

Climate Change Dossier



The climate is changing; countless temperature and precipitation readings confirm this. In the past century the average temperature in the Netherlands has risen by more than one degree. There is considerable consensus that human activity is responsible. The warming is largely due to the emission of greenhouse gases, carbon dioxide (CO₂) being the major greenhouse gas. It is virtually certain that mankind will continue to influence the climate in the foreseeable future. The KNMI (Royal Netherlands Meteorological Institute) climate forecast reveals the impact of climate change on the Netherlands in the 21st century if measures are not taken to reduce the emission of greenhouse gases. These are:

- *Rise in average temperature of 1 to 6 degrees Celsius*
- *Rise in sea level of 20 to 110 cm (several metres after 2100)*
- *Rise in winter precipitation of 6 to 25 per cent*
- *Possible extreme summer precipitation of 2 to 10 times current levels and increased possibility of summer drought*
- *Rise in high river levels in the winter.*

Mitigation measures worldwide are necessary to ensure that the warming is halted. In the Netherlands the Cabinet presented the 'Clean and Efficient' programme in 2007 containing ambitious targets for reducing the emission of greenhouse gases, boosting energy-efficiency and more use of renewable energy. A certain level of climate change is inevitable, however, given that the global climate will not respond immediately and past greenhouse gas emissions mean that some of the warming is still 'in the pipeline'. The Netherlands must therefore be prepared for the likelihood of flooding and damage. The recommendation of the Delta Commission 2008 (Veerman Commission, September 2008) sketches the measures and investments needed to make the Netherlands climate-resistant in this respect. Warmer and drier summers will also require the built environment and farming to adapt. Nature policy will have to take account of shifts in the distribution range of species.

Solutions to the climate problem have to be sought through a multidisciplinary approach. Combining the knowledge of different fields is one of the strengths of TNO, an independent and internationally renowned knowledge institution. We focus on making knowledge applicable: in new products, services and processes, customised for our industry and government customers. TNO is committed to preventing climate change ("Netherlands climate-neutral") and diminishing the impact of the changes that do occur in the climate ("Netherlands climate-resistant"). The following sections provide an impression of the respective products and services in relation to the climate system, mitigation and adaptation.

The Climate System

Research into the climate and the weather in the Netherlands is largely the domain of the KNMI (Royal Netherlands Meteorological Institute), though TNO is also involved in this. The models used to make projections about the future climate are becoming increasingly more complex and detailed, with account taken of even more feedback in the climate system. This means that in addition to purely climate knowledge, information concerning the impact of land use and vegetation, for instance, as well as the emission of non-greenhouse gases must also be processed in the models. TNO is a key organisation for modelling the interaction between the effects of the climate and atmospheric pollution (local, national and international). Particles or aerosols have a cooling effect that is likely to have an impact in the shorter time frame and at continental scale. The models are validated using terrestrial and satellite observations. In this context TNO studies the feasibility of satellites as observers of greenhouse gases and atmospheric pollution. New measurement instruments are being developed for this purpose. The models are used by governments in Europe to find the most cost-effective combination of measures and standards to combat atmospheric pollution and the greenhouse gas effect.

TNO also studies climate changes that took place in the distant past as well as the presence of the 'heat island' effect around cities, which can heat up urban areas more strongly.

Climate mitigation

In order to cut greenhouse gas emissions such that global warming is minimized, many different measures are needed from all sectors (industry, transport, households, agriculture, etc.). At TNO we have knowledge of many methods and concepts to combat greenhouse gas emissions. These are outlined below. This practical knowledge allows us to answer policy questions from industry as well as local and national government concerning the reduction of greenhouse gas emissions. We consider which measures generate the best result in terms of greenhouse gases and atmospheric pollution, using models and scenarios customised for the scale of the questioner. TNO has also recently carried out energy and CDM (Clean Development Mechanism) projects in developing countries.

Greenhouse gas emissions

Climate change mitigation starts with excellent knowledge about the emission of the greenhouse gases that are released through the combustion of fossil fuels, cement production, deforestation and drying of peat bogs, farming and waste landfill sites. TNO has many years of experience in compiling emission registers at home and abroad. TNO also contributes to the international guidelines for reporting the emissions of atmospheric pollution and greenhouse gases, for example for the European Commission and the climate panel of the United Nations, the Intergovernmental Panel on Climate Change (IPCC). This has enabled us to gain enormous knowledge about the sources of greenhouse gas emissions and the emission factors of every possible process. This knowledge is put to use in assignments for the European Commission and for Dutch and foreign governments. For industry and industry associations too TNO can advise on changes in processes and operations that can reduce greenhouse gas emissions.

Mitigation in the energy sector

In the Netherlands 36 per cent of the emission of carbon dioxide is generated by the energy sector (2006). The Dutch Cabinet's 'Clean and Efficient' programme stipulates that the energy sector has to contribute a quarter of the reduction target for carbon dioxide by 2020. That can be achieved by raising the efficiency of the energy generated in power plants, using residual heat and by using alternative fuels and renewable energy. A key development towards sustainability is the decentralized generation of energy. TNO supports this through the development of "smart power systems", linking demand and supply in a flexible balance.

Research is also being carried out into gas infrastructure in relation to using hydrogen as an energy carrier or more use of "green gas" (gas from biomass). TNO also has the geoscientific knowledge, experience and software needed for the successful development of geothermal energy, a highly promising source of sustainable energy.

Despite these efforts, the world will still depend heavily on fossil fuels for the next few decades. So the challenge is to develop methods that will enable fossil fuels to be used without causing substantial emissions of CO₂. Cost-effective capture and storage of CO₂ (CCS) is a temporary measure that can be used to bridge the transition to a renewable energy supply on an industrial scale. TNO is playing a major role in knowledge development in this field, as in the development of technologies to capture carbon dioxide in electricity power plants and in the process industry at source and then store it in different types of subterranean structure. Broad geoscientific knowledge puts TNO in a unique position to evaluate and monitor individual storage reservoirs. Furthermore, TNO can make realistic capacity estimates for CCS by matching the dynamic supply of CO₂ with potential storage reservoirs in time and space. Finally, TNO supports Dutch and European governments in the development of legislation for the safe and controlled application of CCS.

Mitigation in the transport sector

The 'Clean and Efficient' Cabinet programme aims to give the Netherlands one of the most efficient transport systems in Europe by 2020, with sustainable and climate-neutral fuels a major contributor, making this initiative a contributor of some 20 per cent to the programme's emission targets. TNO supports these aims in all aspects of the transport system. TNO is collaborating with the car industry on the development of cleaner, more efficient engines. Our facilities can assess the new fuels. We advise the European Commission on CO₂ standards for vehicles and our knowledge of vehicle emissions is integrated into various traffic models that are used to advise on specific projects, measures and locations. Like advising local authorities on transport policy. Our analyses extend to logistics and improvements to the efficiency of entire transport systems. In the field of biofuels TNO investigates the production of biodiesel and ethanol from cellulose ("second generation biofuels"), greenhouse gas emissions and atmospheric pollution from biofuels and the consequences of more use of biofuels (production capacity, emissions, chain analysis).

Mitigation in the built environment

Globally buildings are potentially the greatest contributor to the reduction of greenhouse gases. Modifying buildings and installations and their use can save on energy and help alleviate the climate problem. In the building sector many measures can be taken at low cost, though the barriers are high. The building and construction sector is highly fragmented, which often causes conflicts of interest among principal contractor, subcontractor, architect, constructor and installation company in the role each plays. Therefore, TNO focuses on the whole process whereby new approaches are generated with all the different parties. In this respect TNO also supports the Energy Transition Platform for the Built Environment (PEGO) and plays a leading role in the development of new technologies and concepts for building and construction. Whether new building materials and components, lighting, cooling or heating. For instance, through research into heating and cooling storage, the use of micro power supply (WKK) in households and the integration of sustainable energy generation in constructional elements like walls and roofs. Ultimately it must be possible to build energy-neutral homes cost-effectively and on a large scale, taking account of the possible effects of future climate change. Modifications are

being developed that are both energy-efficient and maintain or boost living comfort. TNO is able to advise local authorities and housing associations about all the options for new building development plans as well as modifications to existing housing and commercial complexes.

Mitigation in industry

In addition to generic measures to save energy and reduce emissions of industrial greenhouse gases, like the use of more efficient electromotors, all kinds of process-specific options exist. Using chain analysis that can range from suppliers to choice of raw materials, TNO can advise on the savings potential for specific industry sectors and products. A key part of the energy consumed by the process industry will be in the separation of materials, liquids and gases. This is an area in which TNO makes a key contribution by investigating how to raise the efficiency of the separation processes. Furthermore, research focuses on the production of biofuel from waste flows and other applications of industrial biotechnology as well as the capture of carbon dioxide from flue gas.

Mitigation in greenhouse horticulture

Greenhouse horticulture uses around 10 per cent of the natural gas in the Netherlands. For horticultural businesses energy consumption is a major expense. More efficient energy consumption coupled with optimisation of the production process is necessary if the horticulturalist is to survive financially. TNO helps the horticultural sector improve the climate process (heat pumps, moisture management and semi-closed and closed greenhouses), with illumination and methods of using carbon dioxide to promote crop growth. In this way the battle against greenhouse gas emissions goes hand in hand with making the sector more financially robust.

Umbrella policy issues

TNO not only develops mitigation technologies but also contributes to the policy. We support initiatives that facilitate mitigation measures, such as sustainability labels, standards and verification systems. We develop strategic information so that other sectors are prepared for the large-scale introduction of mitigation measures. Since we always keep at the forefront of the very latest technology developments, TNO is perfectly positioned to respond to policy questions concerning the consequences of the large-scale application of mitigation technologies. This implies giving practical answers to questions about the impact of bio-energy applications or the effects of climate mitigation on energy supply and infrastructure (of a city, region or country) or the effects of switching to a largely electrical car fleet. TNO also has knowledge in house to advise in situations where many different technological and social changes occur simultaneously, as in the energy-neutral building of neighbourhoods or industrial parks, realising “climate-neutral municipalities” or financial products like “CO₂-neutrale credit cards”. Chain analysis, like ‘life cycle assessments’ or CO₂ footprints, offer support in mapping out future technology routes and ‘innovation agendas’ for sectors and industries. In all these analyses TNO combines knowledge of greenhouse gas emissions and the use of technology and behavioural change to reduce the emission.

Climate adaptation

Despite any reduction in the emission of greenhouse gases in the Netherlands and globally, a certain degree of climate change is inevitable. Depending on the speed and extent of mitigation measures, we will be confronted with changes in mean temperature, precipitation and wind, extreme weather conditions and rising sea levels. These changes affect safety and security, economy, ecology, society and social structures, health and the quality of the habitat in its broadest sense. The effects of climate change will not be restricted in the Netherlands to the coastal zone and hinterland. Urban centres will also feel the impact of climate change and the risk of damage and disruption will be high considerable given the high population density and economic value (industry, housing) as well as the fact that towns and cities in the Netherlands are situated for a substantial part in low-lying areas and are therefore vulnerable. The effects of climate change on the urban environment demand a specific approach. TNO has a strong position in terms of structure and design issues for urban and industrial areas. TNO wants to put its knowledge and experience to use to create optimum urban design that is able to withstand disruption and retain liveability.

Adaptation in the built environment

Adapting residential and commercial buildings as well as neighbourhood design will be necessary to ensure safe and comfortable living and working environments.

Climate robust building

The main implications of climate change for Dutch buildings relate to energy consumption and indoor climate. A rise in temperature will increase demand for cooling and lessen demand for heating. To prevent the demand for energy-slurping cooling equipment, TNO is working on new concepts for passive cooling, local energy generation and consumption as well as climate control. Examples are innovative (natural) ventilation, heat and cold storage plus thermochemical heat pumps. The use of new building materials can also help minimise the energy consumed by housing. Adapting to climate change goes hand in hand with preventing greenhouse gas emissions and even more global warming. In such circumstances the indoor climate in a home must remain at a qualitatively high level despite other weather conditions and installation concepts. For TNO this goes beyond technological intervention to consideration of how the space is used and the needs of the users.

Changing climate conditions may also affect the durability of building materials and the constructional safety of buildings. The combination of high temperatures and more precipitation adversely affects porous building materials like bricks and concrete. In designing flat roofs account will have to be taken of the impact of extreme precipitation. TNO has all the research facilities in house to study these effects and can advise on the possible consequences in terms of standards and design regulations.

Cooling neighbourhood

Buildings have a significant influence on the energy balance of a city.

Conventional buildings and paving absorb solar rays and retain a lot of heat. Clever use of the large surface of buildings, like painting roofs and walls white, mounting solar panels or laying verdant roofs, can contribute to a positive change in the energy balance. In a broader sense the entire configuration of buildings, roads, water and parkland are all co-determinative for the urban climate. In spatial planning account must therefore be taken of future climate change. Urban Strategy is the TNO software tool that visualises the effects of intervention in the urban environment in an interactive manner, such as the laying of roads and buildings or even a whole neighbourhood. The impact of this on the quality of the environment can be revealed straightaway. The effects are then calculated using different models for traffic, atmospheric pollution, security, noise the impact on health of these changes and groundwater. Supplementing Urban Strategy with models that describe the quantitative effects of urban structures, roads, water and parkland on the urban climate can support the planning process. Urban Strategy can also be used to take account in the planning phase of potential water disruption and risk of flooding.

In compact urban areas extreme precipitation or higher river levels can cause problems: there is too little space to stow the water. TNO can advise on methods to stow the water temporarily in the city, such as water yards or verdant roofs. Floating buildings could offer a solution for locations of high economic value such as city centres.

Adaptation of mobility and logistics

Extreme weather and high water caused by climate change are more frequently having an impact of Dutch mobility. Traffic jams are already a major problem in and around the major cities. The situation will be compounded by the weather unless a more robust road network is created. Account will have to be taken, for example, of road subsidence, railway expansion lower headroom at bridges. In the context of the 'Roads to the Future' innovation programme of the Ministry of Transport, Public Works and Water Management, TNO has developed a floating road that can be used as a temporary diversion when major maintenance is being carried out to bridges and roads, as a road in areas that are regularly submerged and as a connection in areas with a soft undersoil.

In the case of flooding or other disruptive weather like heavy storms that play havoc with traffic, traffic models combined with methods of communication (predetermined emergency routes or instructions via sms) help traffic and evacuations to flow more smoothly. TNO is active in both areas, developing traffic models (and using them to simulate extreme weather conditions) and communication resources for traffic and transport.

Health and liveability

Not only do rising temperatures have a direct influence on health but high nightly temperatures during heat waves can also disrupt sleep. A disrupted sleep can, in turn, affect health, productivity and learning performance. TNO is working to fill in the knowledge void that exists in the relationship between heat and health.

Adaptation and safety and security

More drainage by the Delta Rivers and a rising sea level mean more likelihood of flooding. TNO has accumulated substantial expertise in the analysis of flood scenarios over the years. One of the results of this knowledge is PC/Ring, a program developed for Rijkswaterstaat (Dept. Public Works), which calculated the possibility of dyke-related flooding. It shows the variables that are the most decisive, where the flooding is most likely to occur and the possibility of different scenarios. All the dykes in the Netherlands will be calculated over the next one and a half years using this program. Calculating the risks of flooding is necessary in order to be able to take the right measures.

Floods and other extreme weather conditions mean a higher risk for external safety and security. The release of hazardous substances from chemical installations could be attributed, for example, to the moving of tanks en installations, the collapse of buildings, moving waste or equipment waste. TNO can advise on precautionary measures for external safety and security risks as well as how these measures can be incorporated into the relevant policy.

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