Whitepaper

DIGITISATION CRUCIAL FOR CIRCULAR INDUSTRY

TNO innovation for life

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Climate change and the predicted scarcity of materials are challenging society to build a circular economy that takes into account CO_2 emission neutrality, efficient energy use and the recycling of materials. This paper describes the goals, means and a roadmap required to achieve this for the Dutch technology manufacturing industry, its supply chain and ecosystem.

The ultimate goal to be reached in 2050 is CO_2 neutrality or carbon circularity, made possible by the complete redesign, implementation of new technology and rebuilding of the industry's processes. Smaller and (from today's point of view) extremely flexible factories will operate close to the consumer. The continuous training of employees will help them acquire new (digital) skills. And new business models based on re-supply and "servitisation" ensure that products are no longer sold to the customer, but instead leased, continuously supported and taken back after use.

The way to realize this is for the industry to become "digital", then "smart" and ultimately: sustainable[1].

1 This does not only hold true in the Netherlands. As the ManuFUTURE paper by the EU states: "Europe will have to address new opportunities and increase its investment in research and innovation towards manufacturing in order to ensure competitiveness and long-term success." See: http://www.manufuture.org/strategic-research-agenda/strategic-research-and-innovation-agenda-sria/ Similar thoughts are voiced in the Made in Europe Strategic Research and Innovation Agenda https://ec.europa.eu/info/sites/default/files/research_and_innovation/funding/documents/ec_rtd_he-partnership-made-in-europe.pdf

CONTENT

DIGITALISATION

The central issue to start with is the question every consumer and manufacturer in a value chain will ask themselves: “where do the materials, components and products I ordered come from, what is their status now, and how can I return them and have them recycled in a responsible way after use?” The answer is: digitalisation! Because the re-use of materials is in fact a digitalisation challenge. For plastics, re-usage is an unsolved problem at the moment, but one of essential importance if we are to work towards a sustainable industry.* The digitalisation challenge is crucial for Europe as a whole as well, as described in the document *Policy solutions for an effective platform economy* by the Joint Institute for Innovation Policy (2020).

CO_2 COSTS AS A DRIVER FOR CHANGE

Manufacturing costs are expected to increase due to taxes on CO_2 emissions as well as the development of alternatives. Both will elevate the cost of materials. To keep overall costs down, materials must be re-used as much as possible. This will require the design of cost-effective re-use configurations from the start.

A scrap heap like this will be a thing of the past in 2050.

NEW BUSINESS MODELS

"Servitisation" will become a new business model. The manufacturer (Original Equipment Manufacturer – OEM) produces and sells the product and, sometimes, takes it back at the end of its lifetime, disassembles it on an economically sustainable basis, and re-uses whatever can be re-used. During the next step, the Equipment Solution Service Provider (ESP) comes along, which leases the product to the user, takes care of all the required support, takes the product back at the end of its lifetime, and is responsible for recycling in the broadest sense. While the OEM will need a fully digitized "manufacturing data space"**, the ESP will require "product data spaces" based on the real-time monitoring of product and usage for optimal maintenance, repair, recycling and resupply.

THE WAY AHEAD

Digitalised data on design, production, usage, position in the user chain, and user data will need to be gathered, saved and made accessible to partners in the value chain. Big industries like the aerospace and petrochemical industries already do this to some degree, but for a lot of other manufacturing and user chains this process is yet to take shape. They need to start with product and component tracing during manufacturing. This is what we refer to as the "digitalisation" of your factory. Most companies have started digitisation. In due time, more digital information will become part of valley chains by exchanging data with other digitalised partners in the chain.

"Digitalised data and user data will need to be gathered, saved and made accessible to partners in the value chain. This is what we refer to as the 'digitalisation' of your factory"

ROADMAPS FOR MANUFACTURING COMPANIES AND THE VALUE CHAIN

Sustainability will be reached through smart manufacturing and “Re-x”. This includes everything from cost and emission reduction to regaining materials, refurbishment and resupply. During the design phase, one has already to think about aspects like the disassembly of the used and returned product, the identification and automated scanning of products and components, monitoring components wear, and the type of re-use envisioned. All of this data can turn the digital factory into a place for autonomous, flexible manufacturing where products are assembled, but also, later on, can be disassembled too. In a number of cases the “digital factory” retrieve the data it needs such as 3D printing or disassembly info from a manufacturing or product data space and remain small, in close proximity of the customer as metropolitan manufacturing. “Smart” design and production will provide the basis for reducing energy and material use, and will ideally lead to zero “waste”.

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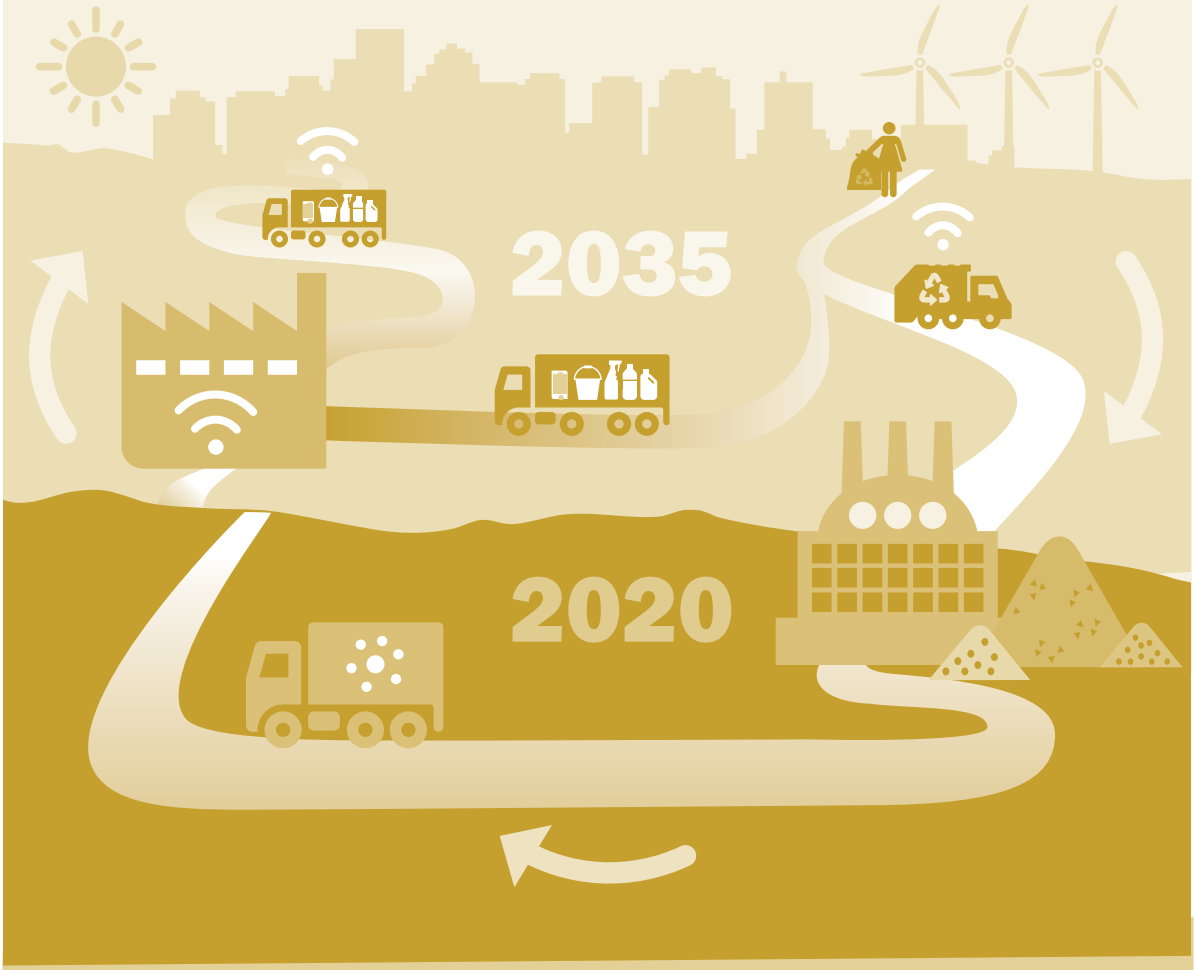
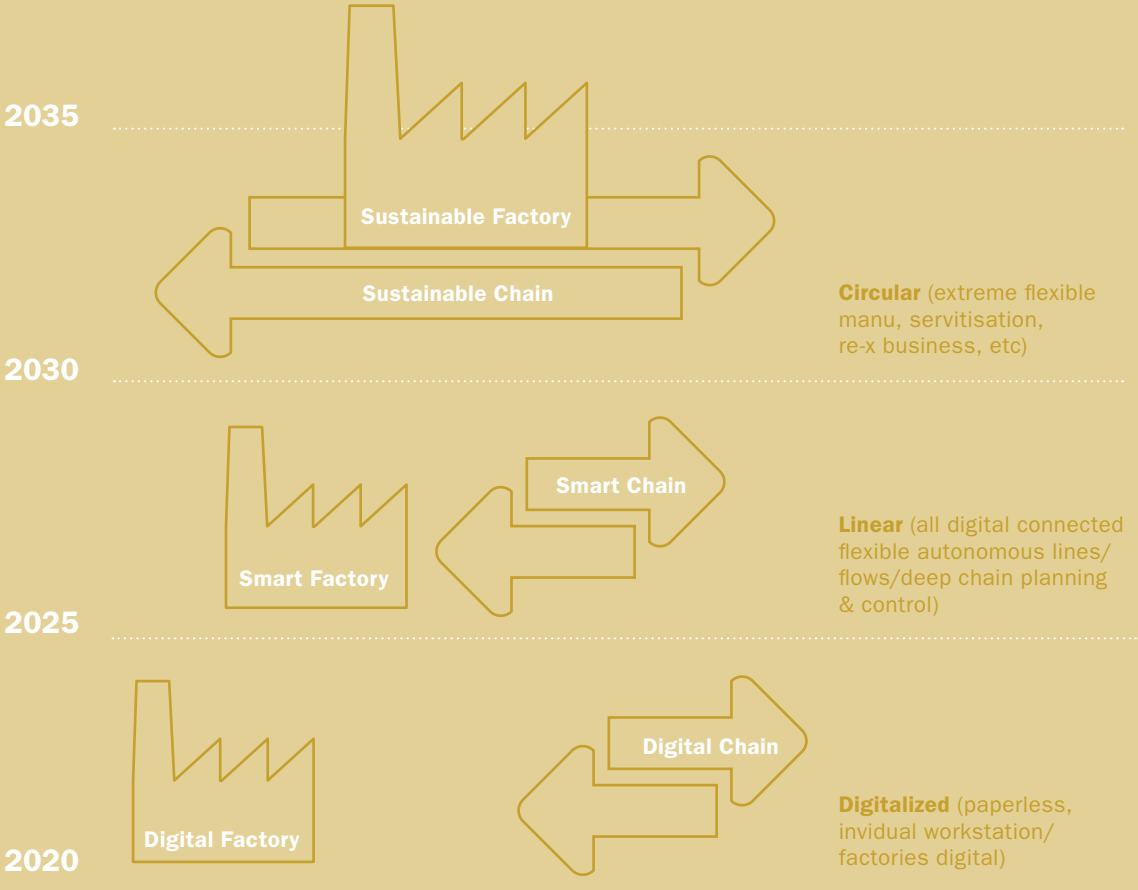
ZERO WASTE THROUGH SMART DESIGN AND PRODUCTION





GOALS

The ultimate goal for 2050 involves a roadmap as follows:

Digital factory/chain: By **2025** we have the most flexible and (digitally) best connected supply chain for the manufacturing of technological goods. All process steps in the factories are digitalised and several workstations run autonomously with zero-defect and product change over with zero-programming.

Smart factory/chain: By **2030** we aim to have 80% of the value chains for high-tech equipment fully digitalised, autonomous flexible production lines will be common, and CO_2 emissions from every factory have been reduced by 50% (compared to the 1990 level). This implies that:
– Not only in the factories themselves, but also between factories all data regarding design, orders, manufacturing processes and information on quality/traceability can be exchanged digitally next to other real-time chain-deep planning and control;
– Autonomous flexible production lines will largely consist of equipment with machine learning/AI technology with zero-time loss and zero extra investment change over to new product types.

Sustainable factory/ecosystem: By **2035** we aim for 80% of all products to be traced digitally from manufacturing to use and return. Furthermore we envision a functional circular “Re-x” business in operation for 50% or more of all returned technological goods with a 50% reduction in CO2 emissions during production and usage/recycling phase.

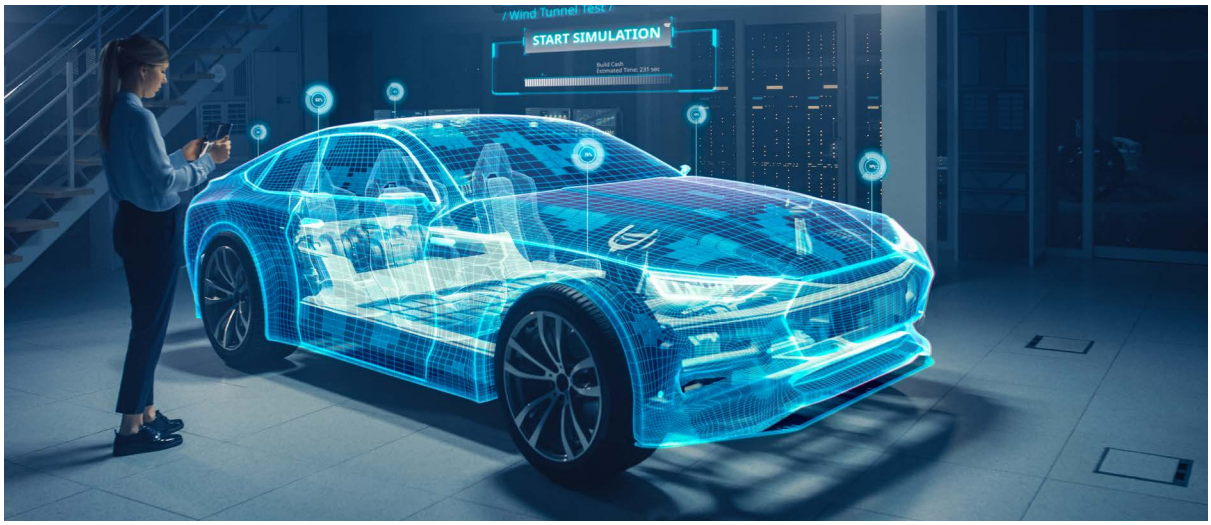
Additionally:
– It is expected that CO_2 or carbon neutrality will lead to higher material prices. As a result, the re-use of already owned materials or replacing such materials with reprocessed materials will become economically viable around 2030 or shortly thereafter.
– Our ambition is to create a complete CO_2 neutral production process and a 95% reduction in the user phase.
– “Re-x” suppliers will use product data platforms and extreme autonomous flexible systems for disassembly.

Re-use targets for plastic and metal materials as of yet depend too much on different products and therefore are difficult to quantify in this timeline. For the recovery of critical/scarce materials, separate requirement goals apply.

“The ultimate goal is for the Dutch manufacturing sector to become leading in sustainable manufacturing of sustainable products and solutions”

MORE KNOWLEDGE AND RESEARCH NEEDED

To achieve these ambitious goals, more knowledge and intensified applied research will be needed in a number of fields: integrated systems engineering, artificial intelligence, machine learning for robotics, and automated guided vehicles. New business models as well as smart and sustainable services will challenge conventional market concepts. Equally important is for us to gain more knowledge on digital twins (the digital translation of physical objects), manufacturing and ultimately product data spaces. We also need to take into account that extensive data sharing demands robust cyber security. Finally, of further interest are: human-centered technology for a highly automated and constantly changing work environment as well as more insights into the impact of the smart industry revolution and its disruptive technologies.



A car as a service, not a product.

High-tech equipment market and ecosystem
The high-tech equipment industry in the Netherlands serves a large number of enterprises, from mass-production for the electronic industry to big capital goods for the maritime sector, and from complex machinery for the agriculture and food sectors to new concepts for building. In a number of regions vast industrial ecosystems have evolved, with sometimes up to 10,000 subtiers and a large, highly skilled workforce. These ecosystems are big players in specific, worldwide niche markets. Their high technical levels and the extent of their networks offer huge opportunities to create smart factories and smart chains. But everybody has to participate to make the effort a success, and we need to start now. The 2050 horizon may seem far away, but we have a lot of work to be done before we reach our goal.

“The high-tech equipment industry in the Netherlands serves a large number of enterprises, from mass-production for the electronic industry to big capital goods for the maritime sector”

CONCLUSION

The high-tech equipment manufacturing ecosystem in the Netherlands is able to switch to a sustainable economy. It will take a few decades and will require a lot of effort in digitial solutions but it is possible. TNO regards itself well-equipped to be a leading partner for industry in this systemic transition. If our efforts are successful, we will have contributed to making the world a better, more sustainable place.

* TNO described this problem in a publication which can be found here: http://publications.tno.nl/publication/34637386/joEUx6/TNO-2020-circulaire-plastics.pdf.

** Data spaces require robust solutions to data protection, privacy issues, and data responsibility in a world where not only people, but also things produce and exchange data. TNO paid attention to these aspects in a publication which can be found here: https://publications.tno.nl/publication/34637924/c6SScX/TNO-2021-technologische.pdf

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