materials, presenting significant opportunities for achieving circularity in manufacturing. Transforming waste is crucial for fostering a resilient and eco-conscious manufacturing landscape.

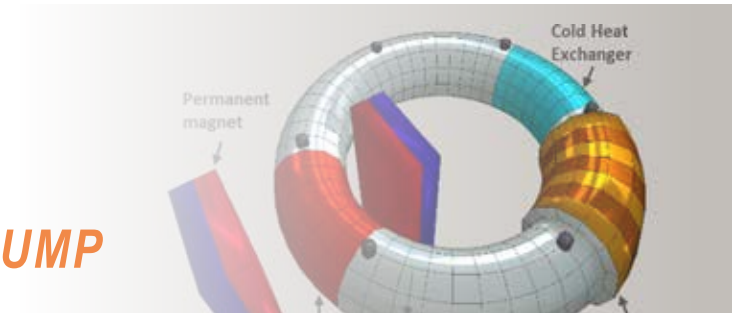
One promising area is **high-value scrap recycling**, where valuable materials like inconel and titanium can be recovered from process waste. This consequently reduces supply chain dependency and maximizes raw material use.

Another important topic that is often neglected is **remanufacturing,** which involves refurbishing used or damaged components to like-new condition. This process extends product life, reduces the need for new raw materials, and enhances sustainability.

Additionally, it is critical that manufacturers seriously consider **design for circularity**. A key step in product design is to consider the entire lifecycle of the product. By implementing eco-design principles early in the process, a product can be more easily reengineered for sustainability. This includes exploring innovative and sustainable materials, using energy and material-efficient processes, designing for repairability, and ensuring products are also easy to disassemble and recycle.

Interested in exploring circularity in your production? *Engage with us to transform your manufacturing processes.*

THEME 02_



NEW PROJECT LAUNCH: MAGHUMP

Innovative solution for thermomagnetic heat pumps

A new energy efficient and environmentally friendly solution is under develpment. Magentic heat pump technology is able to heat and cool spaces where precise temperature control is required. Currently, the permanent magnet assembly component makes the technology costly and prevents widespread adaptation.

The project **MAGHUMP** explores the use of liquid metal as heat transfer fluid. This innovative solution is expected to decrease residence time by a factor of 5 to 10. By manufacturing regenerators with optimized geometry using powder sintering process, the liquid metal can be tested for its thermo-magnetic performance. This is expected to reduce the manufacturing costs by 20-30% as well as minimise energy loss related to heating and cooling processes.

Interested in this project? *Please contact us for more information.*

THEME 03_

COMPLETED PROJECT: VITALS

Visualising information trends using data analyses for production systems

Unplanned maintenance activities can lead to significant costs and production delays. The **VITALS** project integrated sensor technology to collect real-time production data, systematically storing it in a comprehensive repository for advanced analytics.

A machine learning algorithm was developed to differentiate between healthy and failure modes of critical components, essential for monitoring component health and anticipating potential failures. The project demonstrated the potential of using advanced analytics for monitoring industrial processes, enhancing predictive maintenance capabilities, and extending these methods to other engineering systems.

Interested in using data analytics to improve your production? *Do not hesitate to reach out!*

PART 2

H2 FUTURE

Christina Keysers
Team Manager,
HyDriven

Charlotte Geuß
Technical Manager,
HyDriven

HyDriven aims to prove the potential of hydrogen to accelerate the energy transition towards zero emission. Since 2011, we have been known as ‘Green Team Twente’, but not anymore. We have rebranded and changed our name, logo, and colours. The reason for this drastic change is all about hydrogen, as this is a big part of our identity. We believe that achieving our goal is only possible with a brand image that screams hydrogen. HyDriven perfectly aligns with the vision of our team.

HYDRIVEN
HYDROGEN RACING TEAM TWENTE

In the last edition of this magazine, we were introduced to the HyDriven, the people behind them, and how twhey face the challenges related to managing a diverse and multidisciplinary team of young people driven by a common goal: harnessing the power of hydrogen as a clean and efficient fuel source for cars. In this second part, we will delve more into the heartbeat of the team: hydrogen. This time, we talked to HyDriven to understand the technical challenges and opportunities linked to being the lead of innovation.

Can you briefly explain what hydrogen is and how it is used as a fuel for cars?

Charlotte: There are two ways of utilizing the energy stored in hydrogen: by combustion or with a fuel cell. Combusting hydrogen is comparable to combusting any other type of fuel. In a fuel cell, hydrogen reacts with oxygen, releasing energy and water. This energy is then used to power an electric motor, which drives the car. Fuel cells are highly efficient and produce only water vapor as a by-product, making them a clean and environmentally friendly alternative to traditional fossil fuels.

Why is hydrogen a viable alternative to fossil fuels?

Christina: Hydrogen is a viable alternative to fossil fuels for several key reasons. It does not emit any greenhouse gases when combusted, producing only water as a by-product, which makes it environmentally friendly. Additionally, hydrogen can be efficiently stored and used as an energy carrier. It can be produced through the electrolysis of water or by breaking down methane with superheated steam. This flexibility in production and storage, coupled with its clean combustion, makes hydrogen an interesting option for a fossil fuel.

How does using hydrogen contribute to sustainability?

Charlotte: The problem with renewable energy sources is that they are highly time- or weather-dependent: there is no solar energy and less wind energy at night, so the entire energy demand needs to be produced during the day. They are also dependent on the location, so energy needs to be transported to locations with a higher energy demand than production. The energy that is produced during the day and needed at night can then be stored in hydrogen. Energy stored in hydrogen is also a convenient way of transporting energy as it can be sent through pipelines used for gas – with some small adjustments.

What are the technical challenges related to using hydrogen for the automotive industry? How do you address those challenges?

Christina: Hydrogen is highly reactive with oxygen, so when it is not handled correctly and with the required safety measures it can lead to explosions. The measures to prevent that can be costly. That and a few catastrophes in the past led to a certain stigma to hydrogen about it being unsafe. This needs to be overcome as well.

How do you envision the role of hydrogen in the future of transportation?

Charlotte: Hydrogen is a promising alternative to electric cars, particularly for trucks and heavy-duty vehicles. These larger vehicles already carry heavy weight, so the additional weight of hydrogen fuel systems is less of a concern compared to electric batteries. Hydrogen fuel cells offer a practical solution by providing longer ranges and quicker refueling times, making them suitable for the requirements of commercial transportation.

How do you see the HyDriven contributing to decarbonization and circularity?

Christina: Our goal is to get hydrogen and the technology more attention. We also lead by example by showing that it is possible to implement a hydrogen system into a race car, therefore it is also possible to implement it into other vehicles. As explained earlier, gaining energy from hydrogen is a carbon-free process.

Of course, it only is an emission-free process if the way the hydrogen was gained is ‘green’, so the electrolysis is done with electricity gained from renewable energy sources.

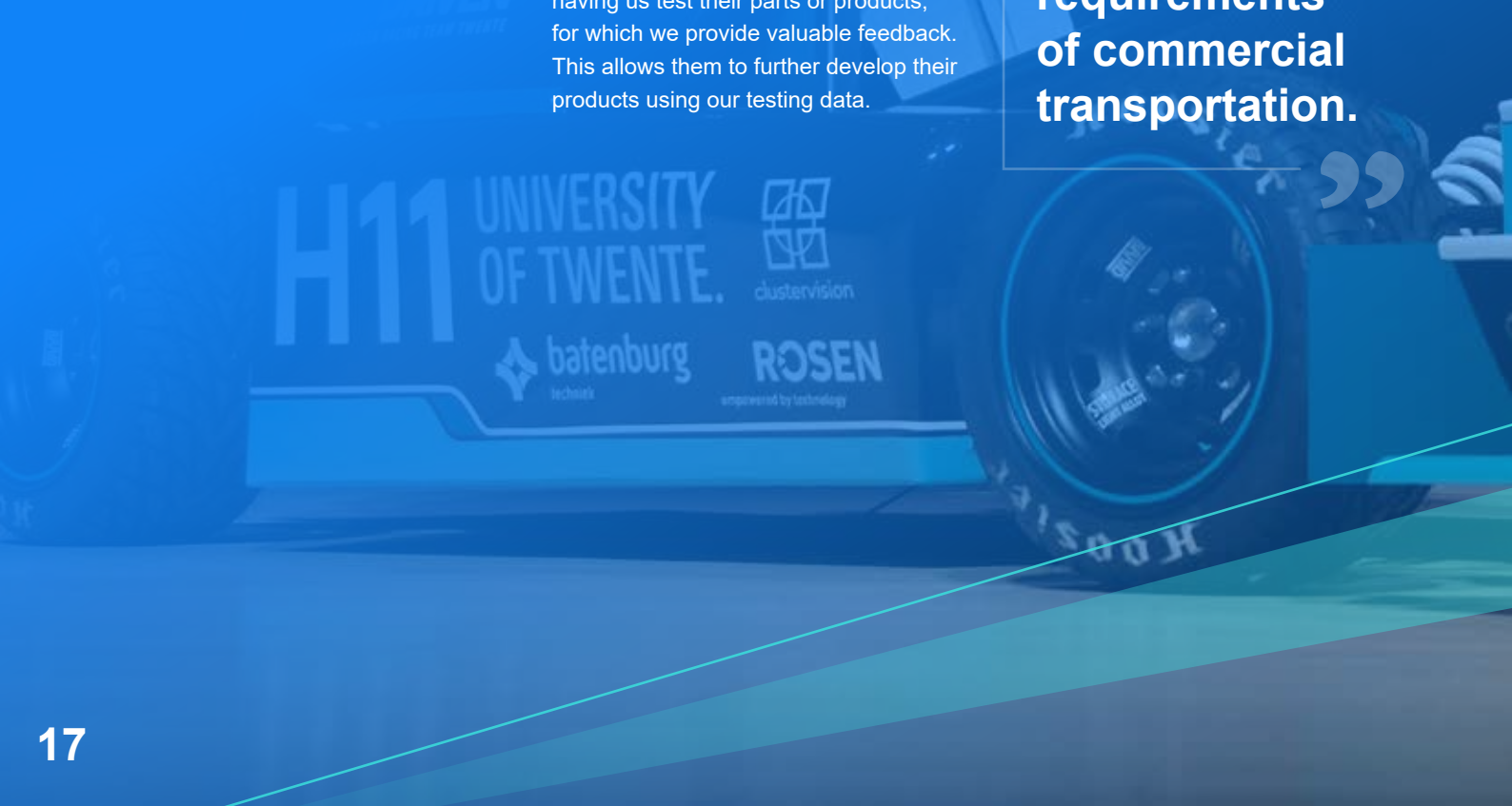
How are your sponsors involved in your journey and what do they hope to achieve by supporting you?

Charlotte: Our partners play a crucial role by contributing their knowledge, parts, or financial support to our hydrogen racing project. In return, we provide publicity to them. Additionally, they get into contact with students who have hands-on experience with hydrogen technology, potentially recruiting them as future employees. Many companies are also interested in having us test their parts or products, for which we provide valuable feedback. This allows them to further develop their products using our testing data.

What are the next steps for your project?

Christina: In the short term, our goals are to finish building and testing our racing car and to compete in the Formula Student competitions. In the long term, we aim to make the battery smaller, so it functions only as a buffer. Additionally, we aspire to convince other student teams to build hydrogen cars and join the competition. By doing so, we hope to attract real competitors who will challenge us in innovation and optimization.

> **Hydrogen fuel cells offer a practical solution by providing longer ranges and quicker refueling times, making them suitable for the requirements of commercial transportation.**



In the long run, we aim to draw more attention to hydrogen technology and its potential, convincing various industries to take a closer look at the possibilities hydrogen offers. Our goal is to accelerate the transition from a fossil fuel economy to a hydrogen economy.

Do you see hydrogen being adopted in mass manufacturing shortly?

Charlotte: There are already some applications, some car brands like BMW or Toyota have hydrogen models and there are also several companies that build trucks driving on hydrogen. For it to be a solution that a lot of people use I think it will still take some time.

> **Fuel cells are highly efficient and produce only water vapor as a by-product, making them a clean and environmentally friendly alternative to traditional fossil fuels.**

What would you like our audience to have as a takeaway from this project?

Christina: Hydrogen is a good alternative to batteries to store energy which is often wrongfully forgotten when talking about the energy transition, electromobility, and the lowering of transmissions in traffic

While there is still work to be done towards reducing the environmental impact of cars, we are left with a sense of optimism and inspiration. The dedication, collaboration, and innovation displayed by the HyDriven is inspiring to say the least. Hydrogen is not only a potential sustainable fuel source but also offers opportunities to inspire manufacturers and policymakers to turn their attention to sustainable fuel sources.

Thanks to the HyDriven we got a glimpse of a future fueled by clean energy, where the vehicles on the road could contribute to circularity and decarbonization of our global economy. It is a future worth striving for, and thanks to teams like this one, it's a future worth working for.

TNO innovation for life

STRATEGIC CHOICES FOR FUTURE EARNING POWER

In the rapidly changing world of technology and industry, digitalisation and smart industry play a crucial role in shaping the economy of the future. For the Netherlands, embracing digital transformation and innovation is essential in the pursuit of greater strategic autonomy and strengthening our competitiveness in the global arena.

SMEs, including startups and scale-ups, are a key driver of the Dutch economy and are at the heart of innovation and creativity. To ensure SMEs' resilience and growth, we need to help them seize the opportunities of digitisation and innovation. But there is also work to be done for big business.

National Technology Strategy

For decades, we almost took it for granted that the Netherlands is a prosperous and resilient country. But with rampant digitalisation and many geopolitical changes in the world, the picture now looks very different. This also has implications for Dutch industrial policy. We cannot be dominant in every industry. So, as a small country, we have to make strategic choices. The launch of The National Technology Strategy (NTS) early this year is a good start.

The NTS' priority list includes 10 key technologies to be boosted that not only make a major contribution to our country's earning potential, but are also important for addressing societal challenges and strengthening national security. In doing so, prioritising key technologies helps our country pursue technological leadership in those areas.

For Dutch industry, it is good that strategic choices have been made and that, in terms of technology development, there is now clarity about the course to be followed. As TNO, we expect the NTS to give a major boost to the future of industry and Smart Manufacturing in particular.

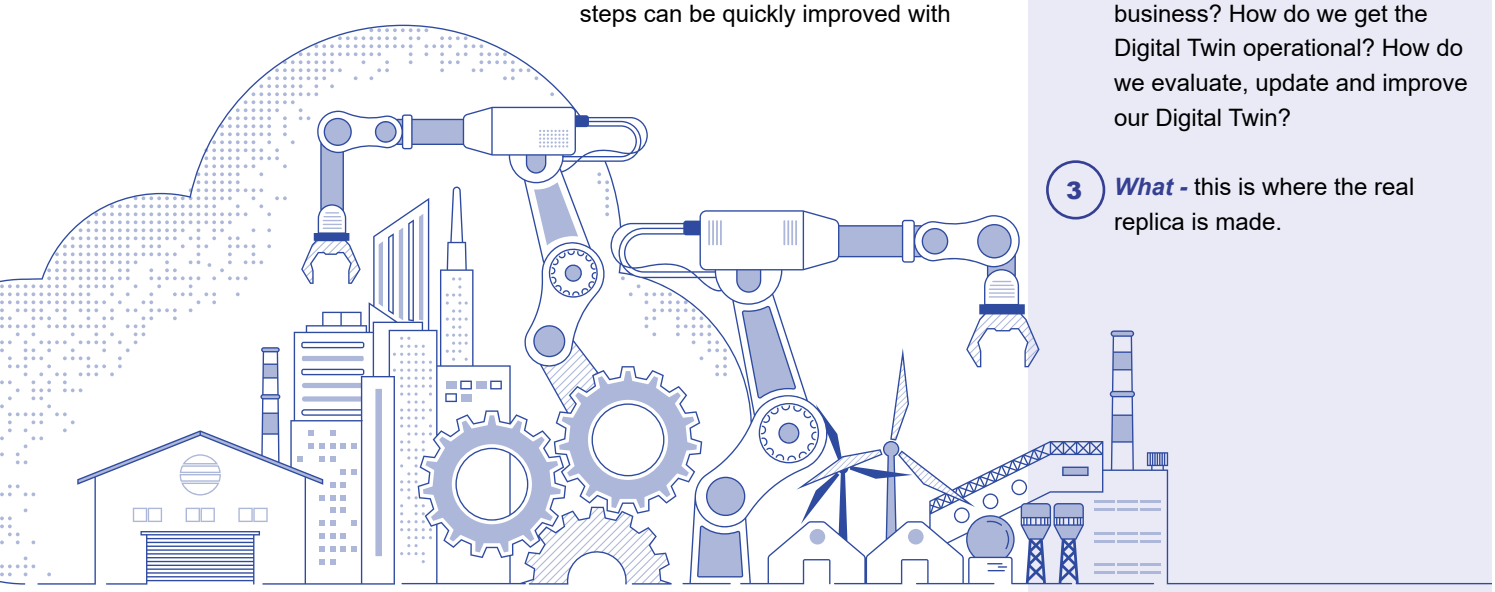
Indeed, if our manufacturing industry now fully commits to digitalisation, we could already be a major forerunner within Europe in the next decade.

Data & AI

One of the key technologies that will have to be strategically deployed is “Data & AI”, something that requires radical changes and innovation in the throughout the entire manufacturing value chain. Take as an example the future requirements of a digital product passport. The creation of a digital product passport is an important development on the way to a circular economy. It is a tool that allows monitoring the environmental impact and critical raw materials over the entire life cycle of a product. Implementation of this is slowly being forced by European laws and regulations.

For manufacturing companies, this means that they now have to prepare to adequately unlock data in production processes and thus harness the power of AI applications. This can be done by deploying a so-called digital connector to make data interoperable and apply it in a Digital Twin.

The Digital Twin is a crucial element for harnessing the power of existing data from the production process and the end product to value through the use of all kinds of future AI applications. By investing now in a solid framework from which data can be easily accessed, you as a company in the manufacturing industry will be able to quickly integrate new disruptive digitalisation applications. Think of improving your manufacturing throughput and quality with improved planning and utilisation of existing production facilities. Often the insight directly results in improved productivity so that non-value-added steps can be quickly improved with the familiar Lean Manufacturing way of working. It also makes it easier to more easily link future operator support systems such as automatically generated work instructions to the existing business automation. This also creates the possibility of sharing the data from the Digital Twin in the value chain from supplier and service provider to the end customer.



Implementing a Digital Twin requires a different way of working. To avoid the usual pitfalls in technology implementation, TNO uses a seven-step model in Digital Twin projects based on three basic questions:

1. ***Why -*** what is the purpose? What is the scope? And what is already there?
2. ***How -*** how do we make the technology applicable within our business? How do we get the Digital Twin operational? How do we evaluate, update and improve our Digital Twin?
3. ***What -*** this is where the real replica is made.

Standardisation

One of the ways to make a Digital Twin accessible to smaller companies is to use (European) standards where larger organisations have defined how a Digital Twin works and what the best way of working is. From Europe, there is increasing attention to Digital Twins so that it is becoming clearer how to link data, simulations and the business process. An example of this is the “ISO standard 23247 - Digital Twin Framework for manufacturing”, which makes a Digital Twin modular and clarifies how components must be linked.

Additionally, from the German Platform Industrie 4.0, there is the “Asset Administration Shell” that describes what information a Digital Twin of a device can contain and where a standard interface is agreed upon that a device should have to universally connect to other devices. Combined with the OMG Digital Twin Consortium’s “Digital Twin Capabilities Periodic Table”, it is then possible to prioritise, create a roadmap, and an overview of the information needed for the purpose. This approach was developed from the EU project Change2Twin in which 30 SMEs in Europe developed a first Digital Twin for their manufacturing company. This provides a structure in which you can properly describe what production data you need, what the result looks like in a dashboard, whether you can capture the behaviour of the device in Machine Learning (AI) or whether you can link the Twin with your factory planning, and you can plot this functionality over time in which the business case can be continuously expanded.

Champions League

In short, Smart Industry and digitalisation in particular is a crucial element in building the future earning capacity of a manufacturing company, large or small. With a pragmatic approach in cooperation between companies and knowledge institutions, we can ensure that the Dutch manufacturing industry can continue to operate at Champions League level in the years to come.

What is a digital product passport?

A product passport is a digital record in which the composition and other technical data of a product are collected. The addition “digital” thus applies to all references to product passports in this article. The product passport in the working definition develops across the chain, with each link in the chain adding data and information. The passport can be shielded from outsiders.

A raw material (extracted from the earth or recycled) will be an initial product in a product passport. A product passport then builds up over the chain, with several passports together forming a product passport of a composite product further down the chain. A vehicle, prepared meal or building can be seen as a collection of individual products and their individual product passports.

Smart Industry is more than just technology; it is strategic choices and culture change for your future earning potential.

Digital Twins in practice: Rheavita

When RheaVita called on TNO for help in developing a Digital Twin, it soon became clear that the company already had a good idea of why this was needed. The freeze-drying equipment it develops and produces is becoming increasingly sophisticated.

To take that technology to an even higher level, it had developed a process in which all the water evaporates and only the important material remains. The result is nice and light, and therefore easy to transport. And the material can also be stored for much longer.

So there are many advantages, but it is a complicated process that requires many steps and everything has to work correctly to ensure those advantages are achieved.

'Before creating a prototype, the experts at RheaVita wondered whether they could skip some prototype steps by using a software-based solution,' says Jeroen Broekhuijsen, Senior Business Consultant Smart Industry at TNO. 'They envisioned a digital tool that not only controls the machine, but can also indicate the right process settings and recipes for different products. A Digital Twin would lend itself very well to that.' ■

Authors:

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BOOSTING INNOVATION ACROSS BORDERS:

MANUFACTURING NextMaterials

In the fast-paced world of advanced materials and manufacturing, small and medium-sized enterprises (SMEs) often face significant hurdles in scaling up from prototype development to full production. The Manufacturing NextMaterials (MNM) project, a collaborative initiative under the Interreg program, aims to bridge this gap, fostering innovation and economic growth in the Dutch-German border region. Judith Inberg from Oost NL and Joost van Lindert from Cato Composites shared their insights on the project's objectives, benefits, and future prospects.

Judith Inberg explains that the MNM project is centred on providing flexible manufacturing technologies to SMEs for processing smart and sustainable materials into lightweight components, advanced battery systems, and sustainable energy solutions. "We see that there is ample government support up to the prototype development stage. But after that, government support stops, and they struggle to scale up to production and reach the market," Judith states. The MNM project aims to bridge this gap by equipping SMEs with the necessary tools to successfully bring their products to market, now and in the future.

The MNM project enhances cross-border cooperation, which is central to supporting SMEs. By combining competencies across borders, the project creates the synergy needed for developing production systems. "With this, we help SMEs not only find cooperation partners across borders and enter neighbouring markets but also provide a wide range of tools and support in designing and implementing test productions," Judith notes. These opportunities are expected to strengthen the region's innovative capacity and competitiveness, leading to more jobs and economic growth.

Core partners of the MNM project include Oost NL, NMWP.NRW, and BOM, focusing on business aspects like dealing with regulations and industry standards in foreign markets. On the technical side, six partners including knowledge institutes such as the Thermoplastic Composites Application Centre of Saxion University, Fraunhofer Innovation Platform at Twente University, and Cato Composites are crucial. These partners collaborate in lighthouse projects focusing on scaling up technical capabilities. They have established cross-border pilot facilities for composites test production, advanced battery production, and 3D printing support.

> **Thermoplastic composites are pivotal in reducing energy consumption for lightweight (electric) mobility and offer significant advantages like corrosion resistance. In additional these material are being re-used and biobased more and more. Their role in the energy transition and sustainability goals is becoming increasingly essential.**
>
> *— Joost van Lindert, Owner and Managing Director, Cato Composites*

We are really excited that CATO Composites will invest in the automated pilot line this year. But we are also looking forward to the services portfolio that Fraunhofer and the University of Münster and University of Twente are developing for the production of battery systems. Last but not least the Rapid technology Centre of the University of Duisburg-Essen is testing with new materials for 3D-printing and developing applications for the use of 3D printing processes within existing production processes.

— Judith Inberg, Business Developer, Oost NL

Joost van Lindert from Cato Composites highlights the main challenges SMEs face when moving from prototype stages to full production. “To set up successful production, SMEs need knowledge, tools, and funding,” he explains. Without government support post-prototyping, many SMEs struggle to convince potential clients and investors to invest in production. Additionally, SMEs often lack the expertise to carry out test productions and navigate regulations and industry norms in foreign markets.

Looking ahead, Joost sees a bright future for composite materials, especially in terms of sustainability and efficiency. “Thermoplastic composites as structural and lightweight materials help reduce energy consumption for lightweight (electric) mobility and have specific properties like corrosion resistance,” he says. The growing range of biobased and recycled thermoplastic composites offers great opportunities for achieving energy transition and sustainability goals.

The MNM project is committed to directly collaborating with SMEs. Through workshops looking at scale-up challenges and opportunities for cross-border cooperation, SMEs can gain valuable insights and support. SMEs can apply for scale-up subprojects with cross-border partners, with potential funding up to €70,000 per subproject and a total budget of €1.3 million available.

Addressing the challenges of thermoplastic composites in production through pilot projects is crucial. Joost emphasises that many SMEs in the program area have developed smart, sustainable composite materials or have concrete ideas for application using these materials, but lack the resources and expertise to scale up to manufacturing. “By using the existing resources of Cato’s Thermoplastic Composites Manufacturing Solution Centre in Rheden and by setting up an additional efficient pilot TPC manufacturing line, we aim to support other SMEs in applying and scaling up circular and bio-based composites,” he states. This initiative hopes to pave the way for further innovation and initiatives.

The MNM Interreg initiative, with the support of Cato Composites and other key partners, is paving the way for innovative advancements and economic growth in the Dutch-German border region. By fostering cross-border collaboration and providing essential resources, the project aims to help SMEs overcome scale-up challenges and contribute to a sustainable future. ■

Interreg
Deutschland – Nederland
Manufacturing NextMaterials

For more information, contact:

Judith Inberg
Business Developer,
Oost NL

Joost van Lindert
Owner and Managing Director,
Cato Composites

FACTORY2030

*COLLABORATING AND STRENGTHENING THE NEXT GENERATION OF **HIGH TECH EQUIPMENT***

empowered by NXT GEN hightech

As an international leader in the field of innovative high-tech equipment, the Netherlands has had to face the challenges posed by political interests and the growing number of competitors around the world. In order to contribute to R&D efforts, the National Growth Fund has defined the NXTGEN Hightech program to ensure sustainable growth for future generations. This will be achieved by working on high-tech solutions around key enabling technologies for societal challenges such as energy transition, health, and food.

NXTGEN Hightech will embark in an exciting path of collaboration between different scientific disciplines and industrial sectors. Together, project partners will build powerful knowledge networks, attract new investment opportunities, developing and retaining talent, strengthen the ecosystem, and further enhance the presence of the Dutch high-tech industry around the globe.

Over the next years, multiple working groups from across the country will focus their efforts in six core application domains to develop smart solutions: agrifood, biomedical production technology, energy, composites, laser satellite communications, and semiconductors. These domains will be supported by key system technologies such as systems engineering, smart industry, optomechatronics, robotics, thin film & plasma, semicon devices and bionanotechnology.

Smart Industry as a Key Technology

Integrating digital technologies into Dutch factories has already shown its benefits by making production more efficient and more connected. At the same time challenges have emerged as the market demands for an improved use of resources and reduced lead times. One way to address these challenges can be by adopting digitalization strategies from smart industry technologies. Through different applications, smart industry developments have contributed to make factories more autonomous, boost the productivity of personnel, and create smarter machines.

At NXTGEN Hightech, the vision for smart industry is to develop applications that increase the automation of the production chain and innovations that increase productivity, flexibility, sustainability and quality. These efforts will be translated into practice through regional test centres where real production setups can showcase the possibilities of autonomous factories. Through cross-country efforts, the 10 projects under the NXTGEN Hightech Smart Industry domain will work together to build a digital future!

NXT GEN hightech

NXTGEN Hightech is a National Growth Fund program, which started in early 2023, to develop innovative high-tech equipment that contributes to solutions for major societal challenges and to the competitiveness of the Netherlands. The investments are of approximately 1 billion euros by 2030 and involves the collaboration of 330 partners within over 60 projects.

Factory 2030 as the Industrial Cluster East

Factory2030 is the eastern cluster working on developing technologies and strategies for the autonomous factories of the future. Lead by the University of Twente, the consortium includes both research institutions and 10 industrial partners from the region working on 18 industry-driven use cases.

The project's efforts are focused on the development of advanced and flexible production systems across NXTGEN Hightech domains, mainly focusing on expanding the knowledge for:

At NXTGEN Factory 2030, we revolutionize high-tech industries with various cutting-edge smart solutions, driving innovation and shaping the future of intelligent manufacturing.

– Sebastian Thiede, Full Professor in Manufacturing Systems, University of Twente

SMART MACHINE AND PRODUCTION CONCEPTS FOR FLEXIBLE AND EFFICIENT PRODUCTION

TRANSFERABLE SMART INDUSTRY IMPLEMENTATION STRATEGIES FOR DIFFERENT SECTORS

ADVANCED DIGITAL TWIN-ENABLE SOLUTIONS FOR PRODUCTION IMPROVEMENT

INTEGRATION OF DEVELOPMENTS IN PILOT LINES FOR BIOMEDICAL AND BATTERY PRODUCTION

These contributions will be developed over the coming years of NXTGEN Hightech to strengthen the competitiveness of Dutch industrial partners.

In addition, the collaborative efforts within Factory2030 will result in the improvement of smart battery production, advanced biomed production, components for semicon production, and cross sector digital transformation:

Smart Battery Production

The production of batteries encompasses a process chain with highly specific ambient conditions, high cost sensitivity, relevant environmental impact, vital product and operator safety, and specific product requirements. The use of new materials and production processes emphasizes the importance of thoroughly monitoring the production parameters and an adequate planning of the production facilities. Factory2030 is addressing these challenges through 4 use cases and by collaborating with two industrial partners, Demcon and LeydenJar. The outcome of Factory2030 in this domain will be to gain a further understanding of battery production process chains, improving environmental conditions while saving energy during battery production, development of transferable digital twins, and by applying Smart Industry principles to a battery pilot line.

Within the NXTGEN Hightech project for Smart Industry we find great support for our ongoing development of flexible and modular machines in challenging production environments. We're looking forward continuing the journey, together with other tech-partners in the program.

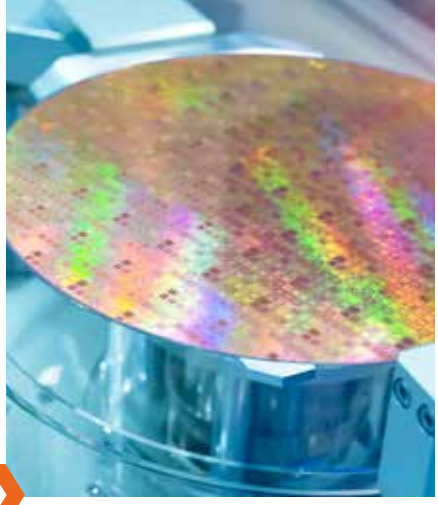
– Thijs Rupert, Managing Director, DEMCON

Advanced BioMed Production

The field of biomed production consists of an extensive array of applications which involve diverse production routes, regulated boundary conditions, and a highly competitive market. Such is the case of high-volume medical disposables production, these need to comply with strict standardised requirements for production environments and achieve the highest levels of quality control. Further development of this production processes will be reached through 4 use cases in Factory2030 and by working together with Demcon and Uneedle. Some of the contributions to this domain will be a systematic requirement analysis for current and future biomed process chains, development of functional building blocks for automated production, and transferring the generated knowledge into a pilot line.

We look forward to leveraging the advanced data analytics toolbox developed by Factory2030 to optimize our microneedle manufacturing processes and drive efficiency in our production lines. This collaboration will undoubtedly lead to innovative solutions that will revolutionize the High Tech Dutch manufacturing industry.

– Sanne Slot, Engineering Manager, Uneedle



Components for Semicon Production

One of the most challenging value chains is the production of semiconductors due to the combination of complex production technologies, highest precision requirements, equipment availability, and cost competitiveness. Therefore it is of great importance to tackle these production and equipment challenges to achieve smaller, more powerful, and more efficient semiconductors from Dutch manufacturers. In this domain, research will carried out through 4 use cases by the Factory2030 team which includes the collaboration with Levitech and VDL ETG. Some of the results for this domain include gaining a systemic understanding of the semicon value chain, development of strategies and tools for materials and performance traceability, and translating these efforts into semiconductor equipment and production.

We as VDL look forward in sharing knowledge and expertise by using data smartly in our factory. It not only supports our slogan: "strength through cooperation"; but it also motivates development and drives our ambition to improve the performance levels within our company; essentially improving the product.

– Jildert Anema and Elrich Kotze, VDL ETG

Cross-sector digital transformation

The learnings and solutions from one field have the potential to benefit another one. Knowledge from domain-specific solutions could be translated to improve product development, manufacturing processes, or production systems. Taking this into account, Factory2030 has taken a broader view from the start to identify the best practices in digitalisation to address challenges in 6 different use cases with industrial partners Cooll, Distribute, Fiberneering, NLR, Odd.Bot, and Specto Aerospace. To bridge knowledge between domains, the collaboration will focus into developing digital product development pipelines, self-organising and smart planning of manufacturing systems, smart models for quality control, and implementation guidelines for digital transformation.

FACTORY2030 PARTNERS

Cooperation over the next years between current and future Factory2030 collaborators will result in a stronger and more competitive Dutch industry. The contributions of Factory2030 will sum to furthering the Smart Industry domain in East Netherlands and other regions of the country. Along with the other projects within the NXTGEN Hightech programme the next generation of high-tech equipment will be created. ■

Do you want to stay informed on the progress of NXTGEN Hightech and Factory2030? Follow us on LinkedIn.

NXTGENHightech

Factory2030

This project received a contribution from the Growthfund programme NXTGEN Hightech.

Within the NXTGEN Hightech project for Smart Industry we support the Dutch industry in further understanding the manufacturing process, improving production and streamlining the dataflow. We are looking forward to continue the project together with the partners in the programme.

– Wouter van den Brink, Senior Scientist, Computational Mechanics, Netherlands Aerospace Centre (NLR)

Members from Factory2030 consortium at VDL ETG.

LEADING THE CHARGE:

TRANSFORMING HEAVY EQUIPMENT FOR A ZERO-EMISSION FUTURE

Today, as the world contends with environmental challenges, the European Regional Development Fund (ERDF) is championing an initiative that promises to reshape the future of heavy mobile equipment. The World Class Zero Emission Mobile Equipment project, a collaboration that marries cutting-edge technology with sustainability, aims to create zero-emission vehicles.

Bridging Technology and Sustainability

The World Class Zero Emission Mobile Equipment project is more than just an ambitious endeavor; it represents a vital leap towards addressing the pressing issues of our time—energy transition, digitization, and raw materials scarcity. By focusing on heavy mobile equipment such as the Empty Container Handler (ECH) and the Hooby Narrow Gauge, the project aims to eliminate CO_2, NOx, particulate matter, and noise emissions. This not only positions the initiative at the forefront of environmental stewardship but also sets new standards for industrial performance.

Four Pillars of Innovation

In the pursuit of transforming heavy mobile equipment towards a zero-emission future, the World Class Zero Emission Mobile Equipment project stands on four pillars of innovation. These pillars not only guide the project's objectives but also underscore its commitment to sustainability and technological advancement.

Modular and Scalable Technology

The heart of the project lies in its commitment to developing technology that is both modular and scalable. This approach ensures that innovations can be seamlessly integrated into various types of mobile equipment, broadening the scope and impact of the project. By creating adaptable technology solutions, the project promises widespread applicability and long-term viability.

Revolutionizing the Heavy Mobile Industry

Innovation in the heavy mobile industry is no small feat. The project aims to drive significant advancements, setting new benchmarks for sustainability and efficiency. By leveraging the latest in technology and research, the consortium is poised to redefine industry standards and pave the way for a cleaner future.

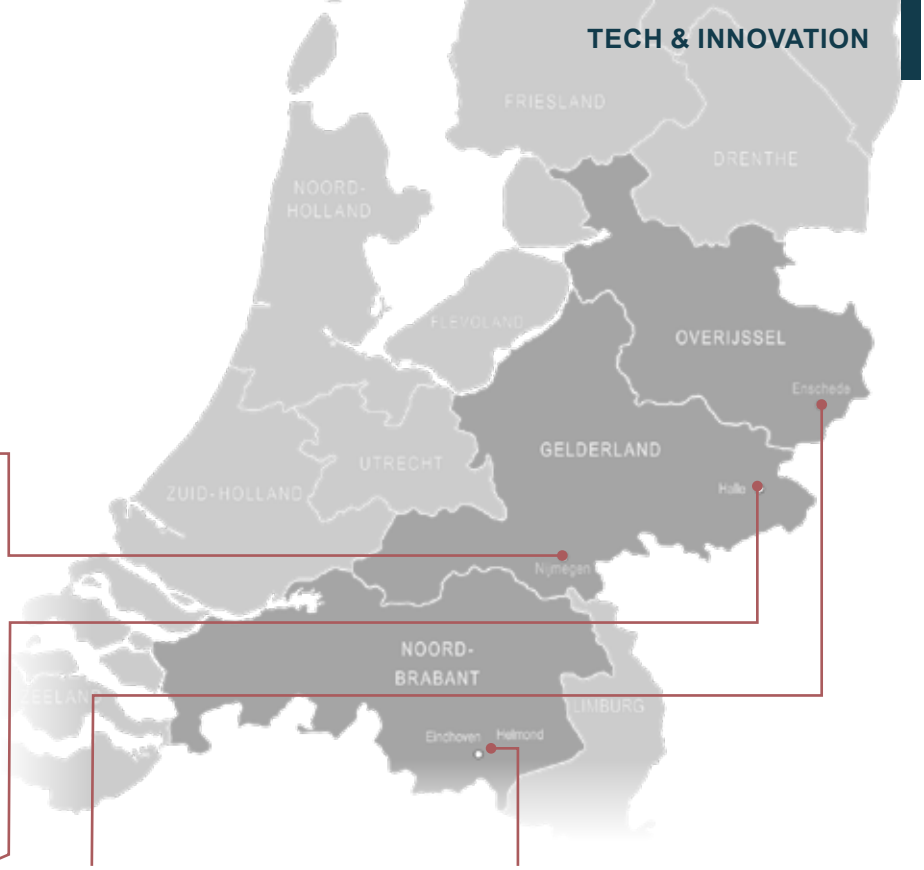
Enhancing Battery Circularity

A critical component of the project is the focus on battery circularity. Enhancing the value chain of battery packs and modules ensures that they are utilized efficiently and recycled responsibly. This not only extends the life cycle of batteries but also reduces the environmental footprint of mobile equipment.

Achieving CO_2 Emission Targets

In alignment with Dutch and European environmental goals, the project is dedicated to drastically reducing CO_2 emissions. This commitment underscores the initiative's role in combating climate change and promoting sustainable practices across industries.

Meet the Innovators Behind the Project



Hyster Yale Nederland BV

As the project leader, Hyster Yale Nederland BV brings its extensive expertise in mobile equipment development to the table. Their industry knowledge and commitment to innovation are crucial in steering the project towards its ambitious goals. By leveraging their experience, Hyster Yale ensures that the project is grounded in practical, achievable solutions that can be implemented across the industry.

Hobelman Halle BV

Hobelman Halle BV specialises in sustainable products and practical field applications. Their role in the project involves integrating cutting-edge sustainable solutions into mobile equipment, ensuring that these innovations are not just theoretical but practical and impactful. Hobelman Halle's expertise in real-world applications helps bridge the gap between research and deployment.

University of Twente

The University of Twente stands at the forefront of the project's research and development efforts. Focused on battery technology and sustainability, the university's contributions are pivotal in advancing the technical aspects of the project. Their research explores novel technologies and methodologies that push the boundaries of what's possible, driving the project towards groundbreaking innovations.

ACE Mobility (part of HAN)

ACE Mobility plays a critical role in bridging automotive education and industry. By facilitating knowledge exchange and driving research initiatives, ACE ensures that the project remains at the cutting edge of innovation. Their involvement helps to foster a collaborative environment where industry and academia can work together to solve complex challenges.

University of Twente: The Research Engine

The University of Twente is integral to the success of the World Class Zero Emission Mobile Equipment project. As a leading research institution, the university plays a crucial role in advancing the frontiers of innovation and sustainability in heavy mobile equipment. Their efforts are concentrated on three key areas:

Innovative Research

The university is committed to exploring cutting-edge technologies that enhance the sustainability and efficiency of heavy mobile equipment. By investigating new designs and processes, they aim to develop solutions that are both effective and practical.

Promoting Circularity

Leading the charge in enhancing battery circularity, the University of Twente focuses on ensuring that battery components are reused and recycled responsibly. Their research into the life cycle of batteries helps to minimise waste and maximise the value of materials.

Knowledge Dissemination

Through active engagement and collaboration with industry partners, the university ensures that research findings and best practices are shared within the consortium. This collaborative approach helps to accelerate the implementation of innovative solutions across the industry.

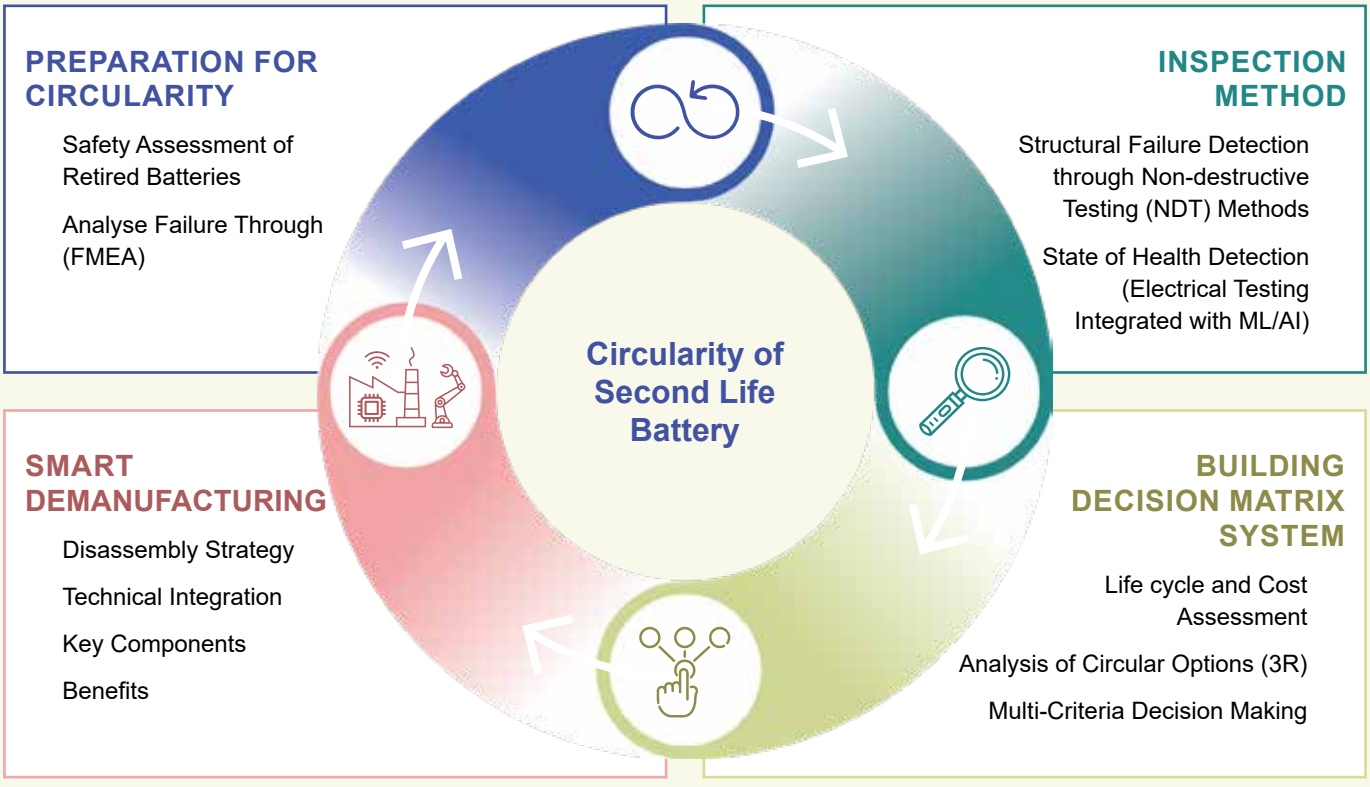
Pioneering Progress: Current Research Status

The World Class Zero Emission Mobile Equipment project has made significant strides across various research areas. The University of Twente has developed a generic Failure Modes and Effects Analysis (FMEA) for lithium-ion batteries, applicable in both ex-situ and in-situ conditions. This FMEA is currently undergoing validation by industrial partners, ensuring that it meets the practical needs of the industry.

To mitigate safety risks associated with retired battery packs, understanding their internal conditions is crucial. Techniques such as industrial CT scanning and thermal imaging are being tested to detect anomalies of the battery cells. Currently, SOH (State of Health) tests are being conducted on retired batteries at different C-rates to determine their potential for secondary use based on their current state. To streamline this process, machine learning and deep learning models will be deployed for automation.

Smart disassembly initiatives are also underway, focusing on efficiently breaking down battery packs into individual cells. By identifying structural complexities and optimizing disassembly processes, the project aims to streamline the recycling and reuse of battery components. These efforts are essential for enhancing the circularity of batteries and reducing environmental impact.

The Big Picture: Overview of the Research Topic



The Road Ahead

The World Class Zero Emission Mobile Equipment project is more than just a research initiative; it is a blueprint for the future of the heavy mobile industry. By uniting industry leaders and academic institutions, the project aims to set new standards in sustainability and performance. With a clear focus on eliminating harmful emissions and promoting circularity, this initiative not only aligns with European environmental targets but also leads the charge towards a greener, more sustainable future.

Through research, development, and knowledge sharing, the consortium is poised to make a lasting impact on the industry and the environment. The road ahead is challenging, but with the combined expertise and dedication of its partners, the World Class Zero Emission Mobile Equipment project is well on its way to achieving its ambitious goals. ■

Co-funded by the European Union

EFROoost
Programme East Netherlands 2021-2027
European Regional Development Fund

World Class Zero Emission Mobile Equipment

SMART TEXTILES

INNOVATING FOR A ***SUSTAINABLE AND INTELLIGENT FUTURE*** *WITH SAXION UNIVERSITY*

This sock with integrated electrodes that can measure stress in patients who cannot express themselves.

As society grapples with complex challenges, smart textiles emerge as a promising solution to address these issues through innovative and sustainable approaches. At the forefront of this revolution is Saxion University of Applied Sciences in the Netherlands, where the research group Sustainable & Functional Textiles (SFT) leads the way. Through practice-oriented research, Saxion is developing advanced smart textiles that merge technology with eco-friendly practices, fostering collaborative efforts, overcoming significant challenges, and showcasing real-world applications.

Collaborative Efforts: Saxion's Partnerships in Smart Textile Research

Collaboration is key to driving innovation in smart textiles, and Saxion excels in forming strategic partnerships with industry leaders, academic institutions, and government bodies. These collaborations facilitate the exchange of knowledge, resources, and expertise, propelling the development of cutting-edge textile solutions.

Projects at Saxion often involve multidisciplinary teams, combining the strengths of various fields such as electronics, material science, and design. These joint efforts result in the seamless integration of sensors and actuators into textiles, creating garments that can monitor vital signs, provide therapeutic benefits, and interact with the environment. By working closely with partners, Saxion ensures that its research addresses real-world needs and has practical applications.

Challenges and Future Directions in Smart Textile Research

The field of smart textiles faces several challenges, including scalability, durability, and integration of electronic components. Saxion's researchers are actively exploring solutions to these issues, focusing on enhancing the robustness and longevity of smart textiles while maintaining their functionality and comfort.

Future directions in Saxion's research involve advancing the technologies used in textile production, such as knitting, weaving, and technical embroidery. These methods facilitate the incorporation of smart materials into fabrics without compromising their aesthetic or tactile qualities. Additionally, Saxion is investigating new applications

The yarns developed at Saxion can be woven on a small scale after threading the heddles.

The circular knitting machine is used to develop sports fabrics with integrated electrodes.

for smart textiles in sectors like healthcare, sports, and environmental monitoring, aiming to expand the impact of their innovations.

Towards Sustainable Smart Textiles: Merging Technology with Eco-Friendly Practices

Next to smart textile development, sustainability is a cornerstone of Saxion's textile research. The university's Circular Textile Lab is equipped with state-of-the-art machinery for recycling, fibre wet-spinning, yarn spinning, weaving, knitting, and confection. This facility enables the rapid prototyping of circular textiles using both recycled and virgin materials. By integrating eco-friendly materials and innovative production methods, Saxion is reducing the environmental impact of textile manufacturing.

Saxion's research focuses on optimising chemical and mechanical recycling processes, employing spectroscopic analytic tools for textile sorting, and exploring diverse applications of recycled fibres in yarns and fabrics. Rigorous analyses ensure the quality and durability of recycled content, fostering sustainability and bolstering the circular economy within the textile industry. These skills become more and more relevant in the development of innovative smart textile products that take end-of-life solutions into account.

The wet-spinning line can be used to spin fibres from chemically recycled raw materials, as well as for medical applications.

> **By integrating eco-friendly materials and innovative production methods, Saxion is reducing the environmental impact of textile manufacturing.**

The ACHILLES sleeve was developed to reduce stress in children in hospital with infusions.

Case Studies

Real-World Applications of Saxion's Smart Textile Innovations

The practical applications of Saxion's smart textile research are manifold, demonstrating the transformative potential of these technologies. In healthcare, where healthcare and textiles converge for impactful innovation, smart textiles integrate sensors for monitoring bodily functions, apply functional coatings, and create intelligent structures for support. These innovations are pivotal for healthier ageing and early disease detection. However, many innovations struggle to transition from concept to implementation due to limited user engagement, high costs, scalability issues, and regulatory constraints like privacy and Medical Device Regulation (MDR).

To address these challenges, a community was established in 2022, bringing together businesses, institutions, universities, and healthcare facilities, supported by Saxion University and University of Twente. This consortium aims to enhance research, development, and education, ultimately increasing the implementation of smart textile innovations.

Key applications include monitoring children's respiration, providing haptic feedback for training, measuring stress in patients with cognitive impairments, and integrating pressure sensors in socks for diabetics. Additionally, advancements in compression textiles, infusion-stabilising gloves, support stockings, exoskeletons, and textiles in composites are underway. Saxion also focuses on functional surfaces with odour-masking and antibacterial coatings, and thermoreactive materials. Emphasising sustainability, Saxion promotes the reuse of hospital textiles, alternatives to disposables, textile recycling, and optimised production processes, driving functional textile innovation for a healthier and more sustainable future.

Another compelling application of Saxion's innovative research lies in the transformation of medical textiles for a circular future. This captivating case study showcases collaborative efforts between Saxion's research group Sustainable & Functional Textiles, Amsterdam UMC, The Bin, and Van Moer Bedrijfskleding.

In this initiative, the project team explores the concept of rejection to renewal, focusing on shifting from disposables to sustainability. At Amsterdam UMC, a surplus of rejected textiles, including doctor's coats, nursing uniforms, trousers, polo shirts, and jackets, awaits repurposing. However, finding a suitable option for giving these materials a second life has proven challenging. Driven by their sustainability goals, Amsterdam UMC seeks to unlock the potential of these materials for both internal use within the hospital and external stakeholders.

For wet spinning, the polymer solution needs to be passed through a spinneret.

Saxion Laboratories are equipped to perform textile processes on a small scale and measure the properties of the resulting samples.

Used workwear can be converted into new high-quality fibres through chemical recycling processes while retaining the original dye.

Smart Textiles can be assembled through technical embroidery. In this example of a luminous curtain, the LEDs are automatically placed, connected and integrated into the design.

The wearable breathing trainer is designed to help children with breathing problems improve their breathing patterns in an interactive way.

Van Moer Bedrijfskleding, the supplier of work clothes to the UMC, shares this sustainability vision and aims to enhance their expertise in sustainability and the circular economy. They aspire to integrate these principles into their product offerings for the hospital. Saxion takes the lead in this research, partnering with The Bin, an organisation specialising in facilitating the transition to circular systems.

The project addresses the hospital's transition from disposable to reusable products. Through meticulous examination, the project team aims to determine the feasibility of creating new products from high-quality rejected textile material (comprising 65/35% polyester/cotton), such as doctor's coats and nursing uniforms. These repurposed items could potentially replace current disposable products, aligning with the hospital's sustainability objectives and fostering a circular approach to textile management within healthcare settings.

Shaping the Future: Saxion's Vision for Smart Textiles

Saxion University of Applied Sciences is at the cutting edge of smart textile research, merging sustainability with technological innovation to create products that address real-world problems. Through collaborative efforts, the university is overcoming significant challenges and paving the way for future advancements in this dynamic field. As Saxion continues to explore new frontiers in smart textiles and textile recycling, the impact of their work will undoubtedly be felt across various sectors, from healthcare and sports to environmental sustainability, shaping a smarter and more sustainable future. ■

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Saxion University of Applied Sciences

THE ROLE OF ADDITIVE MANUFACTURING FOR A GREENER FUTURE

In an era where sustainability is crucial, additive manufacturing (AM) stands out as a significant technology for innovation and environmental responsibility. By minimizing waste, enabling lightweight design, and addressing supply chain challenges, AM not only aligns with the principles of the circular economy but also meets the pressing need for eco-friendly production methods. However, realizing its full potential requires overcoming significant challenges.

Davoud Jafari, an assistant professor at the University of Twente, talks to the Fraunhofer Innovation Platform for Advanced Manufacturing about how additive manufacturing offers a transformative approach to sustainable manufacturing, the obstacles it faces, and the strategic steps needed to ensure it contributes effectively to a sustainable future.

Tell us about Additive Manufacturing (AM) and how it contributes to sustainable manufacturing practices.

AM, also known as 3D printing, presents a compelling opportunity for a more sustainable production paradigm aligned with circular manufacturing principles. However, its impact on achieving net zero production is a complex issue with both advantages and shortcomings. In particular, AM offers several advantages that contribute to sustainable practices and align with circular economy principles. One major benefit is the reduction of material waste. Unlike traditional manufacturing methods that generate substantial scrap, AM builds objects layer-by-layer, thereby minimizing material waste. This efficiency directly contributes to closing the material loop in a circular economy by maximizing resource utilization.

Another advantage of AM is its potential for lightweight design. AM excels at creating complex, lightweight structures, enabling the production of lighter airplanes, cars, and other products. The reduced weight of these products translates to lower energy consumption throughout their operational lifespan. This approach not only enhances energy efficiency but also supports the principles of design for lifespan and disassembly, which are integral components of circular manufacturing. Additionally, AM enhances manufacturing flexibility. It is particularly adept at producing small batches and customized products, reducing the need for large production runs. This capability can lower transportation requirements, thereby minimizing the environmental footprint associated with logistics. The flexibility of AM fosters on-demand and localized manufacturing, which are also key aspects of circular economies. By enabling more efficient resource use, reducing waste, and supporting sustainable product lifecycle management, AM plays a crucial role in advancing sustainable manufacturing practices.

Looking ahead, what challenges currently hinder AM's ability to contribute to a more sustainable future? What recommendations can you provide to ensure AM fulfills its potential for environmental responsibility?

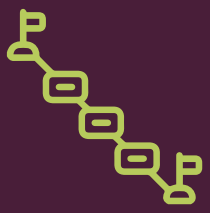
AM holds promise for a more sustainable future. However, to fully unlock this potential, we need to think about the entire AM lifecycle, minimizing waste and maximizing resource recovery.

Several strategies can be implemented:

- ***Energy consumption concerns:*** The AM process itself can be energy-intensive, particularly for certain technologies. In some cases, the energy savings from reduced material waste might be negated by the printing process itself. Optimizing printing processes and utilizing alternative energy sources are important to address this challenge. This involves fine-tuning print parameters and designing support structures that minimize material usage. Additionally, any unavoidable printing waste should be collected and reused in new prints, further reducing the overall environmental footprint.

- ***Limited environmental data:*** Current data on the environmental impact of various AM materials and processes is often lacking. This makes it difficult to make fully informed decisions that prioritize sustainability. Life cycle assessments (LCAs) that consider the entire production chain, including pre-processing, post-processing, and machine utilization, are essential for understanding AM's environmental footprint.

- ***Focus beyond single parts - LCA for transparency:*** LCAs of AM often overlook critical stages, focusing primarily on the printed part itself. This typically neglects the environmental impact of pre-processing (such as powder preparation), post-processing (like support removal and finishing), and the energy consumption of utilized machines. To compare AM with traditional manufacturing methods, it is essential to expand the scope of LCAs to include the entire AM lifecycle. This provides fair comparisons with traditional manufacturing and identifies areas for improvement.



- ***Reducing emissions with on-demand AM:*** Gone are the days of lengthy supply chains and the associated carbon footprint of transportation. AM empowers local, on-demand manufacturing, enabling production closer to consumers. This not only streamlines logistics but also significantly reduces greenhouse gas emissions associated with long-distance shipping. By decentralizing production, companies can respond more quickly to market demands and reduce the environmental impact of moving goods across the globe.

- ***Sustainable design principles:*** Sustainable design is a powerful concept that shapes modern manufacturing. It ensures products are built with both efficiency and the environment in mind. Designers use specialized tools to assess a product's entire life cycle, from creation to disposal. This approach incorporates key strategies:

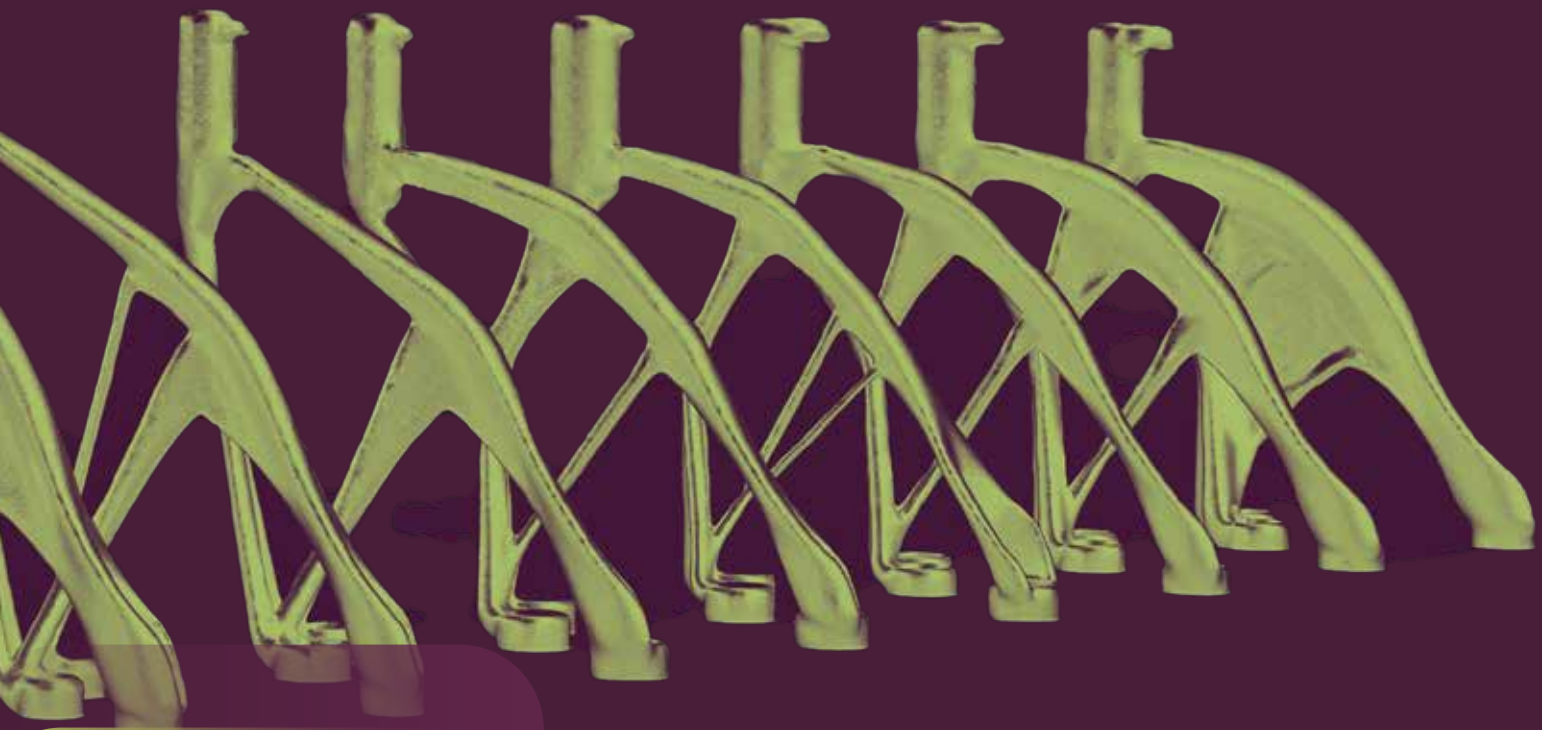
1. Minimize material usage – careful material selection ensures products are built with only what's necessary, reducing waste and resource consumption.

2. Prioritize energy efficiency – designing for energy-efficient operation throughout a product's life minimizes its overall environmental impact.

3. Design for disassembly – easy disassembly at the end of a product's life allows valuable materials to be recovered and recycled for future use. This philosophy extends beyond simple "use and discard." By embracing concepts like "design for repair" and "design for remanufacturing," products become easier to disassemble, update, or rebuild. This extends their lifespan, reduces reliance on virgin materials, and minimizes waste generation altogether.

In essence, sustainable design creates a win-win scenario for both manufacturers and the environment.

- ***Closing the loop with recycled materials:*** Imagine a world where waste from AM processes no longer exists. Advancements in recycling and upcycling technologies allow leftover 3D printing materials to be transformed back into high-quality feedstock for new products. This reduces dependence on virgin materials, lessens environmental impact, and conserves natural resources. Prioritizing bio-based or recycled materials further diminishes the environmental footprint compared to using raw materials. Additionally, incorporating recycled content from other industries into the 3D printing process creates a closed-loop system, turning waste into valuable resources and keeping it out of landfills. This closed-loop system is more than a recycling strategy; it represents a shift in our approach to production and waste. By continually recycling and reusing materials in AM, we establish a sustainable cycle that meets industry needs and environmental goals. This visionary approach promises a future where waste is nearly eliminated, leading to more sustainable and eco-friendly manufacturing practices.



Tell us about your scientific research interest and its link to AM for a Greener Future.

We develop and investigate the fundamental science and engineering of energy materials through AM. We aim to tailor and control functions related to thermodynamics, kinetics, and transport, including providing surfaces for thermochemical or electrochemical reactions, conducting electrons and heat, and distributing fluids. My research team, the AM Solutions for Energy Materials, focuses on enhancing AM processes to create and test complex geometrical shapes and realize hierarchical structures with graded composition and length scales ranging from micrometers to centimeters. We are currently focused on three application areas: (1) heat transfer, (2) electrochemical systems, and (3) thermochemical systems. A key challenge in our research is obtaining control over properties to tailor them for sustainable energy solutions.

The recycling of energy materials such as porous electrodes that are used in batteries, fuel cells, and supercapacitors aligns perfectly with the growing movement towards a greener future. With AM, the design possibilities are virtually limitless. Engineers can design energy solutions such as batteries with built-in features that facilitate easier disassembly and material separation at the end of their lifespan. This directly addresses the challenges of recycling complex structures. By combining efficient recycling methods for existing materials with the innovative design and production capabilities of AM, we can achieve a future with sustainable energy solutions. This not only ensures responsible handling of valuable resources but also paves the way for cleaner and more efficient energy use.

> **Focusing on sustainable design not only reduces the initial environmental footprint but also ensures that valuable materials are recovered and reused, thereby promoting a circular economy.**

As we wrap up our discussion, could you share your final insight?

By addressing its current shortcomings and leveraging its strengths, AM has the potential to be a transformative technology for achieving net zero production. Focusing on sustainable design not only reduces the initial environmental footprint but also ensures that valuable materials are recovered and reused, thereby promoting a circular economy. By integrating the above principles, designers can create products that are efficient, environmentally friendly, and sustainable from conception to end-of-life. This benefits the planet and creates a more resilient and resource-efficient manufacturing landscape. ■

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STERN MOTORCYCLES

PIONEERING THE FUTURE OF ELECTRIC OFFROAD RIDING

STERN

STERN Motorcycles emerged from the innovative spirit of four determined founders, each driven by a shared passion for sustainable motorcycling and advanced engineering. The company traces its origins to Electric Superbike Twente (EST), a student team focused on developing electric superbikes. Among the founders is Tim Veldhuis, who co-founded EST, alongside Anne Bulten, Thomas Maas, and Jan Veenhuis. Their collective experience and the steep learning curve within EST fuelled their ambition to take their knowledge beyond the academic realm and into the commercial market. This drive gave rise to STERN Motorcycles, a company dedicated to revolutionising the offroad motorcycle industry with cutting-edge electric technology.

The Mission and Evolution of STERN Motorcycles

Initially focused on leveraging their expertise from EST, STERN Motorcycles has continually evolved to address the specific needs of the offroad motorcycling community. Anne Bulten, COO and co-founder, highlights the urgency of transitioning to electric vehicles in this sector due to noise pollution concerns and environmental sustainability. The company's mission has sharpened over time, emphasising the creation of electric motorcycles that not only match but exceed the performance of traditional internal combustion engine (ICE) motorcycles.

Performance and Sustainability: A New Standard

In a market that often clings to tradition, STERN Motorcycles aims to disrupt the status quo. Their electric motorcycles are designed to offer an experience that rivals ICE motorcycles, focusing on handling, range, and performance. With an 8.8kWh battery, STERN's motorcycles provide the same range as their ICE counterparts, coupled with higher torque and instant power delivery inherent to electric motors.

A standout feature of STERN's design is the hot-swappable battery pack. This innovative system addresses one of the main challenges in electric offroad riding: the lack of charging infrastructure. Each battery pack, comprising two modules, can be swapped out in just 30 seconds, ensuring continuous riding without lengthy downtimes for recharging. STERN also plans to introduce green energy-powered docking stations at tracks, optimising the charging process and extending the battery lifespan without the need for costly, permanent infrastructure.

Circular Manufacturing and Net-Zero Emissions

STERN Motorcycles is committed to sustainability through circular manufacturing. They are working towards developing fully recyclable battery packs, where all components can be detached and reused. This approach is complemented by the advancement in recyclable battery cell technology, which STERN plans to adopt as soon as it becomes viable for high-performance applications. Additionally, the motorcycles feature aluminium components, known for their recyclability and performance benefits, thus enhancing the vehicle's lifecycle and environmental impact.

Market Reception and Future Prospects

The response from the offroad racing community, though awaiting official

> **By 2030 we want to have build a well known motorcycle brand an manufacture 5000 motorcycles per year. Also by this time we will have started the development of new models. In 10+ years we want to be a major player in the motorcycle manufacturing industry. And on a more personal note, in the future, I will hopefully be able to see my children riding on a STERN motorcycle and see that we have been able to contribute on preserving this beautiful sport for generations to come.**
>
> *— Anne Bulten, COO and co-founder of STERN Motorcycles*

product launch, has been notably positive. Dealers have confirmed a significant demand for road-legal bikes with swappable battery packs, addressing a major pain point in the current market. STERN Motorcycles is actively fundraising to advance the development of their pre-production models, aiming for a market launch in early 2025 with pre-orders opening soon.

Challenges and Overcoming Them

The journey to developing a commercially viable electric motorcycle has not been without challenges. One of the primary hurdles, according to Anne Bulten, is securing funding in the early stages. The team has adopted a lean development approach, utilising techniques like 3D printing to minimise costs and delay significant expenditures until mass production is feasible. This strategy extends to their team and marketing efforts, ensuring maximum output with minimal resources.

The Future of Offroad Racing

STERN Motorcycles envisions a future where offroad racing thrives in an electric landscape. The shift to electric is seen not just as an environmental necessity but as an opportunity to revitalise the sport. Electric motorcycles, being quieter and more accessible, can help mitigate issues like noise pollution and lower the barriers to entry for new riders, potentially expanding the sport's appeal and participation.

Innovations on the Horizon

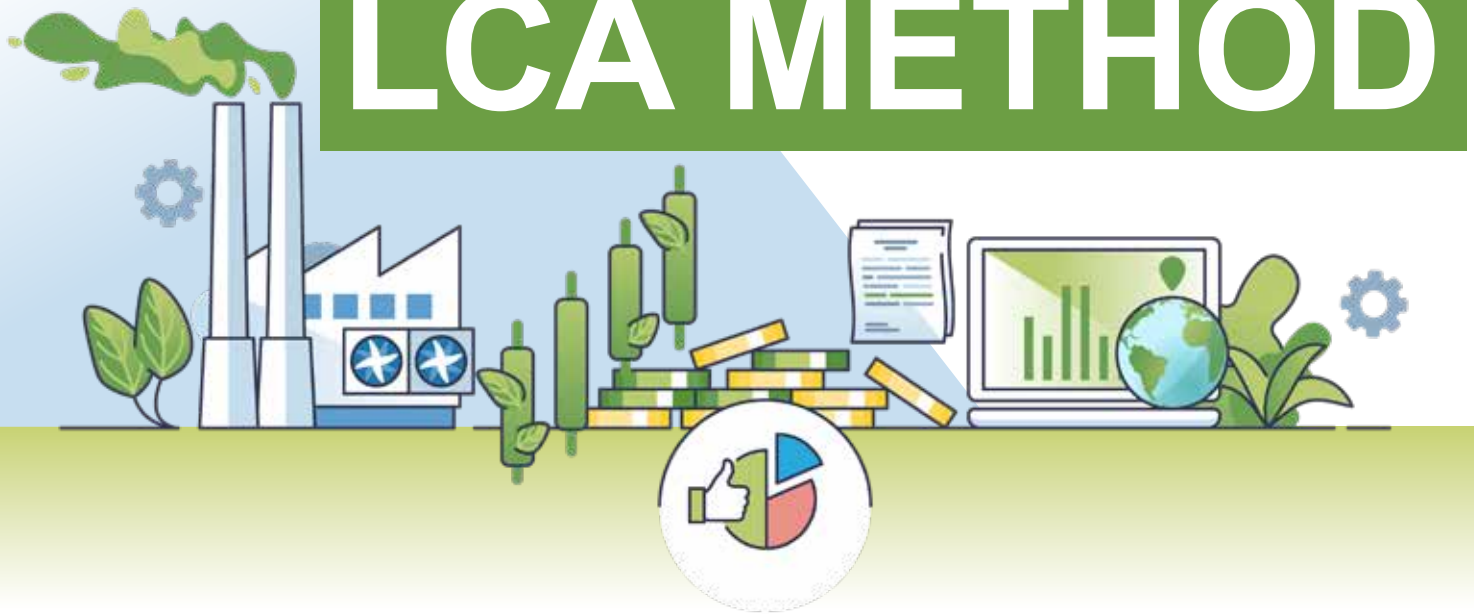
Looking ahead, STERN Motorcycles plans to diversify its product lineup while maintaining a common battery platform. This strategy will allow riders to use a single battery pack across multiple motorcycle types, significantly reducing the resources required for manufacturing. By 2030, STERN aims to produce 5,000 motorcycles annually and establish itself as a leading brand in the motorcycle industry. The founders hope to see their innovations contribute to the durability and sustainability of offroad motorcycling, preserving the sport for future generations.

In summary, STERN Motorcycles is not just building electric motorcycles; they are spearheading a movement towards sustainable, high-performance offroad riding. With their innovative technology and commitment to environmental responsibility, they are set to make a lasting impact on the industry. ■

ENVIRONMENTAL FOOTPRINT CALCULATION

OF PRODUCTS AND PRODUCTION PROCESSES USING THE

LCA METHOD



Why are LCAs important for manufacturing companies?

Growing demands to reduce the environmental footprint of our daily lives also push manufacturing companies to contribute to the effort of overall environmental footprint reduction. These companies are increasingly confronted with stricter regulatory and customer requirements, for example, which they must adapt to in order to operate profitably in the future. True to the motto “if you can’t measure it, you can’t manage it”, one key tool for the environmental footprint reduction is the Life Cycle Assessment (LCA) which is a methodological approach for the assessment of the environmental impacts of products, processes, and services. The procedure for conducting a LCA is standardized by ISO 14040/44 and it is carried out in a stepwise approach containing four consecutive phases with the objective to create transparency about the emissions that are caused over the life cycle of a product. In this way, LCAs are a suitable tool for manufacturing companies to react to growing environmental concerns, since emission transparency allows them one the hand to quantify the environmental footprint of their goods and services and other hand identify optimization potential within their process or value chain. The article at hand therefore focuses on the manufacturing phase of the product lifecycle and explains how the environmental footprint calculation of a product can be carried out using the LCA method. In order to illustrate the described approach, the example of the manufacture of a bipolar plate for fuel cells is used.

How are LCAs carried out?

As stated above, the LCA methodology is standardized by ISO 14040/44 and usually follows a defined approach. Figure 1 illustrates the four phases of the LCA.

1 In the first step, the goal and scope of the analysis are defined. This includes the definition of the overall objective ("Who and what is this analysis designed for?"), the boundaries as well as the focus of the analysis. The focus of the analysis is defined through the functional unit, which is the reference point for the analysis. In the example at hand, this is the product which the LCA is carried out for, in this case a single bipolar plate. In addition, the impact categories are defined in which the emissions caused by the production of the functional unit are quantified. Here the focus is usually on greenhouse gas emissions, but other categories such as water consumption or ecotoxicity can also be considered. In the further course of the analysis, all environmental impacts that are calculated during the analysis are normalized to the functional unit. This first step therefore creates the basis for the life cycle assessment of the considered product.

2 In the second step, the inventory analysis is drawn up. For this purpose, all material and energy inflows and outflows into and out of the defined boundaries that are required for the manufacture of the product in question are recorded. This procedure results in the life cycle inventory (LCI) which forms the data basis for the analysis. This phase of the LCA is of significant importance for the quality, reliability, and validity of the analysis result. In a lot of cases, manufacturing companies are struggling with the compilation of a complete and valid LCI as they lack data and information of the material and energy inflows and outflows, particularly for cross supply chain considerations. For instance, many OEMs have difficulties obtaining data and information on the environmental footprint of the products they purchase from suppliers. This challenge results in the analysis results often being subject to uncertainties.

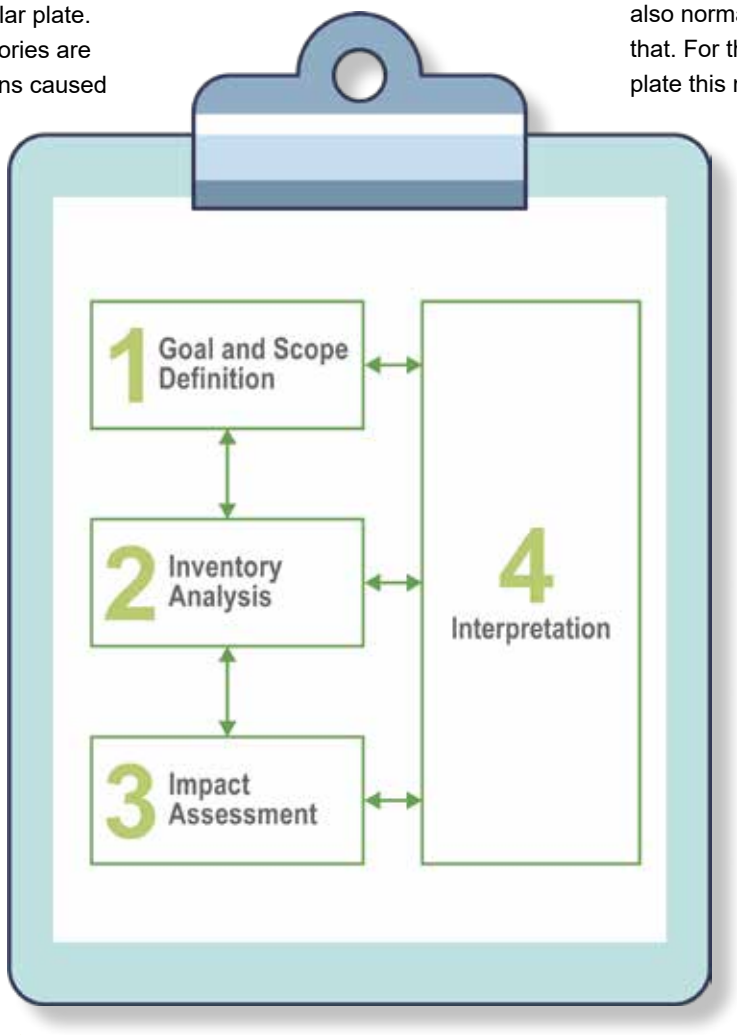


Figure 1: The four phases of life cycle assessment, adapted from ISO 14040:2006

For the exemplary assessment of the environmental footprint of a bipolar plate, the production process for the bipolar plate is divided into discrete, consecutive individual steps which are then supplemented with the material and energy inflows and outflows acquired through measurements or assumptions.

3 In the third step, the impact assessment is carried out. The consumption of material and energy in the manufacturing process inherently results in various environmental impacts which contribute to the product's environmental footprint. These contributions are calculated in the defined impact categories using the LCI that was compiled in the previous step. Each environmental impact is also normalized to the functional unit so that. For the assessment of the bipolar plate this means that all measured or estimated environmental impacts are normalized to the single bipolar plate that acts as the reference point for our analysis.

4 In the fourth and final step, the interpretation is conducted. The calculated results always need to be interpreted with consideration of the assumptions and simplifications that were made in the goal and scope definition as well as the inventory analysis. Therefore, calculated results always must be interpreted with the overall context of the analysis in mind. If, for example, certain assumptions regarding the environmental footprint of consumed materials are made due to a lack of reliable measurement results, these assumptions must be accounted for in the interpretation of the results. Further steps, such as carrying out sensitivity analyses, must be examined in relation to the uncertainty with which the results may potentially be fraught. For the exemplary assessment of the environmental footprint of the bipolar plate, LCAs can potentially be employed for optimization of the

process chain, as the industrial process for manufacturing bipolar plates is still under development. New insights into the impact of certain materials or manufacturing technologies on the product's environmental footprint can therefore be employed for optimization purposes.

The described procedure of LCA creation can be utilized by manufacturing companies for a variety of objectives. As stated above, the LCA results can be employed to market products and services and display an advantage over competitors, if the environmental footprint is lower than that of a competitor product. Other possible applications include the analysis of a process chain and the identification of emission hotspots within the own supply and process chain.

How to get started with LCAs?

The following steps need to be taken by manufacturing companies, if they want to quantify the environmental footprint of one of their products:

1. Define the targeted value proposition of the analysis and then start with the goal and scope definition of the LCA.
2. Select a representative functional unit.
3. Define the manufacturing process that is used to produce the considered functional unit and divide it into discrete, individual process steps.
4. Compile the LCI by collecting the required data for the analysis, e.g., through measurements of material and energy inflows and outflows during running production.
5. Calculate the environmental impacts in the impact categories defined during the goal and scope definition and normalize them to the defined functional unit.
6. Interpret the results under consideration of the assumptions, simplifications, and uncertainties of the analysis.
7. Derive next steps based on the analysis results e.g., like process adaptions to lower the energy consumption. ▪

Fraunhofer IPT

Fraunhofer Institute for Production Technology IPT located in Aachen, Germany has extensive expertise in the realm of production process analysis and optimization for a multitude of purposes. With a proven track record of excellence at the interface of research and industry, Fraunhofer IPT is a trusted partner for international research institutions and manufacturing companies. If your company is facing new challenges in sustainable transformation of production, we invite you to contact us to see how we can support your journey towards a sustainable future of manufacturing.

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www.ipt.fraunhofer.de

6 CIRCULARITY CAPABILITIES

FOR **MANUFACTURING COMPANIES** TO REACH **STRATEGIC POSITIONS OF SUCCESS** IN THE **CIRCULAR ECONOMY**

Manufacturing companies face the challenge of systematically identifying and leveraging technological competitive advantages during the transformation to the circular economy. Therefore, companies need to take up strategic positions of success in the circular economy by correctly bundling their technological resources and capabilities. However, capabilities for the circular economy go beyond those currently required for companies to establish a successful market position. These new capabilities differences specifically manifest through the perspective of considering a product's full life cycle and the potential arising from not yet tapped life cycle phases.

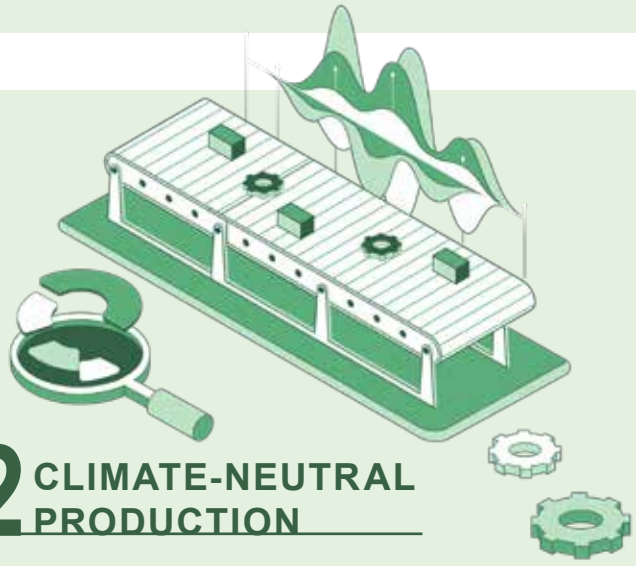
Following this challenge, manufacturing companies are tasked with the question:

Which circularity capabilities are crucial to unlock new circular value potentials and thus act as strategic positions for success?

To answer this question, circularity capabilities were systematically derived from literature and validated by industry partners during the development of the Circularity Capability Assessment in a joint project between Fraunhofer USA Center Mid Atlantic (CMA) and Fraunhofer Institute for Production Technology IPT. The six key capability areas that enable companies to achieve strategic success in the circular economy are described in detail below.

1 REGULATORY MASTERY

The increasing number of sustainability regulations is one of the major challenges of the transformation to a circular economy. Thus, when developing new technologies and products, it is relevant to strategically consider regulatory requirements as early as possible. Therefore, companies need the ability to anticipate new regulatory requirements and interpret their significance for their value creation. Furthermore, cooperation with regulatory institutions and participation in the development of standards allow companies to shape existing and new regulations.



2 CLIMATE-NEUTRAL PRODUCTION

Climate-neutral production enables the manufacturing and processing of products in a greenhouse gas-neutral manner. This is achieved by increasing the resource efficiency of existing production processes and by utilizing new climate-neutral production technologies. In addition, companies can increase their energy efficiency by purchasing energy from renewable sources or by feeding of industrial waste heat into a district heating network. Thus, this capability is closely linked to an energy transition.

3 LIFE CYCLE ORIENTED PRODUCT INNOVATION

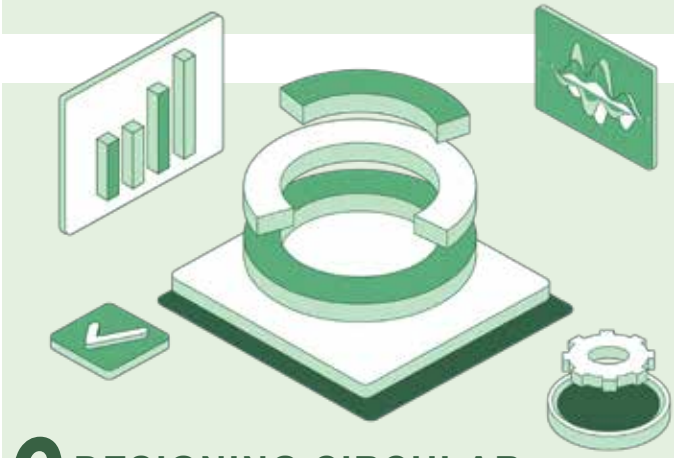
Life cycle oriented product innovation focuses on the design and development of products for the circular economy to reduce emission over the entire life cycle. The basis for such innovation is a modular product architecture. Modular designed products ensure, among other things, the recyclability of products, the reuse of certain product components in other applications as well as the realization of product upgrades. The implementation of product upgrades also requires the creation of a new infrastructure for the market-centered remanufacturing of products. In addition to a modular product design, companies should use recycled materials across different supply chains and industries or use regenerative materials in products to ensure closed material loops.

4 ORCHESTRATION OF THE ECOSYSTEM

To cycle products in continuous value creation between customers and companies and achieve the overall goal of decoupling the economic activity from its environmental impact, there is a high need to orchestrate a multitude of activities and interests. Centrally, to orchestrate these Re-X-cycles of products, companies need to create an ecosystem of enabling partners and a reverse logistics network.
The key challenge in this area is that companies' core competencies don't always match the necessary abilities to carry out all the steps within a circular economy on their own. Thus, companies need to strategically navigate supply chain agreements and foster resource-sharing partnerships for efficiency-boosting synergies and collective innovation.

5 DIGITAL TECHNOLOGIES AND AUTOMATION

Digital technologies act as enablers to enhance product and production transparency. They drive the advancement of production through the integration of autonomous systems and real-time data insights, improving efficiency and decision making. Employing digital twins of a production as well as a digital product pass allow comprehensive material disclosures, ensuring accountability via full traceability throughout production and use, and leveraging data analytics to diagnose product condition.



6 DESIGNING CIRCULAR BUSINESS MODELS

Circular Business Models unlock new revenue potential through innovative product-service bundles, the redefinition of business models and distribution for economic growth independent of resource use. The creation of customer-centric value propositions with services promotes an active participation in the circular economy. Enabling these skills in the monetization of products over multiple use cycles through upgrades, refurbishment, and replacements is a foundation of circular market intelligence that allows the business model design to always reference relevant customer requirements.

Manufacturing companies need to be aware of their existing circularity capabilities in order to be able to build new capabilities and to unlock new circular value potential. The developed Capability Maturity Assessment enables manufacturing companies to assess the maturity level of their circularity capabilities as part of an expert interview. The resulting maturity level can be compared with the benchmark of a growing peer group consisting of previous participating companies. A gap analysis is used to identify company-specific capabilities that need to be built to secure competitive advantages and to be able to take up strategic positions of success in the circular economy. ■

Fraunhofer IPT

Do you need detailed information on circular capabilities or are interested in learning about your circularity capability maturity?

Find out more and reach out to our experts: https://www.ipt.fraunhofer.de/en/offer/strategic-analysis/measuring-sustainability.html

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LEADING THE CHARGE IN SUSTAINABLE PACKAGING

INSIDE AMCOR FLEXIBLES ZUTPHEN'S INNOVATION JOURNEY

In the realm of high-tech manufacturing, where innovation and sustainability are paramount, Amcor Flexibles Zutphen stands out as a beacon of progress. As part of the global packaging giant Amcor since 2010, the Zutphen plant in the Netherlands has been at the forefront of sustainable packaging solutions, showcasing the company's commitment to both functionality and environmental responsibility.

A Legacy of Innovation and Sustainability

Amcor Flexibles Zutphen has carved a niche for itself by focusing exclusively on aluminium containers and lids since 2020. This strategic pivot has enabled the plant to produce over 1.5 billion pieces annually, catering to a diverse range of industries including pet food, human food, healthcare, and pharmaceuticals. The plant's expertise in tray forming and lid stamping is complemented by its comprehensive supply chain, encompassing pretreatment, lamination, lacquering, printing, and forming.

Employing advanced printing techniques such as flexo printing for lids and rotogravure printing for containers, Amcor Flexibles ensures that its packaging solutions not only meet rigorous functional requirements but also adhere to stringent sustainability standards. The use of aluminium foil, known for its strength and barrier properties, further underscores the plant's commitment to producing high-quality, safe, and sustainable packaging.

Commitment to the 2025 Sustainability Pledge

In a bold move towards sustainability, Amcor pledged in January 2018 to develop all its packaging to be recyclable or reusable by 2025. As the first global packaging company to make such a pledge, Amcor directly addresses a major environmental issue with its extensive capabilities and reach.

The company focuses on three key areas to deliver on this commitment:

Developing recyclable materials

Amcor is innovating to ensure that all its packaging can be recycled, wherever it is used.

Creating innovative formats

The company designs packaging that simplifies separation and recycling, avoiding the use of unrecyclable materials.

Increasing recycling rates

By collaborating with customers, suppliers, NGOs, and governments, Amcor is working to enhance infrastructure for collecting, sorting, and recycling packaging.

Investing in European Innovation

Amcor's dedication to sustainability is further evidenced by its significant investment in European innovation hubs. With an annual R&D investment of approximately USD $100 million, Amcor accelerates the development of sustainable packaging solutions through a global network of innovation centres, including the newly opened Amcor Innovation Center Europe (AICE) in Ghent, Belgium. This state-of-the-art facility partners with brands and retailers across the region to design packaging that delivers better results for both consumers and the environment.

The AICE embodies Amcor's Catalyst™ approach, a flexible, collaborative, and creative co-development methodology that ensures packaging solutions align with market demands, consumer needs, sustainability, and recyclability requirements. The Ghent facility supports this process through several key activities:

Material Science Center

Innovates packaging materials to reduce carbon footprints, including recycle-ready mono-material solutions and bio-based and recycled polymer alternatives.

Customer Engagement Center

Hosts collaborative sessions and consumer focus groups, testing packaging appeal and usability in simulated retail and home environments.

E-Commerce Lab

Tests and certifies packaging for e-commerce distribution, ensuring it meets ISTA 6 standards.

Packaging and Recycling Test Center (coming soon)

Will house small-scale packing lines for machine trials and recycling equipment to evaluate real-world recyclability.

These comprehensive capabilities at the Ghent facility underscore Amcor's commitment to driving sustainable packaging innovation in Europe.

A Showcase of Innovation: Bottles of the Year Programme

Highlighting its commitment to innovation, Amcor recently launched the Bottles of the Year programme on National Packaging Design Day 2024. This initiative recognises the best in innovative and responsible packaging designs across various segments. The selected bottle designs exemplify cutting-edge ideas that push the boundaries of traditional packaging norms, reaffirming Amcor's position as an industry leader.

Leading the Path to Net Zero in Europe

As Europe strides towards a more sustainable future, Amcor Flexibles Zutphen and its parent company, Amcor, are at the forefront of driving positive change. Through innovative manufacturing processes, groundbreaking initiatives, and strategic partnerships, Amcor is leading the way towards a circular economy and net zero emissions in Europe and beyond. The Zutphen plant's ongoing commitment to sustainability and innovation sets new standards for the packaging industry, inspiring positive change across the region.

Amcor Flexibles Zutphen exemplifies how high-tech manufacturing can align with environmental stewardship. By embracing sustainability, investing in innovation, and fostering collaboration, Amcor is not only meeting the demands of today but also paving the way for a brighter, more sustainable tomorrow.

> **With Bottles of the Year, our goal is to inspire and empower consumers, manufacturers, brands, and enthusiasts with elegant, thoughtful, and responsible packaging designs.**
>
> *— Terry Patcheak, Vice President of R&D, Sustainability, and Project Management at Amcor Rigid Packaging*

About Amcor

Amcor is a global leader in developing and producing responsible packaging solutions across a variety of materials for food, beverage, pharmaceutical, medical, home and personal care, and other products.

Amcor works with leading companies around the world to protect their products and the people who rely on them, differentiate brands, and improve supply chains through a range of flexible and rigid packaging, specialty cartons, closures, and services.

The company is focused on making packaging that is increasingly lighter weight, recyclable and reusable, and made using an increasing amount of recycled content. In fiscal year 2023, 41,000 Amcor people generated $14.7 billion in annual sales from operations that span 218 locations in 41 countries. ■

FISCAL YEAR 2023

41,000
Amcor team

218
Locations

$14.7 billion
Annual sales

41
Countries

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GREEN & SMART: the intersection between **sustainable manufacturing & AI**

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> **The five concepts of smart product design, supply chain management, resource efficiency and optimization, product lifecycle management, and decision support are inherently interconnected.**

We have all heard of Artificial Intelligence, commonly referred to as AI. Every day we experience the advantages of AI through daily technological interactions, whether it is the navigation system suggesting a faster route based on real-time traffic data, smart home devices automating room temperature and energy consumption, or virtual assistants providing personalized product recommendations based on your location.

Similarly, sustainability has been rising as a trending topic for the last decades, making it increasingly challenging to pinpoint its impact on our daily lives.

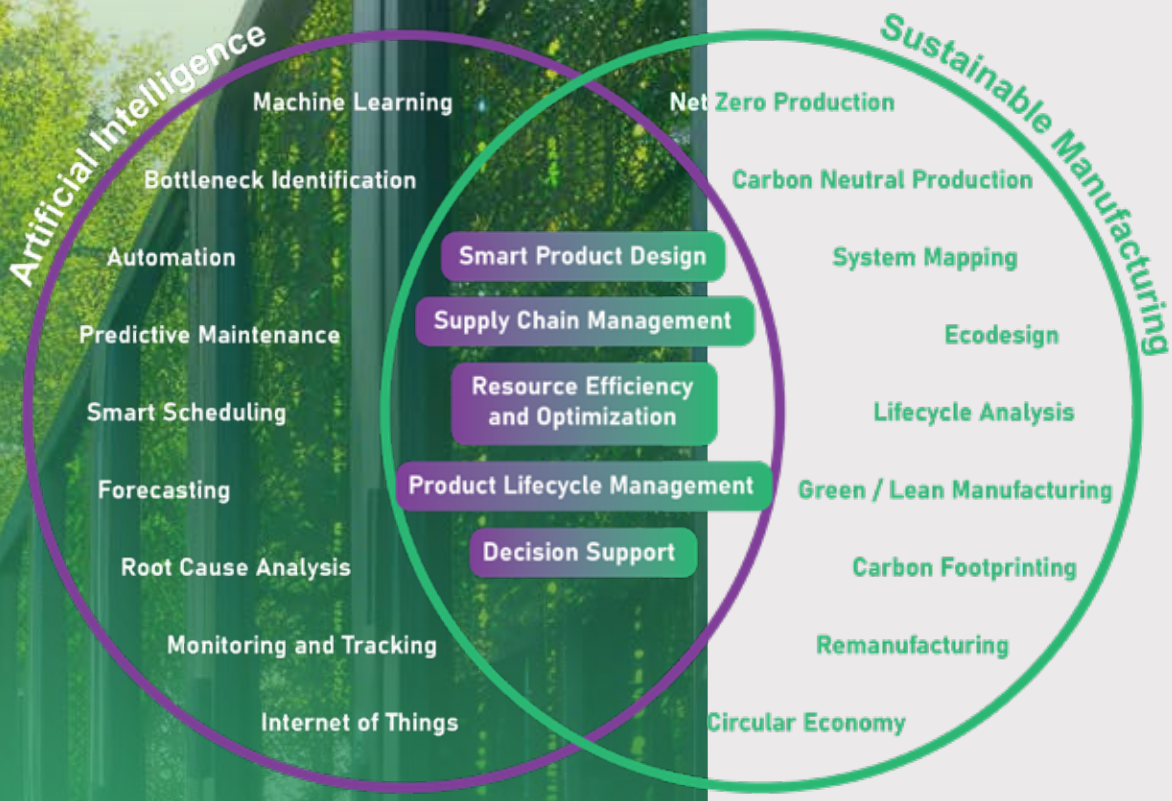
With the general understanding that sustainability is all about resource efficiency and optimization, the overlap between AI and sustainability starts to become more apparent. Faster routes often signify less fuel consumption, automated temperature control devices can help use energy more efficiently leading to cost savings, and getting personalized product recommendations from local suppliers can help reduce the footprint associated with product transport. These are only small examples of how AI is helping us become more sustainable in daily life.

What is sustainable manufacturing?

Sustainability is generally defined as “development that meets current needs without compromising the ability of future generations to meet their own needs”. In manufacturing, this translated to “manufacturing that meets current needs without compromising the ability to continue producing goods for future generations”.

In the context of sustainability, manufacturing is one of the areas that has much to gain from sustainable practices. In the Netherlands, for instance, 27,83% of emissions come from manufacturing industries and construction[1]. Sustainable manufacturing involves leveraging rising technologies to regulate the energy consumption of manufacturing processes or tracking goods through the supply chain to optimize routing and warehousing needs. If done right, resource optimization and supply chain efficiency will result in cost savings. With the regulatory push driving more SMEs to investigate sustainability, AI might just be the key enabler for a greener manufacturing industry.

[1]The Netherlands - Countries & Regions - IEA. (2023)



What is AI in manufacturing?

In the last decades, manufacturing revolutions have been driven by the introduction of digital technologies for performing complex and resource-intensive tasks in the most efficient ways possible. The digital evolution is not just about automating conventional manufacturing processes but also about comprehensive integration of intelligent systems that enhance decision-making capabilities, optimize production workflows, and support stakeholders and production managers in driving innovation. By modernizing manufacturing processes through AI technologies, the efficiency and quality of production are improved.

Advanced processes generate vast volumes of data, which makes intelligent manufacturing possible. This data serves as a rich input source for AI models, enabling them to make informed and smart decisions. Additionally, having access to computing power, along with the repeatability and reliability of performance, further supports this advancement.

The overlap between AI and sustainability in manufacturing

The concepts of AI and Sustainability are not often mentioned together, yet they significantly overlap in methodologies and goals. AI provides the tools and techniques, while sustainability sets the objectives and direction. When sustainability focuses on measuring impact and identifying areas of opportunity, AI acts as the medium for processing and analyzing data.

Among many concepts associated with each discipline, we have identified 5 core concepts where the overlap is pronounced:

1. **Smart Product Design**
2. **Supply Chain Management**
3. **Resource Efficiency and Optimization**
4. **Product Lifecycle Management**
5. **Decision Support**

Core Concepts Exemplified

In this section, the five core concepts are illustrated by examples to demonstrate their potential in the manufacturing industry.

1. Smart Product Design: allows product engineers to iterate over product concepts that utilize new generation materials, advanced technologies, and user-centric approaches meeting key functional requirements and environmental, social, and economic standards.

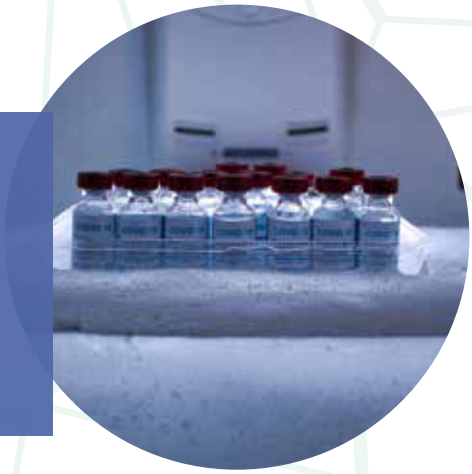
- **Example 1:** Generative Design for Aerospace Applications

An aerospace component manufacturer relocated to a new manufacturing hall further from their material suppliers. To enhance operational independence, the decision was to explore alternate design and manufacturing methods, such as 3D printing, for some of their components. By leveraging AI-driven generative design, several key benefits have been achieved: enhanced design innovation, improved manufacturing flexibility, minimized warehousing needs by producing components on demand, significantly reduced material usage, and consequently lowered fuel consumption in the final aerospace application.

2. Supply Chain Management: enables procurement specialists to manage goods, information, and finances to maximize value and efficiency while minimizing lead times.

- **Example 2:** Cold Storage Demand Forecasting for Medicine

A pharmaceutical manufacturer delivers life-saving medicine requiring cold storage. To mitigate the costs and risks associated with cold storage, the manufacturer uses an AI-driven demand forecasting method to predict demand fluctuations, purchase raw materials in advance, and coordinate optimal transport routes in real-time, ensuring minimal time to market.



3. Resource Efficiency & Optimization: Involves strategically allocating and managing resources—including time, money, materials, and labor—across various processes to achieve specific goals. Efficiency, on the other hand, focuses on minimizing resource usage while maintaining high standards of quality and productivity.

- **Example 3:** Retrofitting an Aluminum Furnace

An aluminum manufacturer used an AI-driven control system to transition from natural gas and AC induction heating to a combination of natural gas (NG) and DC induction heating. The AI system optimizes electricity use by independently switching energy sources based on production demand, energy cost, and grid stability, reducing the environmental impact with minimal investment and production disruption.

4. Product Lifecycle Management:
Integrates people, processes, business systems, and information to manage the product portfolio across all stages from raw materials to disposal.

- **Example 4:** Scenario-based Lifecycle Analysis for Cardboard Manufacturing

A cardboard manufacturer shifted to producing only recycled boxes after increased demand for environmentally friendly products. They developed an AI algorithm to analyze the environmental impact of various sourcing scenarios. The analysis enabled them to source recyclate[2] from their own production waste, local waste, and certified suppliers ensuring a steady supply of fully recycled boxes while reducing production waste and local waste.

5. Decision Support:
Provides real-time insights on production processes, facilitating data-driven strategic decisions.

- **Example 5:** Polymer Process Emission Monitoring and Detection

A polymer processing manufacturer uses an AI-driven Emission Management System (EMS) to reduce the frequency of leak detection tests. This system monitors unwanted volatile organic compounds (VOCs) and other gases in real-time. The EMS helps identify hotspots and calculate the CO_2e[3] of their process. This enabled the discovery of a specific solvent that emitted more VOCs than anticipated and decided to switch to a water-based solvent that operates at lower temperatures, reducing both emissions and energy consumption. The alternate solvent option allowed manufactured products to be sold at a lower cost and have a market advantage over competitors.

> **These are only small examples of how AI is helping us become more sustainable in daily life.**

Conclusion

When it comes to sustainable manufacturing there is no one-size-fits-all approach. Sustainability poses unique challenges for each manufacturer, and gathering a holistic overview of the company, market, products, and processes is critical to determine sustainability opportunities and the AI tools to support it. By leveraging AI as a technological enabler, manufacturers can develop sustainable strategies that are not only effective but also adaptable to their needs.

The five concepts of smart product design, supply chain management, resource efficiency and optimization, product lifecycle management, and decision support are inherently interconnected. Each plays a vital role in creating a sustainable manufacturing ecosystem, where AI-driven insights can lead to significant improvements in efficiency and environmental impact. By embracing AI and sustainability, manufacturers are ready to tackle the most pressing environmental issues in manufacturing, contributing to a better future. ■

[2]***Recyclate:*** *recycled material to be processed into a to new material or product*
[3]***CO2e:*** *metric used to compare the emissions of various greenhouse gases (GHG) based on their global warming potential (GWP) relative to Carbon Dioxide (CO2).*

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