Transition of the Dutch energy system: scenario's 2030-2050

II3050 Management Summary

7 april 2023

Netbeheer Nederland

Summary

As an interim step before publication of the second edition of the Integrated energy system exploration 2030-2050 ('II3050')[1], the system operators jointly present four scenarios for the energy system in 2050 so that everyone may use them. These scenarios have been made possible with the support and expertise of various stakeholders.

This summary discusses the scenarios and explains the reasons for the underlying choices. This scenario study examines fundamental uncertainties. This will help policymakers to make choices and provide a basis for dialogue on working towards climate-neutrality by 2050. The conclusions and recommendations in this scenario report do not take the impact that the various scenario assumptions will have on the energy infrastructure into account. This impact and the consequences in terms of costs, space, human resources and materials will instead be discussed in the final report, which is due to be published end of 2023.

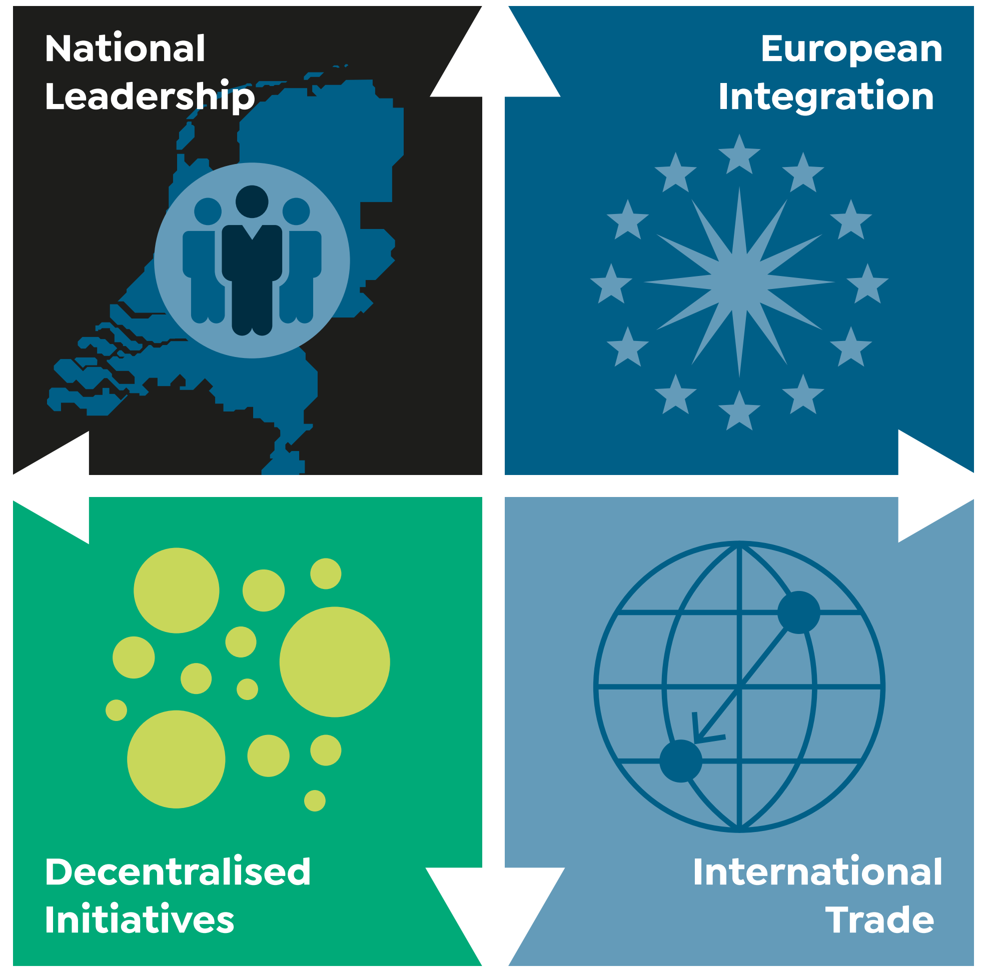
Our energy system has to be climate-neutral by 2050. There are various conceivable routes for achieving this transition, each with a different impact on the energy infrastructure. These routes differ from each other through some important factors. On the one hand, they differ in terms of the extent to which the government steers developments and makes choices, or specifically leaves space for decisions by market parties and a free energy market. On the other hand, the energy transition can be organised more along national (country-wide or regional) or international lines. The energy carriers chosen for deployment in the various sectors will also influence what the future energy system will look like. The various combinations of these factors result in the following four scenarios: Decentralised Initiatives (DEC), National Leadership (NAT), European Integration (EUR) and International Trade (INT).

All four scenarios transition to a climate-neutral energy system by 2050 and have in common that they are ambitious. They require a rapid move away from fossil fuels, a rapid increase in renewable energy generation and a transformation of industry (energy and raw materials), mobility, the built environment and agriculture. This transformation demands systemic changes, and at the base of these changes is the energy infrastructure. The gas, electricity and heat grids need to be completely overhauled. But which way will differ considerably from one scenario to another.

Collective technology choices and management by government

National Leadership
- Limited reduction in industry
- New synthetic molecules industry based on recycled carbon and DAC (direct air capture)
- Strong electrification
- Very high levels of renewable generation; limited nuclear
- Most district heating

European Integration
- No to very limited reduction in industry
- New synthetic molecules industry based on CCU and bio-carbon
- Green gas, also from imports, next to electrification and hydrogen
- CCS to continue and blue hydrogen
- Partially H_2 in built environment
- Base load of nuclear power



National focus, as self-sufficient as possible

International focus, with import possibilities

Decentralised Initiatives
- Strong reduction in energy-intensive industry
- Certain industries leave the Netherlands
- Strong electrification, but also hydrogen in industry
- Very high levels of renewable generation
- Energy hubs

International Trade
- Strong reduction in energy-intensive industry
- Certain industries move abroad
- Substantial amounts of hydrogen, next biofuels, CCS, DAC and electrification
- High H_2 imports
- Built environment fully H_2

Market-driven, individual solutions, with frameworks set by government

1 https://www.netbeheernederland.nl/_upload/files/NetbeheerNL_Rapport-Samenvatting-ENG_A4_FC.pdf

The energy transition entails many uncertainties, as outlined in the scenarios. Despite their differences, these scenarios have reached some generic conclusions and make recommendations that are relevant in each scenario. All four scenarios require a number of fundamental choices to be made over the coming years if the Netherlands is to remain on track to achieve its climate ambitions by 2050.

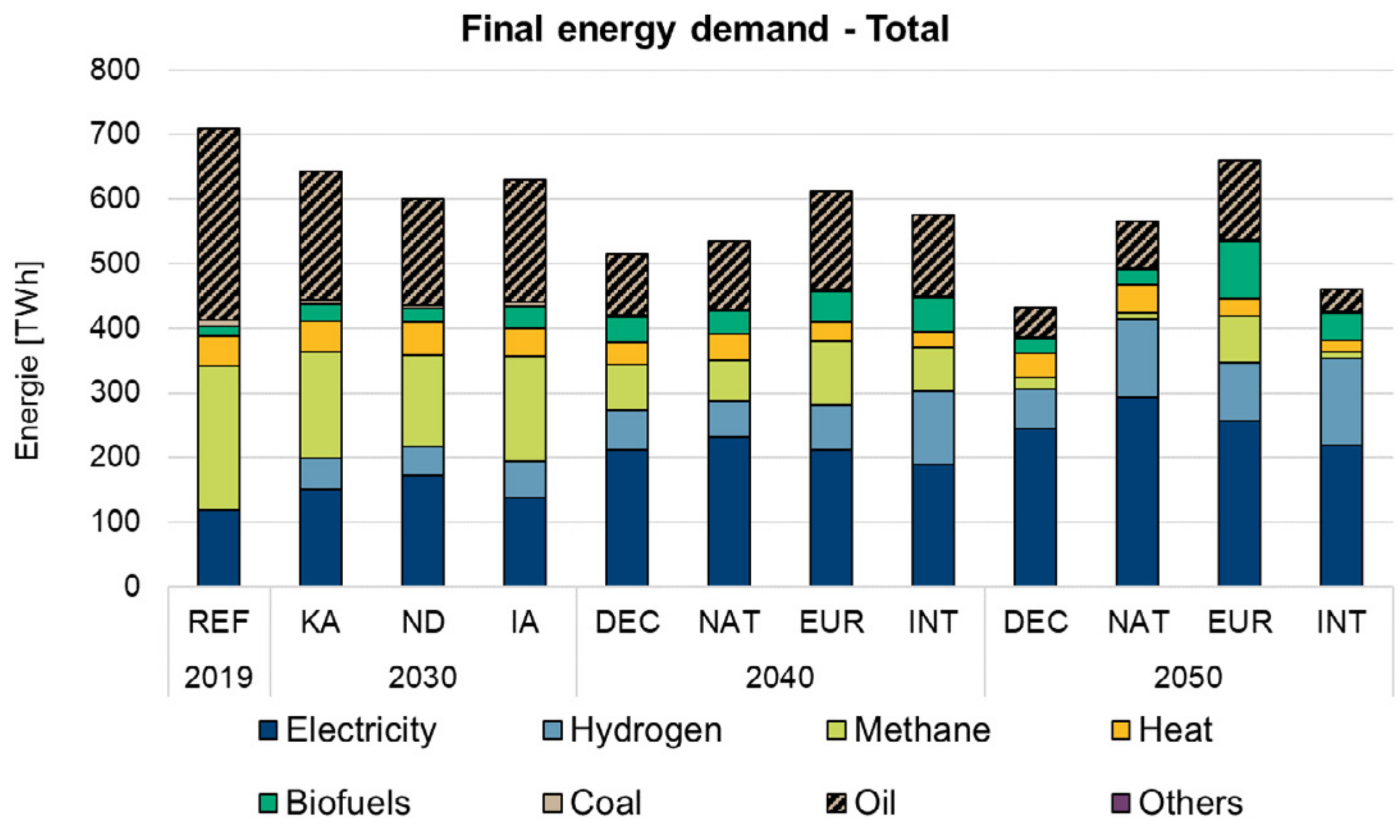
In practice, developments may well differ from those outlined in the scenarios. Societal choices will influence the energy system too. It is therefore important to continue monitoring developments and choices and ensuring that efforts to transition to the energy system of the future are based on up-to-date information and insights.

This summary is divided into three main sections. First, developments in energy supply and demand are discussed. Then the role of flexibility is examined. Lastly, developments in CO_2 and other greenhouse gas emissions and the role of CO_2 in the energy system of 2050 is considered. Each main section ends with a set of recommendations which accumulates to a list of policy documents that provide a logical embedding for the recommendations.

Click to go to the sections

I Developments in energy supply and demand

a. Energy demand

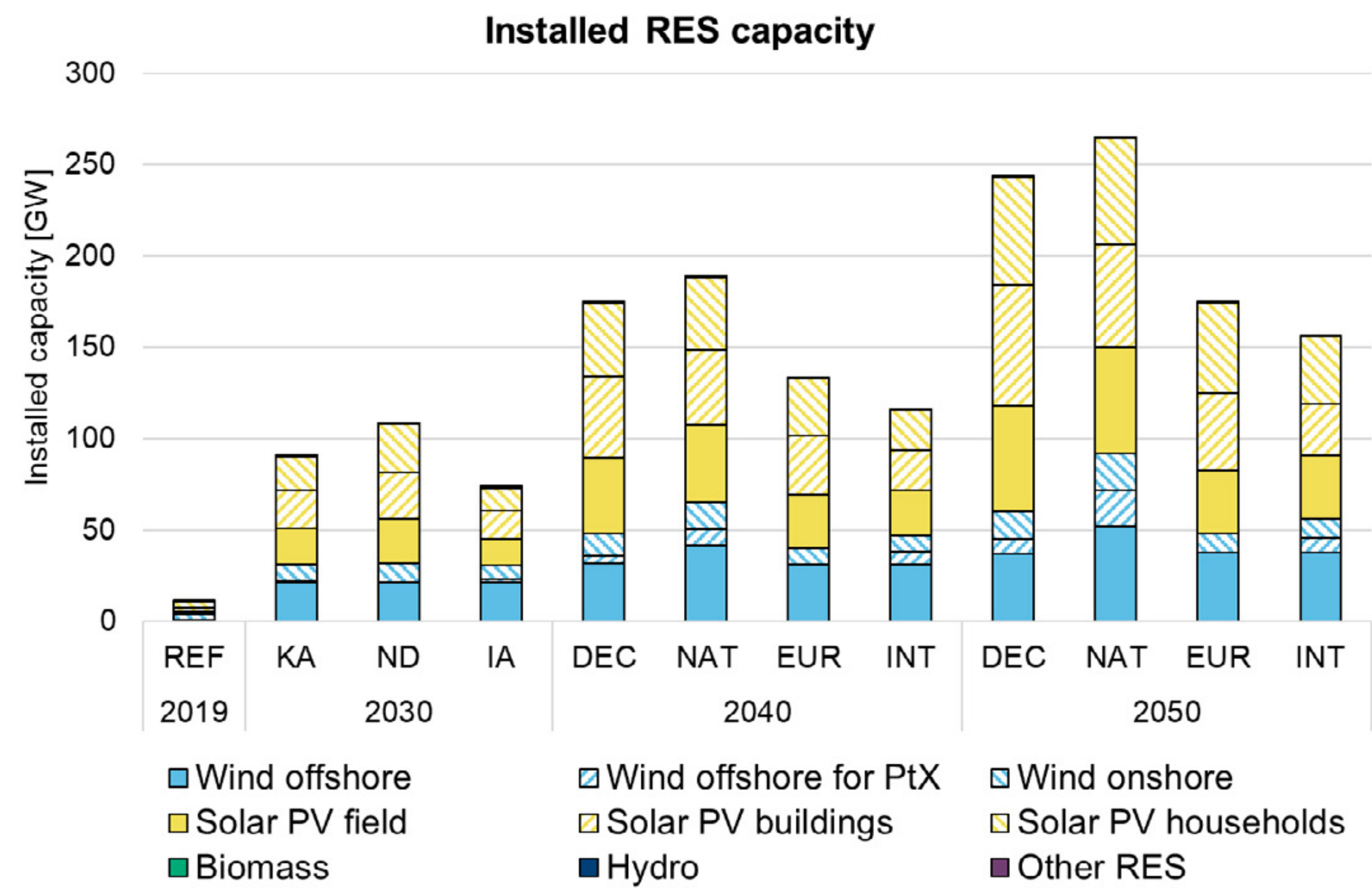


By 2050, all four scenarios see the total energy demand decreasing. The demand decreases by 7 to 39% compared with the base year. This is due to a combination of technological improvements, energy savings, greater efficiency and developments in energy-intensive basic industries. Industries' decisions to come to or stay in the Netherlands in the future will have a major impact on the amount of sustainably generated energy required, as well as on the flexibility resources and infrastructure, and so also on how we will have to structure our climate-neutral energy system in the years to 2050. The market-driven scenarios foresee some highly energy-intensive processes relocating to regions with cheaper sustainable energy. In the scenarios involving more government interventions, by contrast, industrial businesses introduce new processes.

All scenarios assume that demand for electricity will increase by 180-250% compared with 2019. A substantial increase in electrification in almost all end-user sectors will lead to more efficient and direct use of the available renewable electricity. In all scenarios, demand for hydrogen is also set to rise substantially. Hydrogen is used both as a fuel and as a raw material for industry and partially for heavy transport. It is also used as a flexibility resource and, from 2030, for hybrid heating of buildings in two of the four scenarios. Demand for biogenic fuel and raw materials will also increase. Biofuels such as biodiesel are used in the transport sector (including heavy transport). Demand for these biofuels for use in road transport is set to increase in the years to 2040. By 2050, bio-kerosene demand will shift and come from airlines, as road transport becomes largely electric. Biofuels such as bio-naphtha are used in industry, and their use will increase in the years to 2050. Use of biofuels depends partly on whether the industries using them expand or reduce in size.

Demand for oil is set to decrease. The use of oil for mobility will decrease considerably because of cars and freight transport switching to electricity and, to some extent, hydrogen. Industry's use of pyrolysis oil (or bio-crude) will increase strongly towards 2040. The supply of waste materials in the Netherlands suitable for chemical recycling to make pyrolysis oil is inadequate, with the result that almost everything has to be imported. Nevertheless, this form of recycling plays an important role in the production of plastics and synthetics and in fuels for export. Traditional demand for natural gas (methane) is also set to fall sharply, and coal is no longer used for electricity production after 2030. Demand for heat will also reduce. Total demand for energy in the built environment (housing and utility) is set to gradually reduce because of energy savings and buildings being better insulated. Most of the energy demand for housing is for heating purposes. By 2050, this demand will be met by various means, including electric heat pumps, low- and high-temperature district heating and, depending on the scenario, also hydrogen or green gas. Because hybrid systems use a combination of various gases and electricity, gas volumes used will be modest and primarily needed to cover peak demand.

b. Energy supply



The energy supply will change substantially over the coming years: the energy currently comes primarily from fossil fuels (natural gas, oil and coal), by 2050 the energy demand will almost entirely be met with sustainable sources.

By 2050, most renewable electricity will be generated from wind both onshore and offshore, with a generating capacity of between 48 and 92 GW. Wind energy will provide 25-60% of the renewable electricity supply. Although, by 2050, solar power will have by far the highest generating capacity (100-183 GW), the more limited hours of sun mean it will only account for 10-20% of renewable electricity. The various scenarios assume that solar panel installations will be connected to 40-50% of peak supply. The effect on volume loss will therefore be limited. Oversizing renewable energy generation will ensure that supply is sufficient to meet demand for a larger part of the year and also ensure significantly more renewable generation per connection.

A substantial share of the hydrogen capacity will initially be met from imports, steam cracking and residual gases from industry. Green hydrogen production will get started before 2030 (3-8 GW in 2030) and then expand significantly in the subsequent years (13-45 GW in 2050). By developing import facilities, the Netherlands will become a transit country for hydrogen, with volumes of 10-40 TWh in 2030 and volumes of 50-150 TWh by 2050 being re-exported, primarily to Germany. Imports from outside the EU will initially come by ship, with ammonia and condensed hydrogen playing a major role. In the longer term, liquid hydrogen will also be shipped and pipeline imports are possible.

For supply certainty reasons, natural gas will continue to play an important role during the 2030-2040 transition period, both in the Netherlands and elsewhere in north-west Europe. Towards 2050, however, natural gas volumes will be very low, except in the European Integration scenario, when they will be used to produce blue hydrogen. By 2040, most natural gas emissions from industry will be captured.
All scenarios see increasing production of green gas (ranging between 14 and 80 TWh) by 2050. Although lower supply means green gas will not entirely replace current levels of natural gas use, it will continue to play an important role in certain sectors: i.e. in hybrid situations for meeting demand for heating in a limited part of the built environment and in those industries where no alternative for green gas is possible. Part of this demand peaks in the winter, with the result that gas storage will remain important, alongside transport and distribution facilities.

The transitioning of supply and demand set out in the scenarios essentially entails a total transformation of the energy system. A huge amount of new infrastructure is needed. During the transition phase, it is inevitable that not all the required capacity will be directly available everywhere and at every moment of the year as it obviously takes time to adapt existing and build new infrastructure. That is why it is important for energy system operators to use these scenarios to anticipate developments in energy supply and demand in good time. But anticipation alone is not enough. It is also vital to plan more effectively for all these developments. Preparing to manage wide-ranging expectations means making choices. That means making choices on spatial planning and on how we structure society. And also choices on the type, timing, extent and range of technologies to be encouraged or made compulsory. The ways in which individual grid users deploy technology are crucial for how the energy system develops.

The forecast transition in energy supply and demand has resulted in five recommendations:

RECOMMENDATION 1 Determine which energy carrier must be available where, when and for whom. Governments, market parties and energy system operators make this choice together. *This is in the knowledge that the future is inherently uncertain and that we cannot plan the entire transition yet. Determined should be which energy demand should be met for clusters, industries and neighbourhoods and where and when each sustainable energy carrier (electricity, hydrogen, green gas or heat) should be used. When making these choices, take into account developments of energy carriers and the security of supply. These choices need to be made without delay in order to provide certainties for market parties, residents and energy system operators to work towards.*

For the national level, these choices should be made in the National Plan for Energy (NPE), while the choices for the regional level should be made in the provinces' energy plans. Municipalities, too, must be required to make choices. The approach set out in the Transition Strategies on Heating and the Neighbourhood Implementation Plans is resulting in these choices being postponed for too long. It is essential for these choices to be of a binding nature if they are to be effective in steering decisions by market parties and households and allow effective planning by energy system operators. Make these choices binding by embedding them in national and provincial permit regulations and municipal planning procedures. Make sure this embedding extends to the tasks assigned to energy system operators and to their financing. Lastly, conditions have to be imposed on national incentive schemes such as SDE++ so that they more effectively align demand and generating capacity and make better use of capacity available in the electricity grid.

RECOMMENDATION 2 Determine which energy-intensive basic industries are appropriate for the climate-neutral Netherlands in 2050. *The business climate, industrial policy and customised agreements will all play a role in determining what energy-intensive industries in the five clusters do: invest and introduce new processes or leave (or partly leave) the Netherlands. More intensive government intervention (in the form, for example, of grants/funding and standard-setting) could keep energy-intensive processes in the Netherlands. Because energy-intensive basic industries account for almost half of energy demand in the Netherlands, they have major consequences for the amounts of sustainably generated energy, flexibility resources and infrastructure required. If these are to be available in time, choices on the future of these industries need to be made now. If the transition is to be properly planned, targeted policy is vital. Otherwise, the transition will inevitably be delayed.*

Setting out a clear direction is also vital for the sixth cluster – i.e. for the medium-sized industrial businesses spread across the Netherlands, sometimes operating in isolation and sometimes in regional clusters. The direction chosen for the regional energy systems must offer a way forward for these industries and plan for their energy needs so that energy system operators can have the required infrastructure in place when needed.

These choices also impact on the extent to which offshore wind farms should be expanded. Should (over)production be used to meet potential extra national demand, such as for producing green molecules for Dutch industry, or will there be structural exports to fulfil the electricity needs of neighbouring countries?

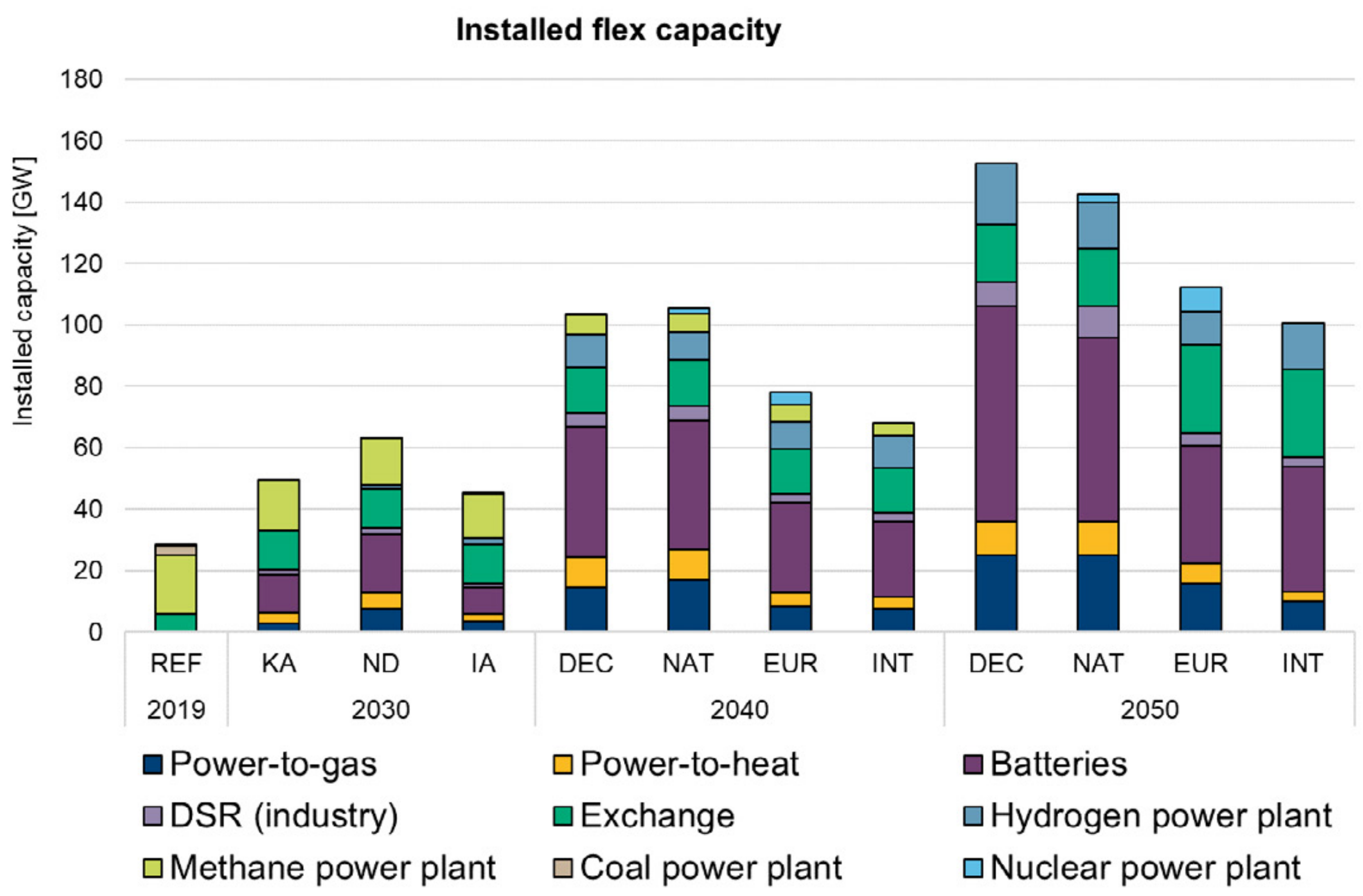
RECOMMENDATION 3 Make policy for further developing sustainable energy generation, including demands to be placed on location choices and connecting capacities, curtailment and flexibility so as to achieve more efficient grid integration. *The objective must be to enable fast development of sustainable generating facilities. At the same time, the energy system as a whole should be as efficient as possible and integration costs to be kept as low as possible. Generating capacity relative to the grid connection has to be oversized for all voltage levels. This applies not only to large-scale solar panel projects, but also to solar panels on small-scale users' roofs and at wind farms. This could include the same connecting conditions for ultimately 40% of the maximal solar capacity and accepting that individual transformers have to limit net production when it is very sunny and demand for energy is low. Combining wind and solar power is a way to generate and integrate far more renewable energy. The SDE++ scheme is currently aimed only at connecting to 50% for new solar panel parks. We would suggest that contracts for existing solar generating capacity should be adjusted to allow capping at 40-50%.*

RECOMMENDATION 4 Introduce legislation and regulations so that not everyone can apply for capacity anywhere and at any time or expand. *Make the basis on which this choice is made transparent. Let go of the 'copper plate approach' due to the physical and financial limits of the system as stated in the Climate Agreements. Otherwise the costs for society may be very high. This will affect, for example, which parties can go down the electric, hydrogen or heat route. This is not always possible, or not always possible everywhere. But more is possible if parties are flexible. The reason for this recommendation is that the energy system operators expect society (citizens and businesses) to be unable or unwilling to accept the infrastructure costs, use of space and the cost of using time efficiently if such a broad-ranging choice of energy carriers is available.*

RECOMMENDATION 5 Determine the position the Netherlands wants to adopt regarding energy carriers in an international context. *The Netherlands is currently an important energy hub because of the country's location, infrastructure, ports, storage and logistic facilities. The Netherlands therefore contributes to ensuring an affordable and reliable energy supply for north-west Europe. The role of fossil energy carriers is rapidly declining. If the Netherlands wants to maintain its position when transitioning to the energy system of the future, choices need to be made promptly in liaison with Germany and other countries around the North Sea, so that the new supply chains are developed in good time. Developing the supply chains for importing hydrogen requires partnerships around the world. As well as the hydrogen supply chain, this also means grids for transporting electricity, interconnections and CO_2 so that carbon capture and storage (CCS) is also possible for neighbouring countries. This has infrastructure consequences, but also implications for the space to be allocated to infrastructure.*

What is needed is substantive and well-considered central government policy on structuring the various energy chains (production, imports, transport, conversion and storage) in a properly connected and balanced manner. The extent to which offshore wind farms should be expanded and how (over)production should be used (recommendation 2) is connected to this recommendation.

II Importance of flexibility in a climate-neutral energy system



The energy transition will create an entirely different momentum in our energy system. The increasing role played by weather-dependent energy sources (wind and solar power) will result in substantial fluctuations in the energy supply. During the day, for example, the supply may fluctuate far more than at present (for example due to clouds). There will also be significant differences between the seasons (winter weeks without wind). In addition, the future energy system has an increasing geographical imbalance between supply and demand among energy carriers, as well as a change in necessary infrastructure as energy will often be generated at locations very different from the traditional power stations. These may include large offshore wind farms or solar panels spread across the country and feeding into regional grids. This means new challenges.

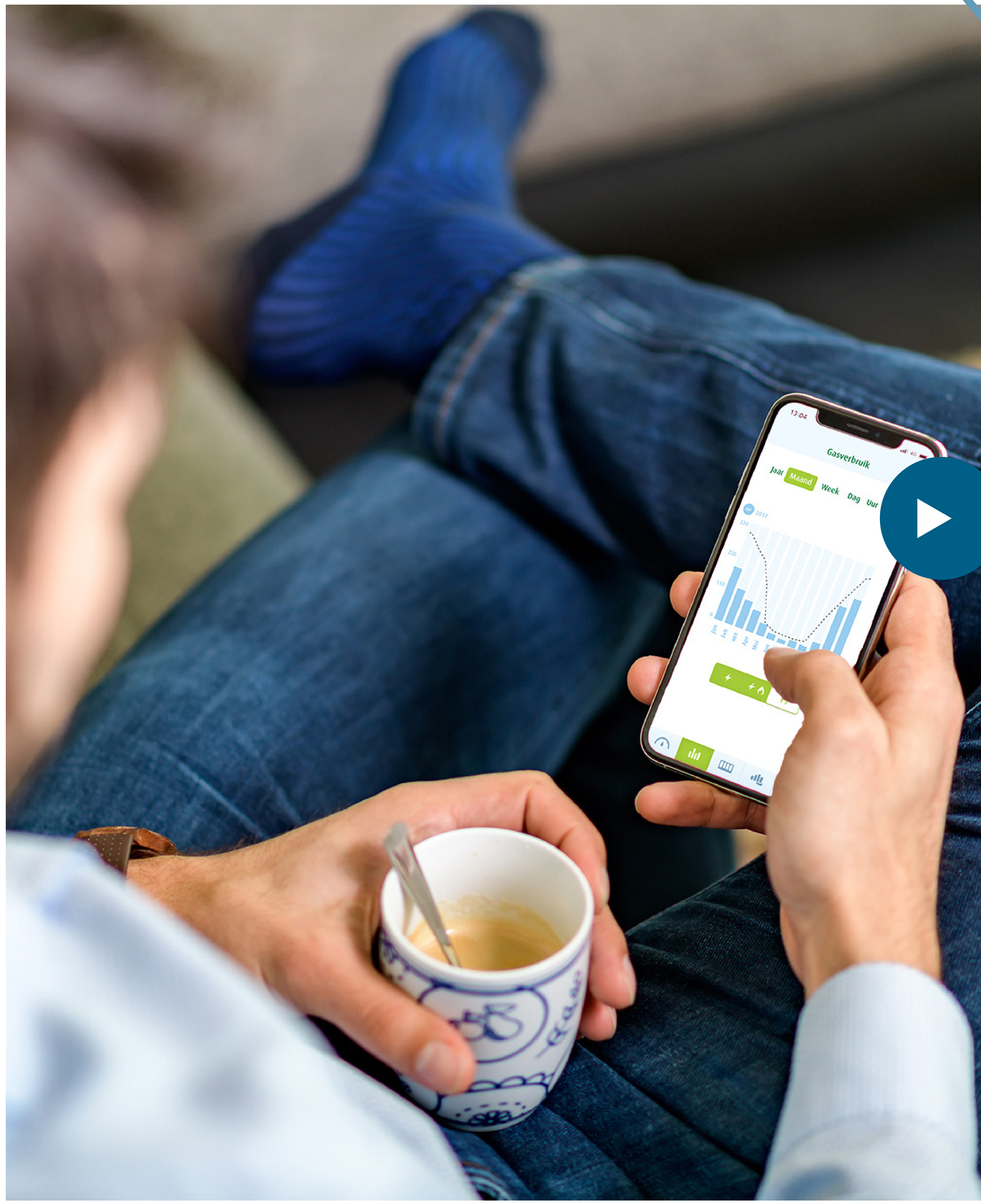
Future demand will be different as well. Industry, the built environment and mobility are all becoming more sustainable and that will have a major impact on their need for energy. Most of the time, supply and demand among the various energy carriers are not perfectly balanced. These differences between supply and demand mean a flexible energy system is needed that can move in line with supply rather than demand, given that the weather cannot be regulated. This will impact on how society – and this applies both to consumers and large users – deals with energy. While this transition is already underway, ensuring supply and demand remain in equilibrium will require substantial measures to be taken in the years to 2030. These changes will be faced sooner than many people realise.

- The flexibility to cover electricity shortages increases from around 3 TWh per year in 2019 to 86-100 TWh by 2050. The big challenge is during the evening peaks and in cold winter periods, when demand for energy is high and the supply of sustainable energy is low.

- The flexibility to cover electricity surpluses increases from around 5 TWh in 2019 to 184-273 TWh in 2050. The big challenge in this respect is to use these surpluses in a cost-efficient way so as to reduce energy losses.

These challenges mean developing and realising high (or very high) capacity to deploy flexibility resources. Depending on how it is arranged, flexibility in the transition to a sustainable energy system may also play a disruptive role. Indeed, whether the required amount and correct form of flexibility are available at the right place and are used appropriately may determine the success or failure of the energy transition. This also demands the use of flexibility resources that are currently scarce or do not yet even exist. As well as continuing to develop the various possible forms of flexibility, efforts need to be made to ensure the new forms of flexibility become available in good time.

What is needed is both flexibility within the electricity system, but also systemic integration with other energy carriers, such as conversions to and from energy carriers such as hydrogen and heat, or hybrid electricity and gas applications.



The effects of various flexibility variants and weather conditions will be examined in more detail in the second phase of II3050 and discussed in the final report. Ahead of that, our recommendations regarding CO_2-neutral flexibility facilities are as follows:

RECOMMENDATION 6 Incorporate flexibility into the energy system by incentivising, scaling up and innovating. *As this flexibility is needed as early as 2030, policy in the coming years must create incentives (see also recommendation 7). If sufficient flexibility resources are not available or are not available on time, any shortages could result in steep energy prices and supply uncertainties. In the event of an oversupply, surpluses will not be used if demand for electricity has already been met. Production of renewable electricity will then not be economically viable.*

RECOMMENDATION 7 Ensure that flexibility resources contribute to maintaining a balance in the energy system and avoiding congestion at all voltage levels. *It is important in this respect that choices of location, connection levels and use of batteries, electrolysers and other flexibility resources are tailored to ensure the energy grid is used efficiently. At present, however, there is no incentive to do this. Ensure appropriate incentives so that new forms of flexibility resolve grid congestion rather than make it worse. As well as a country-wide framework, flexibility requires a new framework at a regional level because of the different balance between supply and demand at lower grid levels.*

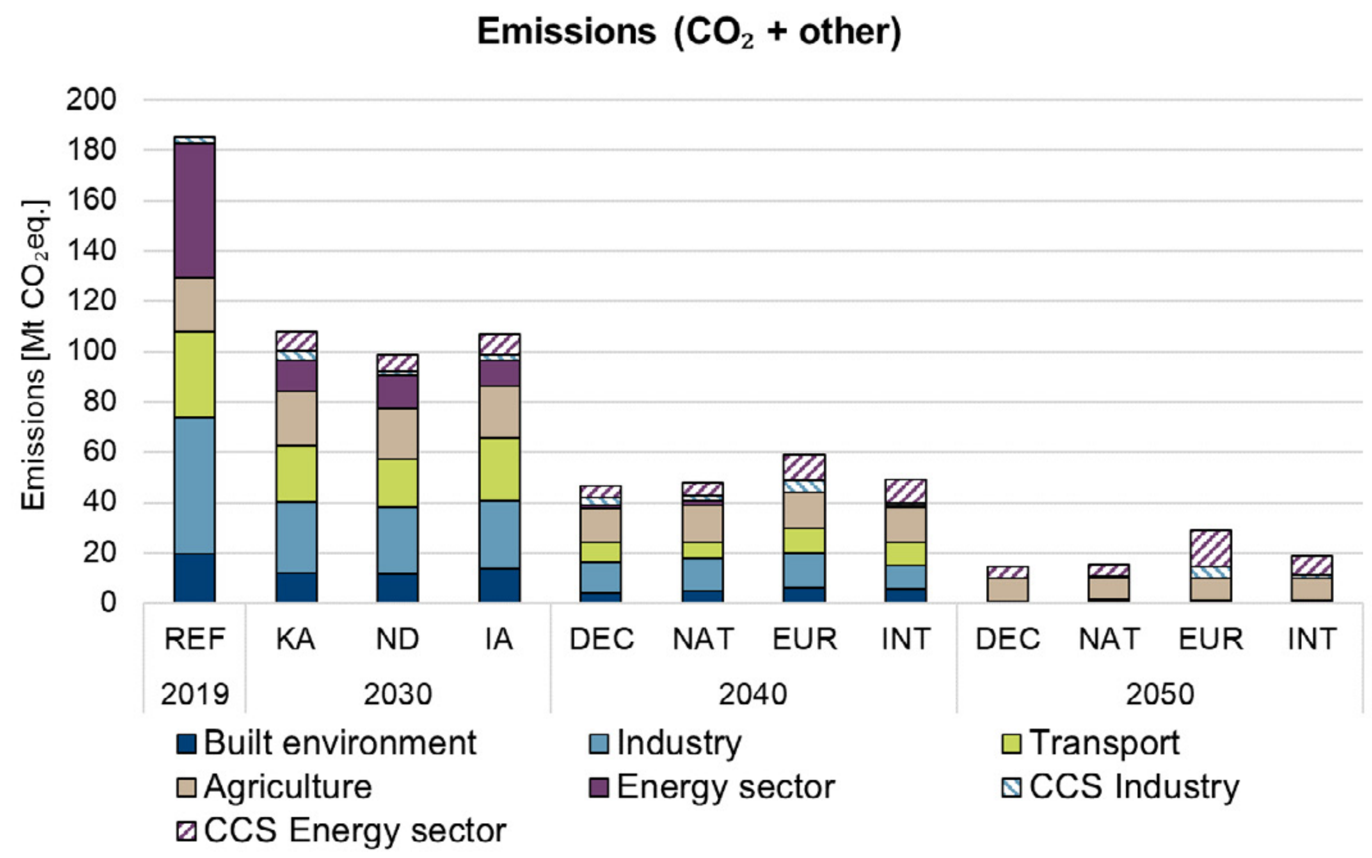
RECOMMENDATION 8 Accelerate the policy for developing hydrogen storage in salt caverns and devise policy for strategic storage of gases. *Storage to keep the hydrogen system in balance is essential, both for imports and production. Otherwise it is difficult to make flexible use of electrolysers for renewable electricity or to use hydrogen power plants as a back-up for solar power and wind. The availability of hydrogen storage needs to increase in line with developments in the use of hydrogen. Salt caverns for storing hydrogen are already needed, therefore, before 2030. The energy system of the future will also need strategic storage of gases to cover shortages in bad weather years (when harvests of energy from sun and wind are low), when imports are low or unavailable or if the main import location becomes completely unavailable. This policy must be available in 2030.*

RECOMMENDATION 9 Intensify collaboration with Europe. *This is essential for future supply certainty and will make it easier to integrate sustainable energy into the grid. Continue aligning the energy transition at a European level for interconnectors, hydrogen, gas transport and the offshore grid. Ensure also that European policy is quickly transposed into national targets and also harmonise the rules at a European level for calculating CO_2 reductions so that neighbouring countries do not engage in illogical activities, such as decommissioning and building nuclear power plants at the same time. With regard to collaboration with other countries, see also recommendation 5.*

FLEXIBILITY RESOURCES		
Electrons	**Interconnection (exchange):** Expanding countries' interconnection capacity enables them to help each other deal with shortages and surpluses. Greater differences between countries – whether attributable to time zone differences, different climates or the local use of other sustainable generating technology – between production capabilities and demand patterns will create more potential for flexibility. The scenarios show an increase in interconnectors to 19-29 GW by 2050. For much of the year this will be used for importing and exporting electricity, with annual imports of around 40-60 TWh and exports of 60-90 TWh. **Demand side response:** Some industries can scale down demand at peak times through market forces or contractually. Options include stopping some or all of a process, starting up additional processes, using hybrid solutions that switch to another energy carrier, or using the industry's own buffers to temporarily cover energy demand or filling the buffers to provide extra supplies for subsequent peaks in demand. Around 300-600 full-load hours and 2-4 TWh are assumed. **Battery storage** is a crucial element of the CO_2-free energy system for offsetting surpluses and shortages during the day or over several days on a national and regional scale. This offsetting may also be partially possible on a local scale. In the years to 2050, the scenarios foresee battery storage capacity of 40-70 GW, which is considerably more than in the first edition of II3050. Batteries have relatively little storage capacity and a relatively high number of recharging cycles. Batteries installed so renewable electricity production is not send into the grid at peak times allows even more renewable energy to be connected to the system, with less use of capping. But this limits the impact of a free market.	**Supply side response (curtailment**) is a flexibility resource that can be used in the energy market or by an energy system operator. It means feeding less renewable production into the grid, either as a response to a market price incentive or due to a signal from the energy system operator. This can occasionally involve high capacity, but the energy losses in the scenarios are limited to 5-13 TWh. The exact amounts that ultimately have to be curtailed can be calculated only after the infrastructure impact calculations. **Conventional powerplants** remain important for covering shortages despite the other flexibility resources. In 2050, the available conventional plants will be part of the merit order and be based on hydrogen and nuclear power, to ensure that electricity demand can be met when there is too little renewable generation. Two scenarios include the nuclear power option (3-8 AGW, meaning around 2-6 large new nuclear power plants). In these scenarios, the adjustable output required from power plants in a year of average weather is between 15 and 20 GW. More conventional powerplants will be needed in an extreme weather year or if fewer other flexibility resources are available. This aspect will be discussed in more detail in the final report. **Conversions** are used as a flexibility resource on the one hand, and to meet demand for green hydrogen and renewable heat on the other hand. See below.
Molecules	**Hydrogen conversions.** Hydrogen makes it possible to use sustainable electricity also at times when supply exceeds demand. This is done by converting some of the renewable electricity supply into hydrogen, partly to meet demand for sustainable molecules and partly to sustainably convert excess supply and store it for a period of one or more seasons. In some scenarios, some of the electrolysers are directly connected to wind farms, but most of them are flexible. The various scenarios envisage installed capacity increasing via electrolysis to 13-45 GW. **Hydrogen storage:** For longer-term storage (several weeks up to the entire winter season), large volumes of underground storage are needed to keep the whole energy system balanced. Strategic storage is also required to cover the possible risk of several years of bad weather in succession, or the possibility of import flows coming to a partial or complete halt or an import location becoming totally unavailable. Storage volumes will have to increase rapidly after 2030 as flexible electrolysers will produce more hydrogen and this will need to be aligned with the demand for hydrogen.	**Methane storage.** Methane storage is also needed for responding flexibly to demand. The total capacity for CO_2-free adjustable output and the total volume of seasonal storage (hydrogen and methane) required are largely the same in all the scenarios.
Heat	**Conversion to heat.** Whereas currently natural gas or residual gases for heating purposes is used, electricity will in the future be one of the sources of sustainable heat. Power-to-heat is also a flexibility resource. In the run-up to 2050, the installed capacity of flexible industrial power-to-heat will increase to 6-11 GW.	**Heat storage.** Heat grids have peak demand that has to be met. Heat storage facilities are needed for the short and long term if peak demand is to be covered without gas boilers or electrical co-firing.

Disclaimer: The adjacent technologies and options are partly complementary, but also clearly interact. Some of these options can also be substituted for each other. This scenario study consequently does not provide advice on the exact amounts of flexibility resources that would be desirable from a security of supply perspective.

III Developments in greenhouse gas emissions leading up to 2050



Greenhouse gas emissions have decreased over the past thirty years (1990-2020) by 25.5%.

The 2022 Climate and Energy Exploratory Study shows that the existing and proposed policies are not yet adequate for achieving the current ambitions by 2030, while the II3050 scenarios assume that the targets for reducing emissions will be achieved. The scenarios make it clear, therefore, that additional efforts will be needed on top of existing and proposed climate policies if these targets are to be met. The scenarios achieve a reduction of 55-60% by 2030 and a climate-neutral energy system and CO_2-neutral electricity production by 2050.

CCS is expected to be the main contributor to reducing industrial emissions in the years to 2030. Between 2030 and 2040, reductions will largely be attributable to the use of electricity and hydrogen. Developments within industry will be very important in the years after 2040. If levels of industrial activity continue to decrease, industry will also have less need for carbon. If the production of synthetic carbon-based molecules is scaled up, the need for circular CO_2 as a feedstock for industry will increase.

CO_2 capture plays an important role in all the scenarios. In the Decentralised Initiatives and National Leadership scenario's CCS is used primarily as a transitional measure. In all the other scenarios, CO_2 capture is still seen as important in 2050 for achieving negative emissions via storage of carbon from the Netherlands and neighbouring countries (CCS) or for obtaining feedstock from synthetic producers and fuels (carbon capture and utilisation, or CCU), i.e. partly biogenic carbon or CO_2 from the atmosphere.

The fourteen industrial groups with the highest greenhouse gas emissions (together accounting for 60% of industrial greenhouse gas emissions) expect to have substantially reduced their scope 1 emissions by around 2040. By then, their emissions will have fallen to 3.1 - 4.7 Mton (i.e. a reduction of around 85% compared to 2019). However, these industries still expect their production, and partly their exports of products and fuels, to contribute significant amounts of fossil carbon to the chain. In all cases, therefore, scope 3 emissions – relating to large-scale production in the Netherlands and resulting in emissions later on in the chain or in other countries – will still be considerable.

Achieving negative CO_2 emissions is another relevant point. Even if the energy system is climate-neutral by 2050, 9 Mton of greenhouse gas emissions (methane and nitrous oxide) are still expected in the Netherlands from agriculture and land use (oxidation of peat soils). The scenarios do not make any provision for measures to compensate these residual emissions within the energy system.

The following recommendations are based on forecast developments in greenhouse gas emissions:

RECOMMENDATION 10 Avoid that multiple sectors expect to have access to the same limited-availability energy carriers. *Any political vision and multi-year programme for the climate challenge should always make the consequences clear for all energy carriers and the energy system as a whole. Consider the energy carriers and amounts of energy needed for the energy transition within sectors (industry, built environment, mobility, agriculture) and for energy chains (electricity, hydrogen, methane, carbon) as a totality and in conjunction with each other. Look beyond national borders and take international developments into account. The climate challenge extends further than just the energy system.*

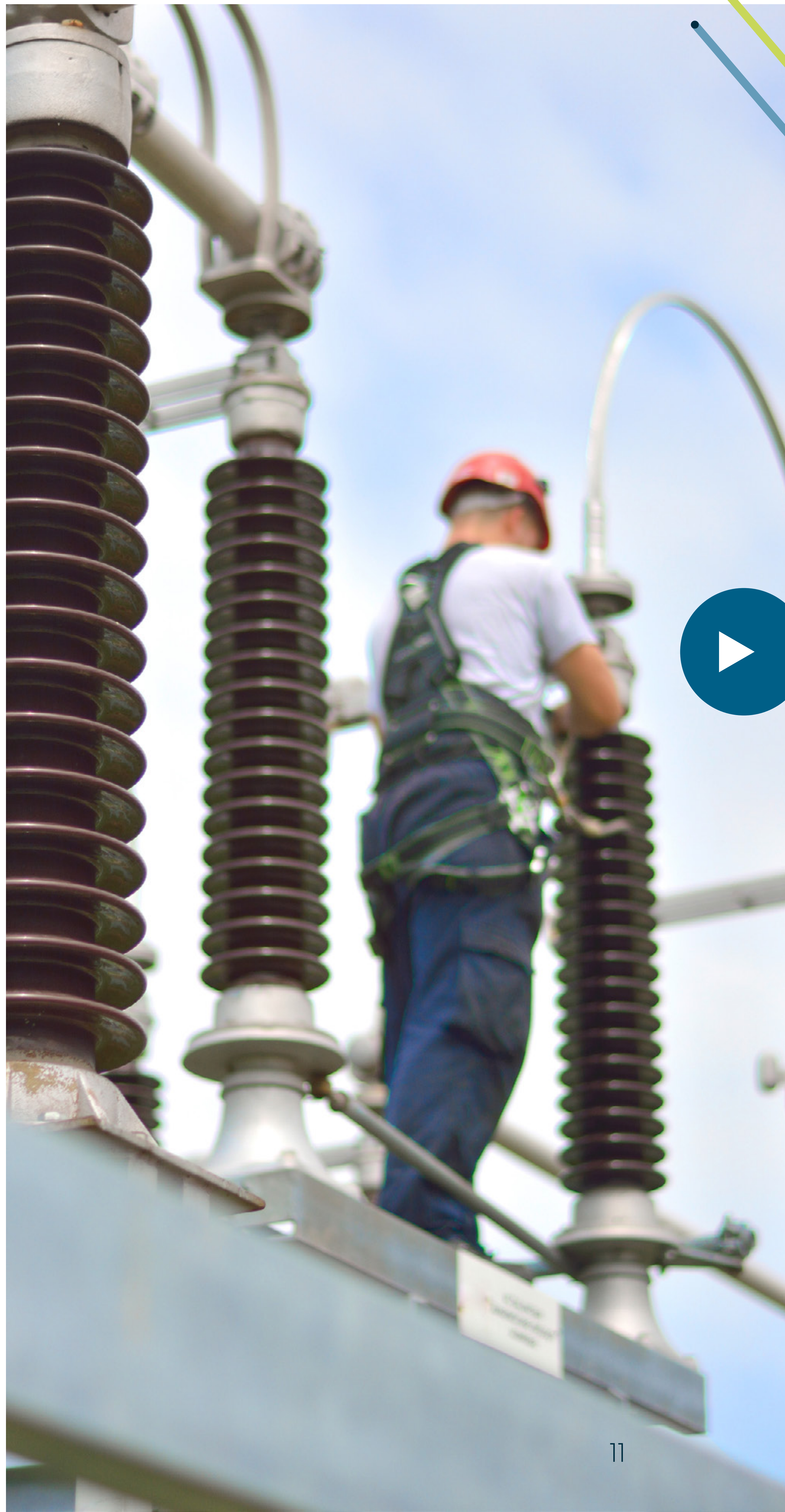
RECOMMENDATION 11 Develop policy for the carbon chain and determine how the Netherlands and Europe should deal with chain emissions on product imports and exports. *This relates to the position of energy-intensive (specifically carbon-intensive) industries on the road to a climate-neutral Netherlands in 2050. Ensure future policy takes into account that the transition from fossil fuels (natural gas and coal) to non-fossil sources means change. Instead of a surplus of fossil carbon molecules (CO_2), there will be a shortage of biogenic carbon molecules and CO_2 from the atmosphere. Policy must therefore make provision for meeting this demand (through imports or own production). It is also important to devise policy for the indirect and foreign emissions that can be attributed to the Dutch system in the carbon chain (i.e. scope 3 emissions). This means that imports of raw materials, fuels and products/semi-finished goods have to take account of emissions generated from production abroad. It also means that exports have to take account of emissions from processing or combustion abroad.*

RECOMMENDATION 12 Do not make the energy sector absorb residual emissions from other sectors. *While the energy system is rapidly becoming more sustainable, it is now coming up against the limits of what is possible in practice. Further acceleration is not possible. Major changes are needed if greenhouse gas emissions are to be reduced to zero. If other sectors respond inadequately or insufficiently quickly, the reflex response is to increase some or all of the tasks imposed on the energy sector. Ensure, therefore, that a customised package of measures is available for each sector so that adjustments can be made in the annual Climate and Energy Exploratory Study (KEV), without burdening other sectors.*

Relevant legislation and regulations, letters to Parliament, reports, policy documents and policy reviews to be presented to the House of Representatives in 2023

On 24 January 2023, the Ministry of Economic Affairs and Climate presented a comprehensive planning letter to the House of Representatives. This specified the documents expected to be sent to the House in 2023 and included legislation and regulations, letters to Parliament, reports, policy documents and policy reviews. Based on this planning letter, Netbeheer Nederland has examined which Parliamentary Papers (existing or future) are relevant to the above recommendations. This is shown in the following table:

Recommendation	Relevant Parliamentary Papers
1	NPE
2	NPE policy document and Parliamentary Report on Progress of Strategic and Green Industry Policy and/or Letter to Parliament on customised approach
3	*Zonnebrief* [Solar Letter], *SDE++*, *Normering Zonneladder* [Standards for Solar Ladders], Draft Main Energy Structure Programme, supplementary SDE++ conditions
4	Energy Act
5	NPE and Main Energy Structure Programme
6	NPE and Main Energy Structure Programme
7	Energy storage route map or Assessment of SDE++ and looking ahead to 2050
8	NPE policy document and Letter to Parliament on Conversion of Gas Power Plants
9	NPE policy document and Letter to Parliament on Energy Diplomacy or Use of Energy Councils
10	NPE policy document and Letter to Parliament on managing the acceleration of multi-year infrastructure energy and climate (MIEK) projects, and Instruments for scaling up renewable hydrogen
11	NPE policy document and Parliamentary Report on Progress of Strategic and Green Industry Policy and/or Letter to Parliament on customised approach
12	IBO (Interdepartmental Policy Study) on Climate; stricter monitoring and conclusions based on the Climate and Energy Exploratory Study (KEV)



Netbeheer Nederland

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