THE FUTURE OF ENERGY-INTENSIVE INDUSTRIES IN THE NETHERLANDS

VISIONS AND STRATEGIES FOR DUTCH ENERGY-INTENSIVE INDUSTRIES IN A CLIMATE-NEUTRAL SOCIETY FOR 2030 TO 2050

THE STORY

QUINTEL INTELLIGENCE

CREDITS

COMMISSIONED BY
Netbeheer Nederland, Topconsortium voor Kennis en Innovatie Energie & Industrie, Institute for Sustainable Process Technology, Urgenda and OCI Nitrogen

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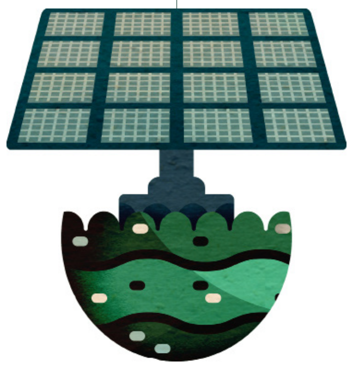

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QUOTES

"Quintel's initiative has resulted in a series of provocative scenarios for all energy-intensive industries. Their vantage point is formed by the trends already known, which - when expanded and accelerated - can be game changers within different sectors of industry. The Story is an inspiring read. I highly recommend it to anyone who wishes to broaden their perspectives."

Ewald Breunesse,
(Shell Netherlands)

"Using a panoramic view of a future in which we have reached our climate goals within the prescribed timespan while also respecting economic conditions, The Story connects highly specialized industrial and agricultural sectors, revealing the links between them and demonstrating the necessity of them following a joint path"

Johan Sanders,
(Wageningen University & Research)

"This study has shown that we can convert electricity surpluses into hydrogen, which in turn, if necessary, can be stored or transported directly to consumption sites. It can then be used to supply these sites with energy and raw materials. This conversion can contribute to a sustainable energy system, in which supply and demand are always in balance. Tennet and Gasunie are keen to join forces with the chemical industry to take the next steps and investigate, amongst other things, what flexibility this option can offer in the electricity sector, and what possibilities there are for transporting hydrogen through the existing gas grid, including gas storage."

Piet Nienhuis,
(Gasunie)

Gert van der Lee,
(TenneT)

"The TKI's mission is to encourage innovation aimed at making the energy system of our (energy-intensive) industries more sustainable. For our planning, it is very important to have some insight into possible scenarios, transition paths and shared visions for the future of these industries. This study by Quintel provides an excellent starting point, thanks particularly to the attention it pays to possible consequences of any radical trend shifts. This sharpens the mind, which will help us to respond accurately to the great challenges of our time. We will definitely be using it in the coming years to finetune our visions and transition paths."

Peter Alderliesten,
(Topconsortium voor Kennis en Innovatie Energie & Industrie)

"If we truly want to achieve the goals of the Paris Agreement and want to prevent the earth from heating up by more than 1.5 degrees, we need to put a halt to our CO_2 emissions within the next 20 years, and we will need to shift to a more sustainable energy consumption and less pollutive production processes. Before, this seemed like an unrealistic ideal, especially for our (heavy) industry. This Story explores possible steps and options that can help us move towards a more sustainable economy. It is a great starting point for further discussion (lots of it), and, hopefully, accelerated action. We need that more than ever. We cannot simply pass on the bills, and the problems, to the next generation. What we need is innovation, investment and action. Surely we can start the movement ourselves? Just. Do it!"

Marjan Minnesma,
(Stichting Urgenda)

"The Story An Industry in Transition rightly points out that our industries can themselves start reducing their carbon emissions, and opens up a discussion about fundamental transformations in our industries. It also presents a beautiful vision with widespread electrification and wind energy as our main electricity source. The capture and storage of carbon dioxide and/or the use of biomass can help us stay within the tight CO_2 budget during the transition."

Machteld van den Broek,
(Utrecht University)

"The Story by Quintel presents surprising visions for the future of the energy-intensive industries of the Netherlands. The decision to take the demand for products as a vantage point contributes to that. Ambitions and wishes have been carefully described in transition paths, which indicate directions for the industries to take as we move towards the year 2050. Several parties have gathered forces to investigate these transition paths. The Story presents an overview of ways in which our energy-intensive industries can work to reach our climate goals."

Jan Jaap Nusselder,
(OCI Nitrogen)

"The societal shift towards a sustainable, circular, bio-based economy is already happening. The paper and cardboard industry, with its renewable resources, carbon emission reductions and high recycling percentage (85 percent), makes a large contribution to the building of a sustainable economy. But this is not a reason for this industry to rest on its laurels. In order for them to be able to cope with the shortages in materials, high quality recycling will have to become even more commonplace. Within the innovation program 'Creating Sustainable Fibre Solutions', the industry has set up an iconic trajectory: 'Reuse and circularity'. Besides goals such as a 'zero-waste factory' and the widespread implementation of recycling, the reusing of paper and cardboard is an important point of attention within this trajectory. This Story helps to raise awareness, in that it stresses the societal importance of reusing materials and the economic opportunities this will create for the packaging industry.

Gerrit Jan Koopman,
(Koninklijke Vereniging van Nederlandse Papier- en Karton-Fabrieken)

"This Story provides system operators with new insights into the future of this industry in an energy transition and the consequences of this transition for our energy system. This exploration, which outlines future paths, invites us to deepen our knowledge and to take our first steps towards the realization of these visions. Grid controllers will be focusing on the creation of the energy infrastructure we need to facilitate the necessary transformations in our intensive industries. They are looking forward to continuing their journey towards the envisioned vision in collaboration with other industrial sectors.

Jan Pellis,
(Stedin)

Sander Schouwenaar,
(Enexis)

Marijn Artz,
(Netbeheer Nederland)

"Sharing these visions with others is inspiring. It stimulates us to act as one. Especially in complex processes, such as energy transition in collaboration with the intensive industries, things can easily get very complicated and abstract. Therefore, we should join together on this journey with this special vision as a starting point."

Abo Rassa,
(Alliander)

"Since it is our shared societal duty to reduce our greenhouse gas emissions by 80% or 95%, we seriously need to consider how we are going to do this. Do we want to create more subgoals to adjust policies, or will we set one overarching goal for CO_2 reduction across the world of business, our knowledge institutions, and our government? With an array of innovation techniques that will convince companies to invest in innovation and sustainable materials as well as different, more efficient installations and processes, so that, in the end, we emphasize things that contribute most to this vision. Quintel's Story, which invites readers to share their ideas and merge them into the visions described, makes for an interesting contribution to this debate."

Reinier Gerrits,
(Vereniging van de Nederlandse Chemische Industrie, VNCI)

"Out of all the industries discussed in the report 'An Industry in Transition', the IT sector is the youngest, fastest growing, most electrified sector. It has the highest sustainable energy consumption rates and, therefore, the smallest environmental footprint. The vision of an energy-intensive industry that is fully climate-neutral does not seem at all alien to us. We are already moving in the right direction, and moving fast. This gives us a very different starting position from most other industries. Despite the strong dynamic in the data center industry, it gives us a relatively clear action perspective. This report also shows that digitalization has a huge impact on all other industries, and that this impact will only keep growing. Both the implementation of smart industry in production and the IT-driven trends described will strongly impact the demand for the IT sector's products and services. This report helps us understand that our energy system will have to become more efficient to make sure our energy transition runs smoothly. All in all, it is an important and hopeful vision, which will help us to set goals beyond the coming elections.

Jeroen van der Tang,
(Nederland ICT)

1. A SENSE OF UNEASE

It all started with a sense of unease.
For years, we at Quintel have been exploring the future of our energy system and helping others who want to do the same with our free, open source Energy Transition Model [1]. After some time, we began to feel that something was missing in our explorations. This feeling grew stronger and stronger. It became so strong, in fact, that we decided to do something about it.

You may have heard the Indian tale (or John Godfrey Saxe's poem) of a group of blind men who encounter an elephant without knowing what is in front of them. They try to discover what they have run into just by touching it. One of them feels the elephant's leg and says: "This has to be a pillar." The second feels the elephant's trunk and concludes: "I am certain this is a snake." The third man feels the elephant's flank and states: "This is a wall." When they hear each other's conclusions, they fundamentally disagree. The point of this story is: When you are looking at things from a limited perspective, you will never grasp the full picture.

1 See http://energytransitionmodel.com

When it comes to understanding the future of energy in our society, our view at present is just as limited as that of the three blind men. We know this future will be very different from the current situation, but we are unable to agree on which changes exactly are going to take place. Hence our feeling of unease.

It is sort of an undisputed fact that we need change. We need to design our society in such a way that our climate will not change irreversibly as a consequence of our lifestyles. And time is short. The earth's climate and global sea levels are visibly changing. According to some, our society will need to be climate-neutral by 2050. Others believe we need to be climate-neutral by 2030 to save our planet. But regardless of whether we have 33 or 13 years to change, we need to really invest in change now in order to reach our goals in time.

To decide what direction to take, we need to envision a climate-neutral society. For many aspects of our society, such pictures have already been outlined. We know more or less how we can heat our homes, how transportation can be climate-neutral, and how we can grow our crops in climate-neutral ways. But when it comes to our energy-intensive industries, which at present account for over 50% of our energy use and one third of our carbon emissions, finding solutions is not so easy. The complexity caused by the diversity of these industries and the mutual dependency of segments of these industries has made it difficult to create clear visions for the future.

Such visions can only be created if within our explorations we start thinking several steps ahead. In our explorations we are constantly making decisions about which factors will have a strong impact on our energy-intensive industries. Of course we are aware of the consequences of these decisions. In many explorations, the rise of electric vehicles has a large influence. This has large-scale effects on the energy use of cars and buses, amongst others. These effects are incorporated in our explorations.

What we have largely neglected so far, however, is the consequences of the consequences of these decisions. Since electrically powered transport does not require any gasoline or diesel, this trend has a large impact, indirectly, on the refineries that produce this gasoline and diesel. These refineries, in turn, have an important role in our energy systems. That role will change as an indirect consequence of the rise of electrically powered transport. This is a consequence of a consequence which we have previously not given enough consideration.

In the summer of 2016 we presented our report An Industry in Transition [2]. In this report we attempted to sketch an outline of a climate-neutral energy-intensive industrial sector. When writing this report, we did not take into consideration the energy-intensive industries themselves and their efforts to save energy, but focused on external trends that could have a radical impact on these industries. Some of these trends are a direct result of measures taken to create a climate-neutral society. However, more often than not, these trends result from seemingly unrelated changes, as in the example of refineries and electrically powered transport. The 2016 report was a first attempt to consider such consequences of consequences of the expected changes in our society.

What you are reading now, is the follow-up to that report. However, this is not a report filled with analyses, figures and graphs. This is a story. A story which relates what a climate-neutral society might look like a few decades from now. It works with "visions" for our energy-intensive industry as a whole and for specific sectors of our industry. This story also contains the strategic steps which can be taken in the coming five to ten years to achieve this "vision".

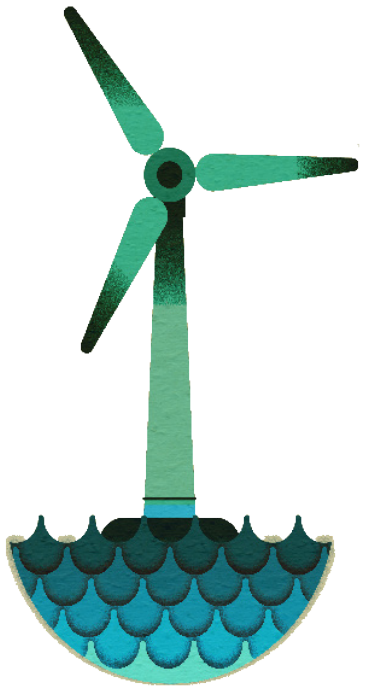
This story is meant to be passed on, expanded and improved. So fire your ideas at us. We are asking you to help us make it a better story. We by no means believe we can present a complete or detailed vision of the future. However, we do believe we present all the important elements needed to envision a climate-neutral industry. And if we can imagine the future in a certain way, we can make that future a reality.

This story has been divided into 10 separate chapters about the future of energy-intensive industries in the Netherlands. Each chapter has its own topic and comprises only a few pages. At the same time, all chapters are somehow connected. Chapter 2 provides a brief description of our energy-intensive industries as a collective. The subsequent eight chapters each explore a separate sector of our industry in more depth. The last chapter provides a discussion of the influence of the people of the Netherlands. In a society free from disasters and wars, there is but one effective tool to influence people's behavior: price incentives. Therefore, this last chapter will discuss how changes in taxes and excise duties can make sustainable products cheaper than their unsustainable counterparts.

"Industry" is a rather abstract term. To reduce the level of abstraction, every chapter begins with an outlook on how our daily lives may change in the next few years if we decide to make our society climate-neutral. This will impact how we use transport, in what homes we live , what we eat and what type of job we will have.

The first outlook for the future will relate to the question: "How do we get the energy to make that new way of living a reality?" Luckily, the amount of energy we dispose of is not the problem. Therefore this section is aptly titled "Whoops, we've got too much clean energy".

2 An industry in transition: Our vision on the future demand for energy and resources in the energy-intensive industry of the Netherlands from the perspective of inconsistencies within the current paradigm, June 2016, Dr. Ir. John Kerkhoven and Rob Terwel B.Sc., Quintel Intelligence



2. A CLIMATE-NEUTRAL ENERGY-INTENSIVE SOCIETY

WHOOPS, WE'VE GOT TOO MUCH CLEAN ENERGY

It is January in the year 2030. During the past ten years, machines fueled by coal, gas or oil have largely been replaced by electrical devices. To power our indoor heating and appliances we now use only electricity. Our cars run on electricity. In our industrial sector, producers are also starting to rely on electricity as an energy source.

Almost all of this electricity is generated by wind turbines and solar panels - although "solar panels" may not actually be the right term here. Solar cells can be integrated into different building parts these days. Windows, roof tiles and walls no longer need to be covered with solar panels; they themselves generate electricity. Besides that, wind turbines, especially those built at sea, have improved and become much cheaper.

The Netherlands is a windy country. On most windless days, the sun comes out at some point. Since wind and sun complement each other well, we have started using the term "weather electricity" to include both "wind energy" and "solar energy". Come rain or shine - our weather provides us with energy.

Thanks to our weather electricity, we rarely experience shortages. In fact, we regularly experience moments of energy surpluses. We call these "surpluses" for lack of a better word, because they are actually not "surplus"; we can put them to good use. We store any surplus energy in the batteries of our shared electric vehicles and in buffer tanks inside our houses, which use it to power our hybrid heat pumps. Large surpluses originating from wind turbines at sea are used by industrial producers, which use it to produce heat, hydrogen gas or ammonia. This is profitable, because electricity is cheap at these surplus moments.

So, we have decentralized electricity storage in the many buffer tanks in houses and batteries in cars, and there is also centralized storage in our industries. This method has allowed us to create a very robust system in which geopolitical dependencies are limited and the associated international tensions are alleviated. Surprisingly, many nations now more often depend on other states for the disposal of energy surpluses than for the import of supplies to meet energy demands.

Of course there are times at which we cannot obtain energy from sun and wind. At those times we will turn to hydrogen, ammonia, or - in extreme cases - the fermentation or gasification of biomass. In more and more places, geothermal energy - the heat from deep within the earth - plays an important role in heating buildings and greenhouses. The production of gas has greatly declined. The small quantity of gas still produced is split into hydrogen and carbon dioxide. The CO_2 is used as a feedstock in some chemical processes. The resulting hydrogen is used as a feedstock or as an energy source in industrial processes.

While reading through public strategy documents drawn up by different industrial subsections, you will soon come across large inconsistencies. In most of these documents it is assumed, for instance, that the use of electrically powered transport will experience a large increase. Electric vehicles do not use gasoline or diesel, but the most powerful Dutch oil companies still expect that their sales will keep rising for years to come. When you think even further ahead, you will come to the conclusion that self-driving cars will have a huge impact on steel producers' revenues. These cars will be shared by many people, meaning the number of cars that need to be produced will likely decline. It seems that steel producers are not taking this into account in their financial plans.

It is not that surprising that the current visions for the future contain such inconsistencies. The direction in which one would have to look to find a solution depends largely on the system boundaries one sets. An example to illustrate: Suppose you wish to reduce the carbon emissions originating from the steel industry. If you look only at the steel industry itself, the best way to do this seems obvious: to produce less primary steel and to recycle more. You need coal to produce primary steel, while recycling can be done with electricity. Yet if you broaden your system boundaries, a whole range of new solutions become available. A lot of steel is used in reinforced concrete for the construction of houses and offices. Reinforced concrete can often be replaced with wood. Suppose you used wood that would otherwise be burnt, you would be killing two birds with one stone; steel production would decline and a large share of the CO_2 emitted during incineration could be stored in wood used for building constructions.

In the following vision of the future, we have attempted to make our system boundaries as broad as possible. We have looked at all of the energy-intensive industries in the Netherlands and the way they interact with the whole of our society. We thus create a consistent view, in which the connections between the different industries are stronger than has previously been imagined. Of course, no nation is an island. Foreign nations have a large impact on our industrial sector. Since we are most familiar with the industries of the Netherlands, we have at first only concentrated our efforts on these. Many of our ideas, however, may be translated into similar ideas for other nations.

THE FOLLOWING IS OUR SCENARIO FOR THE FUTURE OF THE COLLECTIVE ENERGY-INTENSIVE INDUSTRIES IN THE NETHERLANDS OUTLINED IN ELEVEN STEPS:

1.
Oil companies will no longer be refining oil in Northwestern Europe and will cease to sell gasoline and diesel. Instead, they will start building and exploiting large wind farms.

2.
The electricity generated by new wind turbines will be providing our highly electrified society with energy. There will be so much wind power that the supply will exceed the demand at various instances.

3.
Any 'surplus energy' will be used by oil companies to produce basic chemicals which will substitute naphtha wherever possible. Natural gas will only be used if CO or CO_2 is needed for the production of these basic chemicals. Biomass and naphtha will be used as basic materials if the previous chains are too energy- or capital-intensive. In such cases, the carbon atoms in end products will no longer be burnt or emitted into the environment.

4.
Self-driving cars will be the standard for electrified transport. Because they will be shared by large numbers of people, 90% of the number of cars driven now will become redundant. A large amount of steel now used for cars can be recycled and used elsewhere.

5.
The demand for steel for the construction industry will also decline. Wood will replace reinforced concrete as the primary building material.

6.
The steel that will become available because the car industry no longer needs it, as well as the steel originating from demolished houses built out of reinforced concrete will be recycled and used for the creation of wind turbines. Therefore, no new steel will be needed for the construction of wind turbines.

7.
The use of appliances and robots, such as self-driving cars, will generate a strong rise in data traffic and increase the load on data centers. This will not cause any problems because these data centers are already completely electrified. They can easily exploit green energy from wind farms.

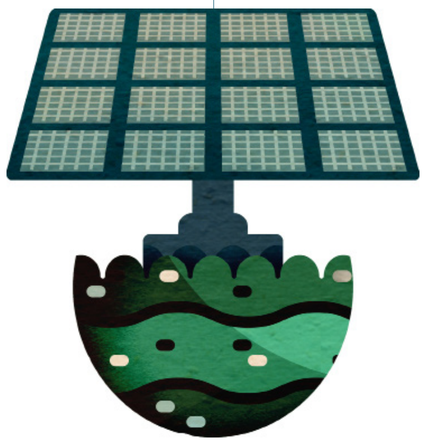
8.
Single usage of produced goods will no longer be tolerated. Paper documents will be replaced by digital files and cardboard for single use will be replaced by reusable packaging.

9.
There will be a change in our diets. A more plant-based diet will allow us to free up agricultural land for the production of biomass as a feedstock for our chemical industry.

10.
We will learn how to use our farmland much more effectively. In the Netherlands, grass will become an important source of protein for humans and animals.

11.
To make sure all of the above can become a reality, our economy and, notably, our tax regime, will need to change. The way in which we use products in our society and the lifespan of those products will form the basis for a differentiation of our tax rates. The incineration of fossil products will thus become too costly. It has become a lot more attractive to replace roof tiles with a roof made of 'solar tiles' which can be sustained for at least 25 years.

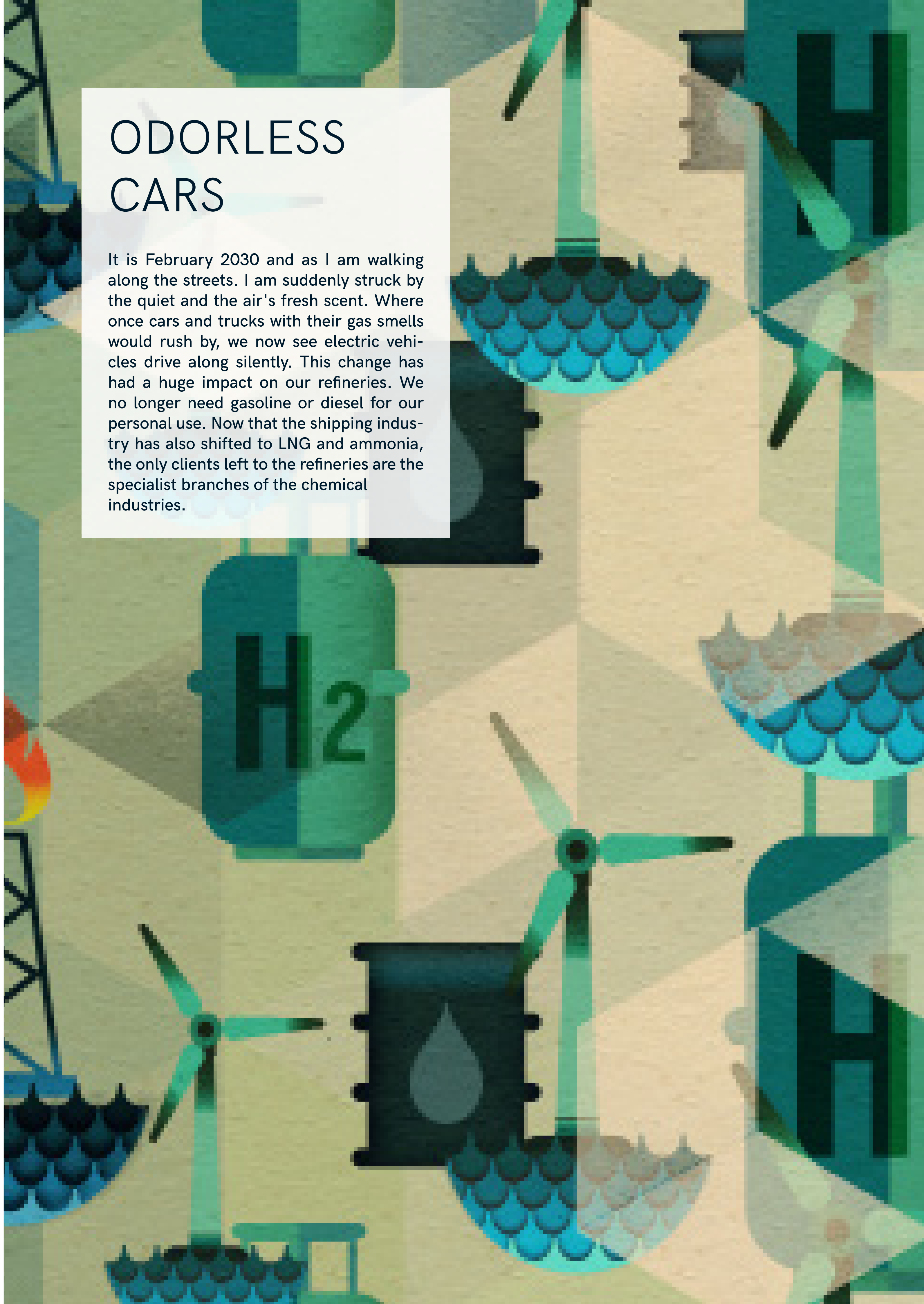
In many ways, what is central to this story is the idea that we will have huge wind farms in the North Sea. This corresponds to current visions off the future of our energy supplies. Large parts of our energy system will be electrified, meaning the demand for electricity will rise. Since other options will not suffice, it is self-evident that wind turbines at sea will be generating this electricity. The conventional generating of electricity with coal or natural gas will need to be phased out due to its high carbon dioxide emissions. These carbon dioxide emissions do not occur during electricity production in nuclear plants. However, there are societal concerns about the safety and high investment costs of nuclear energy. Solar panels do not raise these concerns, yet because there is no sunlight at night, and hardly any in winter, the panels will need to have higher storage capacities than wind turbines. The construction of wind turbines on land is often met with opposition because of possible visual disturbance. The option that remains is building wind turbines at sea, which will - in a joint effort with solar panels on land - generate the "weather electricity" discussed in our introduction.



Artistic impression of the transition for a climate-neutral energy-intensive society

3.

ELECTRIC CARS ARRIVING JUST IN TIME FOR THE REFINING INDUSTRY TO START THINKING



ODORLESS CARS

It is February 2030 and as I am walking along the streets. I am suddenly struck by the quiet and the air's fresh scent. Where once cars and trucks with their gas smells would rush by, we now see electric vehicles drive along silently. This change has had a huge impact on our refineries. We no longer need gasoline or diesel for our personal use. Now that the shipping industry has also shifted to LNG and ammonia, the only clients left to the refineries are the specialist branches of the chemical industries.

In March 2016 the Dutch House of Representatives adopted a motion stating that the Cabinet will strive to have companies sell only emission-free vehicles by 2025. The trend of driving electric cars is visible in other countries too. Norway seems to be aiming to limit the retail of cars run on gasoline and diesel by 2025 and the United Kingdom plans to phase out fueled vehicles from 2020 onwards. The German Bundestag will no longer permit the production of new gasoline- and diesel-fueled cars starting in 2030. Many countries have formulated target figures for the number of electric cars in 2020: Germany will have 1 million, Denmark will have 0.5 million and France will have 2 million. If, eventually, all of Western Europe electrifies its traffic, 46% of the revenues of Dutch refineries, will be lost.

Within Europe there are ambitions to reduce the pollution caused by the shipping industry by making ships run partly or solely on LNG. In the same way that each electric car has an effect on refineries, so does each LNG fueled ship. Petrochemical industries are exploring possibilities for substituting oil-based materials by bio-based materials. This too will greatly reduce the refineries' revenues, eventually. Additionally, home heating oil will no longer be used for heating buildings, as is still done in, for instance, Belgium. This home heating oil will be substituted with alternative resources or may no longer be needed at all once buildings are equipped with better insulation.

The chemical industry in Europe also hopes to substitute petroleum refinery products for the production of raw materials and energy. The substitutes being biomass and sustainable electricity. Out of these two, sustainable electricity has the most potential because it is climate-neutral; electricity can be generated from wind and solar energy without causing any CO_2 emission. Although the combustion of biomass is at present registered as carbon-neutral, this does not mean it is also climate-neutral. The combustion of biomass does, actually, involve carbon emission. This carbon emission can be compensated with replanting, but this takes a lot of time. Solid wood biomass takes 20 to 120 years to absorb the amount of carbon emitted during the tree felling process. We cannot wait that long if we want to reach our goal to limit the global temperature increase to 1.5 or 2 °C (34,7 or 35,6 °F). Moreover, the soil on which biomass is cultured is more valuable for other sectors, such as agriculture or ecological restoration and preservation.

Whatever the correlation between electricity and biomass, one thing is certain: the future does not look so bright for oil refineries, especially now that the global society has ratified the Paris Agreement. This brings us to the question of what role is left to play for big oil companies in the 21st century. What could a company like Shell do to assert its position as a relevant company and profitable partner in a world that wants to get rid of oil and gas? We are using Shell as an example here, because it is an important representative of the Dutch refinery sector.

WE WILL ANSWER THIS QUESTION KEEPING IN MIND TWO IMPORTANT TRENDS:

1.
Our society will electrify. Houses will have heat pumps instead of gas-fueled condensing boilers and electric cars will replace cars running on gasoline and diesel. Solar panels and wind turbines will replace gas- and coal-fired industrial plants.

2.
For sustainable energy generation, offshore wind farms are the most interesting option for the Netherlands. Sunshine is relatively rare in the Netherlands and it is difficult to find locations where inhabitants will not protest against the installation of wind turbines.

Based on the aforementioned trends, we could answer the question as follows: companies like Shell can uphold their position if they start developing upstream offshore wind farms which can provide us with cheaper electricity by 2020 than gas or coal could.

At the time this report was being written, Shell was already at a surprisingly low price level in their tender of plots 3 and 4 of the wind parks near Borssele (Zeeland, Netherlands). Electricity from these parks will be provided for at a little more than 5 euro cents per kWh, which equals €50 per MWh. The current price of electricity generated by coal and gas plants is around €30-€40 per MWh. Assuming that this price is going to rise by 25% or more in the next 15 years and that the price for CO_2 emissions will rise to at least €25 per ton in that time, then a rate of €40 per MWh would suffice to elbow coal and gas plants out of the market with wind energy generated on the North Sea. This holds even if the collection of CO_2 emitted by those plants is taken into consideration.

Both assumptions are therefore so likely to come true, it will become risky to keep investing in fossil-fueled plants. Investments could only be profitable if the business cases for these fossil fuel plants are based on the idea that they function as a backup for moments when wind and sun are scarce.

So why is this relevant now for an oil and gas company like Shell? Because the cash flow they now get from the oil and gas trade will only be able to help them in the near future to generate the tens of billions they need as investment funds to successfully survive the transition described above. There are no other enterprises of Dutch origin which possess enough knowledge and financial clout to realize a completely sustainable supply of energy and resources for our industrial sector. Shell can provide the expertise to manage these large, complex projects. Moreover, their enterprise is experienced when it comes to offshore industry, the use of hydrogen on an industrial scale and the supply of energy and resources for chemical complexes. You might say that the idea of the large-scale introduction of electric cars is arriving just in time to challenge the refining industry to do some fundamental thinking about its future.

VISION

Our energy-intensive industries, like other sectors of our society, will electrify and move towards a climate-neutral economy. Shell will transform into a leading party when it comes to cheap offshore wind energy, hydrogen and ammonia for use in industrial complexes.

STRATEGY

UPSTREAM

Between 2016 and 2020 offshore wind turbines will be built, designed to generate electricity for less than €50 per MWh.

Between 2020 and 2030 the price of offshore wind energy will drop below the price of energy from gas and coal-fueled plants.

The capacity of 'Dutch' offshore wind farms will grow up to 10 GW in 2025, 25 GW in 2030 and over 75 GW in 2050.

The company will be leading in the production of cheap offshore wind farms.

MIDSTREAM

The company will be leading in the provision of energy and resources for the chemical industry in which electricity, hydrogen and ammonia from offshore wind will be its main products.

The company will be a leading party in the development of backup electricity plants running on hydrogen and/or ammonia for the benefit of this industry.

Biomass and oil products delivered to the industry will be used as feedstock for the production of recyclables only.

Natural gas will be used as feedstock, and will first be transformed into hydrogen and CO_2. This CO_2 will be used as a feedstock, and will never be released into the environment.

From 2050 onwards biomass and fossil fuels will no longer be used as energy sources for energy-intensive companies.

DOWNSTREAM

Shell will transform its downstream business to develop fast energy supplies for electric passenger vehicles by placing fast-charging points along main roads and continuous recharging for electric trucks through electricity-wires above the right side of the road.

OR

Shell ends its downstream activities, such as marketing, distribution, and gas stations. This they would do because this business has little added value for Shell's mid- and upstream industrial activities.

The European automobile industry might take over Shell's downstream business, because this would provide them with locations for fast-chargers for their new generation of electric vehicles.

Artistic impression of the transition for the refining sector

4. AIRY CHEMISTRY

VALUABLE MOLECULES IN THE AIR

It is March 2030. I sit and wonder what those huge factories that used to be part of the industrial area of Port of Rotterdam were actually good for. As I am thinking about this, I realize that these factories were the source of almost all of the products we used and that an enormous amount of oil and gas was needed to keep them running. Luckily, we have managed to arrange things differently. We now mainly use electricity produced by wind farms to produce these same products. The most important change that has come about is perhaps the manner in which we treat our end products. We no longer throw things away after using them once. We try to reuse them as many times as possible, repair them if we can and if we can't, we recycle them. This way, we use a lot less resources.

Besides their purpose as fuel for vehicles and heating technology, oil and gas are now a days used as a feedstock in the chemical industry. Oil and gas are used in the chemical industry to produce a broad array of new products, ranging from plastic to paint and from lubricants to fertilizers. Fossil fuels are finite and polluting, which is why we are looking for alternatives.

The most obvious solution for the replacement of fossil fuels and raw materials is a bio-based economy: an economy in which biomass replaces all fossil based fuels and raw materials. But what if we do not have enough biomass for the replacement of fossil based fuels and raw materials, because we want to use the soil on which biomass is grown for agriculture or ecological projects as well? And what if the burning of this biomass causes carbon emissions? In this case, it would be wise to look for ways in which we could supply the chemical industry with fuels and raw materials that are alternatives to fossil products or biomass.

A POSSIBLE SOLUTION, INVOLVING A SYSTEM IN WHICH BIOMASS, NAPHTHA, NATURAL GAS AND ELECTRICITY EACH HAVE THEIR PART TO PLAY, FOLLOWS FROM FIVE IDEAS FOR A SUSTAINABLE CHEMICAL INDUSTRY THAT WE WOULD LIKE TO INTRODUCE HERE:

1.
Carbonaceous end products from a sustainable chemical industry cannot be incinerated.

Carbon atoms from oil, gas, coal or biomass used in a product are only released as CO_2 when the material is burned. End products therefore have to be recyclable and products have to serve their purpose in society for as long as they can.

2.
A sustainable chemical industry is based on the use of 'starter molecules' which require a minimum number of conversions to result in the desired end product.

Some end products are best created from oil or gas, for others it is better to use biomass. The number of conversions necessary to reach the end product determines to a large extent the choice for certain "starter molecules". Thus, energy use and perhaps even carbon dioxide emissions can be lower than they are in a unilateral choice for naphtha, natural gas or biomass as the feedstock. In case hydrogen from electrolysis suffices as a feedstock, no fossil fuels or biomass will be needed at all.

3.
A sustainable chemical industry does not use fossil fuels or biomass to provide heat for chemical processes.

High temperatures can be reached with electricity as an energy source. In some cases, electricity can directly be used and in other cases it is better to convert it to hydrogen first.

4.
The principal energy source for a sustainable chemical industry is electricity generated by offshore wind farms.

In the Netherlands, we can only generate enough sustainable energy for the chemical industry by creating offshore wind farms. Electricity from sun, water and geothermal energy will also make a contribution, but not to the same degree at which offshore wind will.

5.
In a sustainable chemical industry, electricity is converted into hydrogen or ammonia as a primary resource. Gas is only converted to hydrogen in those cases in which CO_2 is also needed as a source of carbon.

Essential feedstocks for the chemical industry can be produced with electricity as well as with gas. Both can be used to create hydrogen. The production of hydrogen from electricity does not cause any CO_2 emission. The production with gas does, yet this CO_2 can easily serve as raw material for certain chemical processes in which carbon atoms are required. Besides, hydrogen can be combined with nitrogen from the air to be converted into ammonia, a feedstock for many chemical products.

These five ideas open up a range of opportunities for the development of a completely new, sustainable chemical industry. The basis for this chemical industry is wind energy. Instead of using the words petro chemistry or bio-based chemistry, we could use the name "Airy Chemistry".

Carbon Capture and Storage (CCS) is a solution which can only be used temporarily and which does not fit into our vision for the chemical industry. It might be possible to collect CO_2 from the air. However, this is only a viable solution once we have realized the ideas mentioned above.

On the basis of these ideas the already modest role of waste incinerators in our energy system will become even smaller. The incineration of waste will need to be gradually replaced by recycling. The high-calorific share of the waste, most notably plastics, will not be available for incineration.

As said before, the Dutch chemical industry produces a broad range of end products. It is not in the interest of the envisioned strategy to find an alternative production process for all of these individual end products. Instead of finding these, we focus on several platform chemicals: the building blocks that most chemical end products rely on. We distinguish between organic chemistry, inorganic chemistry and fertilizers; fertilizers will be discussed in detail in our next chapter.

One of the essential building blocks in organic chemistry is ethene, also termed ethylene. This building block is used to create polyethylene, which we encounter in our everyday lives in the shape of sandwich bags. Ethene is now recovered from the process of cracking naphtha, one of the products from oil refining. However, ethene can also be produced with the CO and CO_2 released during the production of fertilizers and steel, by having these molecules react with water and electricity. The production of fertilizers and steel in combination with sustainable electricity can provide the chemical industry with one of its most essential resources.

An important building block from inorganic chemistry is chlorine. This chemical is mainly created in the process of converting gas into steam and electricity. With this electricity, chlorine is extracted from salt by means of electrolysis. Yet electrolysis may also be done with weather electricity, while the steam from the gas process could be replaced with steam created from hydrogen created with sustainable electricity.

A third example is the replacement of PET. Plastic bottles are often made of PET, a polyester made of terephtalic acid and ethylene glycol. PET is in the world's top 5 of most widely sold plastics. Bio-PET, a bio-based alternative, is the second largest biopolymer in European production. The bio-PET production chain begins by breaking down complex molecules into the most elementary building blocks in chemistry, after which PET is created from these building blocks following the exact same process as that of the fossil PET chain. Therefore, whether the production of bio-based PET is more energetically profitable than that of fossil-based PET is questionable.

There are, however, more efficient bio-based chains for the production of such materials for plastic bottles. One of them uses the material PEF. The bio-PEF production chain is much more streamlined than that of bio-PET and does more justice to the original molecule. The energetic efficiency of the use of biomass in the PEF-chain is also much higher; a maximum of 87% compared with a maximum of 62% for bio-PET.

All of these examples illustrate that important platform chemicals can also be made without oil and often also without gas.

VISION

A sustainable chemical industry is based on electricity, hydrogen and ammonia generated in offshore wind farms. Sustainable electricity will be its energy source. This electricity is used to extract hydrogen from water and chlorine from salt. Gas is also converted into hydrogen, but only to a certain extent, so that all emitted CO_2 can be used as a feedstock for chemical processes. For molecules which cannot be made from hydrogen or ammonia, a bio-based path is followed if this makes for a less energy-intensive chemical process than one in which petroleum is used as a resource. If this is not the case, a fossil-based path seems a more logical option. In processes in which gas, biomass or oil are the feedstocks, these materials can only be used in reusable products which will not end up in waste incinerators or be disposed in the environment.

STRATEGY

Pilot plants will be constructed for the production of basic chemicals. There will be rules for the applications of these basic chemicals, which will comply with the following five guidelines:

1.
Carbonaceous end products of a sustainable chemical industry cannot be incinerated.

2.
For the production of chemicals the choice of starter molecules will favor those which will require as few conversions as possible.

3.
Fossil fuels and biomass will be no longer be used to provide chemical processes with heat.

4.
Sustainable electricity, especially from offshore wind, is the principal energy source.

5.
Hydrogen and syngas, gained from sustainable electricity and, to a lesser extent, gas, will be the primary resources for our chemical industry. Only if these resources cannot be used can they be substituted with biomass or oil.

There will be discussions concerning any necessary amendments to the market model and the ETS-price to manage this production competitively in the EU.

The pilot plants will be scaled up as soon as we have managed to create an EU-wide market in which a non-EU producer pays import tariffs for CO^2emissions resulting from the production of basic chemicals.

Additional offshore wind energy will be contracted to meet the growing demand for sustainable electricity.

Artistic impression of the transition for the chemical industry

5. THE FERTILIZER-WENDE

GREEN GROWTH PROMOTERS

It is April 2030. To be honest, I didn't know much about fertilizers. Until someone told me we wouldn't be able to produce enough food to feed everybody on the planet without them. A lot of gas used to be required for the production of fertilizers. But then we realized we could make this process greener. We now often experience electricity surpluses. We use the surplus energy to produce fertilizers. Just like that fertilizers have become true green growth promoters.

Fertilizers are needed to provide the global population with food, but their production process is very energy-intensive. Additionally, a large amount of CO_2 is released during this process. This is due to the nitrogen atoms contained in fertilizers which suffer from a type of commitment fear.

Nitrogen is one of the most important building blocks for human life. Although the lion's share of the air surrounding us consists of nitrogen, we cannot absorb it directly. We need nature to bind nitrogen to other molecules for us. The molecules that are thus created can be absorbed by the human body. Nature, however, does not bind nitrogen enough for all people on the planet. That is why we give her a hand by binding nitrogen on an industrial scale. This bound nitrogen is blended into the soil in the shape of fertilizers.

In the production of fertilizers, ammonia plays a crucial role. The production of ammonia requires large quantities of nitrogen, hydrogen and energy. The Netherlands has a large fertilizer industry, which accounts for around 15% of all ammonia production in Europe. Because of its ample availability, it seems logical to use natural gas in the production process, as a source of hydrogen and as fuel. Unsurprisingly then, the Dutch fertilizer industry uses lots of gas, around 2.6 billion m3 in 2014, which is approximately equivalent to 7% of the total Dutch gas consumption. In terms of energy, in 2014 the fertilizer-gas consumption was equal to the energy requirements for the collective electricity use of all Dutch households.

The processing of gas to create ammonia causes considerable carbon dioxide emissions. About half of this carbon dioxide is reused as a resource in the fertilizer industry itself or sold to other industries. The other half, however, is released into the atmosphere. This half equals about 2.6 MT, which is approximately 1.5% of all CO_2 emissions in the Netherlands.

These excessive CO_2 emissions resulting from the use of natural gas poses risks to more than just our climate. It is also harmful to the fertilizer industry itself with respect to its competitive international position. Since the gas used for the fertilizer industry has to be high-calorific, at present a large share of it is imported. Since the number of available alternative gas suppliers is limited, gas prices may rise. Moreover, in the European trade system, regulations regarding fines for CO_2 emissions will probably tighten in the next few years. This may also damage the industry's competitive position.

An alternative production method for fertilizers arises from an earlier mentioned side effect of the production of weather electricity. To make sure our society can run exclusively on sustainable electricity, even at times when sun and wind are scarce, it will be necessary to have a larger capacity of wind turbines and solar panels than needed in favorable weather conditions. This will result in occasional energy surpluses. At those moments of surplus, the price of electricity will drop. In case we find a way to use this electricity, by for example making fertilizer production greener, electricity will become more expensive to compensate for the investments in weather electricity capacity. In the example scenario in this story for 2030 (see Appendix A) we are talking 100 PJ of surplus electricity divided over about 4000 hours per year. Once we have built more than 75 GW these 'surpluses' will amount to over 650 PJ.

These surpluses create a problem for TenneT, the company that controls the Dutch high voltage grid. TenneT is responsible for maintaining the right balance between supply and demand on this grid. In a worst case scenario, wind turbines and solar panels will need to be 'switched off' to avoid creating excess supplies. Of course we will do everything in our power to prevent high value electricity from being wasted, but 100 PJ's worth of surplus is not easily stored in batteries, electric cars or heat buffers. 100 PJ is more electricity than the current yearly consumption of all Dutch households.

The fertilizer industry might be able to help out. Instead of using natural gas, you can use water to create hydrogen. All you need is electricity. With the current technology, 100 PJ of electricity would be enough to create enough hydrogen for the entire Dutch fertilizer industry. This hydrogen can in turn be converted into ammonia. At times of electricity surplus, you can thus create a supply of ammonia. This will allow the fertilizer industry to continue producing despite fluctuations in electricity surplus. Moreover, the design of this solution creates opportunities to keep expanding weather electricity resources until the entire industry can be supplied with sustainable electricity.

A part of the CO_2 released in the current production process of ammonia is reused. To produce no more than just this CO_2, you can perpetuate a part of the current gas-based process. By setting this process in motion at times when little hydrogen is produced through electrolysis, the hydrogen supply for the ammonia process can more or less be stabilized.

So, two apparent problems - the use of natural gas in the fertilizer industry and the surplus of weather electricity - give rise to a great opportunity to create fertilizers sustainably using wind and sun as main resources. Moreover, this would create an opportunity for introducing a much larger share of wind and sun energy into the collective Dutch energy system.

In order to realize this plan, it is important to start small-scale change now. High voltage grid manager TenneT has to start taking measures in the next few years to better manage the consequences of the rise of electricity production from wind and sun. At the same time, the fertilizer industry will start practicing the creation of 'sustainable fertilizers'. Thus, the industry can anticipate the increase in gas prices and the rising emission fees, while at the same time contributing to a solution for our climate problem.

The production of ammonia from gas is most efficient when the production process is stable and ongoing. This seems to be incompatible with the unpredictable nature of weather electricity. However, 10% of the hydrogen needed for the ammonia production process can already be fed into the process flexibly. This enables producers to create hydrogen in electrolysis units which can be placed near the production installations already in place. So far it seems that specific technologies designed by Siemens are suitable for this purpose. To create 10% of the required hydrogen with electrolysis units, these need to have a collective capacity of 320 MW. If we assume that an electrolysis unit is active for 25% of the time - sometimes relying on electricity surpluses and sometimes relying on base load - then this would mean that at this capacity, 2.5% of all ammonia could be made from weather electricity on an annual basis.

For reference: TenneT is looking for 'only' 200 MW's worth of reversed emergency capacity for 2017, which is obviously less than the level of flexibility the fertilizer industry is already capable of providing now. An additional advantage is that we only have two fertilizer factories in the Netherlands, meaning TenneT does not need to spend much time making agreements. It is, however, important that the fertilizer industry does not carry all risks for the production of sustainable fertilizers itself. The Dutch government, TenneT and Siemens will have to make a contribution to this change.

TO MAKE THIS ALL POSSIBLE, LARGE QUANTITIES OF ENERGY WILL NEED TO BE TRANSPORTED. THERE ARE MANY WAYS IN WHICH TO DO THIS:

1.
Electricity needs to be delivered to fertilizer producers, who will use it to create hydrogen through electrolysis, which in turn will be converted into ammonia.

2.
Hydrogen needs to be produced at the locations at which wind reaches the shore. This hydrogen then needs to be delivered to fertilizer producers through pipes. The producers will then convert it into ammonia.

3.
Ammonia has to be produced at the locations at which wind reaches land and then transported to fertilizer producers through pipes.

4.
These fertilizer producers would relocate to places where wind reaches land and would there produce hydrogen through electrolysis to then create ammonia.

Which of these options is the best remains to be investigated further in 2017. For now it seems more logical to transport hydrogen through pipes than to move the electricity, the ammonia or the factories. This is because the largest share of our weather electricity will originate from the wind farms the Dutch are building in the North Sea. To transport the equivalent of 2.6 billion m3 of gas through the electricity net, extra high-voltage lines need to be installed. Because the fertilizer factories are now located in Sluiskil and Geleen (both in the South of the Netherlands), these new lines will have to be long. Hydrogen can, however, already be transported across great distances - part of the necessary infrastructure is already in place. This infrastructure can also be used to buffer a share of the hydrogen from weather electricity, so that fertilizer factories can start producing more continuously.

If the production of hydrogen from weather electricity turns out to be successful, a path can be designed in which the production keeps pace with the electricity surpluses. In case more electrolysis capacity is built progressively at the right locations from 2023 onwards, gas and CO_2 prices rise slightly and the costs of electrolysis drop just a little, all fertilizers in the Netherlands could be made from weather electricity at an internationally competitive price between 2030 and 2050.

VISION

Before the year 2050, all fertilizers in the Netherlands will be produced from weather electricity.

STRATEGY

The government, the fertilizer industry, TenneT, Shell (in its new role) or Air Liquide, GasUnie (in its role as transporter of the 'new' gas) and Siemens will collectively agree on how the risks of taking the first steps in the 'fertilizer transformation' from gas to electricity can be shared.

By 2023, 5% of fertilizers will be made from weather electricity through electrolysis; this will provide enough flexibility for our power grid.

From 2023 onwards, the implementation of electrolysis for fertilizers will be paced with the expected electricity surpluses.

The production of fertilizers will, to the extent possible, take place at locations at which there are electricity surpluses, unless it becomes apparent that it is cheaper or safer to transport electricity, hydrogen or ammonia to the locations now used for fertilizer production.

Natural gas will only be used for the production of fertilizers to obtain the necessary quantity of CO_2 for other chemical processes that require CO_2 as their feedstock and for which the extraction of CO_2 from the atmosphere is too expensive.

Between 2030 and 2050 more than 75% of all fertilizers produced in the Netherlands will be 'green fertilizers from weather electricity'.

Artistic impression of the transition for the fertilizer industry

6.

AUTONOMOUS CARS, WOODEN HOUSES AND OFFSHORE WIND FARMS

HAND OVER YOUR LICENSE

It is 11:30 AM, May 2030. I suddenly feel like paying my sister a visit. I communicate this desire to my watch. Hundred meters from my house, a self-driving car is driving away from the inductive charger it had been stationed at. Two minutes later, the electric vehicle announces itself through my smart watch. I leave the house and get in the car. It says hello and drives me to my sister's. My smart watch knows where she lives and has communicated the address to the car.

I realize how special it is that there are no more parked cars in this street. It is very comfortable not having to worry about finding a spot to park my car, or thinking about its maintenance. Traveling has become much cheaper and much safer. Because all these cars run on electricity, the air has become a lot cleaner. I no longer need a driver's license.

While the car is driving peacefully, I stare out the window and look at houses we pass. Their roofs are no longer covered with normal tiles, but with solar tiles. They are stronger and more attractive than traditional roof tiles. In summer my neighbors and I supply electricity with our solar tiles for not just our neighborhood, but also for our country's energy-intensive industries. In winter, I receive my energy from the gigantic wind farms in the North Sea.

New houses are only built out of wood, glass and plastics. Roof tiles, cement and reinforced concrete are considered outdated now. My wooden house has better insulation than older homes, meaning it uses less energy for heating and cooling. Thanks to the fantastic indoor climate, I can breathe more freely. My home has never been this comfortable.

Cars in the future will not only be electric, they will also be autonomous. Not just automobile companies such as Tesla are developing self-driving cars. Technology companies such as Google are also getting involved. The rise of Tesla and Google is so inevitable that German and French automobile industries felt compelled to also go full speed ahead in the development of electric and autonomous vehicles.

If cars become autonomous, it seems logical that they will also be shared. Autonomous cars are therefore not only more comfortable, but also a lot cheaper. For shared cars, travel costs per kilometer are around 75% lower than those of privately owned cars - much lower than those of almost any other type of motorized transport. Because of the high occupancy rate of self-driving cars, only 10% of all cars currently in use will still be needed in the future.

A direct consequence of this trend is that the German and French automobile industries will produce a lot less cars. In the Netherlands this industry is considerably smaller, but we do have large suppliers that make an important contribution to the European automobile industry. One of these suppliers, which will be heavily influenced by the transition to self-driving cars, is Tata Steel. Electric cars do not contain as much steel, because they do not have a combustion engine or transmission. Furthermore, the shared use of self-driving cars means we will need fewer vehicles. Besides, the production of new cars will probably require different materials, such as aluminum, carbon and plastics. These facts contribute to a decrease in demand for steel from the automobile industry.

While the automobile industry is shrinking, steel from cars currently in use will become available. These cars can be recycled, but their steel does not necessarily need to be used for the production of self-driving cars. A quantity of steel around 2.5 times the volume of the annual European steel production will become available. This will open up possibilities for an increased use of recycled steel as raw material. This will cause the energy-intensive production of steel from iron ore to decrease in volume.

Besides the automobile industry, the building sector is one of the steel industry's biggest customers. In the Netherlands around 90,000 new homes are constructed each year. The construction of these homes requires about 9,000 Ktons of concrete and 160 to 198 Ktons of reinforcement steel. The production processes of both cement and steel are energy-intensive. The use of recycled steel from unused cars can help us save energy.

In the building sector there is yet another, possibly more lucrative alternative to the use of steel: the use of wood. The incineration of wood is a relatively inefficient process, in which the CO_2 stored inside the trees is released into the atmosphere. Yet, instead of burning the wood, we could also use it to create objects or structures which will remain intact for years. In the application of wood in building, the safe storage of CO_2 absorbed by the wood can be guaranteed for up to 100 years. The tree and the house together form a simple construction of negative CO_2 emissions.

The biggest energy gain in the use of wood in construction, however, does not result from the long-term storage of CO_2, but from the avoidance of using cement and steel. In the same way that electric cars require no or barely any refineries for their functioning, the construction of wooden houses requires a lot less raw material from the cement- and steel industries. Innovative wood projects involving low- and high-rise buildings lead to further developments and applications for wood in the construction sector.

The forecast for the number of new homes constructed in the Netherlands is currently 90,000 per year. With the wood that we are allowed to co-fire in coal-fired plants, according to targets from our Energy Agreement (Energieakkoord), we could also construct over 60,000 wooden houses. The wood required for the construction of 30,000 more homes equals about 17% of the current Dutch forest area. This means the Netherlands will not be able to supply their own demand. The extra wood will therefore not only be obtained from the biomass industry, but will also be imported from sustainable European logging projects.

Supposing we built 90,000 new homes between 2020 and 2050, this would amount to a total of 2.7 million homes, meaning a maximum of 35% of the current housing stock can potentially be constructed from scratch and in an energy-neutral way if we use wood.

The transition to autonomous, electric cars combined with the transition to wooden houses will result in a loss of revenues of 16 to 24% for the steel industry. Will the steel industry shrink indefinitely? Probably not, while this revenue loss is arising a new industry with a huge demand for cement and steel is developing: the production of offshore wind turbines. The steel we would otherwise be using in the 90,000 new homes, combined with the steel obtained from surplus cars, would become available for the construction of wind turbines. This means we can create an offshore wind capacity of 1,000 MW each year. This would suit our Minister of Finance's intention to install 1,000 MW of offshore wind capacity at sea each year from 2023 onwards.

VISION

The steel industry will be confronted with a drop in sales to the automobile industry, a more wide-spread availability of recycled steel from non-self-driving cars and a drop in sales to the construction industry. Instead of selling steel for cars and homes, the steel industry would have to redirect their focus to the production of offshore wind turbines. Besides, energy-neutral wooden houses combined with a sustainable European logging policy will offer new opportunities to the wood industry and also create opportunities for CO_2 storage.

STRATEGY

New, energy-neutral homes are built out of wood, instead of cement, iron and steel. This wood will largely be imported from sustainable logging companies.

The building code will be amended to reduce the application of cement, iron and steel for the construction of new homes. New building plans will only be approved if houses are energy-neutral and constructed from wood and glass. This shift will need to be realized within 5 years.

The new capacity created in the construction industry will be used to produce cement and steel for offshore wind farms.

The production of secondary steel will be scaled up, whereby the recycling of cars and steel from demolished houses will become increasingly significant.

Artistic impression of the transition for the steel industry

7.

NO MORE PLASTIC BAGS OR SINGLE-USE CARDBOARD

RETURN TO SENDER

It is June 2030. I buy everything I need online these days. While that used to involve me carrying a load of cardboard packaging to the paper waste deposit at least once a week, we luckily have a more convenient system in place now. I can now hand over my packaging directly to the courier. If I choose not to open my package right away, or if I'm not at home at the time of delivery, I just hand it to them the next time they arrive with a delivery. The couriers make sure they always have enough packaging material in circulation and bring them back to the online stores. This packaging material is then reused several times. Only when they are really worn out, will they be recycled.

The number of online orders is growing each day. The vast majority of these orders is wrapped in cardboard. The customer does not need this cardboard and will probably throw it out right away. Luckily, the majority of this cardboard ends up in the paper bin, so it can be recycled and made into new cardboard. Paper and cardboard are bio-based, and are two of the most circular materials on earth. In the Netherlands, around 85% of all paper and cardboard is recycled.

However, a lot of energy is needed to recycle. This is why the paper and cardboard industry are working hard at making the necessary energy for their production process more sustainable by for instance using bio-gas and geothermal energy. In our transport industry, which is responsible for the collection of waste paper and cardboard, a lot of effort is being put into electrification and the replacement of fossil fuels with biofuels. These are, however, typical 'first-step-solutions'. We would like to find a solution that takes us several steps further.

The prime goal of cardboard packaging is the protection of its contents during transport. After a one-off-use, the packaging is trashed, collected and recycled. Would it not be better to create a kind of packaging that can be collected and reused without being recycled first? This would save a lot of energy otherwise used in the recycling process.

Worldwide, there are already different kinds of reusable packaging techniques for parcels. In Finland, Repack is producing strong plastic bags which consumers can order their goods to be shipped in against a small deposit. This deposit will be paid back if the consumer returns the packaging material. The packaging is then reused up to 20 times on average. Office Depot also offers its customers an option to have their orders delivered in a paper bag or a plastic crate. The courier then brings back the plastic crate for it to be reused. In the Netherlands, CB ships its products in cardboard boxes, which remain the company's property. Undamaged boxes can be folded and returned to the courier, so CB can reuse them.

Besides the fact that less material needs to be recycled, reusable packaging has several other major advantages over single-use packaging. The number of transport movements will decrease, because less waste needs to be collected, and consumers will not be left with large amounts of waste. There will, however, need to be a great shift in order to be able to reuse packaging on a large scale, because a system based on reusable packaging needs to be organized differently.

Whether consumers will be willing to make this change will depend greatly on how convenient it will be to collect and return reusable packaging. A brief shift of focus to a totally different sector of industry can serve as inspiration. In the food industry, there is the socalled Euro Pool System. In this system, plastic crates are used for the packaging of food, such as fruits and vegetables, and reused multiple times. In this system, a separate party collects the crates, cleans them and delivers them to food producers. Other than that, the Euro Pool System makes sure enough crates are circulated to meet sudden fluctuations in supply and demand.

In online orders, delivery services could take on this role. After all, they are already driving to big online stores to collect packages and to consumers to deliver the packages. On their way back, they can stop to pick up empty packaging from consumers and deliver them to the various online store distribution centers. The only thing couriers still need to do to shape their role as a spider in the web, is to create an extra connection with the producers of the packaging material. They will recycle reusable packaging into new products at the end of the package's lifespan.

The question remains: What should this packaging be made of? The two main candidates are plastic and cardboard. The great advantage of plastic is that it has a long life-span: Repack's plastic bags can be used around 20 times, and Office Depot's crates can be used hundreds of times. Plastic also offers good protection. Many of the cardboard boxes we use now cannot be used more than once, because they get damaged when they are opened and often cannot be closed properly afterwards. But cardboard, too, comes in different kinds (heavy duty boxes) and can be made water-repellent or fireproof with sustainable technologies. The resealing problem seems solvable when we take a look at moving boxes. These can be easily opened and closed and are therefore often reused. It is already possible to rent moving boxes and return them to the lessor. Reusable seals for regular cardboard boxes have also been developed.

The future of the paper and cardboard industry will be different from its past. The demand for bulk production will keep declining: we need less paper because of digitalization, we need less toilet paper if we start using shower-toilets. Cardboard production may still be on the rise now, but will slowly decrease after the arrival of reusable packaging. We estimate that bulk production could decrease by 50%. Yet we do not believe this will in any way harm the sector; the decrease in bulk production opens new pathways for more innovative products which allow for high margins and other business models.

Reusable packaging offers amazing opportunities for the paper and cardboard industry to market innovative products with great visibility. If cardboard producers can produce cardboard packaging with a long lifespan, their products can compete with plastic bags and crates. Cardboard is made from renewable sources and is naturally lighter, cheaper and easier to recycle. If the cardboard industry starts producing packaging that can be used five times, this would save them 80% of energy if the extent to which cardboard is used as packaging stays the same. If the sector manages to increase its market share, or to create boxes that can be used more than five times, this percentage could be even higher.

VISION

In the future, we will not consider throwing our packaging out after a single use to recycle them. The couriers will make sure used packaging is returned to be reused. They will also ensure there is always enough packaging material in circulation. They will be able to choose between cardboard and plastic packaging. The greatest challenge for the cardboard sector is to not lose their market position to reusable plastic packaging producers. If the industry does manage to develop robust reusable packaging, new opportunities will open up, especially since cardboard is by nature light, cheap and easy to recycle.

STRATEGY

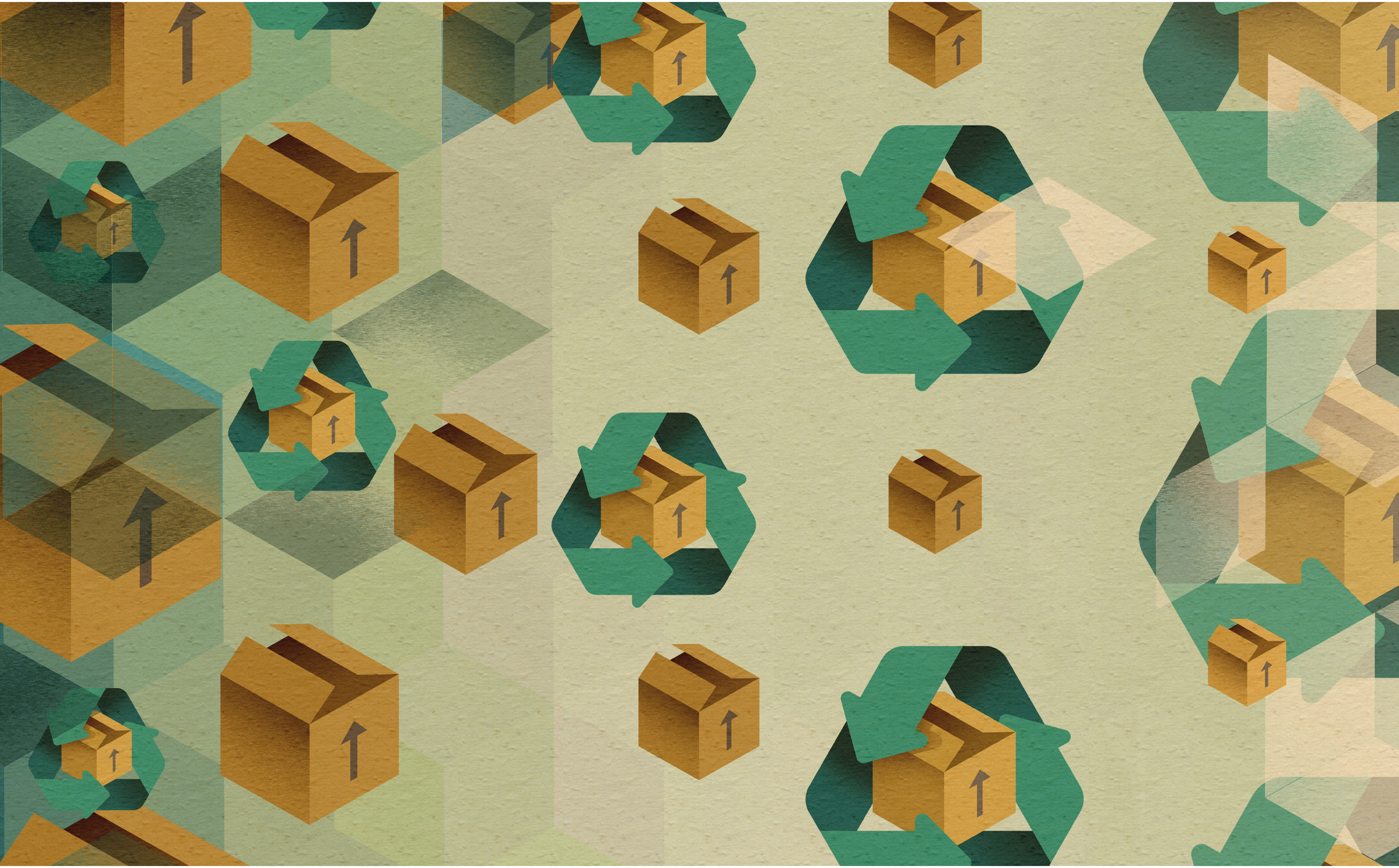
The cardboard industry will develop reusable cardboard packaging that meet the following three conditions:

1. They have a reusable seal.
2. They are easy to fold (so they can be returned).
3. They have a long lifespan.

Agreements will be made with couriers about the standard sizes for these reusable cardboard boxes.

Returned boxes are processed into new ones.

This strategy can start small; apparently CB already managed to achieve this with their own deliveries. The stronger the alliance between the couriers and the online shops, the easier it will be to implement reusable packaging, and the longer they can be used before they are recycled. A good yardstick for the success of this system is the number of times the average cardboard box is used. This number is now one, but with the above strategy it could rise rapidly.



Artistic impression of the transition for the paper and cardboard industry

8.

THE EXPLOSIVE GROWTH OF CLIMATE-NEUTRAL DATA CENTERS

CLOUDS CONNECTED

It is July 2030. Digital data, stored in the cloud, has grown into a significant part of our daily lives.

My watch also functions as an agenda and aa a mailbox. Thanks to the connection to my computer and my smart phone, it gives me reminders and email notifications. My watch also keeps track of my heartbeat and blood pressure. Luckily this application is not vital for me, but it alerts my father, who suffers from heart problems, in time to call the emergency services.

I can also regulate the indoor temperature with my watch. I can monitor the volume and the quality of the air non-stop.

My fridge knows exactly what it is refrigerating. At the end of the week it sends a grocery list to my smart phone. My food processor transforms all ingredients into a warm meal in the blink of an eye. The machine is always updated about Poppy Oliver's newest recipes. She has far outpaced her father as a TV chef now.

The self-driving electric car I use to get to work is also packed with data. At every moment in time, the car does not just recognize the road network, it also knows where all other cars are parked, where they are driving, their speed, and the status of all traffic lights. The car uses this data to calculate the fastest route.

The use of IT in our society is rapidly growing. In the past five years, data traffic, the processing of data and data storage have grown by 15 to 25% each year. We have reasons enough to assume that this growth will persist in the near future. The use of intelligent devices in our homes, self-driving cars, neural networks; all these factors will contribute to the anticipated growth.

The growth of data centers will probably also give rise to a growth in energy use. The extent of this growth will depend largely on the efficiency of these data centers. The devices involved in data traffic, data processing and data storage are being used more and more efficiently. The electricity use of data centers has therefore only been growing by around 3 to 4% per year. Besides, 83% of the current electricity use of the IT sector is sustainably generated, half of which is generated in the Netherlands.

A lot of this efficiency improvement can be traced back to innovation in the function of chips, all components of which are becoming increasingly smaller and more energy-efficient. The rise of virtual servers and the increase in occupancy rate of physical servers has also made a large contribution to higher efficiency. Furthermore, the shift from server spaces and internal local data centers to large-scale, co-located data centers has led to a decrease in the energy growth. Finally, the smarter cooling of data centers is an important factor.

In case the current growth speed remains the same, the IT sector in the Netherlands could have a capacity of over 150 times the current data traffic, data processing and data storage by 2050. Because energy-efficiency measures will have been fully exhausted at some point, energy use can slowly move back to the underlying growth of 15 to 25% per year.

LUCKILY, THERE ARE SEVERAL TRENDS WHICH LEAD US TO BELIEVE THAT THE RATE OF GROWTH WILL REMAIN AT 3 OR 4% PER YEAR:

1.
In 2013, it was estimated that a switch to data processing in clouds would lead to an energy reduction of up to 87% for business software in the US. We have sufficient reason to think that we in the Netherlands would have a similar savings potential. In the Netherlands, less than 15% of all servers are located in cloud data centers. This percentage could easily grow to 80%. Cloud computing can be elevated in the next decade.

2.
There is a visible shift from traditional, local data centers to centralized, 'hyperscale' data centers. Traditional data centers have a Power Usage Effectiveness (PUE) of 1.5 to 2.5. Hyperscale data centers such as Google's are now reaching a PUE of 1.12 on average. By shifting to hyperscale data centers and improving the efficiency of these data centers to a PUE of 1.1 or lower, we could end up saving a lot of energy in the next few years.

3.
Moore's Law, which states that the number of transistors in an integrated circuit doubles every two years, seems to hold. Especially the chips involved in data traffic, data processing and data storage are becoming much more efficient. Now that ASML as the only party in the world has succeeded in making EUV machines which allow chips to have more components, this route also seems to create opportunities for improving efficiency.

4.
The shift to new storage technologies such as SSD and efficiency improvements related to these technologies open up possibilities to save energy.

5.
Alternative forms of computing will possibly be not only faster, but also more energy-efficient. Quantum computing is one of them, although its first commercial application is only predicted for after 2030. Photonics - the use of light instead of electricity - will, according to expectations, be able to create faster and more energy-efficient data centers for some sub-sectors in the next few years.

The baseline of growth in electricity use in data centers in the Netherlands is estimated at 4% a year. Assuming that we can always keep improving efficiency to some extent, we expect the top line to be 10% a year. If the energy use in data centers in the Netherlands amounts to around 5 PJ per annum (as in 2015), it would probably rise to 10 to 20 PJ per year in 2030, and 20 to 140 PJ in 2050.

VISION

Data traffic and storage will grow significantly in the next few years, perhaps by a factor larger than 100. On the other hand, we will only need a fraction of the energy per data byte that we use now. Therefore, the growth of the total electricity consumption in the ICT sector will be under or around 4% per year. Through more wide-spread application of wind and sun energy in this sector, the quantity of primary energy needed can be reduced and the resulting CO_2 emissions can be brought down to 0 in 2030.

STRATEGY

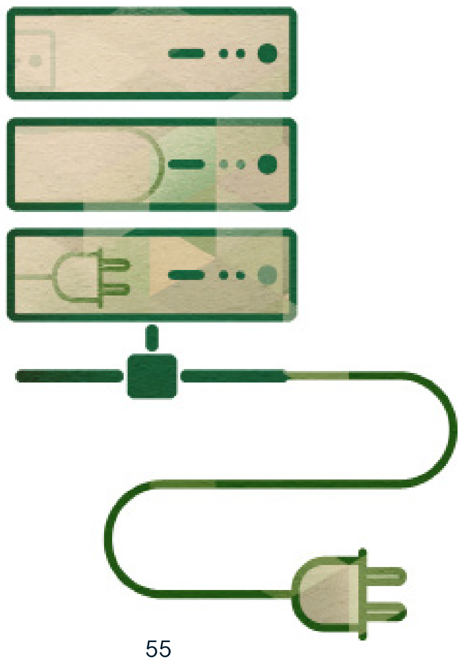
Maximum investment in cloud computing and efficient (hyperscale) data centers.

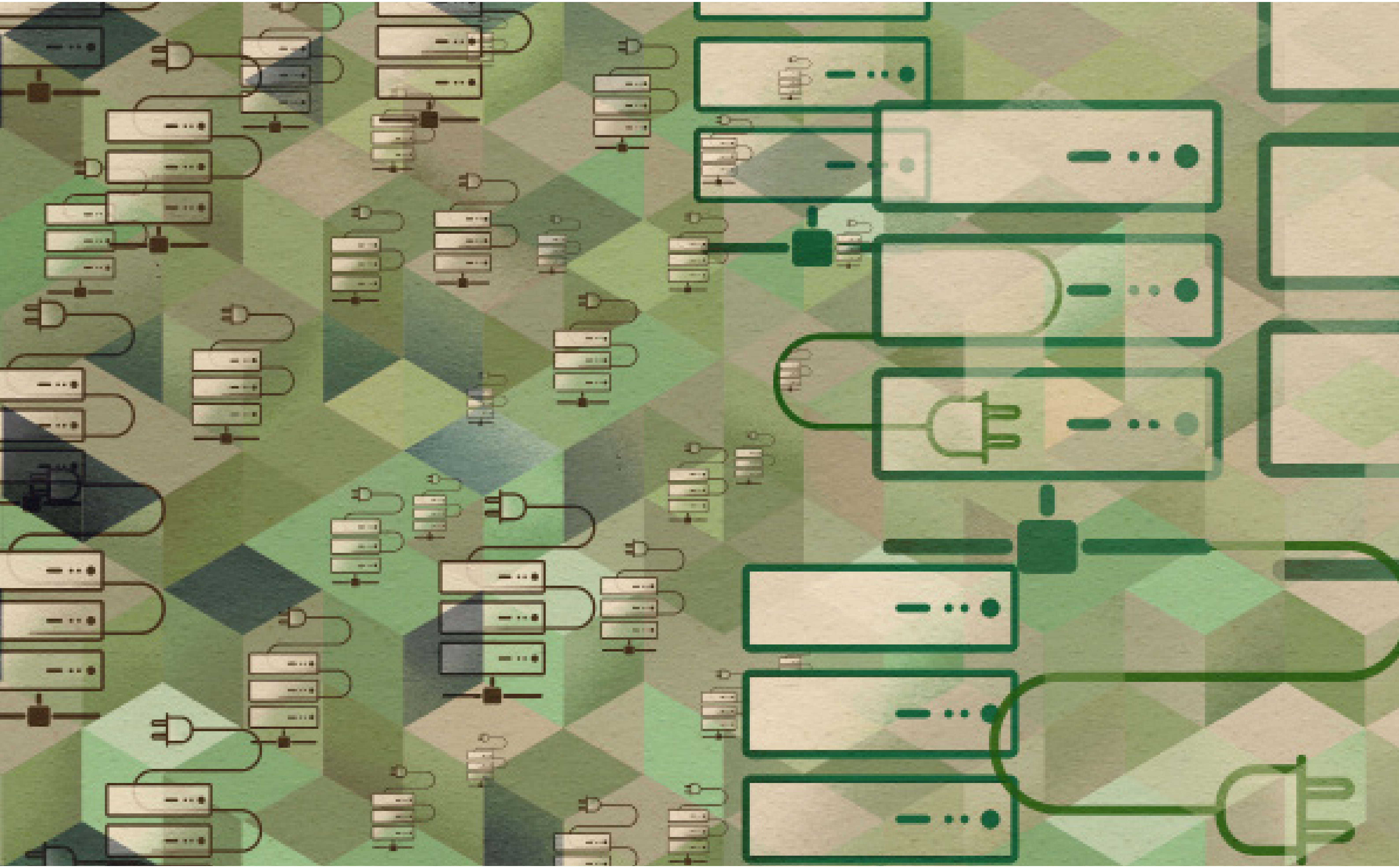
Maximum investment in serverless computing, in which servers are virtualized to the largest extent possible.

Highly energy-efficient chips will be used for data traffic, data processing and data storage, for example EUV-based chips.

'Power path optimization', 'Power loss minimization', temperature regulation and the efficient use of residual heat will be deployed to create data centers with a Power Usage Effectiveness of close to 1.

100% of all electricity purchased will be renewable. New data centers will contract electricity from soon-to-be-built wind and sun farms. Thus, they will stimulate the rise of renewable energy.





Artistic impression of the transition for data centers

9. VEGETABLE FOOD FOR THOUGHT

PLANT-BASED PEKING DUCK

It is August 2030. I call a friend to go out to dinner together. We decide to go to the 'Vegan Dragon', one of the many hip, all-vegan chains in our neighborhood.

We order Peking duck and wonton soup. The flavors are incredible! And the food is cooked from protein from North Sea algae only. For desert, we decide to get ice cream at my favorite ice cream place. They make the best soy ice in the Netherlands, from European soy. As my topping, I obviously pick cricket-brownie crumbles.

The range of vegetarian and vegan products on offer has grown enormously. On the shelves where we used to see only chicken and beef, we now see grass-meatballs.

Food waste has also gained a new value. We waste a lot less, and there is a special waste service which comes to collect my food scraps. My scraps are used to feed the insects used in livestock feed. Livestock feed for the meat that we now eat only during holidays, for tradition's sake.

Being a vegetarian is hip. Based on the number of search items in Google, there has been an almost exponential growth in people's interest in healthy, vegetarian and vegan diets. As a society, we are becoming more and more aware of the fact that meat and dairy production leave a massive environmental footprint. The health risks of red meat and too much protein are also becoming more widely known. The average Dutch person now eats 50% more animal protein than recommended for a healthy diet. Future food policies designed with these insights in mind will spur on the plant based food trend.

The popularity of vegetarian and vegan food has set in motion all sorts of changes in the food industry. The global market for meat alternatives is growing by around 6.8% a year. While the vegetarian food shelves are filling up, meat consumption keeps on shrinking in the Netherlands: from 80.4 kg per person per year in 2005 to 76.3 kg in 2014. Many companies and conglomerates have already chosen to invest in the vegetarian and vegan market. In July 2016, Danone decided to buy WhiteWaveFoods, one of the world's biggest soy milk producers. In the Netherlands, De Vegetarische Slager (the Vegetarian Butcher) makes plant-based 'meat' from lupins and soy, which tastes almost exactly like meat. The popularity of this initiative is huge; it has grown from one shop in 2010 to 2,600 sales points in 13 countries in 2015.

As the development and scale-up of meat substitutes expands, the number of flexitarians and vegetarians in the Netherlands will grow. If the Dutch population went flexitarian - meaning they would consume 35% less meat and more sustainable meat varieties than the average Dutch person – we could avoid the use of 64% of the current 29,000 km2 of agricultural land used for our food production. We would be using a mere 10,040 km2 for meat, dairy and meat substitute production. If everybody became a vegetarian, we would only use 16% of all current agricultural surface. Not only would we be using less land, our greenhouse gas emissions would decrease by 84% if everybody switched to a vegetarian diet.

THIS VISION FOR THE FUTURE CAN BE MADE A REALITY BY ADHERING TO THESE FOUR STEPS:

1.
A reduction of our current protein consumption to a healthy level.

2.
Switching to a flexitarian diet.

3.
A gradual transition to a more plant-based diet.

4.
The use of more efficient and innovative protein production for livestock feed and human protein consumption.

70% of all current meat substitutes are made from soya. Fortunately, we will be able to grow more of this soya in Europe in the future. Legumes, seeds and plant leafs can be used as alternative protein sources.

To create an even wider range of alternative protein sources, we can also turn to insects. They can convert food scraps into sustainable consumable proteins. Around 1900 types of insects are used for consumption worldwide. In Mexico, for example, fried grasshoppers are a popular snack. Innovation and development can help to make eating insects more attractive. Insect flour can be used to bake chocolate cakes and muesli bars, which could become the newest hype for athletes. Insects, soya-, grain- and lupin products will make for a large variety of meat substitutes on our supermarket shelves.

Insects are natural 'upcyclers' of organic waste. In the Netherlands, we waste 135 kilos of food per person per year - this amounts to 2 billion kilos. Most of these scraps, such as potato peels and leftovers, can be fed to insects.

From the 2 billion kilos of food we throw out on a yearly basis, we will make 15 tot 38 million kilos of protein in the future. As a byproduct, this would also give us mineral-rich insect manure for agricultural use. These 15 to 38 million kilos of protein can compensate for 10% of the total protein requirement of the Dutch population. For the production of 1 kilo of protein from mealworms, we will only need 10% of the current agricultural land needed for the production of 1 kilo of protein from beef. With the production of insects from food scraps, we can free up around 3000 km2 of agricultural land.

Insects can be consumed directly, but can also be fed to fish and chickens. In the transition from the current meat consumption to a flexitarian diet, insects can act as a resource for livestock feed. A chicken's natural diet, for example, consists of worms and insects. Protix, established in Brabant (Southern Dutch province), is producing a protein product for livestock feed using 'Black Soldier flies'. Protix is the first company in the world to develop agricultural technology involving insects, which is controllable, scalable and stable. Yet the lion's share of the current supply of livestock feed is still made from soy and fishmeal. Substituting these would offer environmental benefits related to a decrease land use, deforestation, overfishing and an increase in nature conservation.

A concern with the consumption of insects fed with food scraps is food safety. However, infection risks are rated as being low because of the taxonomic differences between insects and mammals. Human pathogens are therefore very different from insect pathogens. The production of insect meat will, just like the current meat production, have to comply with strict regulations to reduce the risks of bacterial infections, prions and viruses.

Besides insects, the bio-refining of different crops can also offer an alternative and innovative source of proteins. Bio-refinery can, for instance, be used for the refining of grass from plains, which can be used in protein products for cows, pigs, chickens and eventually humans. We will elaborate on this in the following chapter. Algae can also be refined. Algae proteins will be used in the future for the production of livestock feed, green chemicals and vegetarian products or dietary supplements. The large-scale production of bio-based raw materials from algae results in a large protein fraction (up to 40%). The costs for the production of protein from algae are now, however, a factor of 10 higher than those for the production of proteins from grass.

With every one of the 4 steps mentioned, we would be freeing up thousands of square kilometers of agricultural land. The agricultural land then available can be used directly for the production of protein-rich plants for vegetarian products. It can also be used for the growth of biomass, for ecological restoration and for forestation for wood supplies.

VISION

Food policies focusing on health and the environmental risks of food production will lead to an increased awareness in consumers and a healthier diet containing less meat and dairy. This will cause the number of flexitarians, vegetarians and vegans to increase.

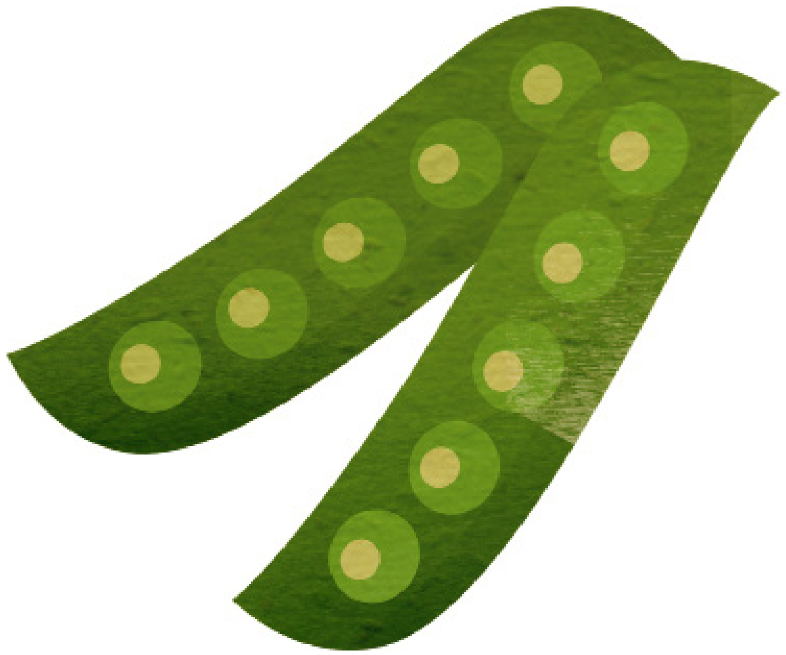
STRATEGY

The current meat and dairy industry will invest in plant-based protein products and alternative sources of protein.

Insect production with organic waste as insect feed, like Protix, will be scaled up. Insect production will first focus on the production of livestock feed and will later expand to protein production for human consumption.

Organic waste is converted into livestock feed by insects. This creates a kind of circularity in the food industry.

Newly available agricultural land will be used for the production of plant-based proteins, for bio-refinery, for raw materials for the biochemistry sector, for energy supplies and for woodlands for the construction of houses and ecological restoration.



Artistic impression of the transition for the food industry

10. THE TESLA FOR THE AGRICULTURE

HOMEGROWN BIO GRASS BURGERS

It is September 2030. I am walking out of the newly planted forest. I see a farmer who is just about to start refining his grass. Haying and ensilage have become outdated. Farmers can mow their land several times a year and use the grass to produce pressed fiber. This pressed fiber is perfectly suited to meet their cows' protein needs.

Several years ago, this farmer here joined forces with other local farmers to buy a mobile grass refining unit. They take turns using the machine. Their neighbor, a pig farmer, also profits. He can buy protein juice extracted from the grass by the machine. The pig farmer uses this juice to replace his soy-based compound feed.

Livestock farmers today only produce limited amounts of beef and milk. They are mostly concerned with the production of proteins which can be seen as "superfoods" for pigs, chickens and people. Thanks to the direct supply of grass proteins to people, the revenues of our grassland are much larger than they used to be. The bio grass burger is an absolute hit. Some people supply refining units with grass from their own lawns, to help with the production of bio burgers.

Because we grow many of our foods locally now, large shares of our agricultural lands have been restored to nature. I now live right next to a beautiful forest.

A large share of our current agricultural land consists of grass. The protein consistency of this grass is nutritious and healthy for cows, pigs, chickens and people. However, at present, grass can only be digested by ruminants, such as cows. Grass refinery can help us reach a higher efficiency in the protein chain and can make grass digestible for other mammals, such as pigs, chickens and people, too. This process is beneficial for agriculture and for the environment.

Grass refining is not a complicated process. It basically boils down to the crushing and pressing of grass. This process results in two fractions which can be consumed by different creatures. The first fraction is formed by the grass juice pressed from the grass. This juice contains proteins suitable for pigs, chickens and humans. The second fraction is formed by the remaining, partially pressed grass. This "pressed fiber" still contains all the nutrients cows need.

In our current farming system, cows eat about 42 kilos of grass a day. Cows use only 30 to 50% of the proteins in this grass. When cows have a diet consisting only of pressed fiber, they receive fewer useless proteins. This will increase the protein efficiency of milk from the current 22% when cows are fed with grass, to up to 35% if they are fed with pressed grass fiber.

The proteins that are indigestible for cows are fed to other types of animals. The protein yield from an area of grassland then rises by around 50 to 300% in comparison with the yield when grass is only fed to cows. The exact efficiency improvement will depend on the grass's protein content and on whether proteins are fed to pigs and chickens first or directly used for human consumption. For pigs and chickens, grass refining creates a local and balanced source of proteins, meaning we will no longer need to import soybean meal.
In other places on earth, this could open up agricultural surfaces for the production of more food for people, more green space, or lands for the production of biomass as a raw material for different industries.

The refining of grass also opens up a chance to use crops grown in the Netherlands directly for human consumption. This would be a sustainable way of meeting the protein need of the Dutch population.

Grass grown on wetlands is especially suitable for refining given its relatively high protein content. The Netherlands has about 1.2 million hectares of grassland. The grass is cut around four times every year. Some of the grass is directly eaten by cows, some of it is made into hay and the largest share is ensiled. Because the grass is left to try for one or two days before it is ensiled, there is a 15% loss of silage. These losses can be prevented by means of grass refining. All the grass which is usually ensilaged or dried to become hay can then be stored as pressed fiber for winter.

The refining technique for grass which is now being developed seems to be applicable to other types of plants as well. Corn leaves, sugar beet leaves and tomato leaves can also be excellent source of protein.

Because cows consume less protein when eating grass from grass refineries, and proteins consist partly of nitrogen molecules, the nitrogen content of manure will decrease. Grass refining can help extract some of the phosphate contained in the grass. Not only the phosphate content of cow dung will drop, manure from pigs and chickens will also contain less phosphate. Grass refining therefore creates opportunities to decrease the current phosphate and ammonia (which is built from nitrogen) surpluses in ground water. The residue that remains after proteins have been extracted from the grass juice can be used as fertilizer on the same fields and thereby partially compensate for the need for extra fertilizers. This, too, will make for less nitrogen and phosphate in the agricultural chain.

Grassa is already developing mobile grass refining units. These units can refine grass immediately after mowing and harvesting. Cutting and refining can then be done in all weather conditions, so farmers do not need to wait for dry weather. These new Grassa units become profitable when shared by around five farmers.

Grass refining makes it possible to abandon the use of large quantities of compound feed. It is an excellent decentralized technique, which will not demand the same excessive use of infrastructure and international logistics as the compound feed industry. If Grassa is the Tesla in the agricultural world, then the compound industry can be seen as its Ford or Volkswagen. The compound feed industry is huge, international and centralized and it has a huge environmental impact. Grassa, on the other hand, is small, local, decentralized and has a much smaller environmental footprint.

Initially it was not at all in the interest of Ford and Volkswagen to develop an alternative to a car with a combustion engine. That changed when the small initiative called Tesla affirmed that fast, smart, emission-free cars are the future. Since compound feed producers also have no reason to stimulate the development of grass refining, funding for this transition will - as was the case for Tesla too - have to come from elsewhere.

The compound feed industry could shrink rapidly as a consequence of the growth of companies like Grassa. The juice from grass refining not only substitutes protein products but can also substitute sugars. If we substitute some of the content of our livestock feed, the amount needed in cattle farms will decrease. If compound feed for pigs is substituted by grass juice, about 20% of the energy needed for the production of livestock feed can be saved. With the use of grass refining, 60 to 100% of Dutch agricultural land could produce enough protein juice to substitute the current 5.1 billion kilos of livestock feed for pigs. That is around 37% of all livestock feed in the Netherlands - the rest is fed to poultry and cows.

VISION

DThe protein production of grassland will increase by 0 to 300%. The protein yield will increase, because grass proteins will become available for cows, pigs, chickens and people. This might cause surpluses of fertilizers, nitrogen and phosphate originating from Dutch agriculture to disappear. Large shares of the import of soybean meal and the Dutch production of compound feed will become redundant. In other places in the world, hundreds of thousands of hectares of agricultural land will become available to be used for example for the growth of biomass as an industrial resource. The demand for fertilizers will decrease once the cycle is closed. Companies owning grassland will become local suppliers to livestock farmers and to the food industry producing meat substitutes for human consumption. The centralized compound feed industry will shrink.

STRATEGY

Funders from outside the compound feed industry will be recruited.

An unmanned commercial mobile grass refining unit will be developed, which will have a processing capacity of 5 tons an hour, by analogy with the current unit with a capacity of 0.5 tons an hour.

The sales and the lease of these 5-ton units will be scaled up massively.

A commercial mobile unit with hovercraft technology will be developed, which will have a capacity of at least 10 tons an hour. This unit can perform all movements on grass by itself. The farmer only needs to collect the protein from grass juice and pressed fiber. The rest of the grass juice will be used as fertilizers.

Within the next 15 years, this technique will be used for at least 50% of grassland and gradually also for other crops, such as corn and sugar beet leaves.

This technique will be used for human protein consumption sometime within the next 5 years. The total protein yield of our grassland will thus increase by 300%.

As a direct result of the implementation of the Grassa technique, soybean meal import will be substituted and manure and phosphate surpluses will be solved.

If the technique is successful in the Netherlands, it will become available for the world to use.

Artistic impression of the transition for grass related agriculture

11.

TAXES: NO PICNIC, BUT WE CAN BRING SOMETHING SUSTAINABLE TO THE TABLE

SHARING IS CARING

It is the last day of the year, the 31st of December 2030. In the past ten years, we as a society have been struggling with our tax system. Luckily, we have figured things out now.

In the old system, whenever I earned a lot, I had to pay more than half of it back to the state in the form of income taxes. I also had to pay over 20% VAT over every product I bought and every service I used. For the energy I consumed, I used to pay energy taxes. Companies which caused high CO_2 emissions also had to pay a carbon tax. All of these things are history now.

None of these tax measures actually helped to sufficiently reduce our environmental footprint. Around 2020, somebody undertook a brave venture to imply an extra CO_2 tax and raise the price of CO_2, but this did not have the desired effect. There was always the risk that Europe's industry would be disadvantaged in comparison to other industries. Between 2015 and 2023, energy taxes for natural gas were raised and those for electricity were lowered. This only influenced the direct energy use of consumers, not the energy consumption of our industries.

Nowadays products that are shared, such as self-driving cars, or products with a long lifespan, such as wooden beams in an energy-neutral house, fall into the lowest tax category. The new tax system has helped enormously to make sustainable products more affordable than products that pollute.

Many ideas from previous chapters are - from a technical and a societal perspective - superior to their older equivalents. They have a much smaller impact on the climate and our environment. And yet these ideas are not being implemented on a large scale anywhere in the world. The simple explanation for that is that all of these ideas are economically less attractive than the current options. Currently "gray" routes are cheaper than "green" routes, because external costs on environmental impact, such as the use of resources and energy and CO_2 emissions, are not - or not sufficiently - considered in the costs of a production chain.

The key to change lies within our tax system. Taxes are not just an instrument for the government to arrange the social and public facilities needed. They are also indispensable as a means of directing production chains towards more sustainable consumption and production of goods and services.

The Dutch government is free to switch between different forms of tax systems, or to invent new ones. It is important, however, that the total sum of all taxes paid suffices to perform the tasks the government is responsible for. Another important condition is that the free traffic of persons, goods, services and capital within the EU remains intact. This means that radical changes to our tax system will have to be adjusted to fit those of other European states, perhaps even all states worldwide, to prevent the outsourcing of the production of goods and services to states or regions with more lenient tax systems.

We will attempt to theoretically explore a changing tax system. As follows from what has been said before, the system needs to change if we want to make use of technical and societal opportunities to create a climate-neutral society.

We hebben in dit hele verhaal aangenomen dat de samenIn this story we have assumed that our society wants to keep enjoying the comforts that we now have - things like ordering online or having the freedom to travel. We therefore assume that people want to live in at least the current level of comfort. We have also assumed that the Netherlands will remain an integral part of Europe. And last but not least we have assumed that the majority of the population will act out of a financial incentive. Whenever people choose to use more sustainable products, this is often for health reasons, rather than environmental ones.

We thus arrive at the conclusion that taxes on the use of goods and services have to rise and taxes on labor should drop - the importance and the use of taxes on labor, however, need to remain intact for the sake of income distribution. This shift gives consumers a chance to have a larger impact with the small choices they make while shopping. People's net income will rise, but they will sometimes pay more for individual purchases. The lifespan of products and materials in our society needs to be lengthened. Having your clothes repaired by a tailor will be cheaper than purchasing a new coat.

The consumer's choice will be stimulated by a price incentive, which will arise thanks to a differentiation between similar products and services. A price incentive which will make sustainable products cheaper than their unsustainable alternatives. This differentiation can be introduced with different systems:

SHORT LIFESPAN TAX

The introduction of a short lifespan tax, whereby the extent of the tax will depend on the average lifespan of a product. Single-use products, such as non-reusable cardboard or plastic packaging, will be categorized as 'high-tax'. The same goes for all fuels. Solar panels that last 30 years or wooden beams in homes that last 100 years will be in the low-tax category. If a product needs to be transported on a ship using fuel bunkered in Europe, that product will be more expensive than the same product produced by a local supplier who ships it in an electric vehicle running on solar energy. Food, water and sustainable energy are exempted from short lifespan tax. Besides the short lifespan tax there will be an environmental surcharge if a certain percentage of a product is traceable in the environment during or after use. This would apply to plastic which ends up in rivers and seas and the CO_2 released during its incineration.

A LADDER SYSTEM IN A CIRCULAR ECONOMY

In a circular economy, waste is used as a resource, renewable resources are used, the 'designed-to-last-principle' is applied as often as possible, products and materials are reused, services are sold instead of products and simple, energy-efficient end-of-life options are applied to products or product parts. For products produced from finite sources, we create a ladder which connects the ideas for a circular economy:

Share
Maintain/Prolong
Reuse/Redistribute
Refurbish/Remanufacture
Recycle

The higher up the ladder, the higher the value of the product and the less tax will be paid for the products.

A VAT-SUPER CATEGORY

50% VAT on unsustainable products and services, for instance. A disadvantage of this is that it is based on a fraction of a price, which, for products such as plastic bags, is too low..

EMISSION TAX

There are more types of emissions than just CO_2 emissions. Think of particulate matter or micro plastics that end up in the environment. Emission taxes would target all forms of emissions that harm our ecosystem..

These alternative tax systems have to be investigated more closely, advocated and implemented not just at a national, but at European level. We need systems that combine sustainable production, sustainable use and sustainable consumption. If we manage to reduce our volumes of waste and unwanted byproducts, to save energy and to lengthen the lifespan of products and resources, we could improve the contributions products make to our society and reduce the harm done to our planet.

Artistic impression of the transition for the tax system

12. SUSTAINABLE HAPPINESS

This story began with the chapter 'A sense of unease'. In this chapter we said that there is little doubt that our climate is changing and we largely agree that time is short. We have only a few decades to change our society, before the consequences of climate change will undermine our possibilities for survival on earth. We also said that we are lacking good visions for the future of our industry in a climate-neutral society.

Has our sense of unease disappeared after reading this story? Perhaps not completely, but we are getting a clearer picture of how our energy-intensive industries can become climate-neutral. And this picture sketches an outline for how our society and other societies can become climate-neutral. If we can imagine such a future, there is a fair chance that we can make it a reality. We will then get more confidence to believe that we can live a happy life not just now, but also in the future.

If we want to be happy and stay happy, there are some things we need to consider. We need a pleasant and not overly extreme climate, otherwise living changes to survival. Safety is extremely important. A climate-neutral industry will help us to reduce the rise of global sea levels, which poses a risk to a country that cannot survive without dikes. If there is an increased risk of dike breaches, we can no longer feel safe. The different chapters which each treat a different sector of industry, and Appendix A in particular, show how our ideas in this story make a contribution to creating a climate-neutral industrial sector which guarantees the safety of our society.

It is important for us to feel free, too. Scarcity of energy and resources could discourage traveling. Shortages also cause international tension, which can lead to a limitation of all sorts of freedoms. Appendix A shows how we can reduce the use of fossil fuels and energy use. In each of our separate chapters there are numerous examples of how we can make better use of scarce resources.

Health is also a vital factor. A climate-neutral industry which does not harm the environment, which restores ecology and supplies us with healthy food will help us stay fit. The chapters on nutrition, agriculture and taxes illustrate this. In Appendix A, we have also outlined how much agricultural land we would no longer need if we were to make all the ideas in this story a reality.

Only happy people can afford to think about a new climate-neutral future in which everyone can be happy. Unhappy people are anxious, frustrated and mostly concerned about themselves. A climate-neutral international industry will be an important factor in connecting people, offering future perspectives and fighting populism that feeds on unhappy, angry individuals, who are scared of each other and all forms of change, including climate change.

On average, we enjoy a high level of well-being in the Netherlands. Our country still has the mental, economic and political space to create this climate-neutral future. However difficult it may be. Because we do not underestimate the complexity and scale of the "refurbishing" of our society.

This story has been written because apart from energy-neutral houses, emission-free cars and sustainable food production, we also urgently need a climate-neutral industry. A climate-neutral industry is an essential ingredient for a world in which people feel comfortable.

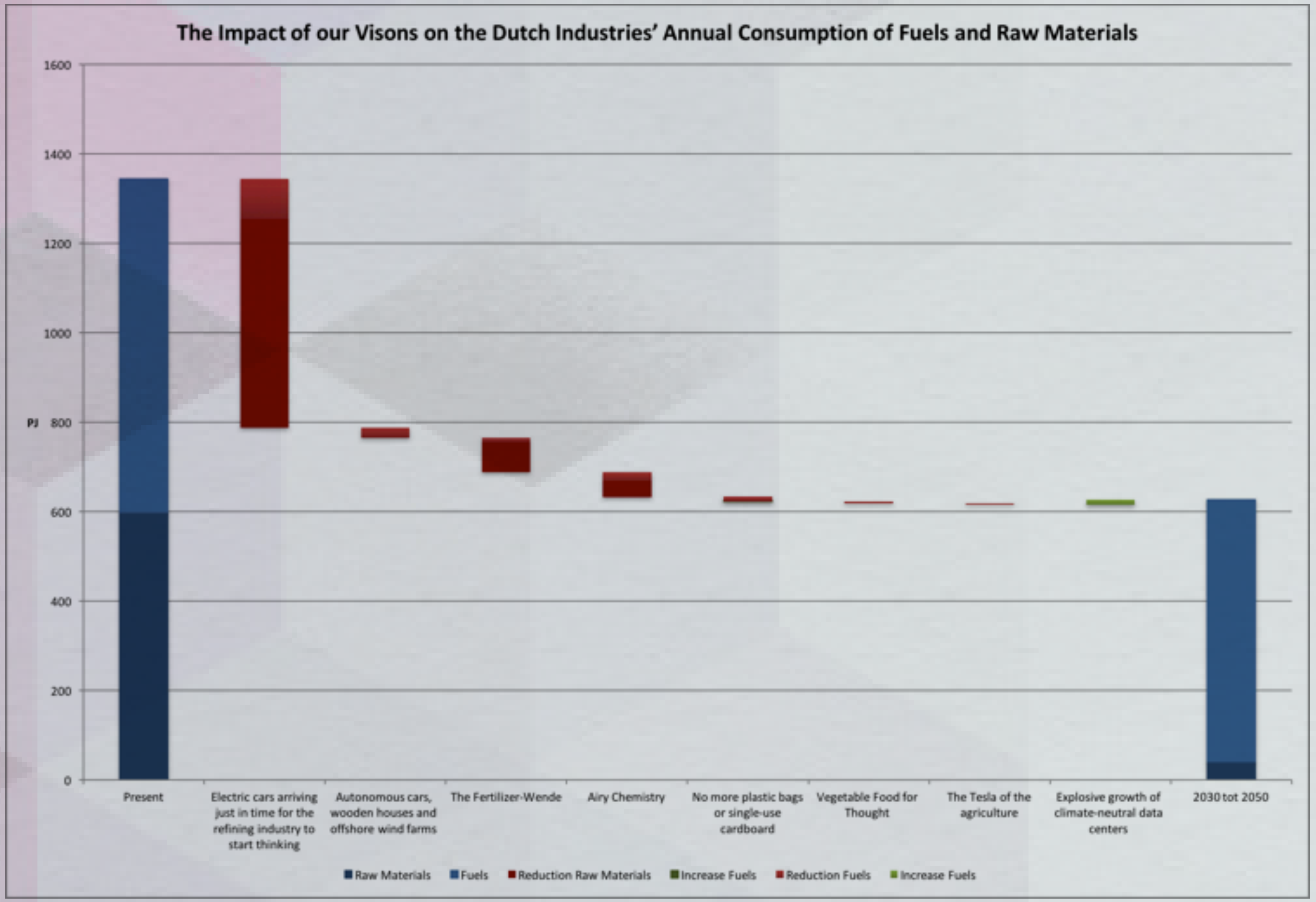
APPENDIX A: THE IMPACT OF THE TRENDS ON THE USE OF FUEL AND RAW MATERIALS, CARBON EMISSIONS AND LAND USE

The impact of our visions in this story

The visions in this story have an enormous impact on the industries of the future, but also offer a lot of opportunity make them more climate neutral. In the report An Industry in Transition dating from June 2016, we called these visions "climate opportunities". We have estimated how big an impact these will have on the parameters used to measure climate-neutrality, such as the use of fossil fuels and resources, biomass, CO_2 emissions and land use. In this appendix, you will find the most significant outcomes of these calculations, adjusted to the new insights we have gained after writing this story.

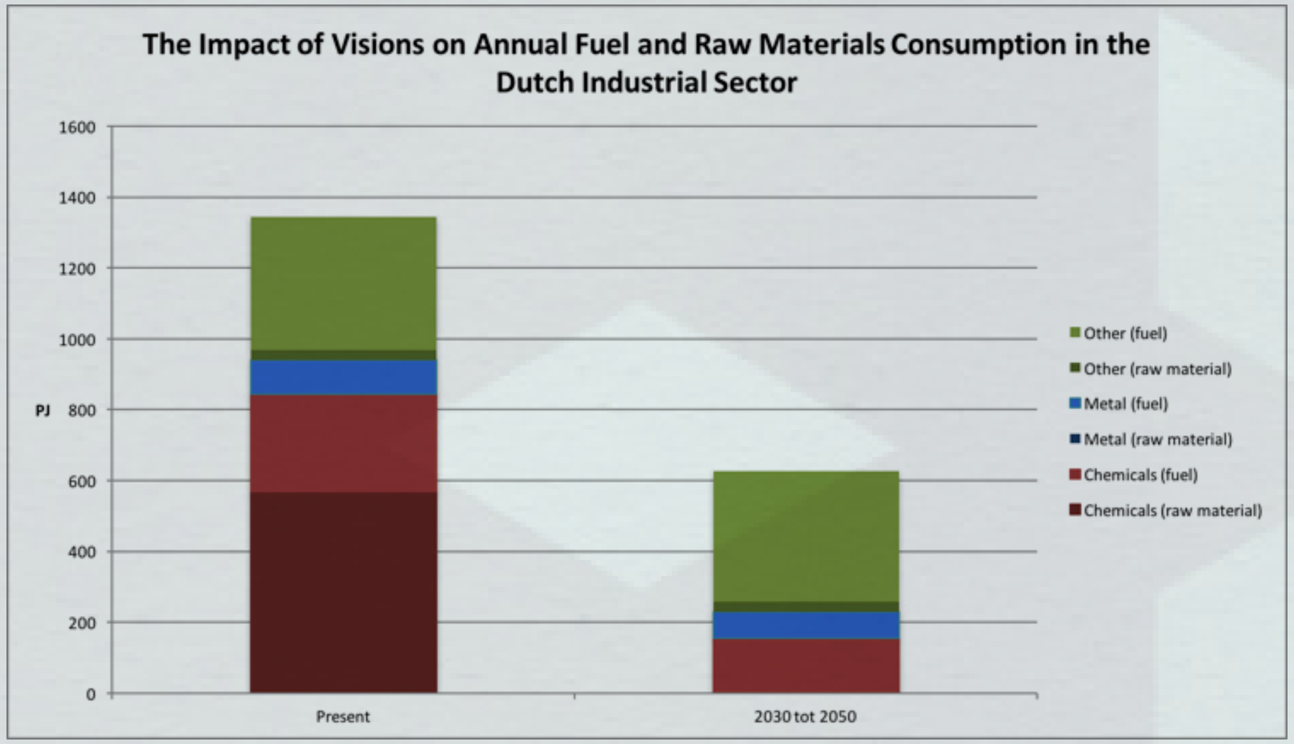
In the first graph you can see the impact on our yearly consumption of fuels and raw materials. We take into account the use of fossil fuels and raw materials as well as the use of biomass. For the sake of clarity, we have assumed that the use of fuels and raw materials in all industries not described in this report, just like other sectors in our society, will not change. This gives us a clear view of what the changes in the industries described might look like, given that other factors stay the same. In our scenarios for the Netherlands and Europe as a whole, we do, however, show that enormous changes will also take place in other sectors of our society as a result of our battle for climate-neutrality. The use of electric cars will not only reduce the fuel and resource consumption of refineries, it will also help us reduce CO_2 emissions, which largely originate from transport. This first effect on refineries will be taken into account in the graphs below, but the second large effect (diminishing CO_2 emissions) is left out of the equation.

What is striking in this story is that the biggest change in our industry will be a result of the transition to electrically powered transport and the impact this will have on refineries and the electrification of the chemical industry and the fertilizer industry

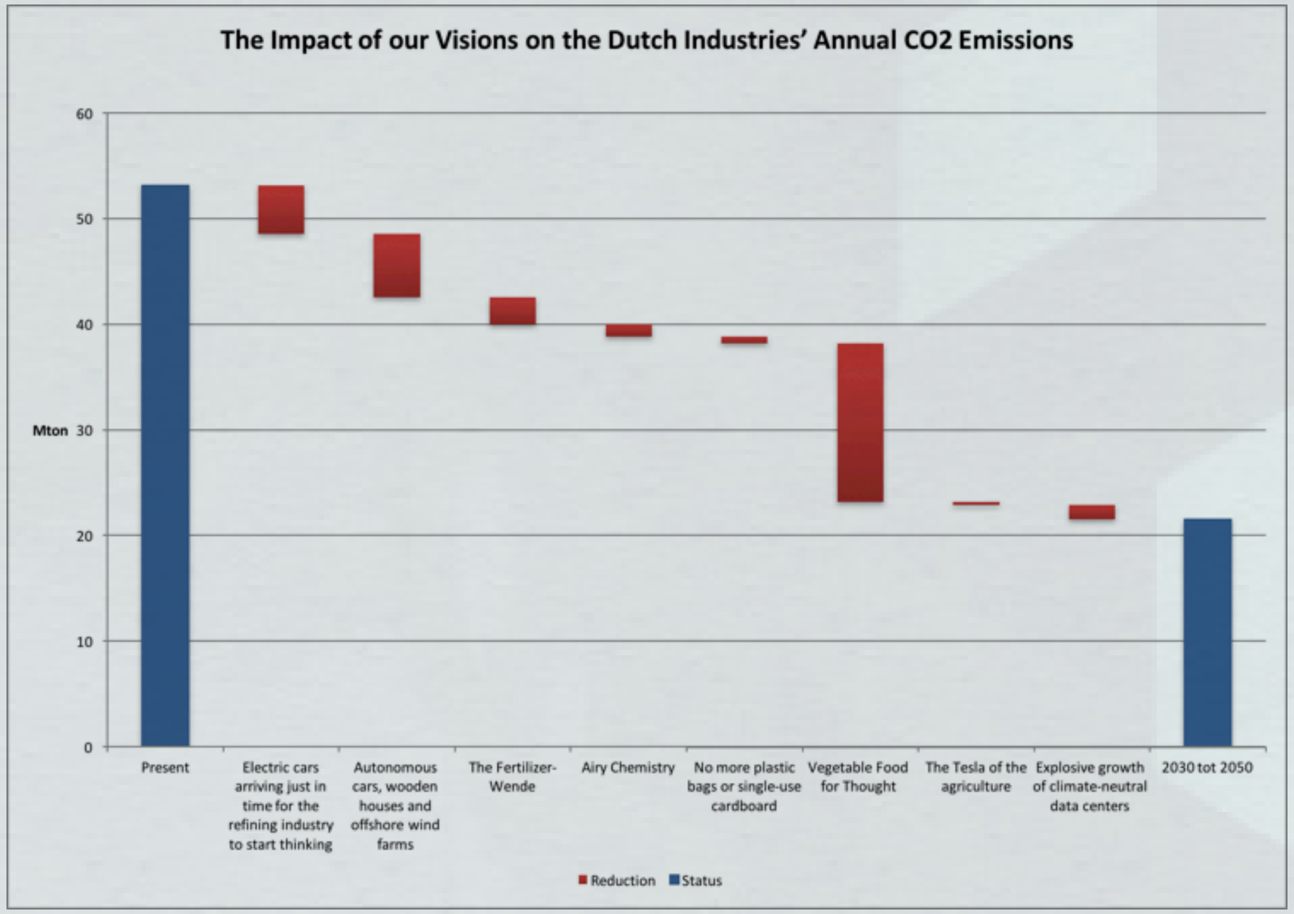


The second graph shows the use of fuel and raw materials per sector. The overall impact of all visions is huge. As result of these visions, the consumption of fuel and resources of our industry may reduce from 1350 PJ to around 650 PJ per annum. Not completely coincidentally, this equals the 650 PJ's worth of 'surplus energy' (see our chapter on fertilizers).

Our society's total demand for fuel and resources would, in this scenario, drop from 2750 PJ in 2013 to 1450 PJ, mostly as a result of the visions described in this report and the enormous efficiency gain all these sectors will experience thanks to processes of electrification. The suggested 75 GW of off-shore wind capacity (see our story about refining) would help provide 1000 PJ of the demanded 1450 PJ. Sun and geothermal energy make up an important share of the remains.

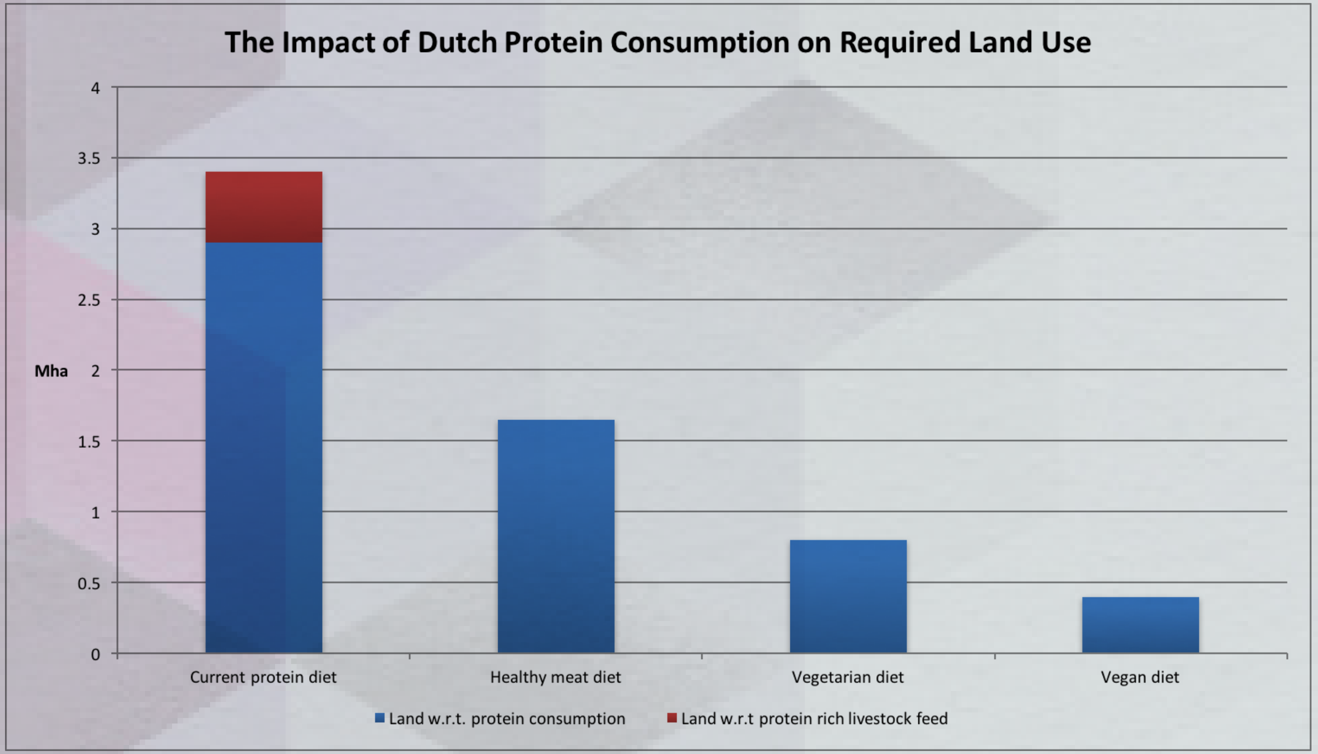


For clarification: one PJ (petajoule) equals the electricity consumption of over 80,000 Dutch households (with an average of 2.3 people per household). At present, these households each use around 3500 kWh a year. A reduction of 700 PJ a year in our energy-intensive industry's consumption thus equals an almost unimaginable reduction in the electricity consumption of around 130 million people, supposing these people use the same amount of electricity at home on a yearly basis as the Dutch do now.



The visions for the refinery sector and the chemical industry also have an impact on CO_2 emissions, but this impact could be much larger if we changed our diets. This is illustrated in the following graph. The total impact of all visions leads to a reduction of carbon dioxide emissions in our industry by over 50% from 53 MT to 22 MT. In 2015, the Dutch industrial sector was responsible for one third of our CO_2 emissions. Bare in mind that these emissions are not a result of agricultural activities in the Netherlands, but of choice of diet of Dutch citizens.

An additional advantage of changing diets is that we will need less land for agriculture. This can be seen in the following graph. At present, 1.85 Mha of Dutch land is used for agriculture. We could free up the equivalent of than 1.5 times the size of our current Dutch agricultural land, elsewhere on the planet, by changing our diets. Land that we need for nature, the growing world population, the rising demand for biomass for our industries and the consumers who want to eat organic foods (the yield per ha inorganic agriculture is still lower than that in non-organic agriculture).



APPENDIX B: RECOMMENDATIONS TO THE OPERATORS OF ELECTRICITY, GAS AND HEAT GRIDS

The trends described in this story all impact our electricity, gas and heat grids, which make up our energy infrastructure. In the case of an almost complete electrification, the electricity grid will have to expand to align the increased (flexible) electricity supply with the demand. Our energy system will need to evolve into a more integrated system in which the central energy carrier, electricity, is connected with hydrogen, heat, storage and other flexibility sources and energy carriers. Our market model will therefore have to change so that offering flexibility (based on different days and seasons) will be central to maintaining the current level of dependability and security of supply. In the case of large surpluses of weather electricity, the availability and financial cost of adequate energy infrastructure will determine if and how surpluses can be used: ranging from large-scale curtailment - in case the capacity is insufficient - to the creation of opportunities for our energy-intensive industries to improve their sustainability while making smart decisions that enhance capacity, flexibility of use and conversion to other energy carriers. It is important to note that hybrid systems could help avoid expensive energy conversion trajectories and could also limit expansions of electricity distribution and transmission grids. All this means that the design of our energy infrastructure has to be taken into account in further elaborations on the different strategies to be used for our industries.

This appendix functions as a starting point for discussions that grid controllers need to have regarding the impact of these visions on the energy infrastructure in our industry (and adjacent sectors of society). We hereby invite the reader to add to our recommendations and fine-tune them.

TABLE 1: CONSEQUENCES FOR ELECTRICITY, GAS AND HEAT GRIDS.

CHAPTER	Highlights relevant to grids	Possible impact on these grids
2	Almost complete electrification of society	**High-voltage grid:** Expansion of grids in the North Sea and expansion of grids to our energy-intensive industries. **Electricity distribution grids:** Expansion required. Gas distribution grids: Will only remain in place in places where hybrid solutions are better because the insulation of homes and/or expansion of electricity grids would be more expensive than the use of "new gas". **Heat distribution grids:** Wherever renewable heat is available.
3	Refinery sector in decline	**Heat grid:** Residual industrial heat from refineries is temporary and only partially available in visions for 2050. Residual heat is substituted by renewable heat, or the heat grid is adapted to the limited availability of residual heat. **Electricity grid:** We need to take into account additional use of (hybrid) heat pumps in areas adjacent to refineries in case geothermal energy cannot be applied.

CHAPTER	Highlights relevant to grids	Possible impact on these grids
3	A strong increase in the production of hydrogen by offshore wind farms in places where wind reaches land.	**Gas grid:** The expansion of H_2 networks from places where offshore wind cables reach the shore to locations at which energy-intensive industries are based. **Electricity grid:** Aim for the use of conversion to hydrogen as a flexibility source.
4	Strong increase of syngas as a resource	**Gas grid:** Expansion H_2 and syngas grids at locations where the chemical industry is active.
5	Strong increase in the use of H_2 as a feedstock for fertilizers	**Gas grid:** Possible installation/expansion of H_2 grids to Geleen and Sluiskil
6	Self-driving cars shared by multiple people	**Electricity grid:** Preparing the grid for the charging of electric cars (especially at night) at central locations (squares outside cities and villages and/or in parking garages). Charging one's car at work or at home is a thing of the past.
7	Shrinkage of cardboard industry	**Heat grid:** Reduced availability of residual heat in the surroundings of paper and cardboard factories.
8	Explosive growth of climate-neutral data centers	**Electricity grids:** Expansion of E-networks surrounding data centers.
9/10	Plant-based diets and grass refining.	No direct influence on grids.
11	Alternative tax differentiation	**Electricity grids:** Adoption of new electrical devices is determined by the moment at which electric devices are cheaper than their fossil alternatives. This moment is strongly dependent on the moment at which new tax differentiation is introduced. The pace at which this adaption takes place will be determined by the degree of this differentiation. Grid controllers will have to anticipate the time at which tax amendments take place with their grid capacity. The market model for the electricity market needs to change taking into account the fact that weather electricity has no marginal costs and the market needs to be able to manage real-time pricing for consumers and other, new, customers.

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This appendix functions as a starting point for discussions that grid controllers need to have regarding the impact of these visions on the energy infrastructure in our industry (and adjacent sectors of society). We hereby invite the reader to add to our recommendations and fine-tune them.

TABLE 1: DIRECTIONS IN WHICH THE GOVERNMENT CAN STIMULATE DEVELOPMENTS THAT WILL POSITIVELY IMPACT OUR SOCIETY'S JOURNEY TOWARDS CLIMATE-NEUTRALITY.

CHAPTER	Direction	Explanation
2	Stimulating the electrification of homes	Raising energy taxes on electricity to gas for small consumers. With this method, hybrid heat pumps and, later, geothermal energy and fully electrified heat pumps will become more attractive than gas-fueled high-efficiency boilers.
2	Campaigning to raise awareness for the complete electrification of society	Electric devices will be the new standard. Devices powered by fuel will be framed as outdated and polluting.
3	Stimulating the use of electric vehicles and non-oil-fueled vehicles	The refining industry, one of our most energy-intensive industries, will shrink considerably.
3	Stimulation of the large-scale installation of offshore wind farms	This will give rise to a new, sustainable industry serving as an alternative for a shrinking oil industry.
4	Stimulation of the use of alternative materials for the chemical industry	Primary chemistry based on wind energy. Secondary chemistry based on natural gas (H_2 and syngas), tertiary chemistry based on biomass and quarternary chemistry based on naphtha.
4	Prohibition of incineration or residues in the environment of products containing carbon atoms from fossil fuels and biomass.	Inciting producers to create end-products with long lifespan, and stressing the importance of circular production.

CHAPTER	Direction	Explanation
5	Stimuleren inzet off-shore windstroom voor kunstmestproductie	Enorme mogelijkheden voor het balanceren van het landelijk hoogspanningsnet met een variabele kunstmest-productie.
6	Popularization of self-driving vehicles, timber houses and offshore wind farms made from	The steel industry will substitute its use of iron ore as a raw material by already produced steel.
7	Stimulation of the use of reusable packaging for online orders	Cardboard will not be recycled to the same extent and will therefore demand less energy.
8	Stimulation of the exclusive use of sustai-nable electricity for hyperscale data centers	Phasing out of small data centers and/or data centers using "grey" power.
9	Stimulate the consumption of plant-based foods	Influence on health and, as a result, government expenses as well as availability of agricultural land for the growth of biomass as a tertiary resource for the chemical industry, for instance.
10	Stimulation of better use of grassland in the Netherlands by refining of grass	Huge impact on agricultural efficiency. Solution to manure surplus problem and huge reduction of soybean meal import
11	Implementation of new tax differentiation.	Taxes shifted from labor to goods and services. The taxes on goods and services are determined on more grounds than just CO_2 emissions. This differentiation will be used to make sustainable products cheaper than their unsustai-nable alternatives.

APPENDIX D: STEERING/SUPPORT GROUP THE STORY

Steering Committee Members		
Jan Pellis	Strategist	Stedin
Abo Rassa	Corporate Strategy	Alliander
Sander Schou-wenaar	Manager Innovation	Enexis
Piet Nienhuis	Project manager transport infrastructure development	GasUnie
Marijn Artz	Manager Sustainability & Energy Transition	Netbeheer Nederland
Marjan Minnesma	Director	Urgenda
Jan-Jaap Nusselder	Manager Public Affairs and Special Projects at OCI Nitrogen	Ocl Nitrogen
Johan Sanders	Professor	WUR
Peter Alderliesten	Director	TKI I&E
Tjeerd Jongsma	Director	ISPT
Andreas ten Cate	Director International Business Development	ISPT
Gert van der Lee	Long Term Transmission Gridplanning	TenneT

With the cooperation of		
Reinier Gerrits	Head of Unit Energy and Climate at VNCI	VNCI
Ewald Breunesse	Manager Energy Transi-tions	Shell
Jeroen van der Tang	Manager Sustainability and Environment at Nederland ICT	Nederland ICT
Anita Westenbroek	Director Innovation	VNP
Corneel Lambregts	Secretary	VNP
Machteld van den Broek	Assistant Professor	Universiteit Utrecht
Marco Kavelaars	Team Manager Industry and IT	RVO
Marcel Verzand-voort	Team Manager Oil, Construction and Monitoring	RVO
Aart Dekkers	Head of Unit Knowledge and Energy Strategies	Min. EZ
Bouke Bussemaker	Policy officer Energy and Energy Saving	Min. EZ
Peter Besseling	Senior Policy Advisor Sustainable Industry	Min. EZ

ABOUT QUINTEL INTELLIGENCE

Quintel Intelligence aims to accelerate the necessary energy transition by helping governments, NGOs, companies, citizens and students understand this transition. We have been doing this since 2008 and this is our only goal. Our team is made up of ten people; strategists, modellers, cloud programmers and researchers. Four of them hold a PhD, most of them in Physics; this is helpful because of the complexity level of our research questions, which we usually approach in a quantitative manner.

In the past few years, we have facilitated hundreds of projects in which visions, strategies and scenarios have been designed with regard to our energy supplies for Europe, European nations and different regions, municipalities and districts within the Netherlands. We usually carry out projects commissioned directly by our clients, but sometimes we also function as auditor for other consultants.

We have helped Urgenda work on its vision for 2030, we have supported the SER (Social and Economic Council) in the creation of the Agreement on Energy for Sustainable Growth and we have worked for the Dutch Council for the Environment and Infrastructure during the preparations for the report A Prosperous Nation without CO_2 (2015). Urgenda has challenged us to make the most out of transition in the near future. The Social and Economic Council has taught us how a diverse group of parties can cooperate to reach a shared goal. Finally, the Council for the Environment and Infrastructure has stimulated us to think about the inconsistencies and dilemmas in our "visions" for 2050. Based on these experiences, we came up with the idea of taking initiative and writing An Industry in Transition (June 2016) and its sequel, this Story (March 2017), in which we have managed to involve a broad variety of parties. We want to thank everyone involved in the creation of this story for their contributions.

Since 2008, we have always translated (almost) everything that we are learning into a free, open source and open data tool accessible at https://energytransitionmodel.com. Everyone, whether student or policy maker, can use this tool to design energy scenarios.
In the Netherlands, approximately 50,000 scenarios are made with our Energy Transition Model each year, and together with our 40 partners we have been able to invest over 100 man years in the development of our tool.

MAKING YOUR OWN IMPACT CALCULATIONS

These stories are an open invitation to you as the reader to rise to the challenge and pass them on, add to them and polish them. To calculate the impact of your own contributions, you can use our free, open source Energy Transition Model (http://energytransitionmodel.com), which will allow you to explore the future of our energy system.
We have already attempted to take several trends into account in two scenarios (a maximum effort aiming for 2030 and a mediocre effort aiming for 2050), in which we have focused on two different parameters.

THESE SCENARIOS, WHICH CAN BE USED AS A STARTING POINT FOR FURTHER EXPLORATIONS, MAY BE ACCESSED HERE:

A scenario in which we aimed for 100% sustainability in 2030
https://pro.energytransitionmodel.com/

A scenario in which we aimed for 80% CO_2 reduction in 2050
https://pro.energytransitionmodel.com/

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If you have any questions, comments or ideas that would help to enhance the quality of our story, you can contact us by email: info@quintel.com. We will of course try to get back to you as soon as we can.

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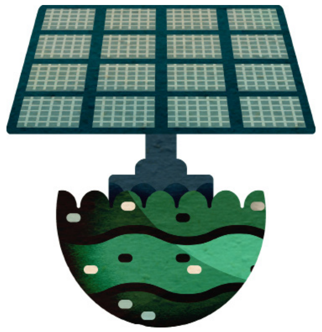


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