Whitepaper

DIGITISATION CRUCIAL FOR CIRCULAR INDUSTRY
LOOKING BACK FROM 2050

TNO innovation for life

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INHOUDSOPGAVE

DIGITISATION CRUCIAL FOR CIRCULAR INDUSTRY LOOKING BACK FROM 2050

In this paper, we look back on our era from the vantage point of 2050. And we learn how to use digitalisation to achieve a sustainable society and circular economy. This document describes the goals, resources and a roadmap required to achieve this for the Dutch manufacturing industry. Smaller and flexible factories will operate in close proximity to the consumer. And new business models will ensure that products are no longer sold to the customer, but leased and taken back after use. The way to achieve this is for the industry to become ‘digital’, then ‘smart’ and ultimately: sustainable.

VISION FOR THE FUTURE

The Netherlands, 2050 – The transition to a sustainable society and a circular, CO_2-neutral economy is well under way. Road traffic is already demonstrating this quite well: our cars are all electric. Car ownership no longer exists. Traditional car dealers and garages have also disappeared. A new chain of production and use has been created.

The manufacturer builds cars in a sustainable way. And as a car driver, you enter into a usage contract with the manufacturer. The car is full of sensors that send the manufacturer real-time data about the status of each component and about its use. Based on this information, a regional branch of the car manufacturer will occasionally visit your home to replace small parts that are not working properly. These are made on demand by a specialised 3D print shop. For the replacement or adjustment of larger parts, you will receive a call from a refurbishment centre in your area. If too many parts of your car have reached the end of their service life, the manufacturer will deliver a new one to you. Your old car is then fully recycled at the factory.

> “Car ownership no longer exists. Traditional car dealers and garages have also disappeared. A new chain of production and use has been created”

LOOKING BACK ON THE 2020s

This method of working has its origins in the early 2020s. The scarcity of materials expected at the time and the inevitable climate change meant that action had to be taken. There was no choice but to focus on maximum reuse of materials, complete reduction of waste, CO_2-neutral production and sustainable generation of energy. The COVID-19 crisis of 2020-2021 suddenly emphasised how important raw materials and production chains really are. It also showed that the United States and China had become supreme in the field of service platforms and social media. Europe may have had a strong manufacturing industry, but the countries were not sufficiently unified to provide a real counterbalance. A jointly shared digital platform industry based on European values was imperative. Europe therefore faced a major digitalisation challenge.

The reuse of materials, it was realised at the time, is actually a digitalisation challenge. This also applied to plastics, although it was not yet clear how this problem was to be solved.[1] ‘Zero’ and ‘Re-x’ were the keywords of the day. ‘Zero’ stood for a series of developments to arrive at a sustainable production process: designing, developing and working now took place in a mainly digital environment. Fully automated quality checks at every step of the manufacturing process made errors a thing of the past. Self-learning robots put an end to ad hoc programming; incidentally developed and 3D-printed tools were no longer needed. As a result of smart ordering procedures and user monitoring, delivery delays and stockouts became obsolete. Preventive maintenance would eliminate unexpected product failures. Maximum recycling and sustainable energy use could reduce waste streams to zero. Finally, a system of lifelong learning would prevent staff dropouts.

Scrap heaps no longer exist.

1 https://publications.tno.nl/publication/34637387/hCNIhm/TNO-2020-circular-plastics.pdf

“The reuse of materials, it was realised in the 2020s, is actually a digitalisation challenge”

RE-X

‘Re-x’ stood for everything to do with reduction, reuse or recovery: from repairing and recycling to reproducing and redelivering. This would require the detailed digitalisation of every step in a product’s lifecycle, from design, procurement and manufacturing to dismantling and reuse. A ‘manufacturing data space’ made the manufacturing process accessible to all involved in a completely transparent manner. In this way, you knew where your materials or parts were at any point in production and where they had been made. And as a maker, you were already considering disassembly and reuse while designing. You could build in automated quality controls during production and install sensors for monitoring during the use of the product. On the basis of all these data, you could feed robots, automate workstations and produce flexibly. This became the basis of what has come to be called the ‘digital factory’.

But that was not the end of it. Every factory is part of a value chain. There is no point in operating ‘digitally’ yourself if your partner in the chain does not. Therefore, contacts with suppliers, contractors, subcontractors and customers also had to be digitalised. This process mainly related to organisation, administration and finances, both internal and external. It would lead to clear agreements and common practices for all businesses in the industrial ecosystem. All these chain participants had to be able to exchange information in an absolutely secure manner: from designing to selling to delivering and invoicing. The incorporation of all these data in customer portals resulted in the ‘digital chain’.

“With data, you could feed robots, automate workstations and produce flexibly. This became the basis of what has come to be called the ‘digital factory”

THE SMART FACTORY

The next phase was the step towards the 'smart factory' and the 'smart chain'. Manufacturers collected online data, which enabled them to gain insight into the functioning of delivered devices and user behaviour. This led not only to detailed insight into expected repairs and deliveries, but also to new ideas for products or variants of existing devices. This is how 'product data spaces' came into being. This made real-time planning and management possible in the chain. It did, however, require privacy-friendly and extremely robust data use. The sharing and analysis of data is essential in this respect, but there were major issues regarding the privacy sensitivity and legal protection of data. The latter was aptly expressed in the issue of who is the owner and who is responsible in a world where not only people but also things generate data.[2]

Through this development, the factory and chain finally came together in a sustainable ecosystem. The detailed and up-to-date information from both suppliers and customers enabled factories to produce in a flexible and automated way. Redesigning on the basis of recycled materials resulted in new products. Eventually, a new business model emerged called 'Equipment Solution Service Provider' (ESP), in which the manufactured product or device became part of an entire service package for the customer. Manufacturers remained the owners, but provided the customer with all the support needed for the optimal and sustainable functioning of a product. This included preventive maintenance, updates, repairs, taking back after use and redelivery where possible.

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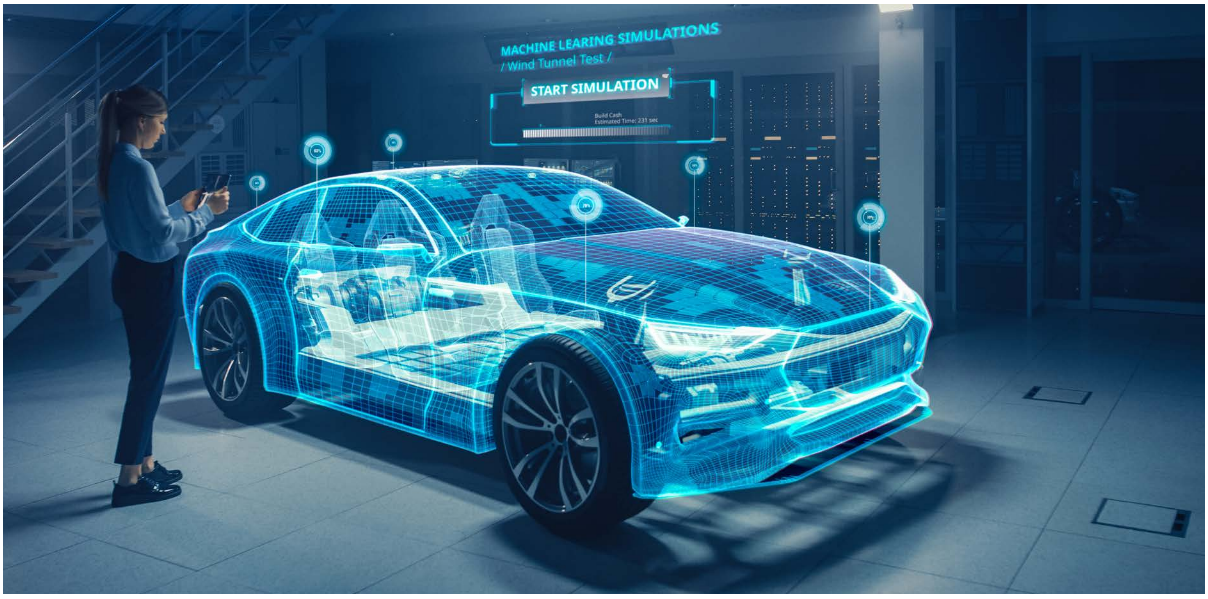


A car as a service, not a product.

2 https://publications.tno.nl/publication/34637925/StFCdC/TNO-2021-technological.pdf

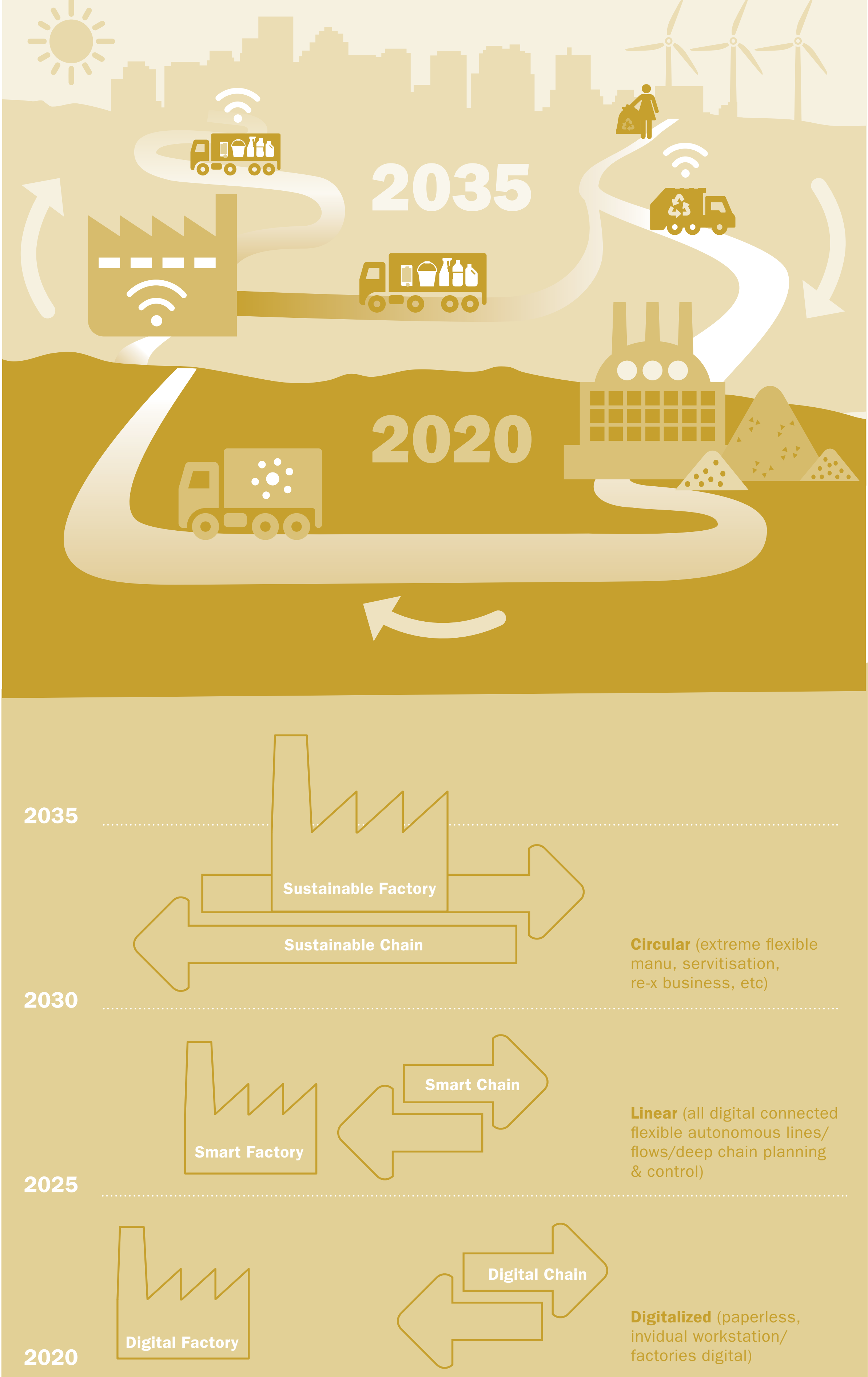
TIMEFRAME

In the early 2020s, TNO published a white paper on steps the Netherlands should take to become the world's leading supplier of automated devices for high-tech factories. The aim was to enable them to work sustainably. It was concluded that the Netherlands had a number of very strong regional technological ecosystems, particularly regarding chip technology, shipbuilding, as well as agro and food. There were networks of up to 10,000 contractors and subcontractors: an excellent breeding ground for developing digital factories and chains. A major role was foreseen for 3D printing. The emergence of flexible companies in close proximity to the consumer was also anticipated. These attractive prospects led many companies to join these entrepreneurial networks and together embark on the digitalisation process. The white paper outlined a timetable, which the Netherlands eventually completed successfully.

By 2025, the Netherlands had achieved the most flexible and digitally connected supply chain for the manufacture of technological goods (components, products, devices). All process steps within factories were digitalised and a number of workstations were already running autonomously.

By 2030, 80% of technology goods value chains were fully digitalised, autonomous flexible production lines had become commonplace and CO_2 emissions from factories had been reduced by 50% compared with the 1999 reference value. This meant that not only within the factories, but also between factories, all data on design, orders, the manufacturing process and real-time tracking of parts and quality could be exchanged digitally. Autonomous, flexible production lines were also equipped with machine learning and AI technology.

ZERO WASTE THROUGH SMART DESIGN AND PRODUCTION



By 2035, 80% of all products could be digitally tracked from manufacture via use back to the factory. In addition, at least 50% of all goods returned after use were processed circularly, so the Re-x ambition became an increasing reality. CO_2 emissions had been reduced by at least 50%. The ultimate goal was to make the production process completely CO_2-neutral and to achieve a 95% reduction during use. Re-x suppliers adopted product data platforms and extremely autonomous flexible disassembly systems.

“By 2035, 80% of all products could be digitally tracked and at least 50% of all goods returned after use were processed circularly”

A SUCCESSFUL TRANSITION

This transition to a sustainable ecosystem of smart factories and smart chains was successful because all parties involved had fulfilled several important conditions laid down in the white paper. For instance, everyone in the chain had started the transition immediately after 2020. In addition, all parties endorsed the condition that more knowledge and therefore more intensive applied research was needed. In particular, they wanted to learn more about integrated systems, advanced digital technologies, artificial intelligence and machine learning. Non-technical aspects such as a different way of doing business, equipment geared towards people and the social impact of the ‘smart’ revolution had also received all the required attention. In short: the road to sustainability was paved with a transdisciplinary approach to the entire ecosystem of technologies, users, business models, consumer behaviour, regulations, values and ethics.

A century ago, the technically skilled science fiction writer Arthur C. Clarke observed that any technology sufficiently advanced is indistinguishable from magic. For the ordinary citizen, there is something to be said for that. The proverbial look under the bonnet of an (electric) car provides no insight into what smart and responsible technology can be found there. You simply notice that everything is cleaner, more economical, more flexible and – if all goes well – more user-friendly than before. And that, after all, is what it’s all about.

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