WHITEPAPER

TECHNOLOGY FOR CLIMATE **BEYOND PARIS: THE NEXT BUSINESS WAVE**

TNO innovation for life

WHITEPAPER
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TECHNOLOGY FOR CLIMATE **BEYOND PARIS: THE NEXT BUSINESS WAVE**

High-tech systems & materials and chemical technologies are **key enabling technologies** to enable our **transition to sustainable energy**, address our climate challenges and create the basis for a whole new and extremely large worldwide market for high-tech equipment and systems.

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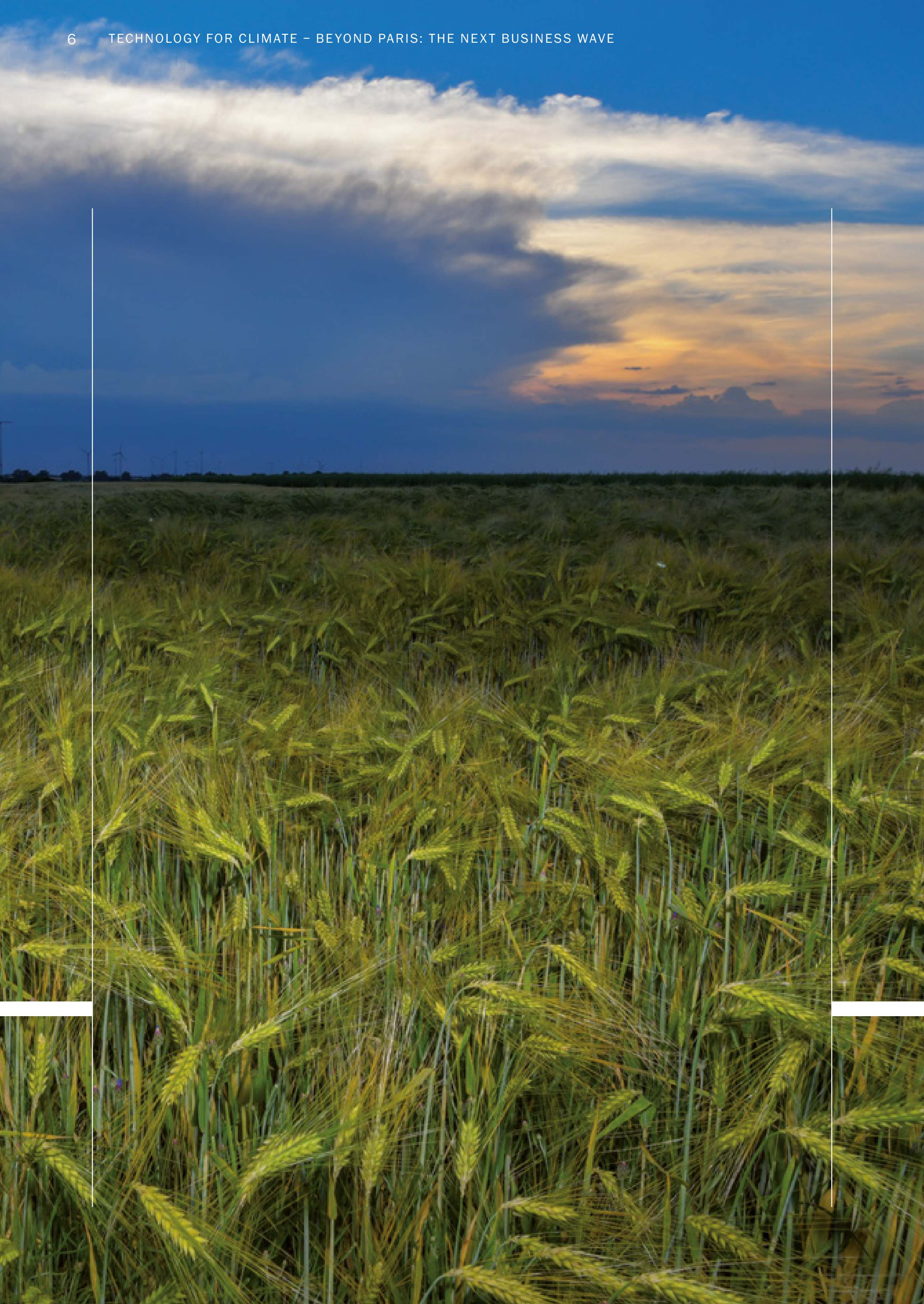


1. INTRODUCTION

Our modern economy is in the midst of a huge transformation: the effort to prevent climate change by transforming our energy, production and consumption systems. A lot of progress has been made in the development and utilisation of renewables and energy-saving technologies such as solar, wind, biofuels, energy-neutral houses and electric cars. But even when taking into account new and ambitious reduction plans, a recent analysis by McKinsey shows that worldwide CO_2 emissions will still be well above a 'safe' 2°C global warming path in 2050.[1] Despite enormous progress in the development and utilisation of renewables and energy-saving technologies, the global energy demand of industrialised, fossil-based economies has continued to rise.

2°C
IN 2050

WORLDWIDE CO_2 EMISSIONS WILL STILL BE WELL ABOVE A "SAFE 2°C" GLOBAL WARMING PATH.

In order to pre-empt this looming trend, we need to ramp up the pace of transformation. This requires both (i) the industrialisation of the deployment of existing solutions and (ii) an increased effort in the cultivation and stimulation of innovation. Industry, recognised as a major contributor of CO_2 emissions, is therefore in a position to take the lead in this scale-up challenge. Industry has a role in bringing innovations to the market and providing and producing solutions for a fully decarbonised society, not only in the domain of energy and industry but in all other sectors.

The latter will bring large business opportunities for the traditional strengths of the Dutch economy. High-tech systems & materials and sustainable chemical technologies will be key enablers of the energy transition. As stated in a previous TNO White Paper on cheaper energy for the energy transition[2], a targeted investment in innovation can both significantly reduce the costs of the energy transition and provide substantial business growth opportunities for a clean and futureproof industry.

1 Based on today's plans for CO_2 reduction, as collected worldwide, McKinsey Energy Insight indicates that we will reach a 22% reduction of human-induced greenhouse gases by 2050. This is insufficient to reach the IPCC limit of max 1.5 degrees global warming by 2100. To reach the IPCC target, as agreed in Paris, we need a 66% reduction by 2050.

2 TNO (2019), Energie wordt goedkoper innovatie maakt de energietransitie rendabel. André Faaij en Ruud van den Brink, Den Haag, maart 2019.

This White Paper deviates from that position and sketches a contemporary industrial landscape of realistic opportunities. It does so by describing:

THE CHALLENGE
Section 2 explains that there is no easy solution for decarbonisation. No silver bullet exists. Fortunately, there is a broad variety of options, some of which are all but 'manufacturing-ready'. The challenge is the need for a coordinated and systemic approach.

THE NEXT BUSINESS WAVE
Next, the paper indicates business opportunities for Dutch industry. These opportunities describe technologies ranging from complete systems and products to key components. Business opportunities arising in the chemical industry and in the field of energy storage are elaborated on in particular.

POSITIONING OF TNO
This paper shows a number of specific technologies that TNO is actually involved with, in cooperation with private companies in ecosystems like the Brainport region and the Chemelot Campus. This allows us to show in a very concrete way how Dutch companies can work and are already working on these new technologies.

MODUS OPERANDI
However, it is not just industry that should step forward to grasp these business opportunities. To paraphrase Mariana Mazzucato, an entrepreneurial state is needed. Government involvement is of great importance in setting up targets or missions, stimulating markets, developing legislation and acting as a launching customer. Once the market is there, competition will lead to lower cost prices and improved reliability and performance. Given the global challenges, there will be large global markets for the deployment of the best solutions with significant opportunities for private enterprise.

“There is no easy solution for decarbonisation. No silver bullet exists. Fortunately, there is a broad variety of options, some of which are all but ‘manufacturing-ready’.”

2. THE CHALLENGE OF DECARBONISATION

In the Netherlands, industry is responsible for almost half of primary energy use and the corresponding greenhouse gas emissions. Zero or even negative emissions require a complete conversion of the industrial capacity and associated energy infrastructure. Efforts need to focus on reduction of fossil sources of carbon, therefore often is referred to de-fossilisation.

This conversion requires a multitude of options. There is no silver bullet. In addition to 'conventi-onal' energy saving and the use of green energy carriers (sustainable electricity, heat and hydrogen), it is also possible to switch to sustainable raw materials (bio-based), comple-tely new production processes and the use of CC (U) S[3]. In addition, circular concepts (reuse, recycling, back-to-monomer, cascading) are important ways to significantly reduce the demand for (scarce) primary raw materials, which in turn influence many value chains and industrial infrastructure and logistics. Essential in all of this is large-scale flexibilisation of both energy and material flows. Storage of (renew-able) energy will become a major element in flexibilisation.

Options differ in regard to technological maturity, from early R&D to those on the verge of mass industrialisation and cost reduction. Simultaneous work on options in all of the different stages of development is necessary. The combination of options provides different transition paths for each sector. The extent to which green electricity, green hydrogen, CCS, biomass (etc.) will become available over time and at what costs remains uncertain.

In order to channel this complexity, it is crucial to start from an integral picture of the required transformation that is based on a broad understanding of the existing situation, in-depth insights into the possibilities that new technologies (will) offer and linking them through socially and economically responsible development paths. A clear, mission-oriented policy on climate change is what is needed for the Netherlands to guide technology development over the next decades.

At the same time, it would be foolish to keep searching for an 'optimal' strategy per sector. Technology development takes a very long time to go from an idea to the first products and finally to affordable, worldwide deployment. As for the coming decades, there will be a myriad of possible combinations and dependen-cies. More often than not, the final applications of technologies cannot be foreseen, nor can their impact be fully appreciated until afterwards.

> "The big challenge is to design a coordinated, systemic approach that channels the available innovations at a greater pace and with more direction."

3 Carbon (CO_2) Capture (Utilisation) and Storage

One should keep in mind that technology is certainly not the only determining factor here. Everything depends on sustainable business cases and (new) revenue models. The role of the (regional) government as a buyer, policy maker and innovator of laws and regulations is crucial. The role of the financial markets and (for example) the central role of accounting are co-determining, partly in light of the strong management of international owners and stakeholders. Last but not least, consumers and other social stakeholders are increasingly important for the successful realisation of innovations.

Fortunately, to sum things up, there is a broad variety of decarbonisation options, some of which are all but ‘manufacturing-ready’. The big challenge is to design a coordinated, systemic approach that channels the available innovations at a greater pace and with more direction.

3. THE NEXT BUSINESS WAVE

At the same time, addressing climate change offers opportunities for Dutch industry. A near future in which the new generation of industry will be clean and at the same time more competitive than the current one is conceivable. Among other things, this would be due to higher efficiency, less dependence on primary raw materials and fossil fuels with large price fluctuations, cleaner production and a minimal CO_2 footprint. Clean solutions are well-known for all sectors and are sometimes already established. But for large-scale decarbonisation to become a reality, the associated business cases need to be developed and investment decisions must be planned in time.

Business opportunities are in place for all decarbonisation options. However, Dutch industries are better positioned for some options than for others. For some options, it is better to 'buy' them, whereas for other options it is better to 'make' them.

> "Supporting the industrialisation of the energy transition requires an approach that is open, sensitive and adaptive in order to support emerging ecosystems as they arise."

Against this background, TNO analysed which key technologies offer the most market potential for the energy transition in the Netherlands.[4] The analysis looked into knowledge (#publications), technologies (#patents), economic activity (sector growth) and international dynamics as

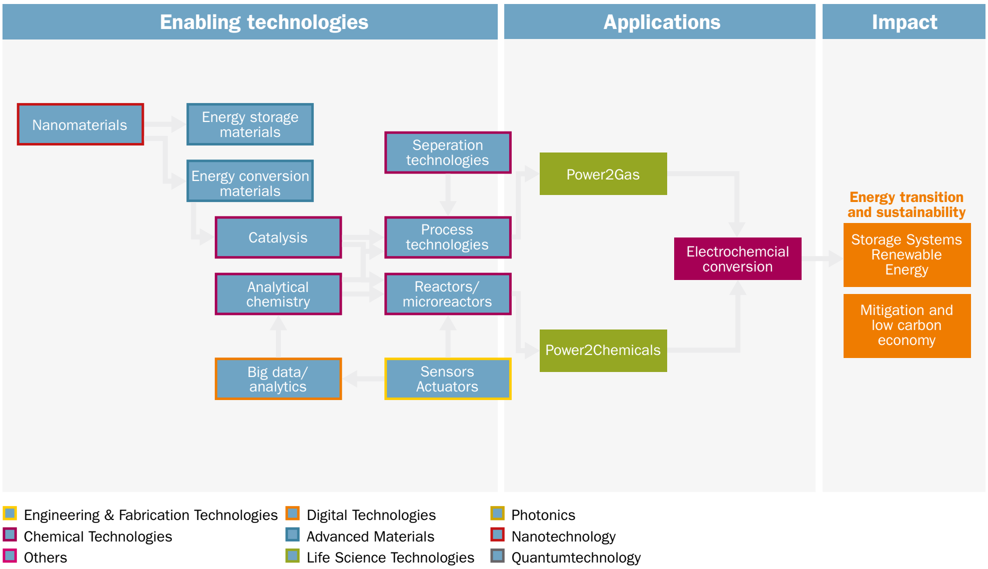


FIGURE 1: THE POTENTIAL CONTRIBUTION OF TECHNOLOGY TO SOCIAL CHALLENGES

the main factors in business opportunities. The key opportunities identified were in the chemical industry, equipment manufacturing, the electrotechnical industry (precision instrumentation), the information and communications industry and the off-shore industry.

Note that the opportunities are not limited to the manufacturing of final applications (e.g. a solar panel) but apply to all steps in the associated value chain. For a final application produced abroad, the Dutch value chain may consist of businesses providing key components, advanced materials or high-value services. As an example, Figure 1 describes the large set of technologies contributing to 'Power2Gas' and 'Power2Chemicals' applications, both of which are important solutions for greening the chemical industry. This is particularly clear in the case of wind turbines. The Netherlands does not have a strong position in wind turbine production but is a key player in off-shore wind parks, building upon the strengths of its off-shore sector.

The key message here is that important opportunities may lie in the development of components, in manufacturing technology or in highly specific, niche applications. Supporting the industrialisation of the energy transition requires an approach that is open, sensitive and adaptive in order to support emerging ecosystems as they arise.

The following sections of this paper describe a number of specific technologies, showing the business opportunities arising in the chemical industry and in the field of energy storage.

4 TNO (2017), Portfolio-analyse: Kansrijke innovatieopgaven voor Nederland - Fundament voor het maken van keuzes, Den Haag assigned by Ministery of Economic & Climate Affairs. TNO (2018), de potentiële bijdrage van technologie aan maatschappelijke uitdagingen, Den Haag.

4. THE NEXT BUSINESS WAVE IN THE CHEMICAL INDUSTRY

The chemical industry is an energy-intensive sector with a strong position in knowledge and innovation. There is a need to rapidly decarbonise the sector's consumption of fossil energy and feedstock. CO_2 reduction, more efficient use of energy and feedstocks and reducing waste are key to turning this need for sustainability into practice. At the same time, the European based sector is coping with increased pressure from global competition. The profitability of commodity chemicals production has declined. Which may or may not be compensated by profitability of high value products like specialties and fine chemicals.

Cost reductions and the search for new growth markets, are on the top of the agenda. The result is that becoming less dependent on fossil resources is regarded as a necessity for the sector to continue its operations into the next century. A sustainability challenge has turned into an opportunity for disruptive innovation. Moreover, recently it has been recognized that the chemical sector can play this role, not solely for its own activities, but also for other sectors. With its expertise in high-tech chemical and material research, chemical engineering and scale-up to world-scale production, the sector can contribute to disruptive sustainable solutions. Solutions like green hydrogen powered lightweight cars, biobased plastics produced with renewable energy and building materials based on circular or biobased feedstock. Not only will this contribute to the decarbonization goals of society, but also to increased profitability in the chemical sector in the near future.

For example, the energy and chemical sector can help each other to solve some of their most difficult challenges with respect to energy use, efficiency and selectivity. The chemical industry can use flexible and abundant sustainable electricity directly and indirectly in production of fuels, plastics and fertilizers. Which in turn will lead to a high-tech industry delivering technical solutions enabling this industrial electrification.

CHEMELOT TO BE CO_2-NEUTRAL IN 2050

One of the main sites for the chemical process industry in the Netherlands is the industrial site of Chemelot. The site hosts a number of large chemical companies like DSM Engineering Plastics, SABIC and OCI Nitrogen. Chemelot is one of the largest emitters of CO_2 in the Netherlands but is now on a mission to be CO_2-neutral in 2050. That is a huge challenge. Key elements of the roadmap to CO_2 neutrality are electrification of the site using renewable energy, greening of feedstock and raw materials and increased process efficiency and optimisation. For instance SABIC uses naphtha as feedstock for the production of plastics. Biomass might be used as feedstock for the production of green naphtha. OCI nitrogen uses hydrogen from natural gas for the production of fertilizers. The hydrogen can also be made with electrolysers from renewable energy. As Chemelot is an integrated site, companies work together in achieving CO_2 reduction making use of each other's processes. TNO works with Sitech Service, Maastricht University and Brightlands Chemelot Campus in the Brightsite knowledge center. At Brightsite new technologies for the process industry are developed which will increase the sustainability of the companies on the Chemelot site. Chemelot works with the five I's[5]. In addition to the technological Innovations Chemelot demands attention for the necessary Infrastructure, the policy Instruments to make business case possible for technologies, the International dimension and Involvement of society.

5 Source: Robert Claasen, Executive director Chemelot

CHEMELOT - CREDITS: MCM PRODUCTIONS

VOLTACHEM – ACCELERATING INDUSTRIAL ELECTRIFICATION

To facilitate and accelerate the development of industrial electrification, TNO, ECN and Holland Chemistry together with industrial partners have initiated VoltaChem. This business driven Shared Innovation Programme connects the electricity sector, equipment sector and chemical industry. The programme develops and implements new technologies and business models that focus on the use of renewable energy in production of heat, hydrogen and chemicals. VoltaChem serves and works with industry to strengthen its competitive position and that of its suppliers.

Within the programme a portfolio of technology developments is addressed that is assessed to be crucial for achieving the sustainability goals in the chemical sector and industry as a whole. Most prominent are:

- The development and integration of electric cracking technology for production of chemical intermediates for plastics.
- The industrial integration of green hydrogen based on renewable energy and the reduction of its production costs through industrialized manufacturing of electrolysers.
- The development of electrolysers converting biomass and CO_2 to fuels and key intermediates for plastics and their scale-up towards electrochemical production plants.

- The reuse of stored low temperature heat.
- Furthermore, VoltaChem pays a lot of attention to analyzing the context of industrial electrification with respect to the future developments in the energy, resource, infrastructure and technology domain.

This enables VoltaChem partners to assess the business case of specific technology developments in detail and to understand its dependency on policy and market conditions.
The key message is that chemical industry in Europe can provide the solutions to a climate neutral industry and society and is on the verge of making large investments in business opportunities with a tendency to be disruptive to existing carbon-based chemical production infrastructures as well as to other sectors.

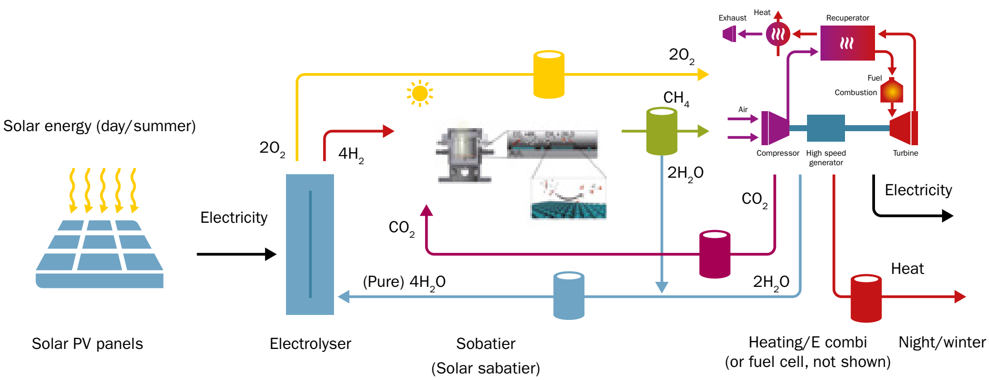
Vice versa, the chemical industry will need the expertise, skills and infrastructures of other sectors to achieve this, primarily when it comes to high-tech manufacturing and advanced materials.

USING SUNLIGHT FOR CHEMICAL REACTIONS AT TNO – ENABLING A NEW TYPE OF CHEMISTRY?

TNO and Hasselt University (Belgium) may have found a breakthrough in using sunlight to convert CO_2 into methane (CH_4), one of the main ingredients of natural gas. The reaction converts CO_2 and H_2 into CH_4 and O_2.
This reaction has been known for a long time as the Sabatier reaction, but this requires a high temperature and pressure, resulting in an energy-hungry process. By using a catalytic agent (ruthenium), the reaction now only requires (concentrated) sunlight as an energy source. In an experimental setup, the catalyst has already allowed 55% of the energy of the sunlight to be used.

The process is still in an early R&D phase in the lab, but could offer very interesting applications when available at a larger industrial scale. For example, the reaction could also be used to create syngas, which is often used as a feedstock for chemical processes and to produce chemicals in desert areas with surpluses of sunlight. A lot of additional research is still needed to get the technology to an industrial scale. For instance, as the process needs sunlight, transparent reactors with light concentrators need to be developed.

SOLAR HOUSE



COMBINATION OF ALL TOPICS ADDRESSED IN THIS PAPER. THIS IS HOW ZERO EMISSIONS COULD BE ACHIEVED FOR HOUSES AND CHEMICAL INSTALLATIONS.

5. THE NEXT BUSINESS WAVE IN ENERGY STORAGE

Solar panels and wind turbines are being rolled out on a larger and larger scale today. Incidentally, it already occurs that peak loads of the renewable energy being produced cannot be accommodated by the grid. Calculations indicate that such situations will happen so often by 2025 that a further roll-out of these solutions will become economically unattractive. From 2025 onward, buffering and storage of surpluses will become necessary.

BATTERY TECHNOLOGY. CREDITS: HOLST CENTRE

Once storage becomes widely available, one could argue that the market for (electrical) solar/wind/storage solutions will replace fossil fuel markets and ultimately become as large as fossil fuels are today. Once commercial storage is within reach, it will reshape industry on a large scale.

Energy storage technologies already exist in different areas of application. McKinsey expects a rise in the number of flexibility options on the power grid, with 109 GW installed between 2016 and 2020 and 565 GW installed between 2031 and 2035 in selected countries representing 75% of global power demand. Most of the increase is to be managed by new flexibility options such as batteries, fuel cells and other CO_2-free options.[6]

TECHNOLOGY BREAKTHROUGHS FOR ELECTRICITY STORAGE IN BATTERIES

In the coming decade, the demand for battery storage will grow significantly. Initially, automotive will be the main driver of lower costs and increased reliability, but ultimately batteries will be used for stationary peak-shaving and day/night storage too. Whereas Moore's law predicts a doubling of speed for integrated circuits every two years, the price/performance curve for batteries so far does not evolve this fast. Nevertheless, the industrialisation of battery production has taken off. Recent plans show a massive expansion of manufacturing capacity for Lithium-ion batteries around the world. The 35 GWh Tesla 'Gigafactory' in Nevada captured headlines in 2016 and more than half of the planned new capacity is in China. Most of the new manufacturing capacity uses the dominant Lithium-ion technology for batteries.

There is still plenty of improvement possible for state-of-the-art batteries. R&D continues to work on (intrinsic) safety, energy and power density (allowing for smaller batteries), cycle life, charge time, sustainable and circular approaches and greener production, both at a battery cell level and at a battery system level.

6 McKinsey Energy Insights' Global Energy Perspective, January 2019

INNOVATIONS IN BATTERY TECHNOLOGY AT TNO

At the Holst Centre in the Brainport region, TNO develops new, more powerful and intrinsically safe battery technologies. The latest is a 3D LioN battery. This so-called Gen4 battery is an entirely solid-state battery based on Li metal. This new type has a number of advantages over regular Li-on batteries. It is safer because it does not use flammable or explosive solvents. It allows for faster charging and discharging. It lasts longer without deterioration through charging and discharging, and it has a larger energy density which allows for smaller batteries.

The key to making these new types of batteries is the use of technologies from the display and semiconductor industry. To create the very small-scale 3D structures for the batteries, so-called Spatial Atomic Layer Deposition technology (S-ALD) is used. Building the equipment for this technology is one of the strengths of the Dutch equipment manufacturing sector in the Brainport region. Several companies have commercialised the production of this manufacturing equipment. This new generation of batteries might therefore offer exciting new market opportunities for the Brainport region.

VDL is one of the companies in the Brainport region that is working with TNO on the development of the next generation of batteries. The S-ALD technology that TNO uses for the new battery is very much connected to the technology that VDL uses in manufacturing equipment for solar panels. The VDL Enabling Technologies Group is an important supplier of manufacturing equipment to ASML in the semiconductor industry and to the worldwide solar panel industry. At the moment, VDL does not have a position in equipment for the current type of battery production. The optimisation of current types of batteries therefore does not offer many opportunities to VDL.[7] However, the new Gen4 batteries might open up possibilities for VDL and a European battery industry.

TECHNOLOGY BREAKTHROUGHS FOR HEAT STORAGE IN THE BUILT ENVIRONMENT

A large part of today's energy consumption is low temperature heating. Next to the storage of electrical energy, the storage of thermal energy will be an important element of the future energy system. Heat may offer a cheap alternative to full electric solutions. Heat storage in the built environment can be such an alternative. Seasonal storage in underground water basins, combined with heat pumps, is already quite common in the built environment, but storage in heat batteries is a novelty. One of the current dominant technologies for CO_2 reduction in the built environment is the use of electric heat pumps. In winter time, when demand for heat is highest but when solar panels deliver only a limited amount of renewable energy, there is a large peak in electricity demand. The use of heat batteries could help to reduce this peak.

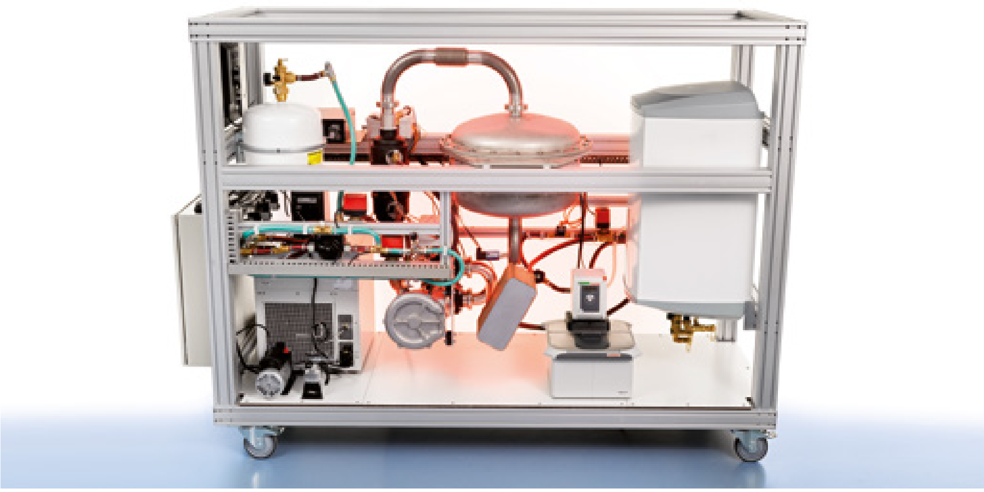
7 Source: Menno Kleingeld (Director of VDL Enabling Transport Solutions).
8 Source: Henry van der Meer – product manager CASC Caldic

TECHNOLOGY BREAKTHROUGHS: A HEAT BATTERY AT TNO

A new heat storage solution using salt hydration for residential and community use enables efficient heat storage close to the users. TNO and TU/e have developed compact hydration tanks to store heat using specific salts. The heat battery is charged when (low temperature) heat surpluses are available (solar collectors, heat pumps/fuel cell heat losses) and the heat is released when demand rises.

Two important breakthroughs enable this technology. The first is the identification of a thermochemical material which can store heat and release it without losses to overcome months of storage. The second is a closed loop reactor which can transport heat to the thermochemical material and also obtain heat from it, distributing it further in the heating system.

The Dutch chemical company Caldic works together with TNO and TU/e on the development of the heat battery. The company is both a producer and a distributor of industrial chemicals: fluids, solids, salts, powders, acids and specialty chemicals. In cooperation with TU/e and TNO, Caldic found K_2CO_3 to be the most suitable thermochemical material for the heat battery. This involved investigating not just the chemical substance but also the form and production methods of the salts. Caldic now provides hybrid K_2CO_3 salts and also the coating of the granuals for the battery. As the batteries require large amounts of salts, widespread use of the batteries would generate an enormous market for Caldic. The consortium of Caldic and TNO plans to bring the heat battery to the market in 5 years.[8] Development now focuses on making the system more compact and combining the system with heat sources like solar water heaters. Moreover, the consortium is taking the first steps towards industrialisation by finding investors for a demo scale factory for producing K_2CO_3.



HEAT BATTERY, USING SALT HYDRATION FOR RESIDENTIAL AND COMMUNITY USE.

6. MODUS OPERANDI

How do we get to battle climate change and create the next business wave at the same time? This section describes two important elements on how to get there: embracing mission-oriented policy and innovating in ecosystems.

MISSION-ORIENTED POLICY

Mission-oriented research and innovation policy is becoming the framework for climate change policy in Europe. This is seen as the way to increase the impact of research and innovation by creating the scale needed for breakthrough innovations and by accelerating the search for solutions to complex societal challenges.

> "... missions must be bold, activating innovation across sectors, across actors and across disciplines. They must also enable bottom-up solutions and experimentation."
>
> MARIANA MAZZUCATO

As an example of a mission, putting a man on the moon is often cited. That mission spurred innovation not only in aerospace but in a lot of other sectors. Without simultaneous innovations in materials, biology, energy and geology, the mission would not have been possible. It mobilised resources that were unheard of before. As a Dutch example, the Deltaworks are often put forward as a mission to protect the country against the sea, thereby creating one of the world's strongest off-shore industries.

The Netherlands has embraced mission-oriented policy in the Climate Agreement. Mission and innovation programs were formulated by the Integrated Knowledge and Innovation Agenda for Energy and Climate (IKIA). This creates new markets and new opportunities for Dutch industry. For the chemical industry, as an example, the mission for industry puts forward a strong challenge: in 2050, raw materials, products and processes must be net CO_2-neutral and at least 80% must be electrified and built around disruptive industrial processes. Missions themselves have been detailed in mission-driven innovation programmes (MMIPs), such as on electrification and disruptive processes.

The success of this approach depends on the participation of industry in taking up the challenges put forward in the missions.

INNOVATING IN ECOSYSTEMS AND FIELDLABS

An important strength of Dutch society is cooperation. The key to capitalising on business opportunities is cooperation in innovation ecosystems and in fieldlabs. The Brainport region, Chemelot and precision instrumentation in the province of South Holland are examples of such ecosystems.

TROPOMI IN TNO LAB

ECOSYSTEM FOR PRECISION INSTRUMENTATION: TNO AND KNMI BRING CLIMATE MONITORING TO THE NEXT LEVEL

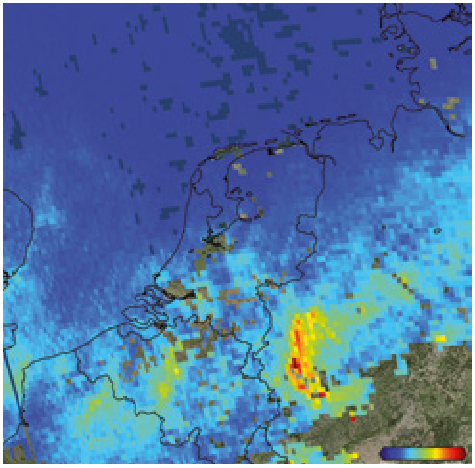
TNO has a long history in developing optical systems for satellite instruments that are used to monitor the atmosphere of our planet. Examples include Sciamachy (ESA), OMI (NASA) and TROPOMI (NSO/ESA). Instruments like these can be used to monitor global background levels of greenhouse gases (e.g. CO_2 and CH_4) and other gases that need to be monitor alongside this (e.g. NO_2 and aerosols).

Another area of opportunity is the offering of services that translate satellite and aerial survey data into actionable information for companies and governments. TNO's atmospheric simulation tool LOTOS EUROS and source apportionment system TOPAS are examples of this. They can be used to trace back atmospheric concentrations, as measured by a satellite, to emission sources on the ground and subsequently label them by location (e.g. city, country) or economic activity (e.g. road transport, power plant), for example.

Interestingly, the optical technology used in the spectrometers for the satellite instruments is also used by TNO in the high-end optical technology for S-ALD, thereby creating a significant spin-off for this R&D funding.

TROPOMI (SOURCE: ESA)

Private companies from different parts of the value chain work together in fieldlabs with knowledge organisations supported by the government. The pooling of innovation resources leads to technological learning and thereby accelerates innovation. Working in ecosystems and fieldlabs assures that the solutions developed are well adjusted to markets, helping companies to bridge 'the valley of death' for their innovations and enabling companies to take the first steps towards industrialisation.



NITROGEN DIOXIDE, THE NETHERLANDS NOVEMBER 17, 2017. ON 17/11 THERE WAS A SUPPLY OF CLEAN AIR FROM THE NORTHWEST, VISIBLE HERE DUE TO THE RELATIVELY LOW MEASUREMENT OF NITROGEN DIOXIDE.

CREDITS - CONTAINS MODIFIED COPERNICUS DATA / PROCESSED BY KNMI

7. HUGE INDUSTRIAL OPPORTUNITIES, ACTION IS NEEDED...

Technology plays a key role in battling climate change. By using technology, a lot has already been accomplished, but more still needs to be done. A clear mission-oriented policy on climate change for the Netherlands can guide technology developments over the next decades. This will create new markets and new opportunities for Dutch industry.

> “ Mission-Oriented Policy on Climate Change will play a key role in developing technologies for Climate Change.”

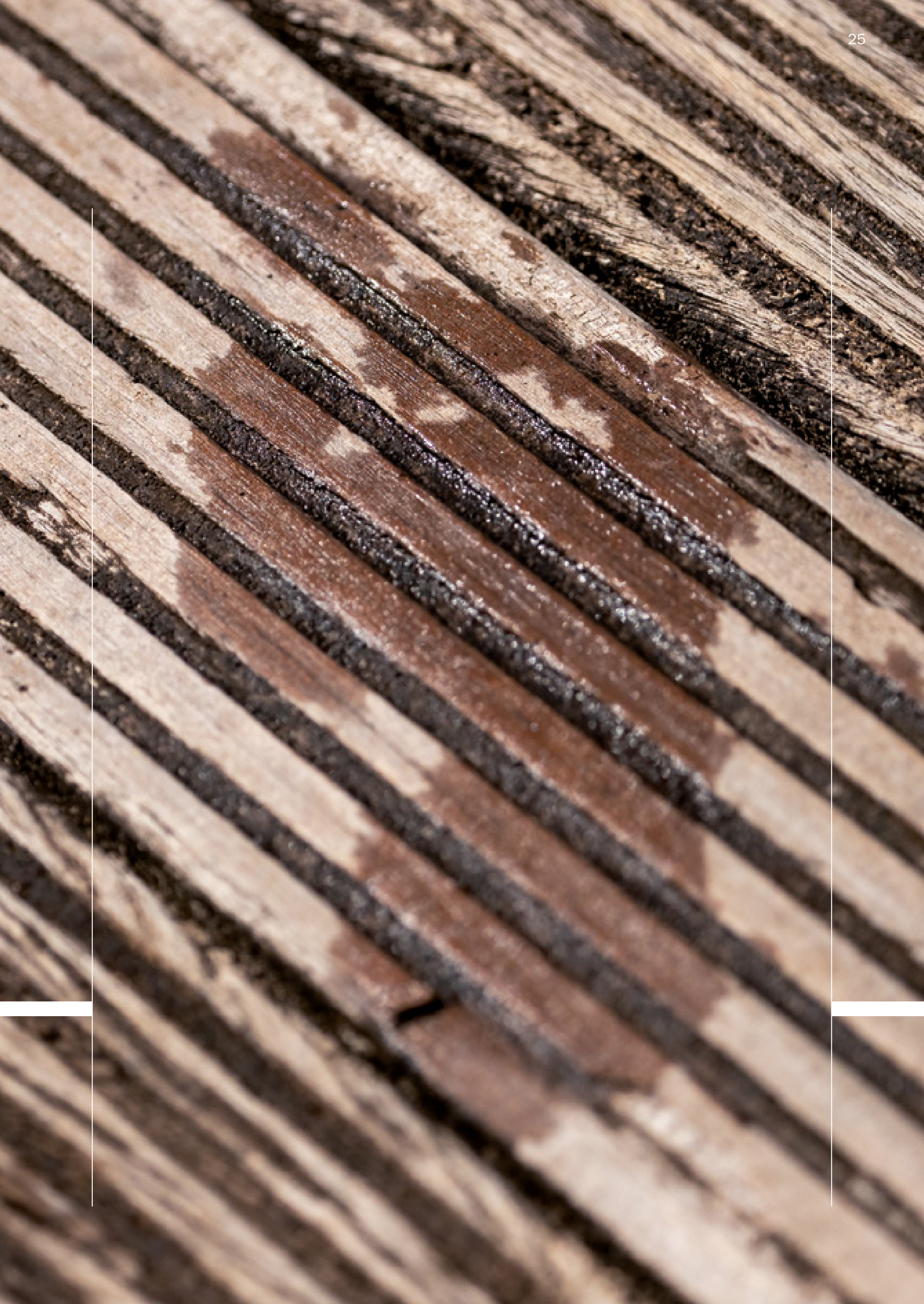
However, technology development takes a very long time to go from the idea to the first products and finally to affordable, worldwide deployment. Moreover, the sometimes surprising final applications of technologies cannot be foreseen. Tech optimism is fuelled by often continuous improvements in physics, perfectly illustrated by Moore’s Law. It is therefore important to keep working on key (enabling) technologies. In this way, a technology ‘pull’ from the mission meets a technology ‘push’ from R&D.

> “ Combine mission-oriented policy on climate change with policy for key enabling technologies.”

For the energy transition, new products such as batteries, heat batteries, electrolysers, reactors and manufacturing equipment need to be made. This offers business opportunities for industry. Not just for the makers of the final product, but for a whole value chain of suppliers across the boundaries to other sectors. This paper shows that to be true, especially when it comes to strong sectors of the Dutch economy such as the chemical industry and the manufacturing equipment industry. Industry will play an important role in the rapid deployment of solutions.

> “ Starting from the chemical industry and the manufacturing equipment industry, the energy transition offers business opportunities for a wide range of companies in manufacturing.”

The key to capitalising on business opportunities is cooperation in innovation ecosystems and in fieldlabs. Private companies from different parts of the value chain work together in fieldlabs with knowledge organisations that are supported by the government. Working in ecosystems and fieldlabs assures that developed solutions are well adjusted to markets and enables companies to take the first steps towards industrialisation.



> "Working in ecosystems and fieldlabs accelerates the flow of innovation from an idea to implementation in mass markets."

Market failure is eminent in the economy of climate change. The costs of CO_2 emissions are rarely priced. This often prevents markets for CO_2-mitigating technologies from growing by themselves. A more visible/prominent role in the energy transition for the government is both required and justified. However, the role of the government should not be to simply fix market failure but rather to create new markets. This role includes: setting up a mission-oriented policy on climate change with an ambitious goal; investing with direct funding of substantial international leading innovation programmes in a number of targeted fields reflecting the strengths of the Dutch innovation landscape and economy; using an innovative policy mix, including prizes and public procurement, that goes further than fiscal arrangements; streamlining regional, national and European efforts; and stimulating markets through legislation and financial arrangements.

> "Government needs to help shape the market through the specific stimulation of R&D, supporting scale-up and putting regulations in place."

In this paper, we have argued that it is possible to move beyond the Paris climate goals. The paper has demonstrated that we are already doing this in cooperation with Dutch frontrunners in strong ecosystems. Large markets for industries are right ahead of us in both the near and distant future. Massive industrialisation of various technical solutions will be required to reduce global warming. If you want to be a part of this, this is the moment to act. Only when we engage together can we solve this challenge and capitalise on the business opportunities; join us now!e on the business opportunities; join us now!

> "Together we can create the next business wave: Tech4Climate."

june 2019

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