# Environmental Outlook 2018

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**ENVIRONMENT AGENCY**

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# **Environmental Outlook** 2018

Solutions for a sustainable future

## COLOPHON

This report is published as part of the series MIRA Future Outlook Reports of the Flanders Environment Agency. The future outlook reports provide fresh insights and help to assess the impact of today's choices on the environment of tomorrow. With these reports, MIRA seeks to stimulate long-term thinking and support the debate.


You can read and download the publication and the background documents via **en.milieurapport.be**.

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# INTRODUCTION

In spite of the measures taken in the past decades, improvements in the quality of the environment in Flanders are too low or slow. This is demonstrated by the environmental indicators, which VMM-MIRA have been monitoring for years. Many of these indicators, such as emissions to air and water, show a positive but weakening trend. Moreover, the impact on humans, nature and the economy remains significant. Current efforts prove inadequate to push back the environmental impact of our major societal systems: energy, mobility and food.

At the same time, there is growing global demand for increasingly scarcer raw materials and resources. Climate change is becoming ever more apparent. But also other global trends, such as demographic changes, growing polarisation and accelerated technological developments, pose substantial challenges for our society. All these developments put further pressure on the energy, mobility and food systems. Business as usual is not an option.

To secure the prosperity and well-being of future generations without overburdening our planet, a fundamental change of our societal systems is urgently required. These sustainability transitions appear to be slowly emerging, but they are still in the embryonic stage. It is therefore important to create, in the short term, the right conditions for taking decisive accelerated steps towards a sustainable society. The *Environmental Outlook 2018* aims to provide insights into how such a transition can be made.

## A new step in the series *Outlook Reports*

The *Environmental Outlook 2030* (2009) already indicated that structural system changes in the short term are necessary to protect the environment in Flanders. However, the transition in Flanders can only be understood if we also take into account the far-reaching developments on a global scale. The report ***Megatrends: far-reaching, but also out of reach?*** (2014) described six global trends and their impact on the Flemish energy, mobility, production and consumption systems and on spatial planning. It also mapped the strategic consequences for Flemish environmental policy in the short and longer term.

The systemic approach was further elaborated in the indicator report *System Balance 2017*. We examined how the three major societal systems perform in relation to the environment and what solution paths are available to reduce their environmental impact. It also became clear that space can play an important facilitating role in this process.

In the Environmental Outlook 2018, we will elaborate on these solution paths. In doing so, we will demonstrate the urgent need for a systemic approach and dwell on the (transition) behaviour of systems. We will then comprehensively examine how the societal systems energy, mobility and food behave during a transition. We will describe a whole range of potential solutions in detail, estimating their potential in terms of (ecological) sustainability. We will look at how the various solutions can strengthen or interfere with each other. Spatial strategies will be selected that support the sustainability transition of the societal systems. Horizon scanning helps us to understand, and take into account, trends and uncertainties that play a role in the transition. All of this will result in a number of important overarching insights and generic levers that could facilitate the sustainability transition in the various societal systems.

## 2050: closer than we think

Almost ten years after the *Environmental Outlook 2030*, this report looks further ahead, to the year 2050. In fact, by 2050, Europe aims to have completed the transformation to a low-carbon economy. To this end, Belgium and Flanders need to reduce their greenhouse gas emissions by 80 to 95 per cent as compared to 1990: an ambitious objective that will have far-reaching implications on the way we live, work, move and relax. Our society will undergo massive changes in the coming decades. The systemic approach adopted in this report provides a framework for the necessary sustainable reconfiguration of each of our societal systems.

2050 is far closer than we think. Steps should now be further implemented and accelerated in the desired, sustainable direction. The *Environmental Outlook 2018* offers a broad and multi-faceted analysis of solutions, possible barriers and suitable levers to achieve a timely transition to an (ecologically) sustainable society in Flanders. We hope it provides you with opportunities and inspiration to help shape the societal systems of tomorrow. Because one thing is clear: the future concerns us all.


Gedragen
Logistiek
Oplossingen
Alternatieven
Hefbomen
Wonen
Integratie
Ruimte
Kernen
Nodig
Open
Infrastructuur
Voedingssysteem
Aandacht
Ontwikkelen
Debat
Maatschappelijk
Betrokken
Aangepast
Werken
Overkoepelend
Conventioneel
Langetermijnvisie
Energie
Geïntegreerd
Elektrisch
Rol
Voedselproductie
Delen
Landbouw
Actoren
Dominant
Opkomend
Maatschappij
Niveau
Cruciaal
Afstemming
Economisch
Bewustwording
Systemen
Druk
Inzichten
Inzetten
Veranderen
Visie
Ecologisch
Gunstig
Onderzoek
Regime
Creëren
Fase
Rekening
Basis
Groei
Schaalniveau
Systeem
Beleid
Ontwikkelingen
Fossiel
Belang
Bevorderen
Energiesysteem
Regionaal
Kennis
Weerstand
Doelstellingen
Verandering
Ruimtelijk
Omslag
Aanzienlijk
Niches
Focus
Duurzaam
Samen
Milieu
Voeding
Aanbod
Hernieuwbaar
Transitie
Schaarste
Huidig
Strategieën
Mobiliteit
Mobiliteitssysteem
Discours
Regelgeving
Lokaal
Partijen
Samenwerking
Ontwikkeling
Duurzaamheid
Vormen
Verschillen
Concreet
Draagvlak
Middelen
Gedrag
Innovatie
Mogelijk
Auto
Inertie

# WHAT YOU NEED TO KNOW WHEN READING THE *ENVIRONMENTAL OUTLOOK 2018*

**The *Environmental Outlook 2018* describes and analyses solutions that can contribute to an (ecologically) more sustainable energy, mobility and food system. We examined the environmental potential and possible *trade-offs* and *co-benefits*, and comprehensively mapped the potential barriers and available levers to achieve them.**

## Three building blocks and two additional studies

This synthesis report is based on various background studies and has been prepared with the help of a broad group of experts.

Three **building blocks** form the basis for this report:

1. An **analysis of the evolution of environmental indicators**, which shows the state of the environment in Flanders and the trends that can be discerned;
2. A **horizon scanning** in which megatrends are updated and societal developments are outlined that can affect the transition to sustainability;
3. **Sustainable solutions** for three important societal systems: energy, mobility and food.

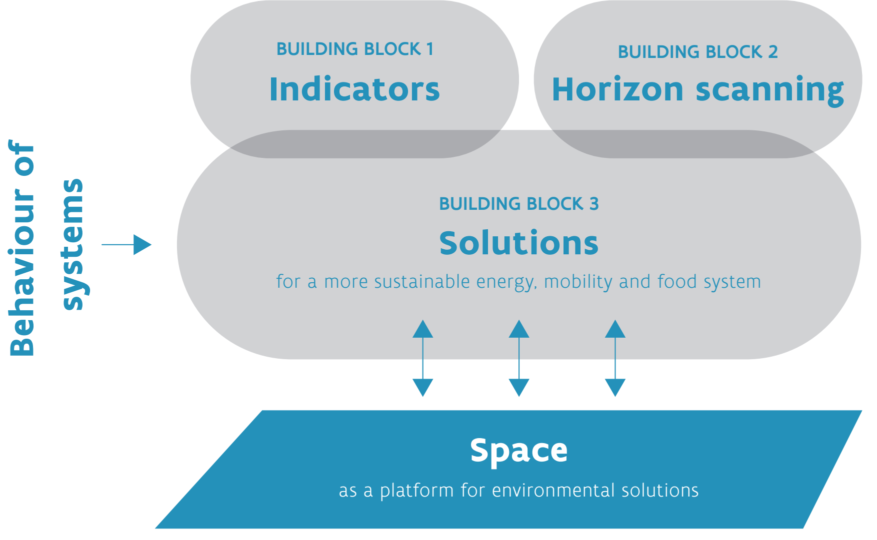
Two **additional studies** provide essential insights in this context:

- ***Towards a diagnostic of system change*** investigates how the societal systems in Flanders behave when they experience an impulse to transition.
- ***Space as an integrating platform for environmental solutions*** offers a selection and analysis of spatial strategies that enable and/or support sustainable solutions for various systems in an integrating manner.

The analysis of the evolution of environmental indicators, being the first building block of the *Environmental Outlook 2018*, is based on the comprehensive set of indicators – already over two hundred – monitored by MIRA at **www.milieurapport.be/indicatoren**. These indicators identify ongoing trends and tell us what this can learn us about the current environmental policy in Flanders.

For the other two building blocks and for the additional studies, we called on external expert-authors, who, in turn, worked with a broad group of (field) experts from various disciplines. For an overview of the different studies on which this report is based and their respective authors, please refer to the overview at the end of this report. The studies (in Dutch, with English summary) are available at **en.milieurapport.be/publications**.

## STRUCTURE OF THE STUDY FOR THE *ENVIRONMENTAL OUTLOOK 2018*

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## Focus on solutions

At the heart of the *Environmental Outlook 2018* is the building block "solutions". Each individual societal system has been subjected to an analysis of potential sustainable solutions through a combination of literature study and a targeted consultation of experts brought together in focus groups and panels.

- In a first step, the various possible **solutions and innovations were inventoried**. These fall within the scope of the solution paths already identified in the *MIRA System Balance 2017* and - deliberately - include a wide range of solutions, from existing to relatively new ones, and in some cases even methods and technologies that are still in an experimental phase.
- In a second step, the **environmental potential of the various solutions** and innovations was mapped as accurately as possible. Also possible *trade-offs* and *co-benefits* were identified within the broader framework of sustainability. These may also be relevant for other societal systems, and sometimes extend beyond the purely ecological level to include the social or economic level.
- Finally, the major **barriers and levers** for each of the solution pathways were analysed. To this end, one or more workshops were organised with a broad group of (field) experts, who examined the role to be played by innovation actors as well as the role reserved for the other actors, including the government.

## How is the *Environmental Outlook 2018* structured?

This report contains a concise presentation of the results from the comprehensive studies as a coherent whole.

In the first chapter, we will identify the dominant trends in the Flemish environment and their implications on the limitations of the current environmental policy. We will also describe the challenges and uncertainties that are inherent in global megatrends. Based on these findings, we will argue why system solutions are central to any reflection on sustainability transitions.

We will then devote three chapters to a detailed discussion of three societal systems: energy, mobility and food. First, we will outline the framework and the state of the transitions. Within the various solution paths, we will describe specific possible solutions with an assessment of their potential in terms of environmental impact and sustainability. We will also dwell on any barriers and possible levers that could facilitate the implementation of the solutions.

Integrative spatial approaches will be addressed in a separate chapter. This results in the formulation of priority spatial strategies that could enable and support environmental solutions across different societal systems.

Intermezzos between the chapters provide an insight into how specific methodologies were applied and the resultant insights. They take an in-depth look at the (transition) behaviour of systems and the importance of horizon scanning.

In a final chapter, we will formulate insights and findings that can be used by policy makers, but also by any other stakeholders, as a basis to help shape the transition to an ecologically sustainable Flanders in the years ahead.

1

# SYSTEMIC SOLUTIONS, A NECESSITY

**Despite the active environmental policy of the past decades, the improvements to our environment are too little and too slow. Many environmental indicators are improving, but various positive trends are slowing down. Other indicators illustrate the major impact on humans, nature and the economy. Moreover, our societal systems – energy, mobility, food – are also under pressure from global megatrends such as demographic developments and climate change. Conventional environmental policy is reaching its limits. To make our societal systems more resilient and more sustainable, a novel approach is needed that develops solutions from an integrative perspective.**

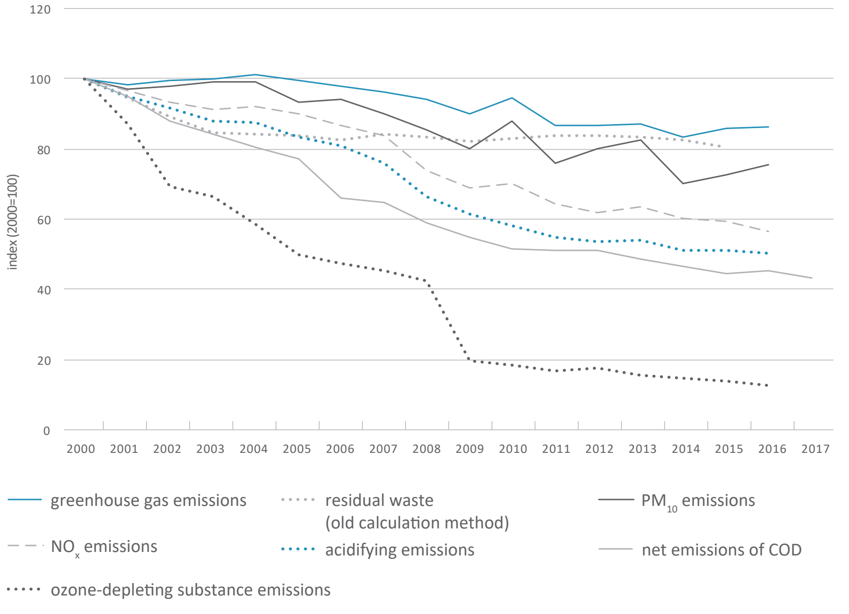
## 1.1 Environmental indicators show progress, but much work remains to be done

Indicators are particularly useful to document, analyse and monitor the state of the environment. By monitoring over two hundred indicators, MIRA keeps the finger on the pulse of the environment in Flanders (**www.milieurapport.be**). The question is how these Flemish environmental indicators have evolved over the past decades. There are certainly numerous positive trends, but recently they appear to have slowed down. Moreover, the impact on humans, nature and the economy remains significant and a substantial part of the environmental pressure in Flanders is also passed on to other regions. Some indicators even show a persistently negative trend. Despite the attention to, and relative growth of, environmentally friendly alternatives, their share is still small. The examples below illustrate these findings.

### Favourable trends are slowing down

Many environmental indicators in Flanders have developed positively, but recently these favourable trends have, to a greater or lesser extent, been slowing down (see figure on next page).

# WEAKENING FAVOURABLE TRENDS (FLANDERS, 2000-2017)

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Emissions of **ozone-depleting substances** detrimentally affect the stratospheric ozone layer (in the upper atmosphere, at 10 to 30 km altitude). The most important substances are chlorinated and brominated compounds such as chlorofluorocarbons (CFCs), hydrochlorofluorocarbons, halons, methyl bromide and carbon tetrachloride. They are used as refrigerants, blowing agents, propellants or solvents. Agreements have been made at international level to initially limit, and ultimately ban, the use of ozone-depleting substances. Emissions in Flanders fell by 87 per cent between 2000 and 2016, but the rate of decline has slowed in recent years. However, in the meantime, the first signs of a global restoration of the ozone layer can be seen.

The carrying capacity of nature (forests, heathland and species-rich grasslands) for atmospheric deposition is expressed as the critical load. The **acidification** critical load takes into account the combined effect of acidifying sulphur and nitrogen deposition. The percentage of total area of terrestrial ecosystems where the acidification critical load is exceeded, fell from 79 per cent in 2000 to 22 per cent in 2015. In recent years, the downward trend has clearly slowed down, and in 2016 the percentage even increased again to 26 per cent. Sulphur dioxide ($SO_2$), nitrogen oxides ($NO_x$, expressed as $NO_2$) and ammonia ($NH_3$) emissions do not equally contribute to potentially acidifying emissions. That is why the sum is expressed in acid equivalents (Aeq), which take into account the acidifying capacity of each substance. Acidifying emissions were halved between 2000 and 2016, but this positive trend has markedly slowed down in recent years. In the past, ammonia emissions from agriculture declined due to, among other factors, low-emission stables and manure processing. Desulphurisation of fuels has led to a significant decline in $SO_2$ emissions. However, the large number of diesel cars in the passenger car fleet has an adverse effect on $NO_x$ emissions.

**$NO_x$** emissions contribute not only to acidification, but, in combination with non-methane volatile organic compounds, to the formation of ozone in the troposphere (the lowest layers of the atmosphere), where it is harmful to the environment and people. The significant reduction in $NO_x$ emissions is the result of new standards and environmental policy agreements in industry and the energy sector and the increasingly stringent Euro emission standards for vehicles.

The annual average **$PM_{10}$** and **$PM_{2.5}$** concentrations show a remarkable improvement. Since recently, however, these favourable trends appear to be slowing down. The downward trend is related to the reduction in emissions of primary particulate matter and precursors (such as $NO_x$, $NH_3$ and $SO_2$ – see also above) that give rise to secondary particulate matter. But these emissions, too, have shown little, if any, improvement in recent years. An increased share of natural gas, more flue gas purification, the reduced deployment of conventional power plants, and increased energy imports from abroad account for the decreasing primary particulate matter emissions in the energy sector. The introduction of emission limit values for large combustion plants, the gradual switch from solid fuels to natural gas, and the introduction of flue gas filters all played an important role in industry. In the transport sector, and road transport in particular, exhaust emissions have decreased due to the renewal of the vehicle fleet. Households are important contributors to particulate matter emissions, mainly from solid fuel heating. These emissions depend largely on temperatures in winter.

Total **greenhouse gas** emissions in Flanders showed a modest positive trend between 2004 and 2011, when they declined by 14 per cent. Since then, however, the trend has largely stagnated. This is the net result of the emissions reduction in the energy sector, the stagnating trend in industry and households, and the increasing emissions in agriculture, transport and trade & services. Greenhouse gas emissions reduced primarily due to specific measures for fluorinated gases, nitrous oxide and methane in industry and agriculture. Also $CO_2$ emissions, which are generated mainly from the combustion of fossil fuels, have been declining since 2005. This decrease is due, among other things, to the higher energy efficiency in industry, the closure of conventional power plants, and the co-combustion of biomass in the energy sector. Moreover, households are increasingly saving energy and switching to renewable energy forms for electricity and heat generation. Despite the increasing fuel efficiency of vehicles and vessels and the increasing use of biofuels, greenhouse gas emissions from passenger and freight transport have increased compared to 2000.

Sufficient dissolved oxygen in the water is an important prerequisite for a diversified ecosystem. The **average oxygen concentration in the surface water** gradually increased in the period 2000-2013, but this favourable trend has largely ground to a halt since then. This can to a large extent be explained by the evolution of the pollutant load to the surface water or the net emissions of chemical oxygen demand (COD), which experienced a steep fall, but the downward trend has been far less pronounced in recent years. The decline in net emissions by industries is a result of the efforts made by companies and the development of the public water treatment system. The percentage of inhabitants whose wastewater is treated by a public wastewater treatment plant (WWTP) has increased significantly, from 48 per cent in 2000 to 84 per cent in 2017. Moreover, the treatment efficiency of the WWTPs has improved. Also, an increasing number of homes not connected to the sewage system now have an individual wastewater treatment unit. The rate at which additional households are connected to public WWTPs, however, is beginning to slow down. Also the average treatment efficiency (for COD) of the WWTPs has stopped increasing.

Excessive **nitrate and phosphate concentrations in surface water** can lead to eutrophication or excessive algae growth. The percentage of monitoring sites in agricultural areas where the nitrate threshold is exceeded, improved significantly between 2005-2006 and 2013-2014 as a result of the manure action plans. However, the improvement has stalled. Phosphate has not shown a positive trend since 2003. One reason for the current phosphate losses from agricultural land to the surface water is historical: saturation of the soil's sorption capacity.

In 2016, 3.19 million tonnes of **household waste** were collected, or 490 kg per inhabitant. Of this waste, 69 per cent was collected selectively, mainly for the purpose of recovering materials (through recycling), fermentation or composting. Most non-selectively collected waste (residual waste) is incinerated with energy recovery. Between 1991 and 2004, the selective collection rate for household waste rose from 18 per cent to over 71 per cent. This was accompanied by a halving of the amount of residual waste. Since then, however, these positive trends have not continued to the same extent. The level of selective collection has stagnated and the reduction in residual waste has slowed down significantly.

## Environmental disruption has a great impact on humans, nature and the economy

Despite the environmental policy of the past decades, the negative impact of certain environmental problems continues to weigh on our society. This has an impact both on humans and nature and on the economic fabric, and therefore represents a significant social cost.

Exposure to environmental pollutants can lead to a variety of **health effects**. In Flanders, environmental pollution leads to a total annual health impact of over 100,000 lost healthy life years. Lifetime exposure to current pollution levels means that every Flemish citizen loses, on average, one healthy life year. The health impact for sensitive groups is probably greater. In 2010, particulate matter accounted for over two-thirds of the health impact of environmental pollution in Flanders. Short-term effects of particulate matter include heart and lung problems, potentially leading, in the long term, to premature death and chronic bronchitis. Long-term exposure to smaller particulate matter ($PM_{2.5}$ and less) does the most damage to health. In 2015, the external health costs due to particulate matter in Flanders amounted to around 4 billion euros. Noise can cause sleep disturbances, stress and even cardiovascular disorders. With 7 per cent, noise is the second-most important factor in the health impact of environmental pollution in Flanders. This is because a major part of the population is exposed to traffic noise due to the dense road network, the growing car fleet, the increasing number of kilometres driven, and the high population density.

The objective of the European Water Framework Directive is to achieve **'good status' for all water bodies**. For natural surface waters, this means, among other things, good ecological status. For artificial and heavily modified surface waters, the targets can be lower (= good ecological potential). Biological quality elements (such as macroinvertebrates, aquatic plants and fish), hydromorphological characteristics (such as meandering and bank structure) and physico-chemical parameters (such as oxygen and nutrients) together determine the ecological status. Only one of the 499 assessed water bodies met the target - good ecological status - in the period 2010-2015. Around 80 per cent of the water bodies have 'bad' or 'poor' status. This means there is still a long way to go before the targets of the Water Framework Directive are met. Although the quality of the surface water is improving, it is still insufficient in most places.  Phosphorus presents the biggest problem. Moreover, the majority of the water bodies are only of moderate or poor hydromorphological quality. The sub-standard physico-chemical and hydromorphological quality hampers the development of a healthy and diverse aquatic ecosystem.

When airborne nitrogen compounds are deposited on the soil surface, they act as nutrients. An excessive amount of nitrogen in ecosystems leads to changes in the composition of plant communities. This **eutrophication** therefore causes damage to nature. In 2016, the critical load for eutrophication was exceeded on 82 per cent of the total Flemish surface area of terrestrial ecosystems. This was the case in all forest and heathland areas in Flanders. For species-rich grassland, 39 per cent of the surface area suffered from excessive nitrogen depositions.

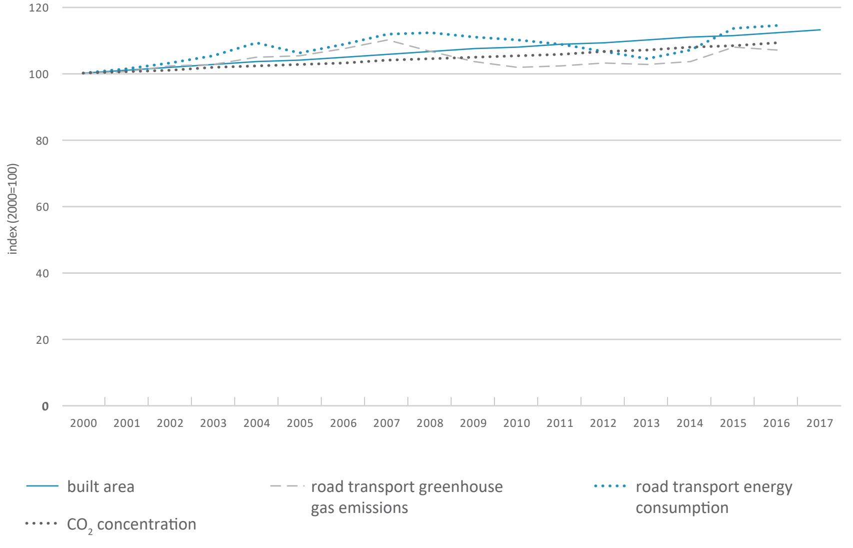
**More extreme weather patterns** also have a clear impact on our society. Floods and heat are natural phenomena that are intensified by human activities. Thus, the increase in paved surfaces increases the likelihood of floods and housing and economic activities in flood-prone areas make for a greater potential impact. In Flanders, more than 220,000 people are potential victims of exceptional floods (order of magnitude once per thousand years). The annual average damage caused by flooding for the whole of Flanders amounts to over 50 million euros. The impact of periods of hot weather is often less visible than the damage caused by, for example, floods or hurricanes. However, exposure to heat appears to claim considerably more victims. In the period 2000-2017, Belgium recorded the highest excess mortality rates during the warm summers of 2003, 2006 and 2010. In all three cases, increases of over 6 per cent, or more than 2,000 extra mortalities, were recorded during heat periods. Especially in cities, people are exposed to heat stress as a result of climate change. Due to the blocking of wind and the retention of heat in concrete, asphalt and bricks, temperatures in cities can be much higher than in the surrounding areas. Cities may thus develop into actual heat islands.

Footprint indicators, such as ecological footprint and carbon footprint, indicate how many resources a country or region uses worldwide for its consumption and/or the amount of pollution that is caused worldwide by that consumption. It also takes into account the environmental pressure created outside of Flanders as a result of our consumption. The ecological footprint is expressed in global hectares (gha), which is one hectare of land or sea surface of global average biological productivity. The **ecological footprint** of the average Flemish citizen is approximately 9 gha. However, the biologically productive land on Earth is only 1.8 gha per inhabitant.  The ecological footprint of the average Flemish citizen is therefore too high by a factor of 5. The carbon footprint of Flanders is the total amount of greenhouse gases produced worldwide as a result of Flemish consumption. The **carbon footprint** in Flanders amounts to about 20 tonnes per inhabitant. To limit the average global temperature rise to 2 degrees Celsius, global greenhouse gas emissions need to be reduced to an average of 2 tonnes per capita by 2050. Both the ecological footprint and the carbon footprint of Flanders is therefore many times higher than what is ecologically sustainable in the long term. Limited changes in consumption patterns and in production efficiency will therefore not be sufficient.

## A few unfavourable trends persist

Some indicators show a thoroughly negative trend (see figure below). Even though these problems have been known for some time and despite the numerous policy measures taken, no change has been forthcoming.

**UNFAVOURABLE TRENDS**
(FLANDERS, 2000-2017)

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The **amount of built area** in Flanders continues to grow. On 1 January 2017, over one-quarter of the total surface area of Flanders consisted of built land. This represents an increase in the percentage of built plots by almost 30 per cent compared to 1990, and is attributable mainly to new-build homes and business premises. The construction of houses, roads, public buildings, businesses and other structures seals off soil and adversely affects natural soil formation and functions such as infiltration and water storage. In addition, building activities outside the centres of cities and municipalities exert strong pressure on, and fragmentation of, open spaces (such as agricultural land, forests or dunes). Also climate change and the resulting rainfall and heat extremes require space for the construction of floodplains and infiltration areas, for green space in urbanised areas and for renewable energy production.

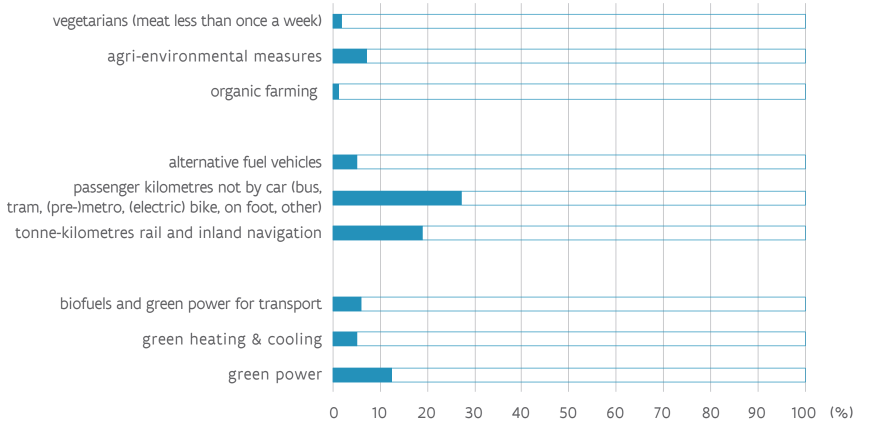
**Energy use and greenhouse gas emissions from transport** also continue to rise. The transport sector accounts for a major share of energy consumption and all kinds of emissions to the atmosphere, such as greenhouse gases, particulate matter and nitrogen oxides. Despite the increase in passenger and freight transport by road, the sector did manage to reduce its nitrogen oxide and $PM_{2.5}$ emissions by 41 and 64 per cent respectively between 2000 and 2016. Energy consumption and greenhouse gas emissions by the transport sector, however, continued to increase. Even though passenger cars and lorries are becoming more energy efficient, total energy consumption nevertheless increases due to the increase in the number of kilometres travelled. This led to a 7 per cent increase in greenhouse gas emissions between 2000 and 2016.

In 2016, the annual average **atmospheric $CO_2$ concentration** exceeded the threshold of 400 ppmv. At 403.3 ppmv, the concentration is now 45 per cent higher than the pre-industrial level of 278 ppmv. Of all the carbon dioxide emitted by human activities, about half remains in the atmosphere. The dwell time in the atmosphere is also long enough to obtain a globally homogeneous mixture. The exact location of emissions is therefore not really relevant. The current rate at which the atmospheric $CO_2$ concentration is increasing has also never been higher in the past twenty years. This is caused by the growing emissions at global level. Due to the increase in greenhouse gas concentrations, the average temperature on Earth rose by nearly 0.9°C between 1850 and 2017. In Belgium (Ukkel), it is now an average 2.5°C warmer than in the pre-industrial period. The effects of climate change as can already be observed today in Belgium, include more frequent heat waves, wetter winters, more extreme rainfall and a rise in the sea level.

## Limited breakthrough of innovations

Ecologically more sustainable innovations cover a broad spectrum, from wind farms, solar panels, electric cars and bikes to reduced meat consumption. Interest is clearly growing, both among policy-makers, research institutions, citizens and businesses. This is evident from policy visions, research budgets, media coverage and new forms of economic activity. However, the breakthrough of sustainable innovations has thus far been limited (see figure opposite).

# LIMITED BREAKTHROUGH INNOVATIONS (FLANDERS)




www.milieurapport.be, Department of Agriculture and Fisheries, Mobility Behaviour Survey Flanders 5.2 (commissioned by the Department for Mobility and Public Works)

## Energy system

Green heat covers a variety of technologies whereby heat is generated from renewable energy sources. These include not only large-scale applications of biomass, but also relatively small-scale applications of thermal solar energy, wood boilers and burners, cold/heat storage and heat pumps. Some of these techniques can also be used for cooling. The share of **green heating and cooling** in gross final energy consumption for heating and cooling has increased from 2.7 per cent in 2005 to 5.1 per cent in 2016.

**Green power** is produced from renewable energy sources such as hydropower, solar power, wind energy, biomass, geothermal energy, wave energy and tidal energy. The share of green power in gross final electricity consumption has gone up from 1.8 per cent in 2005 to 12.3 per cent in 2016.

Biofuels are all fuels produced from vegetable or animal material that are used for transport. When used in replacement of fossil fuels, they help reduce greenhouse gas emissions from transport. The share of renewable energy used for transport – **green power and biofuels** – increased to 5.9 per cent in 2016.

## Mobility system

**On the whole, vehicles using alternative fuels and/or with alternative propulsion systems**, such as natural gas, hydrogen, hybrid technology and electric battery, are more environmentally friendly than conventional fuel vehicles. The total number of new cars using alternative energy sources has increased by a factor of 19 in the period 2008-2016. However, they still represented only slightly less than 5 per cent of all new passenger cars in 2016.

**Sustainable transport modes** such as train (11.5 per cent), bus/tram/(pre-)metro (3.6 per cent), (electric) bike (4.5 per cent) and on foot (1.8 per cent) and others (5.7 per cent) together account for only 27 per cent of personal kilometres travelled in 2016. The car still accounts for the remaining 73 per cent. In freight transport, **rail and inland navigation** had a combined share of 19 per cent in the total number of tonne-kilometres in 2015. Here, too, road transport dominates the modal split with a share of 81 per cent.

## Food system

As the pioneer of environmentally friendly farming methods, **organic farming** focuses strongly on preserving and improving soil fertility and achieving closed cycles. This involves, among other things, intensive crop rotation, suitable tillage practices and use of green manures and organic fertilisers. Chemical-synthetic pesticides, chemical fertilisers, feed with growth stimulants or antibiotics and genetically modified organisms are prohibited. The balance between animal and vegetable production is preserved by limiting stocking densities. In 2017, the area of organic farming was 7,367 hectares, more than twice the area in 2005 but still only 1.2 per cent of the total Flemish agricultural area.

An **agri-environmental measure** is a voluntary agreement between the farmer and the Flemish Land Agency (VLM) or the Agriculture and Fisheries Department. The agreement, which is generally concluded at plot level and runs over a period of five years, can relate to nature management at a farm, the achievement of certain environmental targets, the implementation of environmentally friendly agricultural production methods or the preservation of genetic diversity. The agricultural area under agri-environmental measures rose until 2008, but has since declined to around 7 per cent of the Flemish agricultural area in 2014.

**Eating fewer animal products** offers significant potential to improve the ecological sustainability of the food system. Meat consumption in Belgium fell by 22 per cent between 2005 and 2016. Yet the number of Flemish people consuming meat less than once a week is not even 2 per cent.

## 1.2 Megatrends are becoming increasingly present

MIRA attempts to present a systemic outlook. In recent years, a number of so-called megatrends were identified. These global trends appear to be so comprehensive and, above all, far-reaching for the environment in Flanders that they cannot be ignored in environmental policy.

### What are megatrends and why do they matter?

Flanders cannot function as an island in today's highly globalised world. The environmental issues in our region and the societal developments that impact them, are in turn influenced by larger global trends. The term 'megatrends' is used to denote long-term, already apparent change processes with a very broad scope. Megatrends have profound, far-reaching and potentially even critical implications. They are already apparent today and can change society over a longer period of time. It cannot be predicted how this will exactly occur. Megatrends are in fact surrounded by considerable uncertainties and also mutually influence each other.

Flanders itself has no grip on such autonomous and powerful trends. Conversely, however, megatrends will fundamentally impact (environmental) policy in Flanders. In the MIRA report *Megatrends: far-reaching, but also out of reach? How do megatrends influence the environment in Flanders?* (2014, **en.milieurapport.be/publications**), we analysed six megatrends:

- changing demographic balances;
- accelerated technological developments;
- growing scarcity of raw materials and resources;
- growing multipolarity in society;
- climate change;
- increasing vulnerability of systems.

The analysis of the megatrends and their effects on the environment in Flanders - now and in the future - indicated that their impact is unavoidable. It manifests itself primarily through the societal systems - energy, mobility, production and consumption (including food) - and through spatial planning. These systems are made up of interconnected and matched elements such as technologies and infrastructures, policy, practices and institutions. But also the relevant societal actors, markets and networks are an integral part of the system. All these elements represent entry points where megatrends impact our societal systems. For Flemish environmental policy to be robust, resilient and effective today as well as tomorrow, it will have to take into account these large-scale developments and their implications.

### Megatrends reinforce the need for systemic solutions

The results of the horizon scanning study carried out on behalf of MIRA (2017-2018) suggest that the six identified megatrends are still very relevant today. Their impact on society and the environment has become even more pronounced, also in Flanders.

In Flanders, **changing demographic balances** have contributed to a change in housing, living and working patterns, for example single-parent families, more leisure activities, teleworking, second earners, and more active seniors. This has led to a growing demand for space for housing, living and working. Growing urbanisation is noticeable, but is often not achieved through clustering or (spatial) densification of urban centres. This blurs the distinction between urban centres and open spaces, and has resulted in Flanders being referred to as 'urban haze'. A spatial vision that strengthens urban centres should promote the development of desirable sustainable options such as heating grids, high-quality public transport and more sustainable and extensive forms of agriculture.

**Technological innovations occur at an ever increasing pace** and profoundly change the way in which we work, live, communicate and consume. Technological innovations can be unexpected and disruptive, such as social media, 3D printing, artificial intelligence or blockchain technology. More than ever, the focus is on technology to maintain economic prosperity and address major challenges, from renewable energy and energy storage over more sustainable mobility alternatives to non-land-bound high-tech forms of agriculture. The risks posed by new technologies need to be managed and mitigated. It can thus be avoided that blind faith in technological solutions to environmental problems stands in the way of a profound transition, for which behavioural change is also required. More attention for the social aspects of technological innovation and the integration of technology into social innovations appears to be of great importance.

**The growing shortage of raw materials and resources** remains a point of concern in the face of the growing world population and economy. Both political and economic factors appear to play an important role. There is, however, increasing interest in the circular economy, which is also a priority in Flanders. This gradually results in increased attention for reuse, recovery, recycling and the closing of material loops. This counter trend is therefore gaining in importance, both with businesses and with governments. Behavioural change with consumers plays an important role in achieving this circularity. Even though initiatives are taken to reduce dependence on materials, they have thus far failed to generate sufficient impact. The decoupling between economic growth and materials intensity remains relatively limited, certainly at the global level.

There appears to be a **growing multipolarity in society**, both in the global economy, political power, social relationships, social patterns, and in behaviour and consumption. This trend is reflected both globally and at national, regional and individual levels. International consultation structures, including climate agreements, are being challenged or abandoned by certain countries. There is a growing polarisation in social movements and counter movements. Also the principle of solidarity, the basis of our welfare society, is being challenged. There is an increasing risk of privacy erosion and there are also fundamental doubts about the reliability of information. Public uncertainty and distrust in government decisions can weaken the support for sustainability transitions. Therefore, it seems to be of major importance to establish a new overall social pact inspired by common challenges, such as tackling climate change.

**Climate change** is an extremely far-reaching megatrend, the effects of which are becoming increasingly apparent, also in Flanders. Growing digitalisation and rising global purchasing power further push up global energy demand. Our high consumption of resources and raw materials accounts for a large part of our total greenhouse gas emissions. A radical change of course is needed to stop climate change before it is too late. In Flanders, summers are becoming hotter and drier, extreme weather conditions occur more frequently, winters are becoming wetter, and there is a greater risk of flooding. This is reflected in the food system, with more variable or declining crop yields. Space is believed to be an important factor in the transition to a low-carbon society. In the energy system, for example, there are sufficient possibilities for the construction of heating grids and wind turbines; in the mobility system, the focus is on strengthening of urban centres, thereby reducing demand for transport and the associated $CO_2$ emissions.

The existing **societal systems are becoming vulnerable** because they have difficulty in keeping pace with global changes. The interconnectedness of societal systems further adds to this vulnerability. The financial and monetary system in particular is a key driving force in this respect. Despite the need for radical choices regarding the approach to tackling climate change, for example, environmental protection is still too often considered outside the financial-monetary and economic realm. Changing this proves to be all the more difficult in Flanders, where there is still not enough attention being paid to the coherence between systems and to a coherent spatial vision. The systematic and significant weakening of virtually all systems constitutes some kind of 'meta-trend' that further strengthens the other five megatrends. A marked increase in bottom-up initiatives, such as citizen committees or cooperatives, represents a counter trend of which the effects are limited for the time being.

## 1.3 Systemic approach as a necessary new perspective

The evolution of environmental indicators shows that the environmental policy efforts fail to produce the desired results. The approach that has been adopted thus far, is reaching its limits. A continuation of the conventional (environmental) policy does not appear to adequately address persistent problems in a sufficiently far-reaching and fast enough manner. Hence the need for other approaches. It is apparent that system transitions for sustainability are essential to providing solutions to persistent environmental problems in order to ensure prosperity and well-being in the future. The challenges and uncertainties brought upon us by megatrends emphasise the need for structural interventions in the deeply embedded organisation of our societal systems. Only in this way can a transition to systems that are ecologically sustainable, be resilient and future-proof.

Structural changes or transitions in societal systems appear to take place quite abruptly, often within a time span of decades. Both administrative systems and social organisations are under pressure to adapt to this rapidly and profoundly changing context. Traditional policy instruments are inadequate to enable the successful transition to an ecologically sustainable society. The government cannot initiate the radical system innovations that are needed by relying only on conventional tools such as regulation and pricing instruments. A systemic approach is considered to be a necessary new perspective. The complex relationships within - and between - systems urgently require more attention. Systems thinking is crucial to understanding and trying to influence the behaviour of societal systems in transition. Only a systematic approach provides us with a good understanding of the technological, institutional, social and cultural innovations that will play a crucial role in these transitions.

# INTERMEZZO

# BEHAVIOUR OF SYSTEMS

**Knowledge on the behaviour of societal systems helps us better understand transitions. Support in this context is provided by models describing how systems behave and how they react to transition impulses. These insights help policy to develop a coordinated mix of systemic solutions.**

## Systems in equilibrium and transition impulses

Societies worldwide are going through rapid and dramatic changes. These changes are caused by global developments - megatrends - and burgeoning innovations ('niches') that challenge the existing situation ('pressure'). There are, however, also internal tensions in the dominant and stable configuration of the societal systems ('regimes').

Thus, the effects of the accumulation of greenhouse gases in our atmosphere are becoming increasingly apparent on a global scale. New technologies based on non-fossil, renewable energy sources are emerging. They lay the foundations for the change of various societal systems, including energy and mobility. However, also the internal tension in existing systems is becoming ever more apparent. The low cost of our fossil fuel-based mobility system leads, for example, to traffic jams and adverse health effects. In short, what we have here is a 'transition impulse', which drives to leave the existing situation.

Every societal system - and therefore also energy, mobility and food - is made up of human actors, institutions and infrastructures that interact with each other and with the environment. When a system is in equilibrium, numerous internal processes are active to preserve this equilibrium. Internal and external triggers will initially not lead to change: the system is robust enough to resist them. Because of vested interests, investments made and economies of scale, the existing stable state is maintained for as long as possible ('inertia'). However, when triggers persist and become stronger, a tipping point can be reached. Minor changes or disturbances can then lead to unexpectedly large and rapid system changes. The system will then leave its stable state and reconfigure itself relatively quickly (over a few decades) until a new equilibrium is reached. The impulse thus leads to a transition.

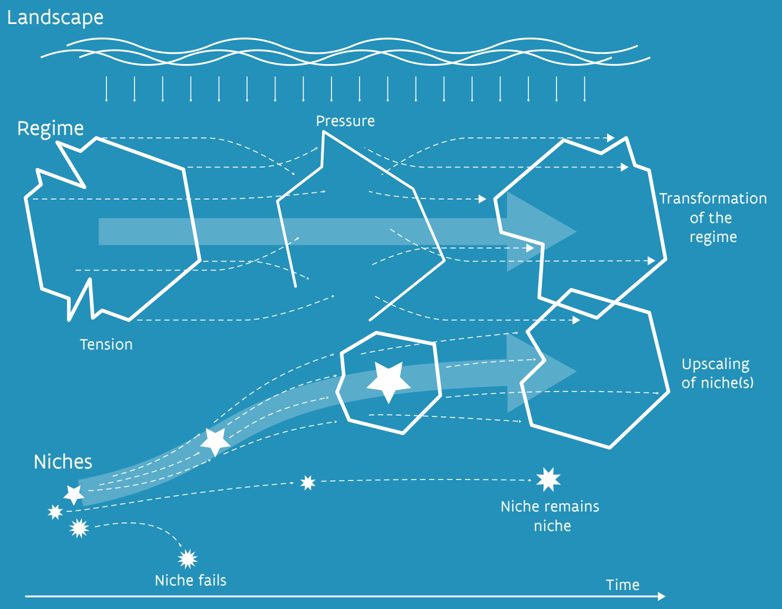
## Transition as a result of interactions between regime, niches and landscape

The study of the complexity of systems has developed mainly since the second half of the twentieth century. New insights into the natural sciences on chaotic behaviour and self-organising systems played an important role in this development. Thus, it appears that not only entire ecosystems, but even certain single-celled organisms can, under certain conditions, organise themselves into a system (the organism) based on relatively simple interactions between individual cells. This enables the system to smoothly adapt to changing conditions and even shocks. This complex adaptive behaviour has been identified in many biological and social systems, from termite colonies to financial markets. Based on these insights, systems thinking seeks to understand how societal systems behave when they are exposed to a strong transition impulse, as is the case today.

### MULTILEVEL PERSPECTIVE

Research into complex systems and their transitions generally considers change as a co-evolutionary, multilevel process. Dominant regimes within societal systems experience not only internal tension, but also external pressure from the 'landscape'. These can be developments within their own society or impacts from global megatrends. In addition, new niches emerge that challenge the status quo within a societal system, thereby adding further pressure. The complex, multilevel dynamics resulting from this interaction is visually represented in a multilevel perspective.

### MULTILEVEL PERSPECTIVE ON TRANSITION



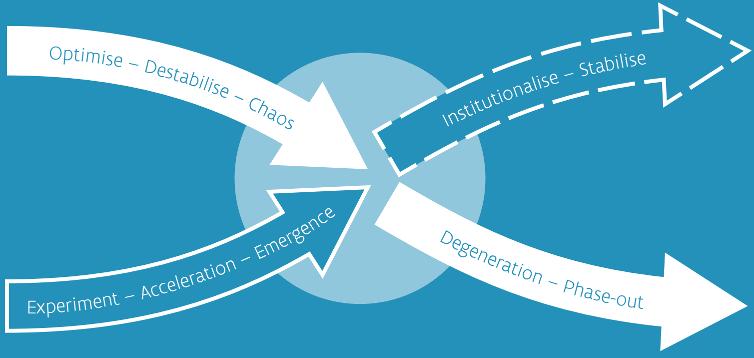

VITO, EnergyVille, shiftN, University of Ghent, Background document *Naar een diagnostiek van systeemverandering* (to: Geels 2002)

From this perspective, it becomes clear how existing regimes transform themselves under the influence of internal tension and external pressure. At the same time, certain niches gradually develop into new co-regimes. Other niches remain more marginal, or fail and disappear again. Transition is a multi-domain process whereby technological innovation interacts with societal, cultural and institutional changes. Four phases are generally distinguished: an emergence phase; a take-off phase in which the niche innovations begin to destabilise the regime; an acceleration phase with a tipping point for sudden reconfiguration, and finally, the stabilisation of the newly established regimes.

#### EMERGENCE AND (PARTIAL) DEGENERATION

In recent years, in addition to the attention given to the development of niches, there has also been growing interest in the processes of degeneration within existing regimes during the transition. The combination of both is represented by means a double S-curve (or X-curve).

### DOUBLE S-CURVE (X-CURVE)




VITO, EnergyVille, shiftN, University of Ghent, Background document *Naar een diagnostiek van systeemverandering* (to: Loorbach, Frantzeskaki, Avelino 2017)

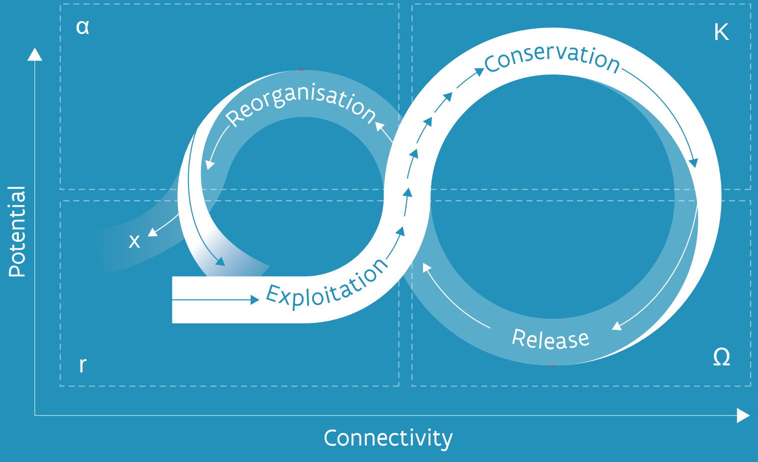
The ascending curve represents the development of new niches to regimes. After a period of experimentation, new emerging niches go through a phase of acceleration and emergence. When they have sufficient potential to offer answers to societal needs, they eventually become institutionalised and stabilised into new (niche) regimes. The descending S represents the degeneration of (parts of) the existing regime. If optimisation no longer allows the regime to withstand the external pressure and internal tensions, a phase of destabilisation sets in. If this pushes the regime into a far-from-equilibrium state, it may end up in a critical state. This state is situated at the boundary of chaos, where minimal disturbances can give rise to major changes ('tipping'). In some cases, this can lead to degeneration and phase-out; a recent example being the rapidly falling sales of diesel cars following the emissions scandals in the automotive sector and the increased attention for the health effects of particulate matter. This has led to a rapid shift away from diesel cars, which could suggest a possible degeneration and eventually a phase-out of diesel passenger cars.

Degeneration of the existing regime does not always take place in societal transitions. In most cases, it is a reconfiguration of the regime or the prevention of niches that temporarily develop into co-regimes. 'Co-evolution' is a term that more aptly describes the complex change in regimes and niches within a system in transition. It obviously depends on the societal system under consideration and its transition dynamics.

**PANARCHY**

The concept of panarchy refers to the structure of systems as a constellation of interacting adaptive cycles on different scales. According to this vision, the life cycle of a system consists of four successive phases: rapid growth (r), consolidation (K), release (Ω), and renewal , **α**. This is visually represented by a lemniscate or lazy eight.

## THE 'LAZY EIGHT'




VITO, EnergyVille, shiftN, University of Ghent, Background document *Naar een diagnostiek van systeemverandering* (to: Gunderson & Holling 2002)

The horizontal axis of the figure represents the connectivity between the components and actors in the system. Low connectivity means that elements are loosely connected, i.e. more flexible and more sensitive to external impulses. The vertical axis refers to the resources that are stored within the system and that help determine the system's change potential. These may be raw materials and energy, but also knowledge, financial resources and human capital.

In the 'rapid growth' phase of the cycle, elements from the system have the possibility to take in disturbed parts of the system. In the consolidation or K phase, additional energy and material is stored in the system. The interconnectedness of the system's elements increases and new elements find it harder to find their place in the system. The growth rate gradually slows down and the system becomes rigid. It thus becomes more stable, but only within a narrower spectrum of external variation. The system becomes increasingly less resilient to external, high-impact shocks. Sooner or later, a powerful disturbance will exceed the system's resilience, thereby disrupting connections and releasing energy and matter (Ω phase). A period of uncertainty and renewal then sets in (α phase). New or smaller elements in the system find their place and are tested.

In the 'lazy eight', two loops are therefore distinguished. The front loop comprises the process of growth and stability, the rear loop that of 'creative destruction' and reconfiguration. This model suggests a rather sequential process whereby a rigid system is broken down before anything new can grow.

Adaptive cycles can manifest themselves on different scales and also influence each other from these different scales. Each scale of the hierarchy follows its own adaptive cycle that interacts with the scales below and above it. These interwoven cycles are called a panarchy. The functioning of these cycles and their interaction determine the viability of a system.

This theory provides interesting insights, such as the existence of traps that indicate undesirable system equilibriums. In a 'poverty trap', for example, a system remains in a state of low interconnectedness and low resilience for a long time. Available resources, if present at all, cannot be mobilised for change. The 'poverty trap' concept has helped to better understand persistent poverty in complex and socio-ecological systems. A 'rigidity trap' occurs when a system is in a stable state of high interconnectedness and many stored resources and energy. External shocks can abruptly disturb this equilibrium. In socio-technical systems, rigidity traps are often connected with a deeply embedded and expensive infrastructure, examples being the natural gas or electricity grid and our comprehensive road infrastructure.

### MODELS AND THE ACTUAL COMPLEXITY OF TRANSITIONS

Each of these models and visualisations of transitions provides a highly simplified schematic view of a highly complex, dynamic set of interactions. Transitions follow pathways that can be comprehensibly represented with these models, but which in reality are much more layered and chaotic than can be depicted with the models. Each of these models nevertheless provides us with useful insights that help us in our search for environmental solutions from a systemic approach. In this search, it is important to identify which models are best suited for understanding the system and the transition and taking policy-based action.

## Surprising and undesirable behaviour of systems

Models can help us gain a better insight into complex systems. We would, however, be wrong to assume that we can simply control the dynamics of complex systems. Our capacity to understand complex systems is limited anyway. Moreover, our cognitive apparatus is limited by all kinds of biases that can lead us to suboptimal choices. In decision processes, this is referred to as bounded rationality, a consequence of the combination of complexity, cognitive limitations and scarcity of time and resources.

Complex systems should therefore preferably be organised, so that they are able to autonomously deal with incentives for change. Systems must be able to adapt to changing conditions and, at the same time, minimise the risk of having to face sudden and fatal changes. In other words, they must be able to learn efficiently. If systems do not learn, they will eventually facilitate undesirable system dynamics or system failures. These are summarised and designated as 'system archetypes'.

Unwanted system behaviour can take various forms. Some of the most relevant ones are briefly discussed below.

- Lock-in keeps the system running at an undesirable level of performance. Stability is maintained by various feedback mechanisms. Important investments committed to infrastructure are a form of lock-in, but so is the entire policy that is founded on existing and dominant regimes and, as such, are not adapted to new niches.
- 'Erosion of goals' is a variant on lock-in that gradually pushes the system to lower levels of performance. Due to a negative perception of previous results, the objectives are adjusted downwards. A reinforcing feedback loop is created whereby deviation from the desired level of performance leads to a downward adjustment of that level. Thus, the performance of a public transport system can continue to decline over a longer period of time. Operators and users will eventually adjust their expectations.
- The so-called tragedy of the commons manifests itself when users of an exhaustible, shared resource can benefit from its usefulness much sooner than they experience the disadvantages of over-exploitation. This eventually leads to exhaustion and therefore to a drastic decline in its usefulness for all users. Congestion problems in the mobility system are a typical example: each user optimises their own use of the available road capacity, but the cumulative effect leads to long delays caused by congestion.
- 'Pursuing wrong goals': a system can incline towards an undesirable level of performance if the indicators provide incomplete control information or are not properly conceived. It can thus be argued that our environment is increasingly under pressure because the success of a society is measured in terms of economic parameters such as growth and GDP.

Systems can also exhibit behaviour that is not necessarily undesirable but still surprising, such as:

- 'Presence of limiting factors': each system inevitably clashes with limits or constraints in terms of resources or flows. Often, however, it is not exactly clear where these limits are situated and how they affect the dynamics of the system. This can lead to surprises. An example regards the various oil peak predictions, i.e. the point at which oil production will decline.
- 'Delays': system effects may take quite some time to manifest themselves. This dynamic may conflict with the expectations of actors that have to deal with it and can also lead to belated reaction. Climate change is a process that manifests itself as a result of greenhouse gas emissions, but only over a longer period of time. As a result of this delay, humanity will have to take into account the possible consequences of an overshoot of emissions.

Surprising and undesirable properties are not characteristics of actual systems, but of the way in which people interact with those systems. They are based on our bounded rationality. People inevitably act from a limited perspective and on incomplete information. It is a system structure and behaviour that remains hidden to human actors and therefore can lead to dysfunctions. Thinking in terms of system archetypes helps us interpret unexpected and undesirable transition dynamics.

## From insight in system behaviour to action perspectives

Research into the transition to more sustainable societal systems has significantly gained in importance over the past decades. It investigates how large-scale changes in societal systems can be initiated and controlled, the aim being to facilitate the finding of solutions to urgent challenges in the field of sustainability. This involves not only technological innovations, but also shifts in power relations, culture and world views, behavioural practices and social structures. Transition research seeks not only to better understand, but also to assist actors (including the government) in practice in order to reverse the current situation and initiate structural, sustainable change. It offers perspectives for action to initiate, orient and accelerate the desired transition.

However, our capacity to understand complex systems appears to be limited. Systems research teaches us that, rather than trying to control complex systems in detail, we should design and configure them so that they are capable of dealing themselves with triggers for change. It is important that societal systems are able to learn efficiently, so that they can adapt to changing and unforeseen circumstances. This will minimise the risk of them having to confront sudden, disastrous changes. Studying the behaviour of systems therefore does not produce a ready-made blueprint for very specific, targeted interventions. Instead, it offers a reflective framework to identify the pillars that are of special interest in the transition process from a system reconfiguration perspective.

2

# SOLUTIONS FOR THE ENERGY SYSTEM

**Flanders' current energy system runs almost entirely on fossil fuels and nuclear energy. The bulk of this energy is readily available, reliable and affordable, but leads to persistent social problems such as greenhouse gas emissions, air pollution, radioactive waste and high dependence on imported energy. Europe and Flanders aim to address this by focusing on a transition to a sustainable energy system. In this chapter we will analyse the solution paths and levers that enable the transition to the energy system of the future.**

## 2.1 What is it about?

### The current energy system is reaching its limits

Virtually every conceivable activity or sector in our society utilises energy. We cannot live without. The energy system is not an isolated system, it is inextricably linked to other societal systems and sectors such as mobility or industry. All this makes the energy system a pillar of our society, and therefore also a central element in the transition to a more sustainable future.

In 2016, the final energy consumption in Flanders (by households, trade and services, industry, agriculture and transport) amounted to 952 PJ or 264.5 TWh. Almost 66 per cent of this final consumption was met directly by fossil fuels. Electricity accounted for 18.6 per cent of the final consumption, with the proportion of nuclear reactors in total net electricity generation in Flanders hovering around 45 per cent over the past 20 years. The remainder of the final consumption was met by biomass (4.4 per cent), heat (2.9 per cent) and other fuels (8.2 per cent), including fuels recovered from the industry's waste and process streams and the combustion of non-renewable household waste with energy recovery.

The bulk of our energy demand is currently met by energy sources that are not sustainable. This explains the significant impact of the current energy system on climate and the environment. Thus, three-quarters of the greenhouse gas emissions in Flanders are generated by the use or production of energy (58.7 megatonnes of $CO_2$ equivalent in 2015). In addition, the energy system is responsible for a large portion of emissions of pollutants such as nitrogen oxides ($NO_x$), sulphur dioxide ($SO_2$), polycyclic aromatic hydrocarbons (PAHs), dioxins, particulate matter and heavy metals. This air pollution, which has a significant impact on our health, has for years been a persistent problem in Flanders. Nuclear energy production on which we currently depend for our power supply, involves safety risks and the generation of high-level radioactive waste that needs to be stored for hundreds of thousand of years. After almost forty years of research into deep geological disposal, a final and financially sustainable solution remains to be found.

## At the beginning of a profound energy transition

In the Paris Agreement (December 2015), 195 countries agreed to keep global temperature rise below 2°C (relative to the pre-industrial period) and to even attempt to limit the rise to 1.5°C. For the European Union, this means an 80 to 95 per cent greenhouse gas emissions reduction by 2050 as compared to 1990 levels. Since three-quarters of the greenhouse gases in Flanders originate from the use or production of energy, a drastic transition is required. The European Union (which co-signed the Paris Agreement) has committed to a binding target of sourcing 32 per cent of energy from renewables by 2030, and to an indicative target of 32.5 per cent increase in energy efficiency as compared to 2005 levels. Belgium has committed to developing a low-carbon strategy that fits in with the EU's ambition.

A bold and sustained approach at system level is needed to bring about the necessary structural changes in the energy system. This involves changes in energy use, in energy infrastructure and technology both on the supply and demand side, in spatial planning, regulations and policy, but also in the way of thinking and acting of companies and consumers. The core aspects of the system change are energy savings driven by behavioural change, energy savings through more efficient energy use, an increase in the proportion of renewable energy, and matching demand and supply. The nature of renewables (which are often decentralised and variable) means that also the organisation of the energy system will change. We will be moving from a central and demand-driven system, where gas-fired power generation, for example, can easily be adjusted to demand, to decentralised generation based on renewables such as sun and wind, which are not available all of the time. As a result, supply will lead demand rather than the other way round.

### THE CHANGING ENERGY SYSTEM IN FLANDERS: A DIAGNOSIS

**The different societal systems and (sub)sectors in Flanders – housing, transport, agriculture, industry, trade and services, etc. – are all highly dependent on a stable energy supply. Today, this supply is guaranteed mainly by fossil fuels and nuclear energy. The transition to a more sustainable energy supply is still in its initial stage but has already reached a significant momentum.**

#### Drastic changes in the past

The current transition to an energy system running primarily on renewables is not the first energy transition. At the beginning of the nineteenth century, the rise of coal and coal gas (produced during coal degassing) radically changed our energy supply. By the end of the nineteenth century, electricity was introduced in Belgium. The strong growth in electricity supply during the interwar period had a great impact on society as a whole. In the decades that followed World War II, oil and nuclear energy became very important energy sources and an increasing number of inhabitants were connected to the natural gas grid. Since the nineteenth century, our energy supply and energy use have witnessed a long period of growth and finally also of consolidation. This has led to a comprehensive energy infrastructure and a high level of interconnectedness among the constituent parts.

**Pressure on the dominant regime: the transition impulse**

However, our fossil-nuclear energy system has also led to persistent environmental problems such as climate change, air pollution and radioactive waste. In addition, the current system is highly dependent on imported energy sources. Certain trends suggest the first signs of an erosion of the dominant fossil-nuclear regime and emerging new niches. One of them is the shift towards more decentralised energy production. By installing solar panels, many private individuals have become 'prosumers': they not only consume, but also produce energy. The creation of cooperatives and locally organised heating grids reflects a shift from individual to collective interests. Wind energy, both onshore and offshore, is experiencing remarkable growth. The emergence of renewable energy niches, the environmental problems and the dependence on import are putting pressure on the existing energy system. However, compared with the mobile communications boom, for example, sustainable energy does not always fulfil a tangible and attractive need as compared to fossil and nuclear sources. The significance of sustainable energy sources therefore remains rather abstract, namely to solve persistent environmental issues that mainly become apparent in the longer term. The transition impulse is therefore largely fuelled by environmental concerns, which constitutes a fundamental difference in comparison to previous transitions.

**Resistance of the regime to drastic changes**

Our conventional energy supply is readily available, highly reliable and relatively affordable, although energy poverty remains a persistent problem for a small portion of the population. This optimised energy system therefore also offers resistance to change. The inertia is reflected in various areas. Not only the infrastructure and the technologies are deeply embedded, regulations too are still largely based on the fossil regime. External costs associated with its use are still not passed on and our vast gas grid is responsible for a lock-in. All this could impede or slow down the development of an energy system based on renewables. Moreover, dominant societal norms, values and visions on energy are deeply rooted in our way of life and often unmanageable. That is why also our practices remain rather conventional. This is reflected, for example, in the difficult rollout of energy renovation and cold and heating grids, the nuclear phase-out debate, local opposition to the siting of wind turbines, or the increase in the number of passenger kilometres travelled by car. The fossil and nuclear energy regime appears to focus primarily on preserving the use of the existing infrastructure for as long as possible and on further optimisation through increasing energy efficiency. The major challenge for the transition to a sustainable energy system therefore lies in the competition with a well-established and optimised regime, in a free market that, above all, fails to take external environmental costs sufficiently into consideration.

**Where does the change process stand today?**

A significant momentum nevertheless appears to have been reached. The general need for an energy transition is becoming more widely accepted within the government, industry and society as a whole. Various transition initiatives that can structurally change the system have been set in motion, examples being the widespread installation of solar panels, the increasingly stringent energy standards for new buildings, and the construction of a number of heating grids. Destabilisation of the existing regime causes uncertainty. At the same time, renewable niches are breaking through and will eventually become institutionalised. The future system is likely to be a mix of solutions. It is still too early to assess how they will relate to each other and which solutions will be dominant. There is also considerable lack of clarity about how the energy transition should be developed further.

## Steering the energy system of tomorrow

A properly developed and coherent long-term vision on the energy system is important. Such a vision can create a clear and stable environment that enables structural changes and allows the various actors to take up their roles. To make the energy system more sustainable, there are four possible solution paths: energy saving driven by behavioural change; energy saving through improved energy efficiency; making the energy supply more sustainable; and energy demand-supply matching.

In the analysis of the energy system, we distinguished three transition paths as described below. One or more solutions can contribute to the implementation of each of these paths. We also examined in detail which levers could promote each of these solutions.

- **Sustainability of low temperature heating and cooling in the built environment**
  This path concerns energy saving driven by behavioural change and improved energy efficiency of the building stock and making heating and cooling production in the built environment more sustainable. Energy saving driven by behavioural change is also linked with behavioural patterns and choices in the fields of mobility and food. Also the spatial component plays an important role in this context. This aspect will therefore also be addressed in the following chapters.
- **Sustainability of energy supply and (medium) high temperature heating in industry**
  This path concerns the use of renewable sources such as wind and solar energy, sustainable biomass and the nuclear phase-out. Industrial demand for (medium) high temperature heating is regarded as being generic in this case.
- **Matching energy demand and supply**
  This path covers energy storage, local demand and supply management, and active demand management at system level.

### HOW DO WE INTERPRET THE ESTIMATION OF THE APPLICATION POTENTIAL AND THE REDUCTION IN GREENHOUSE GAS?

For each of the solutions, an estimate is made of the application potential and the potential reduction in greenhouse gas emissions in 2050. The majority of these estimates were taken from the core scenario of the *Roadmap towards a low-carbon Belgium by 2050* (Climact and VITO (Flemish Institute for Technological Research), 2013), supplemented with more recent sources. The core scenario is based on a balanced mix of behavioural and technological solutions to reduce greenhouse gas emissions in Belgium by 80 per cent by 2050.

As regards the impact on greenhouse gas emissions, it should be noted that the impact was each time calculated for each individual solution. No scenarios were used that take into account the interdependence of the solutions, therefore the application potential and the potential greenhouse gas emissions should not simply be added together. For example, in calculating the application potential and the greenhouse gas reduction for innovative heating technology, no allowance was made for advanced energy efficiency of the buildings themselves. Simply adding the application potentials and both reduction potentials together would therefore result in an overestimation of the application potential and the total reduction potential.

## 2.2 Sustainability of low temperature heating and cooling in the built environment

The built environment is responsible for 89.7 TWh of the final energy consumption in Flanders. To save energy and reduce greenhouse gas emissions, the focus is on spatial planning and behavioural change, energy efficiency of buildings, and making the energy mix for heating and cooling production more sustainable.

### Energy saving through spatial planning and behavioural change

Choosing a more favourable geographical location for a building can save a considerable amount of energy. Also the choice of typology (detached house versus apartment building), the compactness and the orientation help determine the sustainability of a building. The trend towards a smaller living area per household in Flanders is positive from an energy saving perspective. Smaller residential units and spatial densification offer opportunities for energy saving and the deployment of renewable energy. In the development of new residential areas, for example, densification allows for more efficient use of heating grids. In the future, space will have to be found for new dwellings and buildings by splitting up existing large dwellings or parcels, or by opting for high-rise buildings.

The energy consumption of a dwelling also depends on the behaviour of the occupants. The general attitude of Flemish citizens towards energy saving is positive, but is not automatically reflected in energy-saving behaviour. On the whole, there is no sense of urgency. Household appliances are generally only replaced at the end of their life span, thereby delaying the introduction of energy-saving appliances. Consumer choices involving significant investments are based on objective information about energy efficiency, but habitual behaviour remains hard to break. Moreover, the rebound effect can cause the anticipated theoretical savings through energy renovation to not fully materialise in reality. For example, occupants of a low-energy dwelling are less motivated to keep an eye on their energy use.

Spatial planning and behavioural change generate potential savings of 25 TWh on building heating and cooling, and 11 TWh through more energy-efficient use of appliances and lighting. For Flanders, this means a greenhouse gas emissions reduction of around 4.5 megatonnes in 2050.

#### LEVERS FOR ENERGY SAVING THROUGH SPATIAL PLANNING AND BEHAVIOURAL CHANGE

**Combined spatial policy and infrastructure planning.** More efficient planning of the available space can save a tremendous amount of energy. This can be accomplished, for example, by densifying residential areas and opting for compact and energy-efficient housing construction. However, this is not always easy due to the spatial fragmentation caused by ribbon development and parcelling. Better coordination between spatial planning and investments in energy infrastructure could substantially reduce the societal costs. Planned synergy between spatial planning and energy infrastructure is the best way to achieve this.

**The numbers tell the tale.** Technological innovations, new measurement techniques and apps can help bring about the desired behavioural change in the field of energy use. Monitoring and feedback on specific behavioural choices, for example, can generate energy savings of 5 to 12 per cent. Smart control of appliances can also help further reduce energy use.

## Energy efficiency of the building stock

Since the introduction of the Energy Performance Directive in Flanders in 2004, the energy performance of new or thoroughly renovated buildings has improved significantly. Thus, an energy performance or E-level was imposed on new residential buildings, schools and offices, and later also on renovations requiring permits. An E-level was introduced for all non-residential buildings in 2017. This standard for residential buildings will also be stepped up to E40 in 2018, E35 in 2020 and E30 in 2021, which corresponds to a nearly zero-energy (NZE) building.

The rate of renovation in Belgium and Flanders nevertheless remains low. Each year, only between 0.5 and 1 per cent of the built floor area is thoroughly renovated. Within the framework of the *Environmental Outlook 2018*, the conclusion is that, subject to the implementation of ambitious policy measures, it is feasible:

- to double the rate of renovation to 2 per cent per year;
- for all new-build dwellings from 2030, to meet the passive standard (meaning that heat demand is reduced to 15 kilowatt hours per square metre);
- for all residential buildings, to satisfy the criteria for a low-energy dwelling (meaning that heat demand does not exceed 60 kilowatt hours per square metre) by 2050;
- to reduce heat demand in the service sector by 55 per cent by 2050 as compared to 2010.

The investment cost to renovate a dwelling to the level of a low-energy dwelling lies between 140 and 278 euros per square metre. For new builds based on the passive standard, the additional costs is approximately 22 to 130 euros per square metre. In addition to the return on investment thanks to improved energy efficiency, this approach also enhances the quality of living and the feeling of comfort.

Appliances and lighting have also become much more efficient thanks to technological developments and the introduction of energy-efficiency requirements, standards and labels. There is, however, still a considerable number of appliances that are older than ten years, and the market penetration of energy-efficient appliances is still too low.

If the above potential is realised, it can lead to an emissions reduction of around 5 megatonnes $CO_2$ in 2050. Air pollutants are also expected to decline, depending on the fuel used for electricity or heating production. Energy renovations and infrastructure investments significantly increase material use. Research into innovative building materials will therefore have to focus not only on energy savings, but also on circular economy concepts.

## LEVERS FOR ENERGY EFFICIENCY OF THE BUILDING STOCK

**Modular building and other innovative building concepts.** Both internationally and in Flanders, standards are being implemented for ambitious energy performance, such as the passive standard. During their lifetime, energy-positive buildings produce even more energy from renewable sources than they consume. The quest for ever-higher energy efficiency means that, in the case of renovation, solutions have to be found for thermal bridges, ventilation, space constraints and heritage provisions. New techniques are required to step up the rate of renovation of the existing building stock. The emergence of modular construction can provide part of the solution. For example, prefab components can be used to envelop existing building shells.

**Renovation at district level.** The integration of decentralised energy production and heating and cooling consumption at building and district level offers interesting possibilities. Examples are the combination of photovoltaic solar panels with solar heat collectors or with an electric boiler, or heat pumps connected to a fourth-generation heating grid (see also below: "More sustainable heat and cold production in the built environment"). The Flemish government can provide incentives for the development of such integrated solutions.

**Neutral contact point.** Rational choices about energy-efficient renovation do not appear to be evident to households in general. Technologies for insulation, heating and cooling are evolving quickly. Clear and objective information about the energy efficiency of individual and combined techniques is not always readily available. A neutral contact point that coordinates the entire energy renovation process, could have a facilitating effect. For heating and cooling solutions, a public-private partnership for a digital platform could bring about a breakthrough.

**Alternative financing.** Energy renovation faces the problem of upfront costs: the high investment cost is only recovered over a long period of time through savings on the energy bill. This often constitutes a barrier to investing in energy renovation, especially among households or people with more limited financial resources. A rolling fund could bring down the barrier of the high investment cost for thorough energy renovation projects. A tax shift geared towards sustainability – making renewable energy production economically more attractive by making the use of fossil fuels more expensive – could have a facilitating effect.

**Renovation Pact and dwelling certificate**. The Renovation Pact assumes that, based on sustained and intensified efforts, the existing Flemish building stock will gradually evolve to the E60 energy performance level (according to the EPB (Energy Performance and Indoor Climate) score) or an EPC (Energy Performance Certificate) value equal to 100 kWh/m. Performance improvements both at the level of the building shell and at the level of the heating system, result in improved energy efficiency. The Renovation Pact also introduces the concept of the dwelling certificate. A 'dwelling certificate' can be applied to outline a suitable energy renovation project for each individual home. In the case of change in ownership, certain renovations would then have to be carried out within a certain period of time.

**Adjusting the cadastral income.** The dwelling's energy performance could be taken into account in determining the cadastral income. Better energy performance could then be rewarded, thus creating an additional incentive for households.

**Exemplary role.** The government could fulfil an exemplary role by rolling out an ambitious programme for the renovation of all public buildings. It could also encourage the social housing sector to profile itself as launching customer in the market for large-scale energy renovation projects. Existing incentives to promote energy efficiency or green heat have difficulty reaching the rental market because owners do not reap the renovation benefits themselves. Social housing companies do not consider energy renovation to be a priority and lack the resources to explore innovative concepts. An important incentive is that improved energy performance, which brings down the tenant's energy bill, may be reflected in the rent.

**New business models.** Policy could stimulate the introduction of new business models on the energy renovation market. Sellers of heating or cooling equipment can profile themselves as heating and cooling service providers or brokers. An 'all-service' provider can coordinate and implement the complete renovation project on behalf of the house owner, choosing the most appropriate combination of techniques for the consumer's specific needs.

## Sustainability of heating and cooling production in the built environment

The Energy Pact stipulates that in 2050, our buildings will no longer be heated with fossil energy sources. They will be replaced with more sustainable forms of energy, the most important alternatives being heat pumps ('all-electric solution') and heating grids. They will take the place of more conventional solutions, which are expected to be gradually phased out.

### Heat pumps

The vast majority of the residential heating and cooling demand in Flanders is currently met by individual systems. In new-build homes, the highest growth is recorded for electrically powered heat pumps. In 2014, around 15.5 per cent of all new-build homes were equipped with such systems, mainly as a result of mandatory renewable energy requirements and bonuses for rational energy use. Heat pumps are often combined with solar panel electricity generation. The switch to a heat pump only works optimally in dwellings with a sufficiently high level of insulation and low temperature heat distribution, such as underfloor heating. It is expected that by 2050, 60 per cent of all heating systems will be equipped with an electrically powered heat pump. Electrification of the heat demand via a water pump can provide significant greenhouse gas savings. For Flanders these are estimated at 4.5 megatonnes.

### LEVERS FOR HEAT PUMPS

**Compulsory heat pump.** The (investment) cost of a heat pump is still almost twice that of a condensing gas boiler. That is why, under the current EPB regulations, preference is still often given to relatively conservative solutions such as a natural gas-fired condensing boiler. Prejudices still exist about the performance of electrically powered heat pumps. Their heating capacity is often considered to be (too) low and their electricity consumption high. Where economically feasible and no heating grid is possible, the government could make the use of heat pump compulsory. For existing buildings where this option is not feasible, the government could promote sustainable alternatives such as a hybrid heat pump or a gas adsorption heat pump. The use of solar boilers could be encouraged for dwellings suitably equipped for this purpose.

## Heating grids

Heating grids open up interesting possibilities for sustainable building heating. This can be done by linking them to companies that have residual heat at relatively low temperatures, or to a sustainable central heat source such as geothermal or a biomass CHP. For optimal efficiency, the heat source should not be located too far away from the users, because heat is lost during transport through pipelines. Heating grids are therefore an interesting option for areas of sufficiently high building density, with heat sources that can be guaranteed over a longer period of time.

In Flanders, heating grids currently only account for 0.56 TWh heat a year, enough to supply some 27,000 households. The Flemish government attaches great importance to the further rollout of heating grids. The Flemish Heat Plan 2020, for example, aims to connect an equivalent of 50,000 households to a heating grid, representing an annual energy consumption of 1 TWh. The potential applications of heating grids depend primarily on local conditions and uncertainties about the cost. Generally speaking, residual heat is the cheapest option, whilst sustainable sources such as geothermal energy remain prohibitively expensive for the time being. In 2050, 12% of all buildings in Flanders could be powered by a heating grid.

Especially the technological evolution to fourth-generation heating grids appears to be an interesting scenario for Flanders. These innovative heating grids provide heating or cooling at several temperature levels, also at low temperatures. Energy reductions in industry and centralised electricity production will in time lead to a reduced supply of residual heat at lower average temperatures. At the same time, heat demand per dwelling will be reduced significantly due to measures such as insulation and heat recovery. This enables the use of low temperature heat sources. A recent variant of heating grids is sewage thermal heat, whereby heat is recovered from sewage.

The sustainability impact of heating grids depends on the heat source. When using fossil fuels, central heat generation ensures an energy-efficient process, especially in the case of a natural gas-fired CHP plant. When using residual heat from industrial processes or waste incineration, the total greenhouse gas emissions depend on the form(s) of energy used in the original heat generation process. Renewable sources such as sustainable biomass, deep or shallow geothermal or solar heat emit no or only small amounts of greenhouse gases.

### LEVERS FOR HEATING GRIDS

**Support for fourth-generation heating grids.** In an area that already has many underground pipes and sewers, the development of an additional infrastructure is not evident. The construction of heating grids in residential areas may also meet with social resistance, because the work involved is quite substantial. Consumers have not yet embraced this technology; they have doubts regarding the cost and the security of supply. The government could provide innovation funding to promote the development of fourth-generation heating grids and the associated business models.

**New facilitating actors.** Distribution system operators have set up a new heating company specifically for the rollout of heating grids. The aim is to bundle the strengths of the respective partners throughout the chain of production, distribution and delivery, in order to maximise the potential of heating grids. A possible new role in the implementation of heating grids is that of ‘heating broker’. Such a broker actively searches for potential heat sources and links them to potential consumers. In the rollout of heating grids, it is preferable to take into account the possibility of expanding the heating grid in the future or of switching to another energy source.

**Guarantee scheme for geothermal energy.** One of the barriers for geothermal projects is the geological risk associated with drilling. Such drilling operations are costly and there is a risk that they produce less heat energy than expected. The Flemish government has in principle approved a guarantee scheme, based on an insurance principle, whereby it also acts as a guarantor. Should it transpire after the drilling operations that the estimated output is not achieved, the Flemish government can then reimburse some of the costs. The companies also contribute to the guarantee scheme by paying a premium.

## General levers for a more sustainable building stock

There are different general levers that could make our building stock more sustainable. Most of these can be implemented in the short term. The technology required to make buildings more sustainable is available. The priority issues now are further market penetration and a rapid rollout.

## Policy action at various levels

Habits and vested interests in the traditional energy and construction sectors can inhibit the transition. For an adequate and effective Flemish policy to be put in place, a clear and integrated long-term vision is required. The policy being elaborated by the EU as part of the energy and climate targets for 2030 can be used as momentum to develop an integrated long-term vision at the various Belgian levels.

Better coordination between spatial policy (clustering) and investments in energy infrastructure can reduce the societal cost of the transition towards an ecologically sustainable society. Coordination with local authorities is crucial in defining suitable strategies, because various green heat technologies are applied on a decentralised basis. (Central) cities could play a pioneering role in this, whilst smaller cities and municipalities could be provided with support.

The low price of fossil fuels compared with electricity is one of the main reasons that prevent a stronger breakthrough of sustainable heat in Flanders. Making the use of fossil fuels more expensive ('tax shift geared towards sustainability') would create a larger market share for green heat. Provisions can be made for social and economic corrections.

Data on energy use, investment costs for new sustainable heat sources, and depreciation of infrastructure are essential for steering short- and longer-term policy. A sound policy is only possible if all data that is now being managed by different actors (grid operators and knowledge institutions) are also made available and matched to each other.

Sustainability and renewable energy have acquired a positive, dynamic image in recent years, which has created a broader (policy) base for energy-efficient housing. Investments in energy efficiency and green heat lead to a reduction not only in greenhouse gases, but also in other air pollutants, resulting in a favourable impact on the environment and on health. Reduced particulate matter emissions and improved quality of indoor air will bring down healthcare costs. Quantifying this additional favourable impact on healthcare costs can be used by the government as additional legitimisation for higher policy ambitions.

Where the transition to a heating grid or an all-electric solution based on heat pumps is socially, economically and practically feasible, the natural gas grid can ultimately be phased out over time. It is, of course, very important to inform and involve residents well in advance. An amendment of the energy decree is necessary to allow the disconnection of consumers connected to the natural gas grid. The gas grid technical regulations can also be amended so that wherever an alternative to gas heating cannot be achieved in the longer term, more gas based on renewable energy (biogas, hydrogen, synthetic gas) can be injected into the grid.

### Further stimulate the role of market forces

A significant portion of Flemish households have surplus savings. This capital can be mobilised for investments in energy efficiency or green heat supply. These often prove quite profitable, especially with the current low interest rates. Cooperatives, group purchases, public-private partnerships and crowdfunding are additional financing channels that can be promoted by the government.

A trend towards higher energy efficiency and the use of renewable energy also brings economic opportunities such as higher added value and more locally based jobs if materials and systems are produced within national borders. A shortage of technically qualified personnel could slow down the rollout of new technologies in the field and green heating and cooling. It is therefore important to provide sufficient targeted opportunities for the training of green energy experts.

# 2.3 Sustainability of energy supply and of (medium) high temperature heating in industry

Different energy consumers demand different types of energy. Consequently, the supply of sustainable energy will also take different forms; we differentiate between green power, green heating and cooling, and biofuels.

In 2016, green power accounted for 12.3 per cent of the gross final consumption. For heating and cooling, 5.1 per cent was renewable. Finally, in the transport sector, 5.9 per cent of the energy was renewable. Electrification, mainly for transport, space heating and sanitary hot water, is a cornerstone in the transition to a low-carbon energy supply. Electricity demand is expected to rise to between 77 and 88 TWh by 2050. Of this demand, 80 to 97 per cent should be renewable (62 to 85 TWh).

Apart from further electrification, we must bear in mind that by 2050, green gas and biofuels will probably be the only option for emissions reduction at important energy consumers such as aviation, and possibly also heavy road transport and part of the heat supply in companies. Industrial process heat accounts for nearly one-third (76.6 TWh in 2014) of the final energy consumption in Flanders. The Energy Pact stipulates that 70 to 80 per cent of the thermal energy consumed by our industry should be renewable by 2050.

## Sustainability of the energy supply

### Photovoltaic systems

Over the past decade, Flanders has seen a growing number of prosumers, who both consume and produce power, mainly via solar panels (PV systems). Today, solar panels are well established in Flanders thanks to the support measures taken by the government. In 2017, the installed capacity of PV systems amounted to more than 2.4 gigawatts (or 2.2 TWh of power). Solar power is becoming increasingly competitive due to the declining total cost of solar panels and due to their increasing efficiency.

Solar energy still has significant growth potential in Flanders. Based on Flanders' solar map, the technical and economic application potential, i.e. the potential when all of the favourably oriented roof area in Flanders is utilised, is estimated at an installed capacity of 72 gigawatts, or a power production of 64.6 TWh. In additional, there is a significant potential for solar energy on road and railway embankments. The expected growth should lead to an installed capacity of 7 gigawatts (6.3 TWh) in 2030 and 17 gigawatts (15.2 TWh) by 2050.

Assuming that the additional potential of photovoltaic systems will replace the construction of additional gas plants, the above scenario will generate savings for Flanders of 5.2 megatonnes $CO_2$ by 2050.

### LEVERS FOR PHOTOVOLTAIC SYSTEMS

**Promising innovations.** Global research is focused on finding ways to further improve the efficiency of the existing solar cells and to reduce their thickness in order to further reduce costs. Various research projects focus on the use of thin film cells. These are made by depositing a tiny film of photosensitive material onto a substrate material (glass, steel, plastic). This technology offers significant advantages over silicon-based cells, such as lower cost, less material use and their capability of being integrated into building materials (building integrated PV). There is, however, one downside to this technology: the materials used thus far also have a lower efficiency. Even more innovative concepts utilise organic material and/or nanotechnology. This technology offers mainly advantages in the area of material use. Organic material is also highly flexible in terms of shape and can be applied to virtually any surface, examples being thin plastic films or even paint layers.

Flemish research groups are global leaders in this area. This Flemish expertise contributes significantly to the research into innovative PV technologies. All these innovations can, in the medium term, widen the market for PV applications and have a favourable impact on material use. The sustainability of solar panels is another topic of research. At present, solar panels are produced mainly outside the EU. This raises questions regarding their sustainable character.

**Solar map.** The solar map enables every citizen and business in Flanders to easily assess the potential for solar panels. Its effect on the installed capacity of PV systems is already noticeable.

**Public buildings, schools and social housing.** In order to meet its energy and climate targets, Flanders could also focus more on installing solar panels on public buildings and schools. In this context, the feasibility of installing solar panels on the 150,000 social housing in Flanders is being examined. An initiative to this end has been launched, whereby the costs for removal of an asbestos-containing roof can be recovered through the installation of a PV system (with or without ownership), allowing extra roof area to be used.

**Solar sharing.** The Flemish government supports solar sharing to enable citizens, businesses and governments to invest in sustainable energy by participating in energy projects. This is possible, for example, by 'remote net metering'. Green power that is generated elsewhere on a suitable roof surface can then to some extent be offset on the customer's electricity bill. This can lower the threshold for families or individuals with more limited resources, because limited participation is also possible.

## Onshore wind energy

In 2017, Flanders had some 500 (onshore) wind turbines, generating an overall capacity of 1115 megawatts (2.3 TWh). Wind energy is thus the third largest source of renewable energy generation in Flanders, after solar and biomass. There are around five hundred large wind turbines with a capacity of over 300 kilowatts. There are also twenty or so small wind turbines (with an installed capacity of less than 300 kilowatts), mainly on roofs of SMEs and farms.

Taking the spatial constraints into account, the Flemish spatial potential for onshore wind energy is estimated at 3.6 gigawatts (7.5 TWh) in 2030 and 4.4 to 4.8 gigawatts (9.2-10.1 TWh) in 2050.

Compared with the construction of new, modern gas power plants, the realisation of this potential would allow savings on greenhouse gas emissions estimated at 2.9 to 3.3 megatonnes in 2050. Possible negative impacts of onshore wind turbines are visual disturbance of the landscape, noise pollution, cast shadow and bird fatalities.

### LEVERS FOR ONSHORE WIND ENERGY

**Innovations**. In addition to the continuous improvement of building techniques and rotor technology (other materials, improved aerodynamics, etc.), a gradual scaling up to ever-larger turbines is expected: higher towers and longer rotor blades, resulting in larger outputs. These economies of scale could bring down the price by 5 to 25 per cent by 2025, and even by 35 per cent by 2050, thereby increasing their profitability.

**Small turbines for SME areas.** Small to medium-sized turbines are undergoing substantial technological advances and could be ideally suited for the energy supply of SME zones or farms in a highly urbanised region like Flanders. Compared with large wind turbines (which use higher wind speeds at high altitude), the efficiency of small to medium-sized turbines is limited, so that support measures may be required.

**Covenant of Mayors and participation.** The high population density and the fragmentation of the use of space in Flanders complicate the search for suitable locations for onshore wind turbines. The lead time from design to commissioning of an onshore wind turbine (farm) is currently three to ten years. Onshore wind projects face opposition from citizens (committees), but even more often from local governments. While in some cases such opposition reflects a NIMBY reflex, surveys point out that 80 to 90 per cent of the Flemish population supports wind energy. Under the

Covenant of Mayors, municipalities commit themselves to reducing $CO_2$ emissions. This may help foster a constructive attitude of local governments towards wind turbines. Some of this opposition can also be overcome by actively involving citizens in the project (through participation, whether financial or otherwise). Participation in wind energy projects has become increasingly popular in recent years.

**Clear assessment frameworks.** Clear assessment frameworks for the environmental impact of wind turbines can reduce the lead time for onshore wind farms. The Fast Lane initiative of the Flemish government examines, for various ambition levels, where wind turbines can best be installed to reduce nuisance. This involves an assessment of what the impact would be if the currently applicable basic spatial conditions were to be amended. In this way, it can be evaluated which spatial criteria need to be used to achieve the desired ambition for sustainability, while at the same time minimising nuisance.

**Stronger business case.** Under the technical regulations for connection to the electricity grid, wind farm operators have to meet all sorts of obligations to compensate for the difficulties associated with the connection of wind turbines to the electricity grid. These involve voltage control, tolerance limits, or the supply of active and reactive power. The market for the provision of electricity system services could be opened up more to wind farm operators. This is possible with the existing technology and would also reinforce the business case for wind energy.

## Offshore wind energy

The first offshore wind turbines in the Belgian part of the North Sea were built in 2009. A capacity of 877 megawatts (3.2 TWh) is already operational. Based on the already awarded domain concessions, the expansion of the designated area for wind turbines in the North Sea and the forecasts of the Belgian offshore platform, an additional capacity of 3.8 to 4.3 gigawatts (14.0 to 15.9 TWh) is expected by 2030. The generation of a total offshore wind energy capacity of 5.5 to 7.0 gigawatts (20.3 to 25.9 TWh) is possible by 2050.

Compared with the construction of modern gas-fired power plants, utilisation of the full potential of offshore wind energy would result in greenhouse gas savings of 4.4 to 5.9 megatonnes in Flanders by 2050. Compared with onshore wind energy, there are fewer negative impacts such as noise pollution and damage to the countryside. The turbines are not located near homes and therefore encounter less resistance from the population.

### LEVERS FOR OFFSHORE WIND ENERGY

**Innovations.** As with onshore wind turbines, offshore wind turbines with greater capacity are expected in the future. Turbines with a capacity of 15 megawatts should be available by 2030 (the maximum capacity of today's turbines is 8 to 9 megawatts). Innovations in the field of installation technology are also in the pipeline, such as floating foundations that allow turbines to be installed farther and farther offshore. The evolution towards larger turbines, larger projects and lower risk premiums will further bring down the production costs of offshore wind energy in the coming years.

**Promising economic sector.** Belgium is a global front-runner in installed capacity per capita in the field of offshore wind energy. This creates expertise, added value and jobs in various sub-sectors.

**Power outlet at sea.** To date, all the wind farms in the North Sea are individually connected to the electricity grid. In the longer term, Belgium intends to install a modular grid or 'power outlet at sea', whereby the different wind farms are connected to a high-voltage substation located on an offshore platform. In a next phase, this modular Belgian grid is to be connected to an international platform to allow larger capacities to be transported over longer distances. Talks are currently underway with all countries bordering the North Sea to set up such an international interconnection between the various wind farms on the North Sea. The objective is to also connect other forms of energy to the platform, such as hydropower from Scandinavia. This would enable the storage of energy in energy atolls or conversion to hydrogen in periods of oversupply. In this way, the North Sea grid could secure energy supply even when there is no wind.

## Sustainable biomass

Biomass can be converted into energy in a variety of ways. Several technologies are currently commercially available, such as the combustion of dry biomass (electricity and heat), the fermentation of wet biomass to biogas, the conversion of vegetable oils to biodiesel and the conversion of starch or sugars from biomass to bio-ethanol.

In Flanders, there are currently three companies producing biodiesel and two producing bio-ethanol from food crops such as rapeseed, maize, corn and sugar beet. However, the production of these 'first-generation biofuels' reduces greenhouse gas emissions only to a limited extent. Moreover, they enter into competition with food production. That is why science and industry are examining the possibilities for producing second-generation biofuels based on waste oil, harvest residues or wood waste. The prices of such biological waste and residue streams is lower than that of crops grown specifically to produce energy.

The energy potential from biomass in Flanders is estimated at 108 PJ (30 TWh) in 2030 and at 162 PJ (45 TWh) in 2050. This estimate is based on the cascade principle, which prioritises high-quality material use over energy production. Flanders has a maximum biomass potential of 54 PJ (15 TWh), the remaining biomass has to be imported.

Today, the Rodenhuize power station (along the Ghent-Terneuzen Canal) is the only remaining large-scale biomass-fuelled power plant in Flanders. Flanders further mainly focuses on biogas production through anaerobic digestion of manure and other organic by-products, and residual organic streams from other sectors. Biogas is generally used to generate heat and power in a CHP engine. Possibilities are being explored to admix (purified) biogas to the natural gas grid with the aim of 'greening' the gas consumption to some extent.

If the potential is realised, the use of biomass will reduce greenhouse gas by 5 to 6 megatonnes in non-ETS sectors by 2050. The impact on other air pollutants depends on the biomass and combustion technology used. In any case, more $NO_x$ and particulate matter are emitted than with natural gas combustion, but their impact can be reduced by flue gas cleaning. The combustion of dry biomass (such as wood pellets or pruning residues) accounts for the majority of air emissions. Except for $NO_x$, biodiesel emits lower levels of pollutants than regular diesel fuels.

### LEVERS FOR SUSTAINABLE BIOMASS

**Upscaling of new technologies.** Different technologies to produce bio-based raw materials or energy from biomass are still being investigated, such as gasification and synthesis of dry biomass to bulk chemicals. Others are in the demonstration phase, such as pretreatment and fermentation of dry biomass to bio-ethanol. These innovations will be scaled up in the coming years.

**Bio-based economy in Flanders.** Flanders has a large biocluster in the port of Ghent, a pilot plant, and highly regarded knowledge and research institutions. Our major ports, the industrial complexes located nearby and the wide range of market outlets also offer opportunities to import and process biomass streams. Flanders is also well positioned for the development of a bio-based economy. It has a strong chemical industry, food industry and energy sector, intensive agriculture and horticulture, and properly managed material streams.

**Better utilisation of residual streams.** For large-scale bioenergy projects it is not known whether a sufficient supply of affordable, sustainably produced biomass will be available in the longer term. Some residual streams such as roadside clippings are not yet used energetically, because collection, transport and processing are relatively expensive. However, the transition to a bio-based economy is likely to give rise to new local biomass residual streams that can be used energetically. Coordinated support can help ensure the profitability of biomass plants based on waste and secondary streams.

**More positive image.** The combustion of biomass as an energy source still suffers from a negative perception. Admittedly, the combustion of biomass emits air pollutants, but large incinerators are equipped with advanced flue gas cleaning techniques to minimise emissions from these plants. A monitoring and control system can help to map and monitor the origin and sustainability of local and imported biomass streams. Such a system can be instrumental in improving the image of sustainable biomass-based energy production.

## Gas-fired power stations as temporary response to nuclear phase-out

As outlined in the coalition agreement and the Energy Pact, complete nuclear phase-out is planned for 2022-2025. In Belgium, the nuclear energy debate is currently focused on the option of keeping part of the nuclear capacity operational also after 2025. The production of nuclear energy emits little $CO_2$, but extending the lifetime of nuclear power plants is not considered a desirable solution because of the safety risks, the generated radioactive waste and the debate about the safety and financing of waste disposal.

There is as yet no final, safe and reliable solution for the disposal of nuclear waste. NIRAS (National Agency for Radioactive Waste and Enriched Fissile Materials) has calculated that the geological storage of high level nuclear waste (at a depth of 200 m) would cost 3.2 billion euros, plus 320 million euros for research and development. Storage at greater depth (about 400 m), an option to be considered if storage at 200 m is not selected, would be far more expensive. NIRAS is currently preparing new cost estimates. Due to the safety risks of nuclear power plants and the very long-term impact of radioactive waste, nuclear energy is at the heart of polarised societal and scientific debate.

Gas-fired power plants can be used flexibly, which enables them to temporarily replace nuclear plants and supplement variable solar and wind-based renewable energy production during the initial phase of the transition. The need for new investments in gas-fired power plants in any case depends on the decision as to whether the nuclear phase-out will be postponed. When no more nuclear power plants are operational, the necessary capacity of gas-fired power plants is estimated at 6.3 to 7.5 gigawatts in 2030. Keeping the nuclear plants operational (after 2025) will have a negative impact on the number of operating hours (and therefore the efficiency) of the gas-fired power plants.

### TIMELY NUCLEAR POWER PHASE-OUT AS A LEVER FOR THE TRANSITION

**Timely nuclear power phase-out.** Lack of political clarity and the revision of decisions regarding the nuclear phase-out create uncertainty for investors in renewable energy sources, which could slow down the energy transition. An unequivocal decision on the nuclear phase-out, with allowance being made for the economic and social impact, is needed to shape the transition to a low-carbon society in Flanders. It would create a clear environment for investments in renewable forms of electricity production. During and subsequent to the nuclear phase-out period (2022-2025), it would seem appropriate to provide support mechanisms for the building of alternative production capacity.

## Carbon capture and use (CCU) or carbon capture and storage (CCS)

In principle, a long-term option is to make fossil electricity production and energy-intensive companies low-carbon by capturing the produced $CO_2$ for subsequent reuse (carbon capture and use or CCU) or storage (carbon capture and storage or CCS). Carbon capture can be used at large point sources of $CO_2$, such as power plants, but also in energy-intensive industries. In Flanders, it is particularly suitable for use in the chemicals, refineries, and iron/steel sectors.

CCU, an area of active research in Flanders, offers potential but has a limited market window. Here, $CO_2$ is no longer regarded as a waste stream, but rather as a raw material with applications in agriculture and industry. Conversion to methanol or ethanol, and use of $CO_2$ for algae production and for carbonation of certain building materials, are currently considered to be the most promising CCU applications for Flanders.

At today's low carbon price on the EU ETS market, CCS is not yet commercially viable without additional support. Many CCS demonstration projects in the EU have been discontinued as a result of financing difficulties, technical issues and uncertainties in the regulatory environment. Furthermore, the potential for underground storage is limited in Flanders. For these reasons, CCS has not been included as a solution in the *Environmental Outlook 2018*.

## General levers for making energy supply more sustainable

### Consistent policy choices make the difference

The binding target at EU level for the share of renewable energy in 2030, which was recently set at 32 per cent, constitutes a powerful incentive and legitimisation for a strong Flemish climate policy. To create a larger market share for renewable energy, a tax shift geared towards sustainability is advocated, which makes fossil fuels comparably more expensive than sustainable fuels. As part of such a tax shift geared towards sustainability, the possible introduction of a $CO_2$ tax for non-ETS sectors is being discussed at federal level. This could be an incentive for investors, although allowance should certainly be made for the impact of this measure on households and companies.

To integrate green energy into the market at the lowest possible cost, the support mechanisms need to be optimised. In the long term, it is important to phase out the support of mature, market-ready technologies wherever possible. In the current market conditions, however, existing support measures such as green power certificates, need to be maintained. To create economies of scale in the renewable energy market, it may also be useful to harmonise the support mechanisms of the different regions in Belgium. The government can fulfil an exemplary role by stimulating investments in renewable energy production in public buildings through financing from the Climate Fund.

To protect the competitiveness of Belgian industry, the government could introduce an energy standard for energy-intensive companies. Such an energy standard creates a level playing field with neighbouring countries, so that companies in Belgium do not pay more for their energy than abroad.

### Participation allows broader market rollout

Energy cooperatives and forms of participation in renewable energy production, energy storage and energy efficiency, must be encouraged. That is why the requirements for connection of renewable energy to the electricity grid must be revised to remove barriers to the growth of renewable energy. An amended regulation can be instrumental in promoting direct lines between consumer and energy producer (with minimal losses). The overall sustainability objectives and the social justice of the energy system must be preserved in this process.

## Solutions for more sustainable (medium) high temperature heating in industry

On the whole, the Flemish economy is energy-intensive and largely based on fossil energy. The transition to a low-carbon society will therefore require major modifications. The pace of the industrial transition in Flanders is also bound by the progress at European and even global level. Too speedy, far-reaching or unilateral measures might result in certain industrial activities being shifted to other regions in the world where less strict laws and regulations are in place. This does not contribute to solving climate change. Step-by-step efficiency improvements as such will not be sufficient. The industry sees only limited possibilities to go beyond what is justifiable on the basis of company-specific financial criteria. As a result, energy projects often have to compete with other profitable projects.

The question of how our industrial fabric will develop in the coming decades, is particularly relevant for the energy system. According to some, our economy will evolve towards a niche economy that focuses on high-quality, market-oriented production. In this vision, the most energy-intensive part of current industrial production will probably be shifted to other regions in the world. In such a scenario, the energy demand of the Flemish industry would change drastically. Others, by contrast, believe that the departure of our basic industry would also put the production of high-quality goods, which is associated with it, under pressure. This would drag the entire Flemish economy into a downward spiral. Which of these visions (or hybrid forms) will determine the industrial fabric in 2050 is still a matter of conjecture.

A decisive factor in this respect is also the adopted industrial policy. Flanders wants to focus primarily on the so-called industry 4.0, a whole range of new technologies and concepts within the knowledge and manufacturing economy. The aim is to acquire a strong position in this area in the new world economy. This intention is clearly linked to more efficient use of materials and energy and to the transition to a circular economy. The levers discussed below should be viewed at the generic level and are based on the relevant literature.

### LEVERS FOR MORE SUSTAINABLE (MEDIUM) HIGH TEMPERATURE HEATING IN INDUSTRY

**Flemish chemical cluster and expertise.** Fundamental innovations in production technologies are necessary to further bring down industrial $CO_2$ emissions. The challenge is enormous, but with its chemical cluster and knowledge institutions, Flanders is uniquely positioned to play a pioneering role in this regard. Flanders also has industrial activities that could play an important role in the transition to a low-carbon economy, such as the production of insulation and lightweight materials and the recycling of batteries. Demand for products and services that respond to the transition towards a sustainable economy is growing worldwide.

**Long-term plan and roadmaps.** There certainly is a perspective for far-reaching sustainability of heat consumption in the industry, but as yet there is no concrete and overarching vision of an ecologically sustainable Flemish industry. The climate plan to be submitted in the near future by the EU member states, offers an opportunity to prepare sector-specific roadmaps in consultation with different industrial sectors. Major European sectoral federations (such as CFIC for chemicals, Eurofer for steel and CEPI for the paper industry) have already prepared roadmaps in which they list the options for low-carbon operations management by 2050. Many building blocks for a long-term vision are therefore already available.

**Revision of the Emissions Trading Scheme (ETS).** Due to the technical/financial risks involved, it is not evident to develop a good business case for, for example, electrification, CCS or CCU, or the replacement of oil products by biomass. The price of $CO_2$ emission allowances at European level does not yet provide sufficient incentive for drastic reduction measures. The European Emissions Trading Scheme has been revised, but it remains to be seen whether the revision will lead to a $CO_2$ price that is high enough to initiate the desired transition.

## 2.4 Matching energy supply and demand

Until ten years ago, the Flemish energy system made a clear distinction between producer (centralised) and consumer (decentralised). Meanwhile, the energy mix in Flanders includes a growing number of decentralised sources based, for example, on wind and solar energy. Consumers thus increasingly become producers, and are then referred to as prosumers. Integrating the diversity of decentralised energy sources of intermittent nature is considered one of the major challenges for the future energy system.

To meet energy demand in the energy system of the future, a combination of the following solutions is required:

- **Short- and longer-term energy storage**
  Possible solutions are the use of batteries, power-to-gas technology or other storage technologies.
- **Local demand and supply management**
  Electricity and/or heat demand can be locally matched to the electricity supply. This can be accomplished by energy storage or smart control at building, district or industrial site level.
- **Active demand management at system level**
  Matching electricity demand and supply at system level is possible by, among other ways, balancing services for the electricity market.

Matching energy supply and demand is still in the development phase. Numerous solutions are known and are already being applied in a niche market. However, to speed up this new technology as a whole, companies require help and assistance. The current penetration level of solar and wind energy does not yet require any large-scale application of technologies for adjusting energy demand to supply. However, a large-scale application is expected for the period 2030-2050.

## Energy storage

### Batteries

Batteries have a quick response time and are therefore particularly suited to control demand and supply fluctuations. In the energy system of the future, they can fulfil different functions such as managing imbalances, supporting the local grid, or serving as back-up for grid operators. Lithium-ion technology currently dominates the battery storage market. Because of the compactness of lithium-ion batteries, this technology is expected to remain the first choice for mobiles and cars for quite some time. The cost of batteries has fallen sharply in recent years and the number of actual applications continues to grow. For example, Elia, Belgium's transmission system operator, recently contracted with a Flemish aggregator a central battery storage of 17 megawatts to be added to its primary reserve. This reserve is used to react, within a maximum of thirty seconds, to frequency variations due to injected or absorbed power.

The use of battery storage causes indirect positive effects on greenhouse gas and air pollutants emissions due to better integration of renewable energy. The safety risks of batteries (fire, release of toxic substances) are an important area of attention. Lithium is extracted mainly in developing countries, which raises issues about the sustainability of the extraction techniques and working conditions. The manufacture of lithium-ion batteries also requires a considerable amount of energy.

The cost of battery storage is expected to continue to fall to a level of 150 to 200 euros per kilowatt hour or even less in 2030. In view of the expected strong growth of battery applications, the exhaustion of lithium supplies could be a constraining factor. Commercial recycling of used batteries can play an important role.

#### LEVERS FOR BATTERY STORAGE

**Declining cost.** The principal lever for batteries is their declining cost, which exceeds even the most optimistic expectations. Furthermore, different battery technologies are competing with each other.

**Flemish recycling expertise.** Research into recycling techniques for lithium-ion batteries can offer solutions in the field of material use and sustainability. Given the relatively recent breakthrough of the lithium-ion technology, there is as yet no mature market for battery recycling. The market is currently being explored through research and demonstration projects. The recycling expertise available in Flanders represents an opportunity in this context.

**Vehicle-to-grid (V2G).** V2G technology allows the battery of an electric vehicle to temporarily function as an energy buffer to absorb local peak loads in the grid. The growth in the number of charging stations and urban low-emission zones could favourably impact the electric mobility market. This would not only increase the number of electric vehicles, but also support the development of V2G systems. Incentives can compensate for the relative disadvantages experienced by the owners of the electric vehicles used. Thus, for example, some users find it important that the battery is charged as fully as possible at all times. It is important to note that, based on the current state of the technology, the use of electric vehicles in matching demand and supply still has an adverse effect on the lifetime of the battery.

**New business models.** New business models can be developed in the field of ownership, installation and use of battery systems, for example, in the form of a leasing contract. Building owners would then no longer own the battery system (possibly in combination with other systems such as PV), but pay a monthly leasing fee to the owner and operator of the system. In return, the building owner receives a guaranteed energy service, for example, a guaranteed lower energy bill as compared to a conventional supply contract. Such leasing formulas can also be offered for the use of a common battery at district level. The advantage of a leasing formula is that the building owner no longer needs to shell out the initial investment. In addition, it creates opportunities for other business activities such as battery recycling or giving car batteries a second life.

### Power-to-gas

Electrolysis can be used to convert water into hydrogen, which can then serve as storage medium. Hydrogen can be injected into the local gas pipeline network that provides homes and businesses with heating. Power-to-gas also offers a solution for green power surpluses, which can be used for the conversion to hydrogen. Hydrogen can also be used for the production of synthetic methane, through the combination with CO of $CO_2$ waste streams, or for biomass gasification. For this, $CO_2$ can be used as raw material, which allows an industrial process to be made low-carbon. Moreover, methane is the main constituent of natural gas and can therefore easily be transported over existing pipelines. Underground methane storage also allows demand and supply to be matched over longer periods. The majority of power-to-gas applications are still in the demonstration or pre-commercial phase. European demonstration projects for hydrogen generation and injection into the natural gas grid appear to rely heavily on subsidies.

Power-to-gas can replace the combustion of (non-renewable) natural gas. This would lead to an emissions reduction of 179 grammes $CO_2$ per kilowatt hour.

The investment costs and the current electricity price are currently still too high for electrolytic hydrogen production to be commercially viable in the short term.

### LEVERS FOR POWER-TO-GAS

**Strong hydrogen industry.** Flanders already has a strong hydrogen industry in place. The relevant companies are represented within the WaterstofNet cluster, which has already developed a first power-to-gas roadmap for Flanders. The idea is to further develop demonstration projects, assess their feasibility, and effectively implement the most promising projects.

**The potential of green gas.** The admixture of hydrogen requires modifications to the gas grid. The gas grid in Flanders is unlikely to be phased out within the next hundred years. This means there is still plenty of time for green gas to play a significant role. A technical requirement that could be imposed on new gas-fired power plants is that they are capable of running on a gas mixture that is partly made up of (green) hydrogen.

**Financial incentives.** Electricity is still significantly more expensive than gas, so that electrolysis demonstration projects are very much dependent on subsidies. A tax shift from electricity to fossil gas would make the business case for power-to-gas far more compelling. An incentive for green gas – by analogy with the green power certificate system – could be a lever to roll out electrolysis.

### GAME CHANGERS IN THE ENERGY SYSTEM?

It is not inconceivable that certain technological breakthroughs can act as game changers and radically alter the energy system in the time horizon to 2050. Examples of potential breakthroughs are:

- Supercapacitors that have the ability of being charged extremely fast, which would make them ideally suited for application in cars;
- Small-scale cheap electrolysis systems, which would enable the cheap production of hydrogen as storage medium;
- Inductive charging, which would obviate the need for charging stations;
- The self-driving car, whose environmental impact and effect on electricity consumption is still unclear (see also 3.3 "Shift (modal shift)").

## Other energy storage technologies

Energy can also be stored in pumped-storage power plants, in energy atolls, or via heat-cold storage. Belgium has a number of pumped-storage power plants, the largest of which is located in Coo. They can play a role in energy storage or be extended, or supplemented, with energy atolls in the North Sea, for temporary storage of electricity production by offshore wind farms. At present, there are no plans for the construction of an energy atoll off the Belgian coast. An extension of the Coo pumping station is also highly uncertain due to the substantial investment cost.

Seasonal storage of heat or cold in a reservoir, in natural or excavated pits or in boreholes is another possibility, but has not yet found application in Flanders. Seasonal storage in combination with heat supply by heat pumps or production of sanitary hot water by heat pump boilers could eventually enable more sustainable solutions. Buildings themselves can be used for heat storage in the shorter term via the smart control of heat pumps. A commercial breakthrough is closely linked to the rollout of heating grids in Flanders.

## Local demand and supply management

Devices and systems based on information and communication technology (ICT) are becoming increasingly popular. Such smart devices can be controlled by the outside temperature, signals from the grid operator or from the market. This is referred to as a smart grid. Systems equipped with sensors and software can also anticipate user needs. This not only provides added comfort but also offers opportunities in the field of energy efficiency. Automated, demand-driven lighting, heating and cooling could thus reduce peak demand by up to 20 per cent.

Due to the flexibility in energy use, PV panels, heat pumps, electric boilers, electric vehicles and battery storage can provide support to a smart electricity grid. This allows the grid to be managed and used more efficiently. In exchange for this flexibility, incentives can be provided, such as dynamic tariffs based on available capacity or delivered flexibility. The medium-term (2030) potential for most applications is still uncertain. As applications such as heat pumps, electric cars and PV systems become more firmly established, there is a great need for flexible energy behaviour in the long term (2050).

Smart devices allow power to be used at moments where power supply is greatest. By thus matching demand and supply, peak demand can be reduced. In this way, the use of demand-driven fossil fuel-fired power plants can be reduced, and the use of supply-driven renewable energy such as solar and power, increased. They will thus indirectly reduce greenhouse gas and pollutants emissions. The smart control of devices itself also consumes energy, for example as a result of the need for data centres. This is a factor that needs to be taken into account.

The application of such flexible energy behaviour is closely linked to the development of the necessary infrastructure (smart meters) and incentives to deliver flexibility. The affordability of the various options will largely depend on the market environment. Thus, aggregators could play a facilitating role and encourage flexible energy behaviour by offering new pricing models. It is not certain to what extent consumers are willing to commit to such services. Possible loss of comfort and control as well as privacy concerns could play a role.

## LEVERS FOR LOCAL DEMAND MANAGEMENT

**Differentiated tariff.** Today, consumers do not notice anything of the difference in real cost between energy consumption in the evening (during peak hours) and during the day, when a large amount of renewable energy production is available. Today's private PV systems feature a reversing meter, whereby the meter goes up when electricity is used and down when the PV system injects surplus electricity into the grid. The price per kilowatt hour received for the injected power is equal to the price paid under the signed energy contract. This increases the risk of grid congestion when much solar power is available. The reversing meter system therefore does not encourage prosumers to consume themselves as much as possible of their own generated solar power at the time of production. Regulatory reform has therefore been announced. A possible option would be the introduction of a distribution tariff with a capacity-related component. This would offer prosumers an incentive to avoid peak loads. This is possible by consuming more of the locally generated power, temporarily disconnecting the PV system (curtailment), or investing in home batteries that store electricity at times of peak production and discharge again at times of peak consumption. The challenge for policy is to keep investment in a PV system profitable and therefore financially attractive. An alternative compensating system for the reversing meter will be introduced from 2021.

**Microgrids at district level.** The construction of a microgrid at apartment building, district or city district level would enable the energy demand of the occupants to be matched as optimally as possible to the decentralised production, thereby minimising the load on the connection to the distribution system. Power-to-heat solutions at the level of individual buildings, a street or district, allow flexible matching of local electricity/heat demand and supply.

**Reducing the threshold for smart control.** Smart control of energy systems installed at households and SMEs does not always require a major modification or investment. Undersizing the inverter of solar panels, thereby reducing the peak capacity, enables smoother integration into the grid, for example. If the peak capacity of solar panels is reduced by, say, one-fifth, only a few percentage points of the total produced energy will not be able to be injected into the grid.

**New activities for system operators.** Grid operators are not expected to provide services aimed at managing possible grid congestions before 2030. For these services, 'aggregators' can act as a third party for energy users, when the latter are willing to use a portion of their capacity for the provision of flexibility services to the electricity market.

**New IT niches**. Suitable control systems are required to control rapid and large-scale reactions to price differences. With *smart charging*, for example, the available charging capacity for electric cars is distributed according to certain protocols. This makes it possible to prevent overloading of the electricity grid. These new niches are a commercial opportunity for knowledge institutions and IT companies.

## Active demand management at system level

Flexibility on the demand side is already commercially applied at large companies by temporarily shutting down energy-intensive processes without incurring any economic loss. Examples are the warm-up process in the cement industry or the pumps of a water treatment plant. An aggregator controls flexible on-site demand and makes the connection with the market. In the future, flexibility on the demand side can be extended to include the residential and service sector, for example via smart devices.

### CURTAILMENT

In Belgium, negative electricity prices occur from time to time. This is mainly the case when abundant wind and solar power is available, in combination with the constant electricity production by nuclear power plants. Curtailment or the disconnection of decentralised production units can in some cases be the most cost-effective solution to better match energy demand and supply without heavy investments in the expansion of grids.

In the SWIFT (smart wind farm control) project, experience was acquired with the curtailment and smart control of wind farms. This proved favourable for the integration of renewable energy. Only a small portion of the wind energy was found not to be injected into the grid. Also for solar energy, it may, from a social perspective, be more cost-effective to disconnect production for a short period of time. This could allow for more decentralised production in anticipation of expansion of the low-voltage network. In the recent Clean Energy Package, the European Commission recommends the cancellation of priority grid access for renewable energy. This could promote the adoption of smart curtailment in national regulations. This must, however, be communicated carefully so as not to create the perception that energy is 'being thrown away'. This can carry a negative connotation for both the general public and investors. Some sort of compensation could be envisaged.

### LEVERS FOR ACTIVE DEMAND MANAGEMENT AT SYSTEM LEVEL

**All-in service as a new business model.** New business models are becoming possible, such as all-in energy services for households, SMEs or apartment buildings. The customer pays a monthly fee for a comfort level of heating, cooling and electricity, but no longer needs to invest in the necessary infrastructure. The all-in service provider is also responsible for the optimal combination of demand, energy storage and decentralised energy generation.

**Strengthening the interconnections.** The higher the level of interconnection, the more stable the prices. Strengthening the interconnection capacity with foreign countries is therefore a good way of protecting Belgian electricity users against price volatility in the electricity market. In the field of electricity transmission, several projects have been planned to improve the interconnection with neighbouring countries. One example is the planned direct interconnection with the German grid via the Alegro project. The Stevin and Nemo projects cover the interconnection with the UK. These, along with some other projects, must ensure the availability of more than 6 gigawatt import capacity after 2020. The level of interconnectivity that Belgium and Flanders should aim for in the longer term, is uncertain. In case of electricity shortages, security of supply is not guaranteed and interconnections require large-scale, expensive infrastructure works.

**Heat pumps, home batteries and electric cars as lever.** It is not certain that the average consumer is automatically willing to shift their demand in time in order to participate in the emerging flexibility market. Moreover, it requires additional knowledge from the occupants in order to optimally utilise the potential. Vulnerable groups probably have only limited possibilities to participate in the flexibility market. As heat pumps and electric vehicles find broader application, it will become more interesting for residential customers to participate in the market.

**Transparent information about curtailment.** The disconnection of decentralised production units may raise questions among prosumers about the profitability of their own PV system. Transparent information about the purpose and the criteria used for curtailment will promote social acceptability.

## Generic levers for matching supply and demand

### Clear policy orientation necessary for the choice of matching technology(ies)

A clear, long-term government vision - at different levels, from European to regional - will be a major lever to drive investments in matching technologies. This gives rise to various questions: What forms of matching do we need? What are the social costs and benefits? How do we distribute these over the users of the energy system? Such a long-term vision can also serve as the framework for establishing support mechanisms such as subsidies for storage technologies.

With the Clean Energy Package, the EU focuses on the further integration of the European energy market. The new European directive remains to be approved by the European Parliament, but provides an important framework for better matching energy supply and demand.

### Digital meter as a key enabler

The compulsory, phased rollout of digital electricity and gas meters will be launched in 2019. This marks an important step towards the matching of energy demand and supply. All Flemish households are expected to have a digital meter by 2035. The detailed consumption data that will be obtained can be used to support grid management, the development of new tariff structures, and choices in the field of grid modifications or energy storage.

## 2.5 Conclusions

### Towards a sustainable energy system

Energy is essential for every conceivable activity and in every sector in Flanders. It is simply indispensable to society. Most of this energy is readily available, reliable and affordable, but also has a downside. The dominant regime, which is based on fossil fuel and nuclear energy, has a great impact on climate, the environment and our health. Nuclear energy production involves certain safety risks and generation of radioactive waste. If global warming is to be kept below 2°C (as compared to the pre-industrial period), as specified in the Paris Agreement, greenhouse gas emissions will have to drop significantly. For the European Union, this implies a greenhouse gas emissions reduction of 80 to 95 per cent by 2050 as compared to 1990 levels. In Flanders, three-quarters of greenhouse gas emissions arise from the use or generation of energy. The transition to a sustainable energy system is urgently required. This transition is still in its initial stage but has already gained significant momentum. To bring about the transition to a sustainable energy system, there are four possible solution paths: energy saving driven by behavioural change; energy saving through improved energy efficiency; making energy supply more sustainable; and matching energy supply and demand. Many solutions are already available, but need to be rolled out on a much larger scale.

### Levers for the transition

Energy saving driven by behavioural change and improved energy efficiency are the cornerstone of the transition trajectory for making the supply of low temperature heating and cooling in the built environment more sustainable. Increasing the building stock's **renovation rate** constitutes a tremendous challenge in this transition. The increase can be accomplished in different ways, including the creation of a neutral contact point that coordinates the entire energy renovation project, the introduction of a dwelling certificate, renovation at district level, or the deployment of innovative building concepts. The remaining low temperature heating demand must be met by **sustainable heat sources**. The all-electric solution could mainly apply to new builds or existing homes that were thoroughly energy-renovated and where connection to a heating grid does not prove feasible. For buildings that cannot be connected to a heating grid and where an all-electric solution is not feasible, a possible solution would be the use of hybrid heat pumps, gas adsorption heat pumps or green gas- or sustainable biomass-based heat supply. **Vision building and strategic planning** (with a key role for the local level) should provide an answer to the central question as to which sustainable energy networks are specifically desirable and feasible for different Flemish neighbourhood typologies. Adequate coordination of spatial policy (clustering) and investment policy for the modification of the energy infrastructure can keep the societal costs for the transition to a sustainable energy system under control. The growing positive recognition of 'green', 'conscious' and 'sustainable' by broad sections of society can leverage more energy-efficient living. Savings surpluses can be mobilised for investments in energy efficiency or green heating supply. Investments in energy savings and improved energy efficiency can generate additional added value and jobs.

As concerns the sustainability of energy supply, there is great consensus in Flanders on the application potential and the sustainability impact of renewable energy. The support of renewable energy production is considered a reasonably mature policy area for which the necessary policy instruments have been developed over the past decade. The sustained use and optimisation of these policy instruments is necessary **to create the proper market environment** and encourage entrepreneurship, thereby ensuring the timely implementation of the necessary technologies. Many technologies are already available and will be further improved. No radical new breakthroughs are expected. The challenge will therefore be to create a large market for the existing renewable solutions. The **binding target** of the European Union to obtain 32 per cent of energy from renewable energy sources by 2030, provides a solid legitimisation and incentive for the Flemish policy to be conducted in this field. Making renewable energy more economically attractive by making the use of fossil fuels more expensive, for example by imposing a **$CO_2$ tax** on sectors that do not fall under the European emissions trading scheme, can play an important role in this respect. **Energy cooperatives** or other forms of participation allow citizens to co-invest in renewable energy.

The sustainability of Flemish industrial energy demand by 2050 is still surrounded by great uncertainty and lack of clarity, both in terms of the nature and size of the future industrial activities and in terms of how the remaining energy demand will be met. The pace of the transition of the Flemish industry is also closely linked to the progress at European and even global level. Major European sectoral federations have already prepared roadmaps outlining the options to contribute towards a low-carbon economy by 2050. A concrete **guiding vision of a sustainable industry** in Flanders is essential. Flanders has various industrial activities that could play an important role in the transition to a low-carbon economy, such as the production of insulation and lightweight materials and the recycling of batteries.

Solutions for matching energy demand and supply play a key role in a sustainable energy system. They do not have a direct positive environment impact as such, but they do have an indirect impact in that they facilitate the integration of renewable energy. An important commercial role is reserved for aggregators capable of trading the flexibility of industrial, commercial or domestic electricity users on the energy market. Batteries, whose cost is declining, are considered to be an important part of the solution mix for matching demand and supply. **New business models** on ownership, installation and use of battery systems can speed up the rollout. With a sufficiently large share of electric vehicles, the V2G technology also offers a major opportunity to use car batteries as a means of balancing demand and supply on the power grid. The environmental impact during production and mining of raw materials remains an important area of attention. Flemish recycling expertise can offer solutions in the field of material use and sustainability.

In the longer term, when renewables are expected to account for a significant percentage of energy supply, **power-to-gas** applications that use temporary power surpluses to produce hydrogen would grow in importance. Flanders already has a strong hydrogen industry with international players. If the gas grid is modified, hydrogen could be injected into the grid and serve as seasonal storage. Hydrogen electrolysis will not be commercially available in the short term due to the high investment costs and electricity prices.

Also **smart devices**, which use power when the power supply is greatest, can play an important role in matching demand and supply in the new energy system. Due to the flexibility in energy production and/or use, PV panels, heat pumps, electric boilers, electric vehicles and battery storage can provide support to a smart electricity grid. The development of suitable control systems for demand-side management and batteries is essential, such as smart charging for electric vehicles. The rollout of **digital electricity and gas meters** will provide a more detailed insight into consumption data that can be used to support grid management and grid development, the development of new price structures and decisions on additional grid upgrades or local storage technology. Another interesting avenue appears to be the application of a **microgrid** at apartment building, district or city district level. The energy demand of the occupants of the apartment building would then be optimally matched to the decentralised production within the building, thereby minimising the load on the connection to the distribution system. Finally, curtailment or smart control of decentralised production is another possibility of making more decentralised production feasible, without the heavy investment cost that is associated with the expansion of networks.

# INTERMEZZO

## HORIZON SCANNING

**Horizon scanning helps to timely identify contextual developments and assess their threats and opportunities for the environment in Flanders. Within MIRA, this foresight process is receiving increasing attention. We will outline the horizon scanning process and discuss the results of a recently completed project.**

Horizon scanning aims to strategically explore weak signals and new or unexpected issues that may have an important social impact. However, persistent problems, emerging trends or changing (mega)trends are identified as well. The aim is to zoom in on developments that occur at the boundaries of current thinking and current policy planning, to better understand their threats and opportunities for the environment (and environmental policy), and to identify gaps in our knowledge of them. The ultimate goal is to make (environmental) policy more robust, also in the longer term.

The work carried out by MIRA in the period 2017-2018 builds on the insights gained from a previous study conducted within MIRA. The report *Megatrends: far-reaching, but also out of reach? How do megatrends influence the environment in Flanders?* (2014) thus identified six megatrends and analysed their implications for the environment in Flanders. The conclusion was that megatrends impact society through our societal systems in a complex and far-reaching way, now and in the future. Those who seek to develop an adequate vision and policy are therefore well-advised to give due consideration to them. In the wake of the report, the VMM, together with Argus and The Shift, organised the conference *Megatrends: How to go about them for a sustainable and resilient Flanders?* at the end of 2015. In the presence of a broad range of societal stakeholders, views were exchanged about the way in which Flanders can deal with megatrends in order to facilitate the breakthrough of sustainable and resilient societal systems.

Via a new horizon scanning study, MIRA validated and updated the megatrends identified in 2014 (see also 1.2 "Megatrends are becoming increasingly present"). The study also looked at interconnections, weak signals and possible counter trends. In addition, a number of broad societal developments were identified and described, which, together with the megatrends, set the context for the implementation of ecologically sustainable systemic solutions. These developments will be described below, at the same time illustrating how knowledge about them can help with the implementation of systemic solutions.

## Clustered societal developments

The recent horizon scanning process revealed seven quite diverse societal developments, which we have clustered into three groups. These are developments that are on the one hand still fairly dominant, but at the same time already exhibit counter trends and weak signals of change. The interaction between prevailing contextual developments and counter developments can result in (far-reaching) societal shifts or even a tilt depending on the societal development in question.

The developments also affect the way in which systemic solutions, with a view to transitions to ecological sustainability, can be implemented. Some are very directly relevant to what systemic solutions can look like. For example, the centralised or decentralised organisation of production or supply in societal systems. Others are probably situated on a more fundamental level. For example, is the premise that society is based or not on the current forms of (physical) economic growth. Still others are more indirectly relevant to the implementation of specific systemic solutions, for example the role of technology in tackling major societal challenges.

## Shifts in value creation

This development is about possible shifts in the dominant, global economic growth paradigm, whereby economic development is predominantly based on economic and financial principles. Shifts in this growth paradigm can then be labelled as a 'meta'-driving force for societal change and environmental challenges.

**Shift from financial/economic to (more) social/ecological added value creation**
There are clear signals that pursuing economic growth in its current form is no longer tenable. More attention must be given to the creation of social and ecological added value and the way in which social progress and prosperity are measured. Economic growth as a central paradigm is hardly being challenged. Among policy makers, but also producers and consumers, this leads to the almost exclusive pursuit of continuous growth, whether exponential or not, in economic policy and in our industrialised society. Decoupling economic growth and the associated use of natural resources, waste production and pollution is still often considered adequate to enable further growth in the future. Therefore, what we have here is a paradigm shift that can probably only occur in the longer term.

## Shifts in mental models, norms and values

The horizon scanning also detected three societal developments that largely occur at the level of mental models, norms and values. A common characteristic of these developments is that they are in a very early stage and uncertain.

**From individual interest to (more) societal interest in consumption**
Some developments suggest a shift in consumer considerations when choosing to buy or use products and services. However, the question is whether we are already seeing a developing 'ecological citizenship': a growing awareness that individual choices can have undesirable effects for others and for the environment. Due to the relatively limited scale at which initiatives of greater societal value develop, their impact remains limited for the time being. It is also not certain that this awareness will, in the short term, take hold in Flanders. Individually oriented and cheap consumption continues to prevail. Yet a gradual change in mentality can be observed, especially among certain groups of consumers and citizens. There is also growing policy attention to responsible consumption.

**From objective, uniform to subjective, variable information flows**
Information and knowledge are becoming ever more important, but at the same time there is a growing lack of clarity about their quality and about the reliability of the sources. A powerful shift is already underway towards more subjective information flows such as social media and fake news, i.e. the dissemination of opinions purporting to represent substantiated scientific evidence. A counter reaction seems to be slowly taking place in the form of user groups (peer-to-peer) and bodies that adopt a more critical approach to information sources.

**Towards a more critical vision on the role of technology in society**
Technology plays a dominant role in our society. It provides concrete solutions and represents an important driving force for added value creation and economic growth. At the same time, it is becoming clear that technological development plays an important part in pressing societal problems. Examples are the environment and mobility, but also the organisation of the social fabric. A more critical approach to technology and technological innovation seems to be emerging. This could lead to a shift from the question what technology 'is capable of doing' to what technology 'should be doing' from a social perspective.

## Shifts in organisation and steering

The horizon scanning also flagged a number of societal developments suggesting a shift towards a more local approach and local solutions to societal problems.

**From centralised to (more) decentralised production systems**
There is a trend from mainly centralised, large-scale production and supply (the dominant organisation form) to the emergence of more decentralised forms. For example, shifts to local production and marketing of food products or to decentralised renewable energy production are already noticeable. This evolution will not take place in all societal systems to the same extent and at the same rate.

**From a globally to a (more) locally oriented policy approach to problems**
The growing division over global issues such as the approach to climate change, implies that the centre of gravity of decision making is again shifting to the (lower) international,

national and regional policy levels. A similar process is taking place at European level. Cities all over the world are also developing their own dynamic to address global and supra-local issues themselves.

**From a top-down oriented society to more bottom-up initiatives**
This societal development manifests itself in the emergence of bottom-up initiatives by (organised) citizens, consumers, local entrepreneurs, interest groups and local governments. In this regard, government should preferably act as facilitator rather than an initiator or guide. A complete shift to bottom-up approaches is not expected, although the trend is growing in importance. Policy can determine for which aspects a top-down approach remains necessary, and where support and upscaling of bottom-up initiatives constitutes a more appropriate approach.

## Four possible scenarios for the evolution towards ecologically sustainable systems

To illustrate how horizon scanning can be useful in the choice and implementation of systemic solutions, the seven previously outlined societal developments were combined into four environmental scenarios. In each of these scenarios, the outlines of possible evolutions until 2050 were explored for the societal systems energy, mobility and food. In the following description of the four scenarios, we will also briefly illustrate what these evolutions could mean for the ecological sustainability of the three societal systems.

**Business as usual** serves as the reference framework with which the other scenarios are compared. Within this scenario, none of the societal developments will lead to a major tilt. For each of the societal systems it will probably not be possible to achieve a transition to ecological sustainability. Energy efficiency is further optimised, but overall energy demand continues to grow and the share of renewable energy does not grow (fast) enough. The focus remains on automobility. Also the number of vehicle kilometres travelled continues to rise, so that congestion becomes critical, resulting in a mobility crisis. Only a minority of consumers adopt a more sustainable dietary pattern. The consumer focus remains on price and comfort. In the area of food production, the focus remains on economies of scale, intensification, further automation and integration into the chain.

In the **Tecology** scenario, there is a firm belief in technological solutions for (environmental) challenges. Large industrial players and small emerging technology firms offer products and services that place greater emphasis on socio-ecological values. The consumer follows suit because these companies offer useful solutions, with the support from governments. In this scenario, renewable energy and smart energy use both break through. However, due to the strong focus on new technology, it remains difficult to meet the increasing demand for energy and resources. There is a clear shift to new technologies that enable sustainable mobility, including more sustainable modes of propulsion, alternative fuels, self-driving cars and ICT supported mobility solutions. Major changes in mobility behaviour are rather slow to take hold. Food production is information- and technology-intensive, but not diverse enough. The food consumer is passive and consumes preconceived ecological products.

The **Ecolocal** scenario is based on local interests and a local approach to (environmental) issues, including supra-local and even global ones. An important role is reserved for bottom-up initiatives. Local companies, together with civil society, citizens and possibly local governments, play an active role. There is a shift away from an energy-intensive economy and a drive for self-sufficiency in the field of energy, causing overall energy demand to decline. Citizens increasingly install their own energy production and storage. Production and consumption are increasingly localised. The distance between living and working, study and recreation, decreases. Local communities initiate the transition to sustainable mobility via sharing initiatives, for example. In the field of food production/distribution, there is a regional system with farmers and food producers that produce local and seasonal products for the local market (possibly on a cooperative basis and supported via sharing platforms) and also provide ecosystem services and social services. Local governments develop food strategies.

In the **Ecosense** scenario, the consumption behaviour is shifting to more sustainable products and services. Consumer demand for more environmentally and socially responsible alternatives induces the economy to create and provide suitable solutions. Large industrial players fulfil a more important role in the sustainability of the various systems. By firmly committing to green development, companies find solutions to meet the energy needs. Energy production is also becoming significantly more renewable. User demand provides a strong impulse to sustainable mobility solutions. Companies offer sharing schemes, reducing the number of bottom-up initiatives. Companies and industrial agriculture play an important active role in making food production ecologically sustainable, including through integrated chain management. Food production is partly high-tech, and food chains are becoming slightly shorter. Governments respond to these trends.

3

# SOLUTIONS FOR THE MOBILITY SYSTEM

**To move people and goods, we have access to a vast network of roads and car parks, rails and stations, (air)ports and a range of transport modes. Mobility is indispensable in our society, yet it also leads to air pollution, health problems, climate change, road congestion and traffic accidents. To solve these persistent problems, a fundamental rethinking of our mobility system is required. In this chapter, we will analyse the challenges, possible solution paths and levers for the transition to an (ecologically) more sustainable mobility system in Flanders.**

## 3.1 What is it about?

### Mobility: closely interwoven with other systems, but at a critical point

The Flemish mobility system is closely connected with other societal systems such as economy, culture, spatial planning, and energy. The daily mobility of individuals is to a large extent determined by the spatial location of residential homes, businesses and facilities. Freight transport, by contrast, is closely connected with the way in which our production and consumption systems are organised.

However, due to the multiplicity and frequency of journeys, mobility in Flanders is increasingly being constrained. Congestion is worse than ever and impacts our quality of life and economic productivity. Moreover, both passenger and freight transport are expected to continue to grow. It is becoming clear that things cannot continue as they are.

#### THE CHANGING MOBILITY SYSTEM IN FLANDERS: A DIAGNOSIS

**The dominant regime for passenger transport is still the fossil fuel-powered car. Its immediate availability and high level of comfort, but also a certain image that goes with it, continue to play a role in this respect. This is referred to as car-centric mobility. Freight transport, too, is mainly organised around lorries and vans running on fossil fuel.**

**Drastic changes in the past**

Over the past centuries, our mobility system has gone through a number of transitions whose impact is still being felt today. The foundation of the current Belgian road network was laid in the eighteenth century. However, an overall road programme with a road classification was introduced only in the nineteenth century. After 1850, rail looked set to become the transport mode of the future, but around the turn of the nineteenth to the twentieth century, the first car models appeared on the market in Belgium. Throughout the twentieth century the road network was further developed to serve the needs of cars. This led to a new concept in the 1930s, the motorway: a road which is accessible only to motorised traffic and which does not have any level crossings. In the 1950s, an international network of E-roads was developed. As prosperity grew, an increasing number of Belgians were able to afford a car. The oil crises, the economic recession, the emergence of ecological awareness and the change in mentality on land use led to the first manifestations in the 1970s. Budget cutbacks in the 1980s slowed down the construction of planned roads, which, from the mid-1990s, virtually came to a standstill. Car traffic has grown steadily over the past decades. Automobility in Flanders grew very rapidly, especially until the 1990s. In 2012, almost three times as many person-kilometres were travelled by car as in 1970.

**Pressure on the dominant regime: the transition impulse**

Car-centric mobility causes a number of persistent problems. Traffic jams keep growing year after year. The number of lost vehicle hours for cars and vans almost doubled between 2010 and 2018. Safety, especially of more vulnerable road users, remains a major challenge. Growing public awareness of the climate issue puts pressure on the existing system from the outside. Moreover, there is growing public attention to the persistent health problems caused by particulate matter and nitrogen oxide emissions. Furthermore, questions are raised about the space that is taken up by this car-centric mobility. The dependence on fossil fuels also renders the dominant regime vulnerable to unforeseen developments in the oil market.

There are also many new niches that put pressure on the dominant system. Traffic is restricted and slowed down in play streets during certain hours for limited periods of time. Cycle streets turn the classical balance of power between car and bike upside down. Low-emission zones, and above all local mobility plans, can lead to a modal shift away from the car. The electric bike appears to give a boost to both functional and recreational cycling in Flanders. The construction of bicycle highways vigorously responds to this by providing a more appropriate infrastructure. In many other areas, however, the use of bicycles in general and electric bikes in particular is still inadequately regulated. The high speed of speed pedelecs puts pressure on traffic regulations and today's standards for the design of cycle paths. The success of these fast electric bikes calls for solutions. These are all early signs of a cycling culture that is gradually evolving from a subordinate to an autonomous culture. The search for (combinations of) alternatives to the car has also led to the first initiatives in the field of customised mobility (Mobility as a Service or MaaS). Mobility as a Service integrates different mobility options into single efficient multimodal route planning.

**Resistance of the regime to drastic changes**

In spite of these new trends, car-centric mobility still constitutes the central and dominant regime. It is available around the clock, it is relatively affordable, flexible and supported by a very extensive spatial and economic infrastructure. It proves to be a highly consolidated system that is extensively connected with other societal systems such as economy (via growth), land use (via spatial planning), consumption (via spatial planning and e-commerce) and energy (via energy use).

The regime's resistance to change manifests itself in various areas. Clearly, a substantial amount of capital is tied up in the road network. It cannot be phased out or replaced, not even in the medium term, without major financial and social costs. Furthermore, spatial planning in Flanders - dispersed settlement, ribbon development and lack of clustering - promotes car use. Widespread car use has also spatially separated activities that used to be spatially co-located (living, working, shopping, learning). Car dependency has thus become further embedded in social life. As a result, alternatives to car use are not always evident, especially for chains of journeys, such as commutes between home and multiple locations (office, school and/or daycare) and shopping trips. Also the socialisation of car use - the belief that one has to be able to drive a car in order to fully participate in social life - remains stubborn. Incorporating driving lessons into the school curriculum only seems to confirm that they are an integral part of growing up.

With the low oil prices and the limited offsetting of external costs, car use also remains relatively inexpensive, especially when taking into account the flexibility and the level of comfort offered by the car. Moreover, the status of the car was embedded in the compensation system, in the form of company cars. Originally a fringe benefit for senior positions, they quickly became regular practice throughout the labour market. Under the parking norms in urban planning regulations and the system of parking cards for residents, car owners are often also entitled to claim a portion of the public space in their residential area at no extra cost.

To withstand the internal and external pressure, the car-centric regime focuses heavily on optimisation. Real-time traffic control and rush-hour lanes, for example, are attempts at improving traffic flow. GPS allows for optimised use of the capacity of the entire road network. However, because the situation is already critical and due to the knock-on effect, the improvement is only temporary. (European) policy also actively promotes the greening of internal combustion engines. Major interests are at play in the automotive industry. A powerful lobby attempts to tone down the ambition of European policy on car emissions. From a climate and environment perspective, electric vehicles can be seen as a favourable development, but they can also help to preserve the car-centric regime.

**Where does the change process stand today?**

The existing mobility system is under pressure, that much is clear. However, the ever growing number of kilometres travelled by car and the very modest modal shift indicate that no fundamental change is forthcoming. There are nevertheless signals that suggest a destabilisation of the dominant mobility regime of fossil fuel-powered car, truck or van transport. Some cities and municipalities explicitly opt for quality of life, and make more radical choices in the area of mobility. Examples are mobility plans, low emission zones, or traffic-free streets in the vicinity of schools. They change the rules of play in the mobility system, thereby challenging existing practices. The recent negative perception and turnaround in policy may even lead to an elimination or phase-out of diesel technology for passenger cars. At the same time, an acceleration or even a breakthrough (emergence) gradually becomes noticeable in certain niches. One example is the growing success of the electric bike.

## Steering the mobility system of tomorrow

Our mobility is reaching its limits. The air quality in Flanders is gradually improving, but traffic remains one of the most important sources of air pollutants and greenhouse gases. In 2016, the transport sector was responsible for 51 percent of nitrogen dioxide emissions, 17 per cent of particulate matter ($PM_{2.5}$) emissions and 19 per cent of greenhouse gas emissions in Flanders. Our current mobility system further hampers the ambitions to meet the internationally agreed climate targets. Longer term forecasts by the Federal Planning Bureau estimate direct greenhouse gas emissions in 2030 to be about as high as in 2012.

A structural solution to these problems will take more than minor adjustments and further optimisations. Our mobility system is facing a fundamental reconfiguration. In other words, a sustainability transition in the mobility system is needed. Three possible approaches or solution paths play a role in this regard:

- **Avoid**
  This is possible by reducing the number of trips or the distance travelled per trip.
- **Shift**
  This implies a shift to ecologically more sustainable modes of transport (modal shift).
- **Improve**
  This is possible by converting the range of transport modes to a more environmentally friendly fleet and through better utilisation of these transport modes.

This threefold framework was designed to promote sustainable mobility in urban areas and is used by the European Environment Agency. As we will see below, some solutions contribute simultaneously to avoiding, shifting and/or improving travel.

Various solutions and innovations are addressed in the public debate on the sustainability of the mobility system. Based on literature research and expert surveys, ten groups of solutions were selected, spread over the three above-mentioned solution paths. Innovations that are only aimed at improving the environmental performance of conventional fossil fuel-powered vehicles, were not taken into consideration because they do not contribute to, or may even slow down, an actual transition.

## 3.2 Avoid

Avoiding travel is the most evident way to reduce the environmental impact of mobility. Distance working, learning and meeting is therefore often cited as a solution that could lead to less travel. This is, however, not evident because both passenger mobility and freight transport are closely related to the spatial location of houses, businesses and facilities. Moreover, both freight transport streams and a portion of the passenger transport are the direct result of the way in which our production and consumption systems are spatially organised. The consumer can make a difference by choosing short-chain products that require less transport. However, developments in international trade, production processes and inventory management result in ever longer transport distances. For example, companies with only one or a few production units per continent have a great impact on logistic flows. Given today's relatively low transport costs, it will not be easy to reverse this trend. Logistics will therefore be discussed in 3.3: "Shift (modal shift)" and 3.4: "An (ecologically) more sustainable fleet".

### Distance working, learning and meeting

The share of employees who regularly work at home or in satellite offices located closer to home, has tripled in the past twenty years, to around one in eight. The Flemish government set an example in this area: e-working or teleworking is possible for 80 per cent of all Flemish civil servants. With e-learning, pupils or students no longer need to go to school or campus. They can attend class from home or from any other location. Efficient systems already exist that enable interaction between teacher and student. E-meetings, too, can reduce the number of journeys. Many meetings can be organised without any form of physical attendance. Moreover, the technology is constantly evolving, so that e-meetings are becoming increasingly similar to conventional meetings.

These ways of working, learning or meeting have a direct positive environmental effect. Trips are either avoided or shortened. Admittedly, the environmental gain among people who already take the train or bike, is small. In the longer term, this trend could also result in smaller office buildings being erected, which has a positive environmental effect. A further increase in e-working by employees who used to travel to work by car, can reduce the congestion problem as the majority of jobs are concentrated in and around cities that also have the highest levels of congestion. Many studies are available on e-working, but fewer on e-learning and e-meeting.

There may, however, be various rebound effects. Houses and satellite offices require heating, so that overall energy use may increase. Since daily commuting is no longer necessary, people may choose to live, or continue to live, farther away from the workplace. E-working not only frees up time, but also an additional portion of the household budget that can be spent on other activities or products (with the accompanying transport). The knock-on effect of having fewer vehicles on the road can also (partly) cancel the positive effects on congestion, the environment and energy use. Studies show that, both in terms of time savings and avoided kilometres travelled per year, almost three-quarters of the teleworking effect risks being eroded due to these rebound effects. As regards energy use, the rebound effect of additional heating in the home or at the satellite office is so great that the effect is actually reduced to zero.

Even the highly ambitious scenario where 80 per cent of employees would be e-working two days per week – even without any rebound effect – results in only 10 per cent of Flemish vehicle kilometres being avoided. When taking into account the rebound effect, it is even less than 3 per cent. Even in such an extreme scenario, the effect therefore remains quite limited.

This environmental impact is bound to change in the future, because both buildings and the vehicle fleet are evolving. Buildings are increasingly better insulated, so that the negative environmental impact of additional heating declines. When part of the vehicle fleet will be driving on renewable energy, the environmental gain will be smaller. More e-working is therefore a facilitating solution for discouraging individual car use, but apparently does not lead to a significant reduction in environmental impact.

### LEVERS FOR WORKING, LEARNING AND MEETING FROM A DISTANCE

**Better work-life balance.** Many people see commuting as a negative factor for their work-life balance. E-working has a positive image among employees. For employers, e-working could be an opportunity to save costs. On the whole, Flanders is evolving towards a service society, whereby the potential of e-working increases.

**ICT facilitating.** Distance working and meeting facilities are closely linked to the organisational culture of a company. Especially the nature of the work is an essential factor. On the one hand, ICT increasingly provides opportunities that facilitate distance working and meeting. Remote monitoring or control of machinery is also possible to some extent. On the other hand, ICT can also be used to make commuting more efficient and pleasant. This could reduce demand for e-working. A minimum of face-to-face interaction will always be required, so the possibilities of distance working and meeting are limited anyway.

**Smooth acceptance of e-learning.** For e-learning, too, ICT offers the necessary facilities for distance interaction between student and teacher. The average young age of the users implies that they have sufficient knowledge and skills to assimilate e-learning.

## 3.3 Shift (modal shift)

The solution path ‘shift’ aims to abandon existing transport modes wherever possible by switching to a more environmentally friendly mode. Various solutions are possible: (electric) bikes and light electric vehicles (LEVs), carsharing, efficient mobility services, logistics modal shift and possibly also autonomous vehicles in the longer run. Such modes deserve to be examined for their contribution to the sustainable mobility system of tomorrow.

### (Electric) bikes and light electric vehicles (LEVs)

A modal shift from the car to the regular bike appears to be not that simple in Flanders. New technologies such as electric bikes and LEVs can give a boost to the shift away from the car. They also fit in with the drive for energy-efficient vehicles and nicely complement the short-distance options – for which the conventional bike is ideally suited – with alternatives for longer distances.

The electric bike (e-bike) with pedal assist or pedelec is a hybrid vehicle that combines human power and electric power. In the ‘slow’ variant, pedal assist is limited to 25 kilometres per hour; in the ‘fast’ electric bikes or speed pedelecs, a speed of up to 45 kilometres per hour can be reached. Electric bikes are booming in Flanders. Cargo bikes, which are suitable for carrying extra luggage, goods or passengers, are an interesting option when fitted with an electric drivetrain. In some places they are already being used for urban distribution.

In 2016, the (electric) bike was used in Flanders as principal means of transport for 25 per cent of trips up to 5 km and for 7.6 per cent of trips between 5 and 15 km. In total, this represents 15.5 per cent of the number of rides and 4.5 per cent of the number of kilometres travelled. These numbers pale when compared to the Netherlands, where a quarter of all trips are made by bike. However, bicycle use is also becoming increasingly popular in Flanders. Illustrative in this respect is the creation of Fietsberaad Vlaanderen (2014) by the Flemish government, which acts as a knowledge centre and promotes the development, dissemination and exchange of practice-oriented know-how. In this way, Fietsberaad Vlaanderen wants to support cities and municipalities in accelerating and improving their cycling policy.

Any type of bike can also be used in BiTiBi services (*Bike-Train-Bike*) as an alternative to the car for longer distance trips. BiTiBi stands for the intermodality between bike and train, and is named after a European project. By using the bike for travelling both to the station of departure and from the terminal station to the final destination, the train (or bus) can more often serve as an alternative to the car. To also have a bike at the place of arrival, there are sharing systems such as Blue-bike.

LEVs are situated somewhere between the conventional bike and a small car. They vary in type from reclining bikes with pedal assist to lightweight electric cars. LEVs are still quite scarce and, as a niche, they are still primarily in an experimental phase among a small segment of the population. An overview of the different types is available on the website created by KU Leuven (University of Leuven), VUB (Free University of Brussels) and ASBE (an association that promotes the use of electric vehicles and supports scientific and technological developments) on behalf of the Environment Department of the Flemish government (iiw.kuleuven.be).

In general, (electric) bikes and LEVs are light and their lower speeds make them over thirty times more energy-efficient than conventional cars. The environmental impact obviously depends on the form of energy used to produce electricity for the drivetrain, and on the type of vehicle which the electric or LEV replaces. Based on available statistics and reasonable assumptions, a shift to (e-)bike, LEV and BiTiBi would allow for a 29 per cent reduction in the number of passenger kilometres by car by 2030. Moreover, the additional societal health gains appear quite substantial, even more substantial than the already significant environmental gains. It is important to note that significant policy support is required to make the use of these alternatives more attractive and to discourage individual car use.

In addition to short distance trips by car, where a shift to the (electric) bike or LEV is possible and desirable, longer distance trips by car (more than 40 km) must also be borne in mind. These account for nearly half of the number of car passenger kilometres. Here, too, the bike-train-bike combination can offer an alternative with significant environmental gains.

### LEVERS FOR (ELECTRIC) BIKES AND LEVS

**Trendy image and health effects.** In Flanders, cycling already had a positive image as being particularly suitable for recreational purposes, but now more and more also as a functional transport mode. The emergence of the electric bike provides an additional impulse. In combination with growing awareness of the importance of exercise for health and the health impact of air pollution, (electric) cycling is showing an upward trend in Flanders.

**Flexibility and coupling to other modes of transport.** An obvious asset of bikes and LEVs is their great flexibility ('door to door'). The promotion of cheap park-and-ride facilities in combination with the provision of (shared) bikes can contribute greatly to the quality of life in cities.

**Low cost.** An electric bike costs significantly more than a regular bike, but far less than a car. LEVs contain much less material than conventional cars and are therefore cheaper to produce. Larger production volumes could lead to a significantly lower cost.

**Suitable and sufficient infrastructure.** Flanders still has an insufficient number of bicycle highways that allow safe and optimal use of (e-)bikes. A feeling of road unsafety could impede the market breakthrough of electric bikes and LEVs. It is, however, significantly cheaper to further develop the infrastructure for bikes and LEVs than to build new motorways. In addition to a riding infrastructure, suitable charging and parking facilities (especially for LEVs) are important.

**Effective policy choice in several areas** Flanders will need to drastically reduce $CO_2$ emissions from the mobility system by 2030 if it is to meet its international climate commitments. A shift from the car to the bike, the electric bike and the LEV can substantially contribute to this. The significant health impact of additional exercise is an important bonus. Policy incentives in this respect can therefore be particularly effective.

**Need for consistent policy.** Policy financially supports both cycling (tax-exempt bike allowance) and driving (company car, free (second) resident permit and parking spaces). As a result, the electric bike does break through, but often not as a replacement for the private car. Car use should be further discouraged, for example, by introducing road pricing. There exist also differences, that are difficult to objectify, between support measures for electric cars or mopeds and the lack of such measures for LEVs and electric bikes.

## Carsharing

The sharing of cars, but also of other vehicles such as scooters, has grown strongly in recent years. In conventional carsharing, the vehicles have a fixed location. In *one-way* carsharing, the shared car can be dropped off at a different location than the pick-up location at the end of the trip. This can be a location for shared cars but also a freely chosen location within a defined area, as in *free-floating* systems. The latter are very flexible, but also more complex to manage.

Car-sharing companies can provide the fleet themselves, but it is also possible to share privately owned cars via an online community, with a company being responsible for the practical and legal arrangements. Scooter sharing, carpooling in companies, sharing of company vehicles between companies, or the use of car-sharing systems for business trips, also fall under these forms of shared mobility. In addition, there are systems where cars can be shared with neighbours, friends or acquaintances (peer-to-peer) for non-commercial purposes. As can be seen, there is a great diversity of systems. Membership of car-sharing organisations in Flanders has more or less quintupled to over 35,000 over the past five years. The supply of peer-to-peer cars is growing rapidly, but sometimes outstrips demand. Many people actually offer a car, but it is not clear whether it will also be used. It is as yet unclear what the societal importance of shared mobility will be in the future. It is perceived primarily as an option within a mobility 'service package' (Mobility as a Service). Results of studies on the impact of car sharing also vary greatly according to the area and period under study. It is also difficult to compare the studies because of differences in methodology.

Nevertheless, a number of important findings can be drawn from them. For example, with carsharing one becomes more directly aware of the costs of car use, which puts a brake on excessive use. The possession of a car means that at the time of using the car, the costs for purchase, insurance and the like are considered to be sunk costs. As a result, one tends to underestimate the average cost per kilometre by focusing mainly or only on the operational cost. This will lower the threshold for the use of one's own car. Consequently, the comparison with the cost for the use of a shared car is not always made correctly. Moreover, the shared car is located at a certain distance, so you will be less inclined to use it for just about anything, which could lead to fewer trips ('avoid').

The fact that carsharing allows you to choose the appropriate type of car (rightsizing), leads to improved energy efficiency and lower emissions. Due to the more intensive use of shared cars, the car fleet can also be rejuvenated faster to more efficient types with lower emissions. This will also contribute to an ecologically more sustainable fleet ('improve'). Electric cars are in fact particularly suited for many relatively shorter trips in areas with a dense network of charging infrastructure. This is often also the case in the typical urban environment, where shared mobility is most popular. In such an environment, carsharing can also reduce the need for parking spaces, which can have a noticeable impact on land use. If carsharing leads to reduced car use, it could also help solve the congestion problem. However, there is also a risk of possible increased car use. Furthermore, it could induce people who did not have a car to start using one. Carsharing can, however, also lower the barriers to a shift towards public transport, by providing a flexible solution for pre- and post-transport. It is therefore essential to create the right framework conditions to achieve the desired positive impact.

According to studies, members of car-sharing organisations are increasingly prepared to dispose of one or more cars or to postpone the purchase of a private car. In addition, members travel fewer kilometres than they would with their own car. The direct confrontation with the costs of car use appears to be an important factor in this regard. Users of carsharing systems are generally young and their lifestyle is comparatively less dependent on the car. Studies suggest that the average Flemish citizen would be far less inclined to abandon individual car ownership. On the other hand, the positive experience of these young urban frontrunners could inspire others and lead to further growth due to imitation effects.

### LEVERS FOR CARSHARING

**Further experiments needed.** There remain quite a few challenges in the fields of communication technology, business models and cultural barriers. It would be appropriate to organise additional experiments. Competition appears desirable, so that various forms of shared mobility can be integrated into a total package of transport modes.

**Low entry cost.** The financial benefits – no high acquisition cost or maintenance – and user-friendliness of carsharing are a strong motivator, especially for a younger audience.

**Availability at short distance.** An important factor for users is that a shared car is readily available at relatively short distance. More urban areas are therefore particularly suited for shared mobility.

**Rightsizing.** Carsharing provides rightsizing options. For example, the user can choose a smaller car that is cheaper per kilometre travelled. However, where appropriate, the user can also have a car that is suitable for carrying several passengers or larger loads.

**Stimulating policy.** A more dissuasive policy in respect of car ownership and individual use, such as the phase-out of benefits for company cars and the introduction of road pricing, would favour shared mobility. Cities and municipalities could assign specific priorities to shared cars, such as a sufficient number of reserved parking spaces. Such measures strengthen the position of carsharing and promote a sustainable and progressive urban image. Some car makers could also be encouraged to participate more actively in shared mobility initiatives.

**Objective information and awareness raising.** The user of a carsharing system is more directly confronted with the cost per kilometre travelled, giving him the impression that carsharing is expensive compared to driving his own car. Tools that allow an objective and fair comparison to be made between the actual cost of car ownership and the use of shared mobility may have an awareness-raising effect.

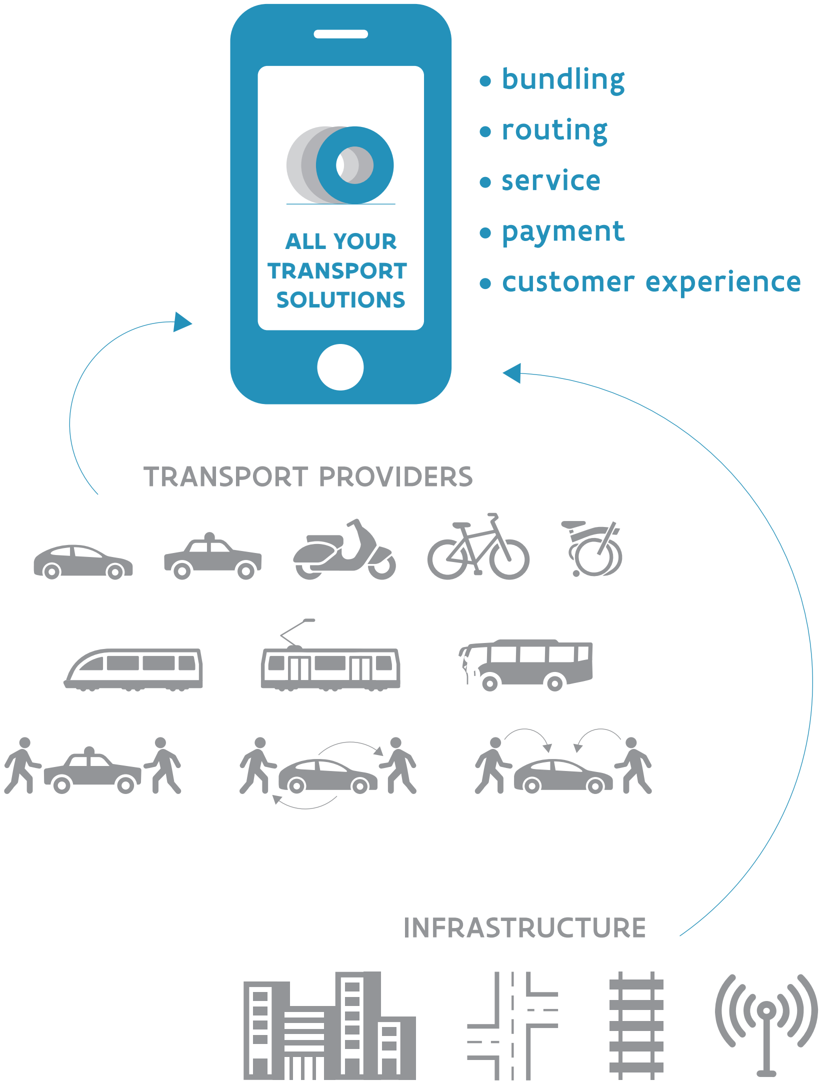
**Part of Mobility as a Service.** Shared mobility can become a major option within a mobility service package (Mobility as a Service). The necessary communication technologies are in place, but to further increase user-friendliness and flexibility, matching request and offer should be further optimised.

## Efficient mobility services or Mobility as a Service

Today, mobility is still largely based on having one's own car. Mobility services or Mobility as a Service (MaaS, see figure opposite) seek to offer similar user comfort that is no longer based on individual car ownership. This concept is based on the user's specific mobility requirements. The available mobility options are customised to the user's needs. A central role is reserved for state-of-the-art communication media. Mobility as a Service assumes the integration of current public transport services in terms of use and tariffs. Consumers can access all information via an online ticket booth and make payments using a single card or transparent pricing system. Public transport services are supplemented with individual solutions for pre- and post-transport.

Recently, there have been a number of tentative developments towards such customer-oriented solutions. For example, public transport is supplemented with new peripheral facilities such as shared bikes or shared cars. Better communication media allow different transport services to be better harmonised and users to be informed in real time. Online route planners already combine certain forms of intermodal information for users. Moreover, commercial platforms are being created that go one step further. These relatively new economic players, so-called mobility integrators, inform users about the available mobility services and the best possible combination of such services. They assume the role of brokers offering door-to-door customised mobility solutions. This includes not only a comparison of time and costs, but also the necessary reservations, payments and support in case of real-time changes. Based on knowledge of the user's previous mobility choices, personalised proposals can be made.

# MOBILITY AS A SERVICE




Transport & Mobility Leuven, HIVA - KU Leuven, Background document *Oplossingsrichtingen voor het mobiliteitssysteem* (to: Crow 2017)

Studies show that it is crucial for public transport to remain the core of the proposed mobility solution. Only then can the environmental potential of Mobility as a Service be maximised. Furthermore, the environmental gain is only clearly positive if Mobility as a Service is used as an alternative to travel by conventional car. In all other cases, the environmental impact is limited or possibly even slightly negative.

Comfortable public transport that is an integral part of efficient mobility services can also ensure that travel time is perceived less as lost time. Promoting (electric) (shared) bikes in combination with public transport will also make the latter more attractive. Reliable information will lower the threshold for the use of mobility services, especially among the younger generation which is familiar with ICT applications. With the breakthrough of Mobility as a Service, digital literacy will become even far more important than it is today, which may pose a problem for certain disadvantaged groups. Privacy considerations are also an important factor in the context of Mobility as a Service. Business models focusing primarily on profit margins might reduce the available transport capacity, make it more comfortable and raise prices. This could lead to the exclusion of socially vulnerable groups of transport users. As with shared mobility, monopoly positions should preferably be avoided. Efficient mobility services and vehicle sharing can lower the cost and threshold of occasional mobility, thereby allowing also people from low-income groups to have access to full-fledged mobility options.

### LEVERS FOR MOBILITY AS A SERVICE

**ICT developments.** The most important lever for the emergence of Mobility as a Service is without any doubt the further evolution of real-time communication technology. Information can thus be readily shared and linked, and be made available in a user-friendly manner.

**Deterring car use in urban areas.** When it becomes difficult, or even impossible, to reach certain parts of the city by car, this will lead to choices for other forms of transport. Mobility as a Service can play a facilitating role to make the most efficient choices based on the user's travel profile.

**Efficient public transport.** The government will have an important steering and facilitating role to ensure that public transport constitutes the core of Mobility as a Service. The provision of efficient pre- and post-transport is an important accompanying measure. Public transport can also be made attractive for local use within the city. There is still a lack of alternatives to the car outside peak periods and/or in non-urban areas.

**Collaboration between public transport companies.** The most appropriate solutions for mobility often run across different transport networks. In many cases, however, collaboration and coordination between transport companies, cities and regions is not yet optimal.

**Properly working market.** There is as yet no final business model for Mobility as a Service. If one party were to become dominant in the Mobility as a Service playing field, this could impede further improvements. Society and environment benefit from a policy that prevents the creation of a monopoly position.

## Logistics modal shift

The bundling of flows from different consignors and/or consignees will allow larger volumes to be handled per transport operation. Also transport by rail and ship can then become a cost-effective option because these modes require larger volumes for profitable operation. However, a modal shift to rail or waterways does not seem evident. The main reason for this are the rather limited transport distances. Rail and waterways are particularly interesting over longer distances (several hundreds of kilometres), because it enables the transshipment cost and the additional time loss to be reduced. The average transport distances in Europe are relatively short compared to Russia or the United States, for example. The limited potential for a modal shift is also illustrated by the modest effect of the European incentive policy. It appears that it will be quite difficult to achieve the objective of organising 30 per cent of all freight transport over 300 km by water or rail by 2030.

Exchange and management of real-time data could (eventually) facilitate synchromodality. This mobility is based on the combination of different transport modes for the carriage of goods, whereby it is possible to readily switch or transship between the different transport modes. An example can be found in the Netherlands, on the Rotterdam-Venlo transport connection. On this axis, four freight transport operations by rail are organised every day. In addition, there is a waterway and a motorway. It is therefore possible to always choose the most optimal transport mode depending on the circumstances, the available capacity, and the customer's needs and requirements. Based on detailed information about the different transport modes and the goods to be carried, the ideal transport choice is made.

The comparison of such methods to optimise logistics with the operation of the internet has even led to a futuristic vision of a possible 'physical internet'. This would be a profoundly optimised logistics network where cargoes are distributed in standard packages and forwarded via a network of hubs and transport modes.
It implies an extensive standardisation of the packages used, so that they can easily be combined. This requires a system without any separate transport companies, but instead with generic transport modes that are optimally used by different logistics parties. It is questionable whether such a visionary system can and will be realised.

The potential environmental benefits of shifting part of the freight transport to rail and/or inland navigation are obvious. A modal shift on such a significant scale is, however, quite unlikely in the short to medium term.

The still theoretical concept of a physical internet could lead to significant reductions in greenhouse gas emissions. City distribution could provide a smaller-scale testing ground, which would allow for a better assessment of the potential environmental impact.

### LEVERS FOR LOGISTIC MODAL SHIFT

**Coordinated logistic hubs.** Transshipment and bundling of flows can be organised in regional logistic hubs. Strategic choices for the location of such hubs and their embedment into spatial planning can benefit the modal shift.

**ICT and synchromodality.** Collaboration between providers of transport and mobility solutions can lead to ICT-driven platforms that enable synchromodality. This allows different transport modes to be used optimally on the basis of a real-time comparison of information relating to the availability and characteristics of both freight and various modes. Modern communication technology and real-time information play a key role in this regard.

**Logistics as a Service.** A logistics third party or broker who has access to all relevant information and provides logistics services (Logistics as a Service or LaaS) can play a powerful facilitating role. He ensures that the goods reach their destination as efficiently as possible by allocating them to modes of transport, thereby optimally bundling goods flows.

## Autonomous vehicles

Vehicles have different levels of autonomy, ranging from no to full autonomy. Cars with adaptive cruise control and lane support, which have already made their appearance in Flanders, belong to one of the lower autonomy levels. The higher levels are still under development and pose not only technological but also ethical and legal challenges. For example, questions are raised as to the choices to be made by autonomous vehicles in crisis situations and who is liable if they fail.

Self-driving vehicles with a high level of autonomy can be relevant to both passenger transport and freight transport. The transport of certain goods to the customer, for example, could to a large extent be automated. Or goods could be delivered via small self-driving vehicles from central storage facilities in the city, as an autonomous form of city distribution. A number of trial projects on autonomous vehicles are currently ongoing in Flanders. Flemish partners are also involved in international research projects.

The environmental potential of autonomous vehicles is, however, dependent on their impact on the number of kilometres travelled, the emissions technology and their impact on the traffic flow. Vehicles with a high level of autonomy would allow users to read, work or rest during the journey. Such a high level of comfort might make people less inclined to live closer to their workplace. Also non-work-related journeys over longer distances can thus be made more attractive. If autonomous vehicles lead to less congestion and therefore higher average speeds, this effect can even be reinforced. In the case of connected autonomous vehicles, for example, the overall flow will improve. Autonomous vehicles are expected to have higher energy efficiency because they allow the driving pattern to be optimised. If autonomous vehicles prove to be safer, they could possibly also be made lighter, thereby further increasing their energy efficiency. Autonomous vehicles could make alternative powertrain technologies more attractive. The lower weight of the vehicles coupled with a higher level of road safety could increase the driving range of batteries.

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The impact on the emissions of greenhouse gases and air pollutants is therefore the combined result of a variety of factors and is not necessarily positive. Mainly the use of sustainable powertrain technologies, rather than the autonomous character of the vehicle itself, will make the difference. A high level of autonomy is expected to improve road safety. This could lead to a reduction in non-structural congestion caused by accidents. However, the positive effects will depend on the mix between autonomous and non- or semi-autonomous vehicles and also on the level of autonomy. At a later stage, they can also improve the mobility of people with restricted (car) mobility, such as the elderly or people with a disability.

### LEVERS FOR AUTONOMOUS VEHICLES

**Convincing demonstration projects.** The technology is still too immature to allow for higher levels of autonomy in the short term. Further investments in research and development are required. A high level of ICT security for (online) control will also be crucial.

**Complement to public transport.** Autonomous transport is particularly interesting as a complement to public transport and Mobility as a Service. Self-driving private vehicles are not meant to replace public transport, but they can be used as part of the public transport system. Autonomous vehicles can offer opportunities in the longer term, above all in those areas where the development of conventional forms of public transport entails significant costs.

**Cost.** The cost of a fully automated vehicle is currently estimated to be a multiple of the price of a conventional car. On the other hand, individual ownership is not required and the vehicles can be used for mobility services (Mobility as a Service).

**Ethical and legal framework.** The government will have to create a consistent ethical and legal framework as to who is responsible in case of accidents or glitches in the system. The co-existence of non-autonomous, semi-autonomous and autonomous vehicles could also give rise to challenges in the field of road safety. Comprehensive regulation of such aspects is crucial in order to create support for the fact that driving is taken over by a system.

## 3.4 An (ecologically) more sustainable fleet

'Improve' points at solutions and innovations that enhance the environmental performance of means of transport through technological innovation or better utilisation. Reducing the environmental impact appears to be possible through the use of battery electric vehicles, fuel cell or hydrogen-powered vehicles, or through the use of advanced biofuels. In addition, ridesharing and logistic improvements are considered as solutions to improve the efficiency of means of transport.

### Battery electric vehicles

Recent technological innovations, especially in battery technology, have made the electric drive an alternative to the conventional internal combustion engine. A switch to electric vehicles is now seen as a promising strategy to significantly reduce emissions of greenhouse gases and other pollutants. In that case, emissions are limited mainly to the generation of the electricity used to charge the batteries. Particulate matter emissions from wear and tear of brakes, tyres and road surface, however, remain unchanged or may even increase due to the weight of the battery. There is, however, a 100 per cent gain in terms of $NO_x$ due to the absence of combustion processes. The air quality gain is therefore smaller than the avoided exhaust gases. This is certainly the case when comparing them with diesel and petrol cars that meet the most stringent Euro standards. For those vehicles, wear and tear in fact represents the bulk of particulate matter emissions.

Various types of electric vehicles have been put on the market in recent years. In many cases these are hybrid vehicles equipped with both an electric drive and an internal combustion engine. In the basic variant, the battery is only charged during braking. If the battery can (also) be charged by connecting it to the electricity grid, the term 'plug-in hybrid vehicle' is used. We will only discuss this type of hybrid vehicle because it offers greater environmental potential. An electric vehicle that has no internal combustion engine is referred to as a battery electric vehicle (BEV). In that case, the driving range is an important variable. Some car makers overcome this problem by incorporating an internal combustion engine, only for the purpose of recharging the battery in case of emergency (extended-range electric vehicles or EREVs). The optimism about the potential of electric vehicles is apparent from the fact that even the electrification of (lighter) freight transport is no longer dismissed as utopian. It does, however, remain a challenge: heavy batteries go at the expense of extra freight and there is also the potential loss of time due to the charging times.

Electric vehicles still make up less than one percent of the vehicle fleet in Flanders. About two-thirds of these are plug-in hybrid vehicles. In 2017, the percentage of new electric vehicle registrations amounted to 3.5 per cent, indicating a sustained increase. If innovations in the field of battery technology continue, the limited range of BEVs will be much less of a problem by 2030. Moreover, quicker charging times should also become possible by then.

The environmental potential of a transition to electric vehicles with battery depends mainly on how the electricity for charging the batteries is generated. For hybrids, the emissions released during use of the combustion engine must also be taken into account. In general, electric propulsion, also with the current European energy mix, can be said to be significantly cleaner than the propulsion system of traditional vehicles. It allows greenhouse gas emissions to be reduced by around 40 per cent. Especially the expected longer-term developments in sustainability of the energy mix suggest great environmental potential in the (more distant) future.

The higher weight of BEVs, however, still remains a drawback for non-exhaust particulate matter emissions. The production of an electric vehicle currently also requires about 70% more primary energy than that of a traditional vehicle. There are as yet no efficient recycling cycles. However, the environmental gains during the use phase compensate for the other effects, the more so if the electricity comes from renewable sources. Another advantage is that electric vehicles are much more silent at low speeds, especially in urban areas.

Electric vehicles can make a contribution to more sustainable mobility provided their potential is correctly assessed. They are not a universal solution as such. Problems like congestion, road accidents, and pressure on land use continue to exist. Moreover, sustainably generated electricity is a key condition and the additional demand for electricity represents a challenge for the energy system.

### LEVERS FOR BATTERY ELECTRIC VEHICLES

**No major adaptation.** The transition to an all-electric transport system requires only a relatively limited cultural change. Consequently, from a societal perspective, this solution is simpler than modal shift alternatives, but it does not solve the congestion or road safety problem.

**Rapid technological evolution.** The limited driving range and the long charging times for batteries prevent a broader breakthrough for the time being. Lithium-ion battery technology is evolving rapidly, and this evolution is expected to continue for quite some time. This can reduce the costs and lead to significant improvements in terms of driving range and charging time, Thus making the transition also practically feasible for a larger share of the population. The production of batteries does, however, require critical resources, which raises questions from a sustainability perspective.

**Growing charging infrastructure.** The number of charging stations for electric cars is growing. Collaboration between the government and private players could ensure that the number of charging stations grows at a sufficiently rapid pace.

**Potential key function in climate policy.** A relatively swift transition to electric vehicles can contribute significantly to meeting the international commitments in the field of greenhouse gas emissions.

**Growing attention to air quality and health.** Air quality as a social issue has gained in importance in recent years. The positive impact of electric vehicles on local air pollution and health - especially in relation to diesel vehicles - can promote legitimacy.

**Correct information about the total cost of ownership.** Even if a portion of the cost is recouped through lower energy and maintenance costs and subsidies, electric vehicles still cost significantly more than conventional vehicles of comparable size. A better awareness of the lower energy and maintenance costs could promote the breakthrough of electric vehicles. Additional knowledge, such as a method to correctly calculate the total cost of ownership via a tool or app, could have a threshold-lowering effect.

**Stimulating policy.** Policy can play an important role by introducing a favourable tax regime for electric vehicles. Such a regime would include lower road tax rates, higher tax deductions, or road pricing based on emission factors. Also other measures, such as the reservation of parking areas for electric vehicles and the introduction of low-emission zones, could have an incentive effect.

**Matching electricity demand and supply** The impact of a swift transition to electric cars on overall electricity demand is significant. This will have to be taken into account when matching demand and supply. The growth of private PV panels can play a role in this.

## Hydrogen fuel cell electric vehicles

In addition to batteries, electric vehicles can be equipped with hydrogen-based fuel cells (fuel cell electric vehicles of FCEVs). The electric current generated in the fuel cell is used to power the electric motor. Water is the sole by-product that is generated, due to the reaction with oxygen from the air. This type of vehicle is not recharged, it is refuelled just as an LPG vehicle. In Flanders, there is only a very small number of hydrogen-fuel cell powered electric vehicles. In 2017, only one new car was registered. There is also only one filling station for private consumers, which is located in Zaventem.

Just as with vehicles that are (fully) powered by an electric battery, direct emissions are limited to particulate matter due to wear and tear of brakes, tyres and road surfaces. FCEVs do, however, cause indirect emissions due to the production of hydrogen. Today, by far the most cost-effective method to produce hydrogen is a process based on fossil fuels such as natural gas, which gives rise to greenhouse gas emissions. With production via electrolysis, it would eventually become possible to produce hydrogen gas by means of renewable energy. In view of the high process cost, it is questionable whether this is realistic within the time horizon to 2050. Much will depend on developments in the market of battery electric vehicles. Indeed, if costs continue to fall in this area too, whilst the energy density of batteries continues to grow and charging times keep coming down, this would neutralise the advantages of FCEVs. Fuel cell powered vehicles could eventually (only) prove interesting for niche markets such as (very) long distance freight transport.

### LEVERS FOR HYDROGEN FUEL CELL ELECTRIC VEHICLES

**Higher driving range, easy refuelling** The driving range and the refuelling time are similar to those of conventional combustion engine vehicles. Developments in electric battery technology could reduce this relative advantage of hydrogen-fuel cells in the medium term. For longer distances (outside the city), FCEVs are currently more suitable than battery-powered electric vehicles. They may also be an interesting alternative to long-distance freight transport.

**Development of charging infrastructure.** Hydrogen infrastructure is as yet virtually non-existent in Flanders. This situation is not expected to change in the short term due to the cost of the large storage tanks and the associated safety facilities.

**Lower vehicle and fuel costs.** Today's FCEVs are expensive, due in part to the small production volumes. The price of hydrogen is also relatively high. Production is not always energy-efficient.

**No need for rare earth metals.** The production of electric vehicles requires critical metals such as cobalt for the batteries. Hydrogen is produced without any rare mineral resources. Therefore, there are no issues regarding the use of sustainable materials.

## Advanced biofuels

Three forms of biofuels should be distinguished:

**First-generation biofuels** are derived from rapeseed oil, soya bean, sunflower or palm oil for biodiesel production, and from sugarcane, sugar beet, wheat or maize for bio-ethanol production. The production of these fuels therefore competes with food production.

**Second-generation biofuels** are made from agricultural and forestry residues, suitable waste streams and crops grown specifically for biofuel production. They are produced mainly using (thermo)chemical processes and new fermentation technology, aimed at full exploitation of the biomass.

**Third-generation biofuels** are made from algae specially cultivated for this purpose.

The term 'advanced biofuels' refers to second- or third-generation biofuels. In Flanders, they do not yet play any role of significance in the total energy demand for transport. Several research projects are ongoing in which Flemish research institutions participate.

The carbon footprint (greenhouse gas emissions per energy content) of second-generation bio-ethanol and biodiesel is still uncertain. It is, on average, lower than for petrol and diesel, and therefore also better than the footprint of first- generation biofuels. However, water consumption during production is significant. The carbon footprint of third-generation bio-fuels currently still far exceeds that of diesel.

## LEVERS FOR ADVANCED BIOFUELS

**Customised solution.** Advanced biofuels can be an alternative to fossil fuels for transport modes where electricity is not an obvious alternative, such as heavy construction or agricultural machinery, aircraft and ships. These last two modes are a major challenge in this regard.

**Further research into environmental impact.** In recent years, the breakthrough of biofuels in Europe was hindered by uncertainty regarding the sustainability of these fuels. Also in the case of advanced biofuels, there is still some level of uncertainty about the environmental impact.

**Availability of raw materials.** For advanced biofuels to break through as alternative fuels, a sufficient availability of raw materials must be guaranteed. In addition, they must meet technical and sustainability specifications.

**Efficient production.** Further research is necessary to improve the technical efficiency and cost effectiveness of the different conversion processes. The challenge will be to scale up results from laboratories and demonstration projects to commercially profitable production processes.

**Support.** Compared with the first generation biofuels, the production of advanced biofuels requires more complex technologies. The capital costs are therefore also much higher. In combination with other risks, this makes biofuels less attractive for investors. In the absence of public incentives, these biofuels are unlikely to compete with fossil fuels in the short or medium term.

## Ridesharing

Carpooling or ridesharing means that people jointly complete (part of) their trip by car, thereby maximising the occupancy of the vehicle. Recent ICT developments facilitate the search for potential carpool partners. New trends are so-called dynamic or real-time ridesharing systems where drivers and passengers can receive carpool proposals while en route.

In 2014, the share of carpooling in commuter traffic amounted to 3.3 per cent for business establishments located in Flanders, a percentage which, based on diagnostics on commuter traffic by the Federal Public Service Mobility and Transport, has dropped over the past decade. Flanders has eighty or so carpool parking areas (with a total capacity of over 5800 vehicles). Ridesharing is mainly associated with home-work trips, but is also applied for other trips.

The environmental impact of ridesharing depends on the means of transport that would have been used in the absence of ridesharing. If ridesharing replaces a journey by car where one rides alone, the average occupancy of cars increases whereby the environmental impact decreases. To participate in ridesharing, the passenger may be required to first travel a small distance to the meeting point. Or the passenger is picked up and dropped off, in which case the distance travelled increases for the driver. This means that the net impact on the number of vehicle kilometres travelled, the financial cost and the environmental cost – especially with shorter carpool distances – will be smaller. Assuming the average occupancy per car in commuter traffic would rise from 1.06 (according to the Travel Behaviour Study) to 1.25, then the total number of car kilometres is estimated to drop by 3.9 per cent in 2030. The money saved by ridesharing may, however, give rise to a rebound effect. If ridesharing is applied on a sufficiently large scale during peak hours, and used mainly by people who would otherwise use their car alone, it can have a positive effect on the congestion problem.

### LEVERS FOR RIDESHARING

**Adequate policy.** Car use costs in Belgium remain low. Consequently, the potential financial savings for participants in ridesharing are currently rather limited. Moreover, ridesharing comes at the expense of some degree of flexibility. Coordinated policy choices and incentives are crucial to further encourage ridesharing, such as additional parking facilities for carpooling and tax incentives for commuter ridesharing. Companies could also be stimulated to promote or even organise ridesharing themselves.

**ICT and new forms of service provision.** ICT developments and the growing amount of available data make it increasingly easy to match people's transport needs. New service providers can come up with innovative solutions in the ridesharing market. Flexible real-time systems do, however, require sufficient scale, so that ridesharing requests are also answered effectively and quickly enough.

## Logistics improvements

In a densely populated region like Flanders, it is important that the available transport capacity for goods is used as efficiently as possible. In Flanders, the current load factor of lorries is on average around 40 per cent. Improvement can be achieved in various ways. For example, the volume or tonnage per lorry can be increased by stacking loads more efficiently. Bundling of cargo flows from different consignors and/or to different consignees is also crucial.

Bundling can lead to an increased cargo volume per journey. For cooperation between companies, ICT can be used for rational routing or matching of loads (complementary flows or return freight) or to optimise the frequency of deliveries. Possible opportunities for a logistics modal shift, whereby bundling of certain goods could cause transport to shift to rail or waterway, were already discussed earlier in this document.

City distribution could reduce congestion in the city and improve quality of life. Goods destined for the city are delivered at distribution centres on the outskirts of the city. They are then forwarded to their final destination by smaller, optimally loaded vehicles. The drop density per vehicle increases, resulting in the reduced presence of delivery vehicles in the city. City distribution appears to be promising to improve urban quality of life.

The environmental potential with a better logistic organisation, especially by bundling, is estimated at a reduction in the number of journeys by 10 to 15 per cent. While significant, this reduction should be set off against the expected growth in freight transport by 30 per cent for the period 2012-2030. Logistic improvements will therefore only limit the growth of transport, and the associated rising environmental impact. Moreover, logistic improvements will lead to lower transport costs, which could generate additional transport demand.

### LEVERS FOR LOGISTICS IMPROVEMENTS

**Regional logistics hubs.** Bundling and transshipment of flows becomes more evident through the provision of regional logistic hubs. They should preferably be included and embedded in the Flemish spatial planning policy.

**City distribution.** A guiding government policy that discourages (road) transport and restricts access to cities, can lead to sustainable logistic adaptations. Good examples in the field of city distribution may prove contagious. The resultant improvements in quality of living can contribute to generate legitimacy and support from residents.

**Third parties (brokers).** The efficiency benefits that can be achieved by bundling will allow the market to evolve towards collaborations between logistics players. Third parties (brokers) can play an important facilitating role between parties by lowering the transaction costs. Specific requirements related to delivery or collection times for different recipients could be a challenge in the case of bundling.

## 3.5 Conclusions

### Towards a sustainable mobility system

Several modes and alternatives will contribute to the transition towards an (ecologically) more sustainable mobility system. For a number of them, however, future (technological) developments and their potential environmental impact are still uncertain. There are also real risks of rebound effects or other indirect effects that could undermine the environmental potential. Furthermore, the expected population rise, declining family size and increase in the number of passenger and freight transport operations will put additional pressure on the mobility system.

The majority of solutions are expected to affect also other external costs of transport, such as congestion and road safety. Clear health gains can also be expected with increasing use of the more active transport modes. Furthermore, a number of broader societal impacts have implications for a number of innovations and solutions. These concern aspects such as inclusion, privacy, the market power of providers and the broader economic and social implications connected with the emergence of new technologies and the extraction of mineral resources.

There is no single solution for a sustainable mobility system. We are looking at a combination of solutions, spread over three approaches: avoid, shift and improve. New sustainable niches can be supported and break through. At the same time, however, existing components such as the public transport system need to be optimised and expanded. For public transport will continue to play an important role as the backbone of a future sustainable mobility system.

The interwovenness with other societal systems is significant and likely to increase further. The sustainability of solutions also often depends on developments in other systems, such as the energy system. Fortunately, there is a growing number of people and businesses that are eager to contribute to a more sustainable mobility system. However, habits in our travel and consumption behaviour prove to be particularly persistent. A change appears to have been initiated, but the acceleration in the transition to a sustainable mobility system is still ahead of us.

### Levers for the transition

Specific levers that can make the difference for certain solutions have already been discussed in greater detail elsewhere in this report. There are, however, also more generic levers that are relevant for sustainability transitions within the entire mobility system, or large parts thereof.

A clear, consistent, stable and credible **longer-term policy framework** is needed. This will not only reduce the risks for potential investors, but will also allow behavioural patterns to adapt sustainably. One of the most important policy levers is the social correction of the relative prices of transport choices, taking also external costs into account. In this way, the consumer can and will also take into consideration the (ecological) sustainability of the options. At present, the price of passenger and freight transport does not reflect these external costs at all, or only to a very limited extent. As a result, the organisation of the logistics economy, for example, is too much based on relatively cheap fossil fuel-powered road transport. Price incentives can also play a key role if companies are to be encouraged to take environmental considerations into account in their mobility decisions. It is not the task of a government to advance a specific technology, but rather to impose environmental standards and to ensure a pricing policy that allows (ecologically) more sustainable mobility solutions to find their way to the market.

The **need for integrated policy** among the many relevant areas (space, living and working, industrial policy and mobility) is stressed. This is perfectly illustrated by the teleworking example. This topic can also be found in various other innovations and solutions. Mobility is therefore also directly linked to location choices, networks and how they operate. Spatial strategies geared towards sustainability can play an important facilitating role in this process. Policy makers obviously have a range of objectives that extend beyond purely environmental considerations. This only highlights the crucial importance of policy alignment and integration. A given organisational culture, in itself a part of a social situation or evolution, has a great influence on the various solutions for the mobility system. The **values and norms** that belong to a given culture, fundamentally determine our mobility behaviour. A sustainability transition therefore also requires changes in mentality. Within a given culture and set of values, every individual will make mobility decisions that result in a specific mobility behaviour. These decisions are rationally motivated in some cases, but emotions and habits also play a role that should not be underestimated. The challenge is to install a choice architecture that also allows the integration of non-rational motivations. For example, 'joy of ownership' appears to be particularly persistent in the context of car ownership. Information or education alone is not effective enough. Sustainable examples, by contrast, could prove contagious and lower the threshold to try out a particular behaviour. A properly balanced combination of 'persuading' and 'seducing', but also of obliging and enforcing, is necessary. In this context, it is also found that the effects of public transport improvements on car use often remain limited. Car and public transport remain essentially separate markets. A modal shift will only be possible if the travel time of public transport approaches that of the car. The challenge will therefore be to achieve a competitive travel time for public transport. Making car use comparatively less attractive through **pricing** will be a significant lever in this respect. Both are needed simultaneously: making public transport more attractive and deterring car use.

**Technological developments** in information and communication are crucial for virtually all solutions and innovations. However, technology alone will not be sufficient to change also our behavioural patterns. User friendliness and a distinct advantage of specific choices that are facilitated by technology, will be crucial in convincing people to make the switch. There is broad consensus that electric transport can in future contribute significantly to an (ecologically) more sustainable mobility system. However, this is obviously closely linked to the energy mix. A high percentage of green electricity is a crucial prerequisite. Here, too, the challenge lies in the energy transition and the associated technological developments. The shortage of raw materials also raises questions as to the sustainability of the battery technology itself. The transition to electric cars is in itself not the technological solution for a transition to a sustainable mobility system, but it does have a role to play in the process.

It is particularly important for policy interventions in the field of mobility to pay sufficient attention to all the effects involved, including undesired **indirect effects and rebound effects**. These appear to be a real risk in many solution paths. Teleworking, for example, could lead to people living farther away from work, thereby resulting in (slightly) fewer but also longer journeys. The additional free time (and budget) may also generate additional recreational trips. Policy measures or incentives should therefore preferably take into account the rebound effects, which are less favourable in the environmental field. Autonomous vehicles for their part could lead to new induced traffic and longer commute distances. On the other hand, fewer parking spaces are needed, resulting in space savings. But the search for new customers or parking spaces can lead to additional kilometres travelled. In several solutions, various indirect effects come into play that can mutually reinforce or (partially) cancel each other out. Policy-supportive research is essential to proactively counter these effects.

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# SOLUTIONS FOR THE FOOD SYSTEM

**In Flanders we enjoy an abundant and affordable food supply. Our food system is nevertheless reaching its economic, social and ecological limits. In spite of the many initiatives already taken, important steps remain necessary to further reduce its environmental impact. In this chapter, we will discuss the potential solution paths and levers for the transition to an (ecologically) more sustainable food system.**

## 4.1 What is it about?

### Abundance at the expense of sustainability

Our food system provides us with a broad, varied and affordable supply of products. There are, however, various other areas where the system is reaching its limits.

As a result of globalisation and liberalisation, the actors in the European and Flemish agri-food chain have become players on a global market. Cost leadership – producing highly standardised products as cheaply as possible – has become the dominant competition strategy. This strategy leads to a progressive process of specialisation, upscaling and intensification based on technology and intensive use of resources such as water, fossil fuels and other, often imported, raw materials. The environmental impact of the Flemish food system has thus become too great. The intensive use of resources and the emissions generated in the process are harmful to the soil, water and air. These resources are not only necessary for the proper functioning of the food system itself, but also for other systems. Thus, intensive agriculture in some regions leads to erosion or a decline in carbon content in soils, which is detrimental to food production. Air pollution, climate change, water pollution and loss of biodiversity are, however, also detrimental to other societal systems.

In addition, Flemish agriculture is also economically and socially vulnerable. This is mainly due to low profit margins, unequal distribution of the added value throughout the agri-food chain and the high land prices in Flanders. The way in which we feed ourselves also has an impact on public health. The over-consumption of certain food products has resulted in a significant increase in diseases such as obesity and cardiovascular disorders in Flanders. The food system as we know it today is therefore reaching not only its ecological but also its societal limits.

## THE CHANGING FOOD SYSTEM IN FLANDERS: A DIAGNOSIS

**The western food system is characterised by self-evident abundance and convenience. Economic performance remains the greatest driving force. To this end, the food system is split up into chains that lack transparency and have highly specialised links. These are aimed at maximising profit through growth and cost efficiency. Only a small share of the total added value goes to primary producers in the agricultural sector.**

### Drastic changes in the past

The industrial revolution has drastically altered our food system already from the second half of the nineteenth century. Modernisation allowed agriculture to achieve giant leaps in productivity. This was the result of the use of machinery, pesticides, fertilisers and hybrid seeds, among others. A new wave of change took place after the two world wars. Intensification, specialisation, economies of scale and industrialisation were aimed at developing a production system that was to provide sufficient food at low prices, and that would also make Europe self-sufficient. This led to a high level of food security. Belgium and Flanders are global front-runners in the supply of a broad and varied range of high-quality food products.

### Pressure on the dominant regime: the transition impulse

Growing production volumes used to be the prevailing means to achieve the goal of a guaranteed food supply. However, once that goal had been achieved, the growth paradigm remained intact. Thus, the means became an end in itself, which has implications for sustainability. The broad, varied and affordable range of food currently available in Flanders – and that the consumer expects to find on the market – requires a large and resource-intensive production and processing apparatus. This has implications for the environment, just think of eutrophication and acidification, the impact of pesticides on the environment and the greenhouse gas emissions during production and processing. These effects often adversely affect the basis and the resources of the food system itself. They can lead, for example, to reduced soil quality, declining water reserves and diminished biodiversity. There are also adverse social effects that become apparent, such as high work pressure and income uncertainty due to market volatility and low margins in agriculture. Any further economic benefits seem to be virtually impossible.

There are also health implications. Whereas the system initially developed in a period where sufficient food was a legitimate goal, it has evolved towards a system of excess (lots of meat, energy-rich foods). This leads to an increased risk of health problems. The abundant food system also causes quite a few losses throughout the chains and with the consumer.

In the food system, a number of niches have emerged over the past decades, such as short chain, urban agriculture, multifunctional agriculture, organic farming, and more recently, agroforestry. These offer alternatives that respond to specific problems in the dominant regime.

**Resistance of the regime to drastic changes**

However, the entire food system, which is made up of knowledge, technology, institutions, infrastructure, practices and habits, rules, norms, values and thinking patterns, is geared to an intensive, specialised and export-oriented agri-food chain. This 'path dependency' makes the system stable and inhibits the breakthrough of production and processing methods and eating patterns that deviate from the common model. The regulations, for example, remain tailored to the needs of those who apply the norms and values of the dominant regime. Alternatives are required to operate within outlines that are often inadequately aligned to the goals being pursued.

The same applies for subsidy systems. Where large-scale subsidies used to be an effective lever to achieve a sufficiently efficient food system, they also remained in place afterwards. Public support has thus become part of the economic calculation model, the income and therefore also of many investment-related decisions.

The high investment costs in infrastructure and technology and the low margins, mainly in the agricultural sector, also result in long payback times. This has led to a lock-in which impedes the switch to alternative production and processing methods. This takes place not only at the level of individual farmers; the entire food system is characterised by numerous, and often major, interests tied up with investments in very specific directions. In addition, the outspoken growth and export strategy of the food industry represents a clear lock-in that drives production towards increasingly larger volumes. But also the consumer plays an important role in all this. The consumer takes it for granted that high-quality food is permanently, abundantly and easily available at low prices.

**Where does the change process stand today?**

In spite of the pressure exerted on the system by sustainability issues, societal developments and emerging niches, there appears to be no real sense of urgency for structural changes. The regime of conventional agriculture, food industry and retail focuses primarily on the preservation of existing organisations, structures and institutions, and on transformation based on technologically supported ecological modernisation.

Various alternatives are appearing on the market or are under development. However, they remain relatively small and are mostly still in the experimentation phase. In many cases, the growth rate and scale are not yet sufficient to generate an (effective) acceleration. Demand for organic products is on the rise, for example, but the organic farming area in Flanders remains limited to around 1 per cent of the total agricultural area. Also the market share of short-chain farm selling and farmers' markets is less than 1 per cent of total fresh product purchases.

The niches mainly exert pressure on the existing regime through powerful narratives that inspire and legitimise. They are tolerated by the dominant regime because they are not perceived as a serious threat to the status quo. Some niches are also (partially) incorporated into the prevailing food system. For example, a number of farms are focusing on broadening their traditional business operations with short-chain selling. There is also a relative increase in the distribution of organic products via supermarkets. This can help in upscaling niches, but also holds the risk of eroding the original principles of the alternative.

It is probably neither desirable nor effective to think in terms of a sustainable new regime that is emerging and a non-sustainable regime that is being broken down. More is expected from a co-evolution where a thoroughly transformed regime, built mainly around updated world views and values, exists alongside co-regimes, which have managed to scale-up from niches to full-fledged alternatives. It is therefore essential to actively and strongly connect both paths into a coherent discourse that promotes a meaningful acceleration dynamic. Systems with a sufficient number of good connections are after all the most effective and resilient ones.

## Steering the food system of tomorrow

Addressing the various environmental problems calls for structural innovations throughout the food system. Not only the production links play a crucial role in this regard. It is essential to suitably involve all the other actors such as trade, consumers, authorities, knowledge institutions, lenders, education, interest groups and social organisations.

The *Environmental Outlook 2018* outlines three categories of solution paths that together can contribute to an (ecologically) more sustainable food system:

- **Eating differently**
  The focus here is on achieving more sustainable dietary patterns. More specifically, we look at dietary patterns with fewer animal products, dietary patterns with more local and seasonal products, and dietary patterns with less food waste.
- **System improvements**
  System improvements indicate how the customary production and distribution system can be made more sustainable. This solution path zooms in on further increasing eco-efficiency, reducing food losses in production and distribution, and closing loops as locally as possible.
- **System changes**
  We investigate how differently organised food systems can contribute to a sustainability transition. We look at the application of agro-ecological principles, the provision of multifunctional services, and the introduction of new food systems with minimal use of land.

## 4.2 Eating differently

The sustainability of our food system is highly dependent on our eating habits. Changes in the average eating pattern – what, how, where and how much we eat – can therefore have a great impact. Options that are often put forward for eating more sustainably include consuming fewer animal products and preferably choosing local and seasonal products. Reducing food losses is also considered to be an important part of the solution.

### Dietary patterns with fewer animal products

At present, slightly less than two-thirds of our protein intake comes from animal products, over half of which consists of meat. There is, however, a visible shift in the eating pattern. Meat consumption in Belgium declined by 22 per cent between 2005 and 2016. Consumption of high-quality vegetable protein sources such as legumes, seitan and soy-based products grew by 60 per cent between 2008 and 2014, but remains very small when compared to meat consumption. Dairy consumption in Flanders is also much higher (more than fifteen times) than that of plant based substitutes.

Animal products generally have a greater ecological footprint than vegetable protein sources. Per kilogram of protein and per kilocalorie, they require more land and water and generate more greenhouse gas emissions and nitrogen losses. Poultry, eggs, dairy and pork all score better than beef on these indicators. The results do vary according to the production method used. For some parameters, the environmental impact of the best scoring animal products may differ relatively little from that of the lowest scoring vegetable protein sources.

Despite the large differences between products and production methods, the environmental gain of eating patterns with fewer animal products can be significant. Meta-studies show that a vegan eating pattern in high-income countries can reduce greenhouse gas emissions by 25 to 55 per cent and land use by 50 to 60 per cent. A vegetarian eating pattern can result in 20 to 35 per cent lower greenhouse gas emissions and 25 to 50 percent lower land use.

In a scenario where the EU's consumption of meat, dairy and eggs is halved and there is no increase in exports, nitrogen losses in European agriculture are expected to drop by 40 per cent and greenhouse gas emissions by 20 to 40 per cent, depending on the use of the freed up land. Furthermore, soybean meal imports would drop by three-quarters and energy-rich feed imports would almost be halved.

A smaller livestock also offers opportunities to broaden the focus on more extensive livestock production, which offers animals more space and better living conditions. In addition, it enables a better integration of vegetable and animal production, which could enhance the closing of loops. Livestock has always played a role in closing food loops through the conversion of grass and food waste into meat, dairy and eggs and the production of manure for crops. Even today, quite a number of food waste streams from Flemish agriculture and food industry find useful application as feed. However, the size of the current livestock is such that large quantities of raw materials have to be imported, so that sustainable closing of cycles is ruled out for the time being.

In addition, numerous studies show that eating patterns with fewer animal products can also provide health benefits. The Flemish Institute for Healthy Living (Vlaams Instituut Gezond Leven) argues that a diet with lots of different kinds of vegetable foods and low quantities of animal foods – red and processed meat in particular – is often not only healthier, but has also a lower impact on the environment.

In Flanders, however, the meat and dairy sectors play an important economic and social role. Diets with fewer animal products would therefore also have significant implications for the agri-food chain. Compensating strongly reduced domestic demand by exports seems difficult because demand for meat products within the EU is stagnating. A strong increase in exports to countries outside the EU seems unlikely. Production costs in the EU are generally higher than in countries like Brazil, Australia or the United States. The food industry is, however, strongly focused on growth and exports. Although meat consumption in Flanders is declining, meat exports are currently still growing, so that production remains at the same level. Dairy production is even on the rise, again fuelled by growing exports.

However, diets with fewer animal products also offer opportunities for the agri-food chain. Growing and processing of vegetable protein sources such as soy, and in the longer term possibly also insect farming, algae cultivation, novel protein foods and cultured meat offer alternatives. Livestock farming can also focus on products with higher added value, such as meat and dairy from production systems that guarantee more animal welfare or apply extra environmental criteria. Another option is the switch from beef to dairy production.

## Dietary patterns featuring more local and seasonal products

Food is often transported over large distances. The choice for locally produced food is therefore often seen as a way of reducing the carbon footprint of our food consumption. However, local food does not always translate into lower greenhouse gas emissions. The difference in emissions between a locally produced and an imported food product depends not only the transport distance but also on the mode of transport and the way in which the food products are produced. There is great diversity in transport and production systems and a high level of interwovenness between local and global production, one example being local meat production based on imported feed raw materials. This makes it difficult to make general statements about the impact on greenhouse gas emissions of an eating pattern with more local products.

It is clear, however, that a consistent consumer choice for seasonal fruit and vegetables grown locally and in open air, does provide a significant climate benefit. The effect could be further intensified if producers were to systematically opt for crops for which the climate benefit of local production is maximal. Season-lengthening measures such as more scattered sowing and harvesting, use of different varieties and cultivation techniques such as cold greenhouse, heat from composting or milder microclimates – such as crinkle-crankle walls – could expand supply. In urban agriculture, use can be made of the heat island effect.

Local products can be distributed via conventional distribution channels such as shops and (super)markets or via the short chain. There is considerable scope of improvement in the area of short-chain logistics and distribution. The smaller volumes and the lack of efficiency and professionalisation play a role in this.

For deliveries to the hospitality and catering sectors, fine-mesh city distribution (see 3.4 "An (ecologically) more sustainable fleet") could produce environmental gains. The bundling of perishable products allows smaller, more environmentally friendly means of transport to be used. Various (trial) projects in Europe are showing positive results.

In **short chain** distribution models, food products are sold to consumers either directly or through a limited number of intermediaries. This can be done via farm outlets, food dispensers and farmers' markets, or via collective systems such as food teams or food subscriptions. In addition, consumers could be involved more closely in the production, as is the case in community supported agriculture (CSA) and self-picking farms. In 2015, turnover generated by farm selling and farmers' markets amounted to 92 million euros or 1 per cent of spending for fresh foods.

Short chain also includes non-commercial urban agriculture, a collaboration between socio-cultural associations and active citizens who develop vegetable garden projects. Here, food production also serves as an instrument of social cohesion.

Food production for the local market could offer an interesting economic perspective to producers. This is certainly the case for products with a higher added value, such as regional and/or organic products or food products that are produced with special attention to animal welfare. The renewed link between consumer and producer could prompt consumers to attach greater importance to food (production) and therefore be prepared to pay a correct price. However, the balance between financial benefits and costs is not always evident for producers.

When taking into account a broad range of sustainability considerations – environmental, economic, social, health and ethical aspects, etc. – it appears that neither global nor local chains perform better for all considerations. That is why it is important to look for a new balance between local and global, and to make all chains more sustainable.

## Fewer food losses on consumption side

Over 900,000 tonnes of food was wasted in Flanders in 2015. Consumers account for 23 per cent of this figure. Factors at the basis of this waste include poorly planned or impulsive purchases, campaigns and discounts, too large packaging, and improper storage. In addition to the losses of edible food, there are non-edible by-products that cannot be avoided, such as bones, fruit and vegetable peels and pips.

Three-quarters of these food losses and by-products are valorised: 40 per cent is composted via home composting and organic waste, 28 per cent goes into animal feed, and 6 per cent is digested. Around one quarter ends up with residual waste and is incinerated with energy recovery.

Eating out also generates a substantial amount of food loss. In the hospitality and catering sectors, this loss is estimated at 19,000 tonnes (2 per cent of total food loss in Flanders) and 57,000 tonnes (6 per cent) respectively. These losses are caused mainly during the preparation of meals (hospitality) and due to wrong portion sizes (catering). A good deal of the food losses and by-products in hospitality (69 per cent) and catering (76 per cent) ends up with the residual waste, the rest is digested.

Prevention of food losses reduces the environmental pressure. Food that does not need to be produced does not require farmland, water, nutrients and energy, and does not generate emissions. The impact on greenhouse gas emissions nevertheless appears to be limited: the food loss by Flemish consumers represents only a few percentage points of the carbon footprint of the food consumption by Flemish households. However, the food that is wasted every year by Flemish consumers could be used to feed nearly half a million people.

## Levers

### Develop a long-term strategy on food production and consumption

For the transition towards diets with fewer animal products, more local and seasonal production and less food waste, a broadly shared long-term strategy on food production and consumption is essential. Such a strategy must be supported by coherent policy.

Growth remains the dominant paradigm within the agri-food chain. Therefore, a strategy that focuses on lower production and consumption of animal food products will stress the importance of innovation and reconversion within livestock farming and the food industry. Moreover, the major investments made in specialised infrastructure do not always make reconversion evident. Financial aid and reorientation of existing resources will have to back up the transformation. Also investments in research and the necessary re- or up-skilling are necessary.

Another focal area in a long-term strategy is seeking a new balance between local and global chains. Further research is needed to gain an insight into how they can complement each other, taking into account the different dimensions of sustainability. At the same time, the focus must be on making each of the different chains more sustainable.

A consistent food policy requires alignment and coordination between the different policy areas involved, possibly via a food policy area. Such policy must be supported by consistent awareness-raising about healthy and sustainable food. The food triangle of the Flemish Institute for Healthy Living (Vlaams Instituut Gezond Leven) is a good basis to this end.

Cities can also play an important role in this respect. Ghent, Brussels and Leuven have already taken the initiative to elaborate a strategy that focuses on local and sustainable food. By setting up learning networks, such initiatives can serve as inspiration for other actors.

### Change the entire food environment

Nudging – or gently prompting people to move in the 'right' direction – can be helpful in adjusting habitual behaviour. For example, public restaurants, schools and businesses could reduce meat portions and include vegetarian alternatives in their standard offer. Supermarkets could reduce the packaging size of animal products and give a more prominent place to local products.

However, nudging will not suffice to ensure wider and permanent acceptance of more sustainable eating patterns. In fact, eating habits are shaped by a combination of factors, including norms and expectations, knowledge and skills, available supply, and integratability into work, school and free time routines (convenience). The whole food environment needs to be changed by consistently addressing all these factors.

### Influence food norms and values

Norms, values and expectations play an important role in our eating habits. For example, for many consumers, eating meat every day is part of the culture in which they grew up. Due to the low prices, consumers in prosperous countries often also attach less importance to food. Food is not always treated with proper care. Influencers such as famous cooks, athletes and media figures and a larger supply of sustainable food in the public environment, for example at festivals or in stations, may help in making sustainable food the new normal. More attention could be given to sustainable food in education, youth work and the voluntary sector. The perception of food can also change by shortening the distance between consumer and producer. This can, for example, be done via short-chain selling or by bringing the farmer's story to the supermarket.

Many consumers place great value on convenience. They have neither the time nor the desire to gather and compare information, to locate specific points of sale, or to apply lesser-known or longer preparation methods. For seasonal products there is also the expectation that everything is available virtually the whole year through. The demand for convenience is a major challenge for producers active in short-chain selling. This explains the need for further knowledge development on new economic and logistic models. One example is to set up short-chain hubs and distribution platforms at strategic locations. Local policy can support these via subsidies, interest-free loans or the provision of unused or underused premises. Businesses specialising in home delivery can bundle various short-chain concepts such as vegetable subscriptions, meal boxes and fresh produce. It is also possible to focus on ready meals.

### Promote sustainable products in retail

A greater supply and better marketing in supermarkets and local shops is crucial in bringing about a shift to more sustainable eating patterns. Although a growing number of supermarkets profile themselves around local and sustainable food, the share in the total supply remains relatively small. One of the reasons is the price pressure from the average consumer, who sees cost as a very important criterion in their food purchases. That is why it is important to develop a vision and strategy on correct pricing.

The government could also provide a number of guidelines on sustainable food for retail by means of a 'distribution policy'. This should obviously be based on scientifically substantiated information and developed in collaboration with the actors involved.

### Activate hospitality and catering as customers

Hospitality and catering are also important for the broader adoption of sustainable eating patterns. One barrier is that small, individual hospitality and catering businesses have little market power. As a result, the supply of, for example, local products and alternatives to meat and dairy with their suppliers is often rather limited. The catering departments of the Flemish and local governments are major customers and could join forces to create a larger market for sustainable food products. In this way, the government could set an example and generate leverage.

Smaller hospitality and catering businesses do not always have the necessary time, knowledge and skills to ensure the sustainability of their supplies. Concrete guidelines from sector organisations and public authorities can help in this respect. Such guidelines are also important to reduce food loss. In addition, concepts where consumers scoop the food themselves or are offered a choice of portion sizes, can be rolled out further. Finally, certain aspects of the legislation on food safety could be refined, thereby facilitating the donation of surpluses that do not pose any health hazards.

### Stimulate local production

Producers aiming at the local market often do not come from farming families and therefore rarely have (sufficient) land. The high prices of farmland represent a major barrier for them. Furthermore, existing financing and support systems are still often focused on conventional, large-scale farms. Producers aiming at the local market could be supported in a more consistent manner.

Farmers could themselves promote demand for local products through a more effective embedding in the local community (village, municipality, region). The farm could be made more open and fulfil other – social – functions. This requires a modification in business operations, but could benefit their economic viability.

## 4.3 Improving food production and distribution

Major efforts have already been made throughout the agri-food chain to reduce the environmental pressure of the various links. Technological advances and increasing knowledge have played a major role in this process. There is, however, still ample scope for improving the sustainability of the dominant system. In this part we will discuss the improvement of eco-efficiency, the reduction of food losses in production and distribution, and closing loops as locally as possible.

### Improving eco-efficiency

Our current food system has a high productivity due to the large use of external resources to produce food. In agriculture, intensive use is made of resources such as fertilisers, imported livestock feed, water, fossil fuels, pesticides and animal healthcare products. Also the other links in the chain, such as the food industry and retail, are greatly dependent on the use of energy and water, among other resources. The intensive production throughout the chain places great pressure on the environment. To reduce this pressure, all kinds of efficiency measures were taken over the last decades in order to reduce the use of resources and the emissions per unit of output produced. This approach has resulted in a significant reduction in environmental pressure from the Flemish food system, especially during the 1990s. Over the past decade, however, the reduction in environmental pressure by agriculture has stagnated for a number of major parameters. Emissions of, among other pollutants, methane (greenhouse gas) and ammonia, and nitrate and phosphate concentrations in surface water are no longer declining.

There is still ample scope for further improvement of eco-efficiency. For example, LED lighting could reduce energy use in supermarkets, and solar panels, solar boilers and wind turbines could increase the share of renewable energy in the food industry and in retail. Innovations such as new, soft processing and separation technologies, and refrigeration, stabilisation and conservation technologies could help further reduce the environmental impact of the food industry.

A new concept in horticulture is the exergy-efficient greenhouse (EXE greenhouse) whereby insulation by means of Energy Balancing shields is combined with a vapour heat pump. This concept could reduce primary energy consumption in horticulture by three-quarters. The smart siting and judicious combination of horticulture enterprises could create opportunities for use of residual heat, residual $CO_2$ or other residual streams from other farms or sectors. In intensive dairy cattle systems, optimisation of digestion processes could reduce enteric methane emissions by 15 to 40 per cent.

Another promising innovation is precision agriculture or smart farming, whereby information is collected based on new technologies such as GPS, sensors and drones. This massive amount of data allows very accurate monitoring of crops and animals, so that they can get the precise treatment that they need. Whereas in traditional farming the work to be done is determined per field, smart farming does this on a smaller scale – per square metre or per animal. As a result of this strong focus on a smaller level of detail, smart farming can lead to reductions in greenhouse gas emissions, improved nitrogen efficiency, lower fuel consumption and less soil compaction through more selective use of machinery, and to a reduced use of pesticides. At present, it is difficult to assess the applicability in Flanders and the potential environmental gain.

While such strategies certainly have potential, the stagnation of eco-efficiency in agriculture shows that the low-hanging fruit has been picked. The question therefore is whether the environmental impact of production can be brought within the limits of the environmental space quickly enough without changing the production volumes.

Another focal area is that eco-efficiency improvements are often focused on individual environmental parameters, such as greenhouse gas emissions or nitrogen losses. This could lead to a shifting to other environmental aspects. For example, some techniques to reduce ammonia emissions require a lot of energy, and some measures to reduce greenhouse gas emissions could cause other emissions to increase. By adding more protein to animal feed, for instance, methane emissions per litre milk may decrease, but nitrous oxide emissions from manure may increase and there is also a negative impact on ammonia emissions.

Furthermore, it is important that strategies for eco-efficiency improvement pay attention to the preservation of soil fertility. A fertile soil is not only important for the actual production. It also helps to prevent nutrient leaching, buffer climate change through carbon storage, store water and protect soils against erosion. The principal indicator for preservation of soil fertility is the organic carbon content in the soil. On farmlands and meadows, it is significantly lower than with other land use in Flanders. Options to increase the organic carbon content of the soil in arable farming include the regular administration of organic matter in the form of crop residues, such as straw or organic fertilisation (compost or farmyard manure) or the use of cover crops.

## Fewer food losses on production and distribution side

Agriculture and the food industry have the greatest share in total food loss in Flanders, with 36 and 25 per cent respectively. The share of retail is 5 per cent. In relation to the total production of the different sectors, food loss is comparatively low, only a few percentage points. These food losses are, for the greater part, valorised.

In addition, a portion of the food surpluses from the chain is donated to social organisations. In 2015, 16,400 tonnes were donated, more than three-quarters of which by the food industry. This number is an underestimation, because both suppliers and social organisations do not have any structural monitoring and reporting in place. Not all unsold products in the food industry and retail are suitable for subsequent social redistribution. Possible reasons are quality issues and expiry of the use-by date. There is, however, still untapped potential.

Food loss has various causes. There is the loss that is caused by natural production conditions in agriculture, such as the weather. Examples are glassy potatoes due to drought, or apples and pears with hail damage. Losses can also be the result of technical inefficiencies such as harvest, sorting and storage losses in agriculture, start-up and shutdown of production lines in the food industry, and wrong opening of packages in retail.

There are also structural causes of food loss, such as oversupply, aesthetic quality requirements and consumer requirements relating to product freshness and availability. These causes are deeply rooted in our food system. Oversupply is promoted by the growth-oriented food system which induces farmers to always produce more at the lowest possible cost. This can lead to significant food losses, especially in horticulture, for example when export markets are lost. Consumer expectations and preferences play an important role in food losses in retail. The sector strongly focuses on optimising supply via IT systems that take into account external factors such as the weather. The objective is to have optimal stocks in the shops: not too much, but certainly not too little. Because consumers expect everything to be available at all times.

Food losses caused by inefficiencies can be further reduced with technical measures. Examples are the optimisation of harvesting, sorting and preservation techniques and air-conditioned accumulation tables and towers. These allow for optimal preservation of intermediate products if the production line shuts down. To address the structural causes of food loss, however, more radical adjustments are necessary. This is a shared responsibility of all chain actors, the policy and consumers.

## Closing loops as locally as possible

Closing loops fits in with the drive towards a circular economy, where materials and products are kept in circulation for as long as possible at the highest quality standard. In this way, the use of new materials is minimised. There are various options to close loops in the dominant system. These include the valorisation of food waste at the highest possible standards according to the food waste cascade, the local cultivation of raw materials for animal feed, and the recovery of nutrients from wastewater.

The **food waste cascade** serves as guide in dealing with food waste. Food loss is preferably prevented or food is processed into other food products. Lower on the cascade is valorisation, initially as animal feed and in second instance as material application (fertiliser, soil improver or raw material for the industry). This is followed by the possibility of converting food into forms of energy such as biofuel. The last recourse is to dispose of the food by incinerating it with energy recovery or, finally, to dump or discharge it.

In Flanders, 92 per cent of all food waste is reused within the food system: 43 per cent is used as animal feed, 44 per cent as material – generally as soil improver or fertiliser, with or without prior composting or fermentation – and 5 per cent is used for energy applications. Only 6 per cent is incinerated (with energy recovery) and about 1 per cent is landfilled or discharged.

Valorisation of food waste as animal feed ensures greater value retention than other material applications because it contributes indirectly to the human food supply. In 2015, half of the raw materials used for compound feed consisted of by-products from the food industry.

However, only a portion comes from the Flemish food industry. Around half are by-products from oilseeds such as soybean meal, mainly from Brazil and Argentina, and rapeseed meal from Germany. Research into further valorisation options for food waste from the Flemish agri-food chain is ongoing. Also the local cultivation of feed raw materials such as indigenous legumes (for example lupines and clover) and eventually also soya, algae and duckweed can offer opportunities for the better closing of nutrient and carbon loops. This also applies for a reduction of the livestock, which would reduce the need for importing feed raw materials.

Food waste is converted into soil improver or fertiliser through composting and digestion, the latter with or without composting of the digestate. In case of digestion, also energy is generated simultaneously. Of the food waste in Flanders, 21 per cent is fermented and 6 per cent composted. In agriculture, there are still large quantities of residual streams that could be composted or digested, including food waste from fruit and vegetable production.

Compost and certain types of digestate products can be used to improve the quality of farmland. They ensure a more balanced supply of nutrients as compared to raw animal manure. The higher supply of stable carbon also reduces the risk of erosion. Treated soils can also retain more water in drier periods and drain better in wetter periods.

There is also great potential for the valorisation of food waste through biorefinery. Biorefinery uses techniques to separate biomass into semi-finished and finished products. Certain components from food waste can thus be reintroduced in the food. Another possibility is the extraction of building blocks for chemical or pharmaceutical applications. The majority of these techniques are still in the research phase. There is as yet little quantitative data available on their environmental impact. A prerequisite for a positive environmental impact is that the streams do not travel over too large distances and that the extraction and processing methods cause only a limited environmental impact.

## Levers

### Cooperate from a chain perspective and continue to focus on a common strategy

Cooperation from a chain perspective can create opportunities to achieve a higher environmental gain with the same investment. This implies a better distribution of the costs throughout the chain, including the consumer. New business models can be instrumental in this process. For example, agricultural providers could offer services (such as crop protection) instead of products (pesticides). This could be an extra incentive for suppliers to provide the service as efficiently as possible, and therefore as a rule also with less environmental impact.

Closing loops, too, calls for cooperation, not only within the food chain but also with other sectors such as the chemical industry. Major challenges are factors such as seasonality, limited shelf-life, and geographical spread.

Cooperation – both within the chain and with sectors outside the food system – requires a common long-term strategy and concrete roadmaps. The vision developed by The New Food Frontier, which was reaffirmed within the project 'Transformation to sustainable agriculture and food', can be used as basis. Also investing more in 'matchmakers' and highlighting front-runners could promote cooperation.

**The New Food Frontier** was made up of a network of fifty thinkers and doers who explored new ways to facilitate the transition to a more sustainable agricultural and food system. Based on analysis and creative thinking, they developed visions of the future agricultural and food system.

According to The New Food Frontier, a sustainable agricultural and food system:

- is resilient, dynamic and focused on the long term;
- excels in diversity;
- offers room for innovation and entrepreneurship;
- is made of visible links, the relations between which are transparent and respectful ('partnerships');
- secures access to sufficient food so as to enable a healthy life;
- is internationally fair;
- is efficient, not harmful to people and the environment, respects animal welfare, and uses resources economically;
- offers ecological, economic, cultural and social (ethical) added value, and is economically viable for all actors within the system, also through the application of a correct price;
- assigns meaning to food;
- consists of consumers who opt for a healthy lifestyle.

### Make existing knowledge accessible and stimulate new knowledge development

A great deal of research is being done on eco-efficiency improvement. One area for improvement is providing independent information about new technologies and training to producers. They will then be less dependent on the free information provided by their suppliers.

In order to close loops as locally as possible, much more knowledge needs to be developed. Valorisation options vary greatly depending on the composition, size and geographical spread of the streams. This requires intensive cooperation with practice partners, for example in the form of living labs. Sufficient accessibility of results, for instance through a central knowledge database, could promote the translation into practice.

### Integrate and simplify available financing and subsidy systems

The government provides numerous resources to invest in new technologies. However, the financing and subsidy systems appear to be rather unwieldy and not transparent enough. It is important to centralise (information about) available financing and subsidy systems and to further simplify and speed up the administrative application procedures. Furthermore, existing and new financing and subsidy systems must be aligned with the vision on the sustainable Flemish food system of the future.

Group purchases or agricultural cooperatives could also help make the investment cost more manageable. Moreover, banks could take into account sustainability criteria when granting loans.

### Create room for change through policy and legislation

Policy has many options to promote eco-efficiency improvements and the closing of loops. Thus, more efforts could be made to facilitate cooperation between companies at the spatial planning level. Multifunctional zoning, whereby agriculture and certain complementary economic activities are merged, could be instrumental in this.

To close loops, coherent policy is of paramount importance. The feasibility of high-quality valorisation is influenced by laws and regulations, in particular regarding waste, energy, agriculture and food. Depending on the type of valorisation, regulations on, for example, food safety or waste could be refined or amended. Another important lever is the creation of shielded places for experimentation, where departures from regulations can be authorised under controlled conditions, for the purpose of innovation research.

### Promote valorisation of food surpluses for human consumption

Certain food surpluses can be reprocessed to food products with a longer shelf life. However, current production processes in the food sector require more or less uniform input streams. As a result, it is often difficult to valorise food surpluses via conventional production lines. New experiments can be set up for the processing of non-uniform streams. Quality assurance of finished products is essential to convince consumers.

### Improve the organisation of food donations

To facilitate the donation of food surpluses, an initiative called the Schenkingsbeurs was set up. This online platform links organisations with unsold food products to food aid and social organisations. There is also a growing number of distribution platforms that collect and redistribute surpluses. Optimisation of the logistics is important to expand their role.

Social organisations often have insufficient cooling and freezing capacity to collect large quantities of fresh products, This may lead to food losses. It would be possible to provide resources for food hubs that collect and, where appropriate, process larger quantities of food. Such hubs could be linked to distribution platforms.

## 4.4 Changing food production and distribution

Food production systems that are organised differently can play an important role in the transition to a more sustainable food system. In what follows, we will zoom in on the application of agro-ecological principles, the provision of multifunctional services, and the introduction of new food systems with minimal use of land.

### Apply agro-ecological principles

A fundamental principle of agro-ecology is that nature is the most important production factor in the food system. Whereas conventional agriculture uses numerous external inputs to increase productivity and control natural risks, agro-ecological models use natural processes and services (ecosystem services) wherever possible. Examples include the preservation of soil fertility, regulation of erosion risk, and natural pest control and pollination. Reinforcing and maintaining these processes and services is therefore central to business operations.

Agro-ecology implies a high level of autonomy on the part of the farmer and requires correct pricing with internalisation of environmental and societal costs. It involves the active search for links with society and the creation of social involvement. This is accomplished in various ways, including short-chain selling and cooperation with citizens, scientists and other actors in the food system.

In what follows, we will discuss three systems that apply agro-ecological principles to a greater or lesser extent: integration of vegetable and animal production, organic farming, and agroforestry.

An important agro-ecological principle is closing loops. This can be done, among others, through the integration of vegetable and animal production, which involves the implementation of rotations or the exchange of products across sub-sectors. All of this serves to reduce the use of external inputs, optimise the nutrients loop, and improve the soil structure. Integration can take place at business or cooperative level, but also on a regional scale in the form of partnerships between specialised farms. Such systems can lead to more efficient land use, an increase in the amount of organic matter in the soil, less erosion and a better balance between input and output of nitrogen. All this requires the necessary expertise and planning.

A number of studies show that the operating results of mixed farming systems vary widely, but that farm income is often below average. By contrast, profit margins are not very sensitive to fluctuations in market prices. Further research should provide a better insight into this matter.

Organic farming is based on four basic principles: health, ecology, care and fairness. It is internationally governed by the basic standards of the International Federation of Organic Agriculture Movements (IFOAM), which have also been transposed into national and regional law. Some organic farmers keep to the legal minimum requirements as laid down in European organic farming legislation. Others go further and apply additional agro-ecological principles.

**Organic farming** strongly focuses on preserving and improving soil fertility and on closed loops. This involves intensive crop rotation, suitable tillage practices and use of green manures and organic fertilisers. Chemical-synthetic pesticides, chemical fertilisers, feed with growth stimulants or antibiotics and genetically modified organisms are prohibited. The balance between animal and vegetable production is preserved by limiting stocking densities.

The organic sector is experiencing strong growth in Flanders. The area under organic farming has doubled since 2005. However, in 2017, only 1.2 per cent of the total Flemish agricultural area was used for organic farming, which is well below the European average of 6.7 per cent. In 2017, organic fresh food in Flanders had a market share of 2.4 per cent.

Organic farming is put into practice in different ways, meaning that the environmental impact also varies greatly. However, organic farming soils appear on the whole to contain more organic material, which is the most important indicator for the preservation of soil fertility. Agro-biodiversity is also greater in organic farming. Nutrient losses to water and air and greenhouse gas emissions are lower per hectare, but not (always) per kilogram of product. It should be noted that the environmental impact per kilogram of product does not show whether the environmental capacity is exceeded. In fact, the environmental impact also depends on the production volume, the production density and the vulnerability of the local environment.

Land use per kilogram of product is generally higher in organic farming, because crop yield is lower and animals are allowed more space. The difference in yield with conventional farming does, however, strongly depend on the crop type, the local growth conditions, and the management methods. Polycultures and modified rotations can reduce the difference in yield between organic and conventional farming to less than 10 per cent. Further research into the optimisation of cultivation and management techniques and into the selection of varieties that are optimally geared to organic farming can further reduce this difference in the future.

Research suggests that organic farming can make the European food system more resilient, allowing it to better deal with challenges and shocks such as climate change, pests and diseases, declining subsidies or more expensive external inputs. An important observation here is that an organic food system that restricts itself to the certification of production would likely suffer from the same vulnerabilities as the dominant system.

Agroforestry combines woody plants and agriculture. As with organic farming, some practices can rather easily be integrated into conventional agriculture, whereas other practices require a major transformation of business operations. In 2013, 0.3 per cent of the agricultural area in Flanders fell under the label of agroforestry.
The model could be applied to a large portion of the total agricultural land area. Interest, however, remains rather limited, even though in recent years it has grown among young starters in agriculture.

Agroforestry in general leads to a positive impact on biodiversity, higher nutrient concentrations through decomposition of leaf litter, reduction in the amount of leaching nitrogen, more efficient water use and reduced soil and wind erosion. In addition, the production of ligneous biomass (both above ground and underground) allows a substantial amount of carbon to be captured. Agroforestry even allows a higher total biomass production to be achieved than is possible with separate cultivation of crops and trees.

The system involves additional costs at start-up. However, the combination of agricultural, timber and fruit production enables the farmer to diversify the farm's income.

## Provision of multifunctional services

Apart from food production, the food system can provide other societal services, ranging from biodiversity to education and care functions.

One example is agricultural nature management. This covers activities that farmers undertake as part of their business operations for the purpose of nature development. It ranges from small, low-threshold measures, such as the installation of nesting boxes, to the individual or group-based provision of green services in nature or other areas, such as grazing management, reed mowing, or ecological verge management. A more holistic concept is nature-inclusive farming which is focused on agro-biodiversity, efficient use of raw materials, and care for the landscape.

Provision of multifunctional services may also include multifunctional management of the landscape, whereby agriculture, in collaboration with other actors, carries out various landscape management functions. Examples are water storage, erosion protection, landscape care or preservation of old regional varieties or forgotten vegetables.

## New food systems with minimal land use

Since recently, experiments are being carried out with new food production systems that use (virtually) no conventional farmland. A first group of systems includes food production on buildings (open cultivation on roofs or cultivation in greenhouses on roofs) and in buildings (vegetable production, fish farming in combination with vegetable production, mushroom cultivation, insect farming). These new forms of landless food production often use urban residual and waste streams as inputs. They include fully controlled systems such as LED light cabinets, but also open systems such as roof gardens.

These systems are so diverse that no general statements can be made about the environmental gain. Food production generally takes place close to the end consumer, so that the environmental impact of transport is low. In particular high-tech production systems in buildings are still in the research phase. They require more start-up capital due to the technology necessary for lighting, water/nutrients/climate control systems and the monitoring and coordination of these systems. Roof gardens have been in existence for some time and their environmental effects appear to be generally positive. They consume little energy and produce relatively high yields. Roof gardens can also relatively easily make use of (composted) organic waste from the city.

A second group of landless systems for food production includes technologies such as cultured meat and 3D-printing, a technique used to print food. The latter technique offers numerous opportunities such as the supply of personalised food in terms of taste, shape, texture and nutritional value. Cultured meat does not come from slaughtered animals, but is produced artificially.

Both production methods are still in the research phase. For cultured meat, the high production cost, technological issues and uncertainty about consumer acceptance are still main barriers to its commercial deployment. Potential benefits of cultured meat are reduction in the use of vegetable raw materials, space saving, less water consumption, improved animal welfare and the absence of problems with animal diseases. It is still too early for an effective assessment of the environmental impacts.

## Levers

### Break the path dependency of the food system

In recent years, many initiatives and networks with a different perspective on the food system have been set up. Alternative food systems also attract attention from policy makers, as demonstrated by the Flemish strategic plan 'Organic Farming' and the work on mixed farming systems and agroforestry within the European Innovation Partnership Agriculture (EIP-AGRI).

However, alternative production models still remain relatively small niches. The food system remains strongly focused on an intensive, specialised, export-oriented agri-food chain. This 'path dependency' makes the food system stable and prevents the breakthrough of production and processing methods and eating patterns that deviate from the common model. New models can only find wider acceptance if the various factors making up the food system are addressed consistently.

### Develop a long-term strategy and transition paths

A guiding long-term strategy for a sustainable food system, developed with, and supported by, the various actors, is of paramount importance to facilitate the acceptance of models such as agroecology, multifunctional agriculture and food production systems with minimal land use. Such a strategy must make the transition paths transparent for the diverse group of actors within and outside the conventional food system. Only then can full-fledged opportunities be created for innovation and reconversion.

The clear growth and export ambitions of the conventional agri-food chain and of policy constitute a major barrier to the development of transition paths that bring the system within the environmental carrying capacity. That is why attention to reconversion and innovation opportunities for actors at risk of dropping out due to changes, is of crucial importance. The long-term vision must be consistently translated at the various policy levels (EU, national, regional and municipal) and policy areas (agriculture, nature and environment, spatial planning, economy, etc.).

## Use sustainability and resilience as criterion for success

The success of the food system is often assessed on the basis of efficiency indicators such as labour productivity, yield per hectare or per kilogram of feed, and emissions and resource use per kilogram of product. These indicators provide only a limited picture. They do not indicate, for example, whether the carrying capacity of the environment is exceeded. Nor do they provide an insight into the resilience of the production system, such as sensitivity to diseases, extreme weather conditions, or the economic and geopolitical context.

To give more opportunities to new production models, it is crucial to assess the success of the food system against sustainability and resilience, instead of evaluating it only in terms of efficiency. This also requires the further development of sustainability monitoring instruments.

## Stimulate knowledge development and innovation

There is still a great need for knowledge development on agro-ecology, multifunctional services, and food production systems with minimal land use. In addition to additional technical-scientific knowledge, there is also a need for further socio-economic research into business models and logistics systems for the distribution of products. Apart from science-driven fundamental research, resources are needed for research in collaboration with farmers and the other actors involved. This should preferably be based on their specific needs and demands. More public financing is necessary because private partners often see little value in providing funding for research into models such as agro-ecology.

The large-scale dissemination of research results to (future) food producers is of great importance. Apart from (agricultural) education itself, low-threshold initiatives such as company visits and social media can be used to enable the parties involved to become acquainted with alternative approaches. Also independent advisers to support farmers can play an important role in this process.

## Provide space and financial resources

The lack of affordable agricultural land is a major barrier to agro-ecology. Possible ideas to remedy this are a tax on farmland that is used for other purposes, local authorities that provide land, and a tax cut when undeveloped land is (temporarily) made available for food production.

Alongside space, the lack of financial resources constitutes a barrier to agro-ecology. Support mechanisms for what often are smaller agro-ecological projects can make a big difference. By incorporating a more holistic sustainability assessment into existing subsidy systems, common farming systems could also be eligible for support when they apply agro-ecological principles.

The lack of open space in Flanders is not only a barrier to agro-ecology, but also to the provision of multifunctional services. There is still a trend towards economies of scale and specialisation, whereby farmers seek to maximise their total land area for agriculture. There is concern that nature-related efforts may eventually result in the land being designated as nature reserve. A multifunctional zoning policy could alleviate this concern. The government could also provide land or include the provision of multifunctional services as a criterion for the allocation of available land.

For food production systems involving minimal land use, cities or other actors could provide roofs or vacant buildings. The construction industry could be stimulated to integrate the possible installation of roof gardens in building projects.

### Identify new business models and ways of marketing

For many consumers, convenience is a decisive factor. In addition to short-chain marketing, food produced according to agro-ecological principles could therefore also be made available more often in conventional retail. At the same time, the reach and efficiency of short-chain selling could be increased, for example, through short-chain hubs and combined home deliveries. Farmers are not always familiar with new business models and product marketing strategies. More attention to this aspect in agricultural education, knowledge sharing and cooperation could provide solutions.

Another major market barrier for agro-ecological products and new food systems is the often higher cost. Retail can help increase the consumer's readiness to pay by improving the marketing of sustainable products. There is also potential in the hospitality sector, where the higher cost can be recouped through storytelling. The price difference with less sustainably produced food should moreover be reduced by reflecting the environmental and societal costs of food production in food prices.

The provision of multifunctional services must also give rise to appropriate compensation, which can be included in the price of the food product, but can also come from, for example, so-called 'landscape funds'. These funds consist of contributions paid by actors who use the landscape, such as tourists, local residents and companies, for care of the landscape. Direct agricultural support can also be linked to a number of conditions to be met by multifunctional services. Furthermore, support measures on, for example, agri-environmental measures and management agreements could be revised, whereby the level of support increases as the system becomes more multifunctional or is implemented area-specifically.

### Create consumer support and acceptance

Networks such as 'Voedsel Anders' (Food Otherwise) already help to familiarise citizens with agro-ecological principles and to create public support. Collaboration with civil society organisations with a wider range could augment and accelerate the effect of these networks. The government could give more attention to products from new food systems in its communication and promotion, e.g. via VLAM (Flanders Agricultural Marketing Board). Education can also play an important role in this respect. For the acceptance of high-tech food production such as cultured meat, it is essential to provide clear and substantiated communication on the production method, as well as the advantages and drawbacks.

### Support collaboration

Much is happening in the area of agro-ecology and new systems with minimal land use, but there is too little interaction between the many, and often small-scale, initiatives. Cooperation can help to share costs, expand the customer base and increase entrepreneurship. Knowledge and experience can be shared via networks. Policy support is necessary in order to further develop existing networks and optimise their interaction. For new production forms with minimal land use, consultation with actors from other sectors, including energy, architecture and urbanism, is also necessary.

Cooperation and consultation are also crucial for multifunctional agriculture, which requires effective forms of governance where the various stakeholders attempt to find a balance between the different, and sometimes conflicting, objectives. This should preferably be done with facilitation by a third party. Regional actors could, for example, be given room to freely determine how to achieve an objective that is put forward by the government. Process guidance and any other appropriate public support could be provided for this purpose.

### Aligning laws and policy with new food systems

More clarity is desired on the necessary licence(s) for food production with minimal land use. At present, it is not clear whether such production is allowed on agricultural land, in an industrial area or city centre. A relaxation of the existing food safety laws could be a lever. Low-regulation zones could create experimentation space to further develop new technologies and applications until they are ready for the market.

## 4.5 Conclusions

### Towards a sustainable food system

In spite of the numerous initiatives already taken, major steps remain to be taken towards further reducing the environmental impact of the food system. Many solutions are either already available or in the research phase. The potential impact of the different solutions is quite diverse and not always easy to assess correctly. This is due, among other reasons, to the fact that solutions can be implemented in different ways or have thus far found only limited application.

It can, however, be assumed with sufficient certainty that optimisation of the conventional system will not suffice to bring the environmental impact of the food system fast enough within the limits of the environmental capacity. Over the past decades, the agri-food chain has strongly focused on gradual improvement. In the 1990s, this led to a significant decrease in environmental pressure. Over the past decade, however, key parameters showed a stagnation. There also remain economic, social and health problems. New production and distribution systems and alternative diets that respond to specific problems in the conventional system have difficulties establishing themselves. This is due, among other reasons, to the path dependency of the food system.

Action is therefore needed now. In addition to the sustained focus on system improvements, we must actively create room for system innovations by consistently acting on the various factors that shape the food system. Bringing about a sustainable and resilient food system that is capable of meeting challenges and shocks, is a systemic ‘and-and story’ where the various solution paths complement each other.

## Levers for the transition

Throughout the analysis of the barriers and levers for the different solution paths, the following five key focal areas emerged.

There is need for a **long-term strategy linked to a coherent long- and short-term policy** for the food system. In Flanders, several vision development processes were organised in recent years. The most recent ones are The New Food Frontier and 'Transformation to sustainable agriculture and food'. In the second project, the actors translated their shared vision into both a strategic plan and an action plan. However, implementation is stalling due to the path dependency of the system, among other things. For example, there are the clear growth and export ambitions of the food industry and the lock-ins due to the major investments in infrastructure and technology in the various sectors. Furthermore, there are also not enough economically viable reconversion options. The Flemish government and the actors in the food system can, however, use the shared basis from the vision development processes to work out a policy strategy. In this strategy it is determined how we, in our region, wish to approach food production and consumption and how we can meet the accompanying ecological, economic and social challenges. Flanders is not an island, so a long-term strategy should ideally be linked to a policy vision and dialogue at European level. It should preferably also be consistently implemented at the different levels of government. The strategy should be as broadly supported as possible, but the government must also have the courage to make guiding choices and put forward binding targets. This may require certain sectors to reorient themselves. Support of reconversion and innovation is therefore an absolute prerequisite.

**Cooperation and dialogue** among the actors involved are critical success factors. They enable shared discourses, shared knowledge building and investments, valorisation of food waste and the closing of loops. Dialogue is also crucial to create sufficient support for the food policy in the long term. The sustained focus on cooperation and dialogue can lead to a food system made up of ecologically and economically resilient chains. This also includes a fairer distribution of both the costs of sustainability efforts and the generated proceeds. It also implies a correct food price that reflects environmental, health and social costs, and a correct compensation for the ecosystem and social services provided by agriculture.

In addition, there must be sustained focus on **innovation and knowledge building**, both in the technical-scientific and the socio-economic area. Also the set of instruments for monitoring the sustainability and resilience of the food system must be further developed and refined. Practice-oriented research with a transdisciplinary approach can play an important role in scaling up sustainable solutions and ensuring their broader acceptance. Research funding should preferably be spent on practices and technologies that support the long-term strategy. Research into system innovations can help to break path dependence and provide insight into feasibility and sustainability. Cooperation and knowledge sharing between researchers and practice are important in this respect.

The current **legislative and policy framework** needs to be adjusted to reflect the long-term vision on the food system. Coordination and alignment between the respective policy areas, possibly through a food policy area, are necessary for this purpose. Barriers within legislation and subsidy systems, among others, must be removed to enhance opportunities for solutions that have environmental potential. Low-regulation zones could serve as experimental space.

To support the broader introduction of more sustainable eating patterns – and therefore also more sustainable production – the whole **food environment** needs to be reoriented towards the long-term vision on sustainable food. This involves the broad spatial, economic and sociocultural context that shapes our eating habits. It is driven by the practices of numerous actors, including the agri-food chain itself as well as retail, hospitality and catering, but also education, influencers such as famous cooks, athletes and media figures, non-profit organisations, and above all the government.

5

# SPACE AS PLATFORM FOR AN ECOLOGICALLY SUSTAINABLE SOCIETY

**Energy, mobility, food: in the transition that is taking place in each of these societal systems, spatial solutions or 'strategies' play a key role. In this chapter, we will analyse eight spatial strategies that integrate different sustainable solutions across the three systems. We will look at what those strategies are, what their potential environmental benefits are, what actors should be involved, and what levers are needed to implement them.**

## 5.1 What is it about?

### Sustainable space: a crucial condition for transition

The way in which we organise and use our space plays an essential role in the challenges currently encountered in societal systems. For example, the development of a sustainable and efficient public transport network implies a sufficiently high concentration of users and, therefore, dwellings. At the same time, our scattered housing model constitutes a barrier to finding suitable locations for wind turbines in the open space.

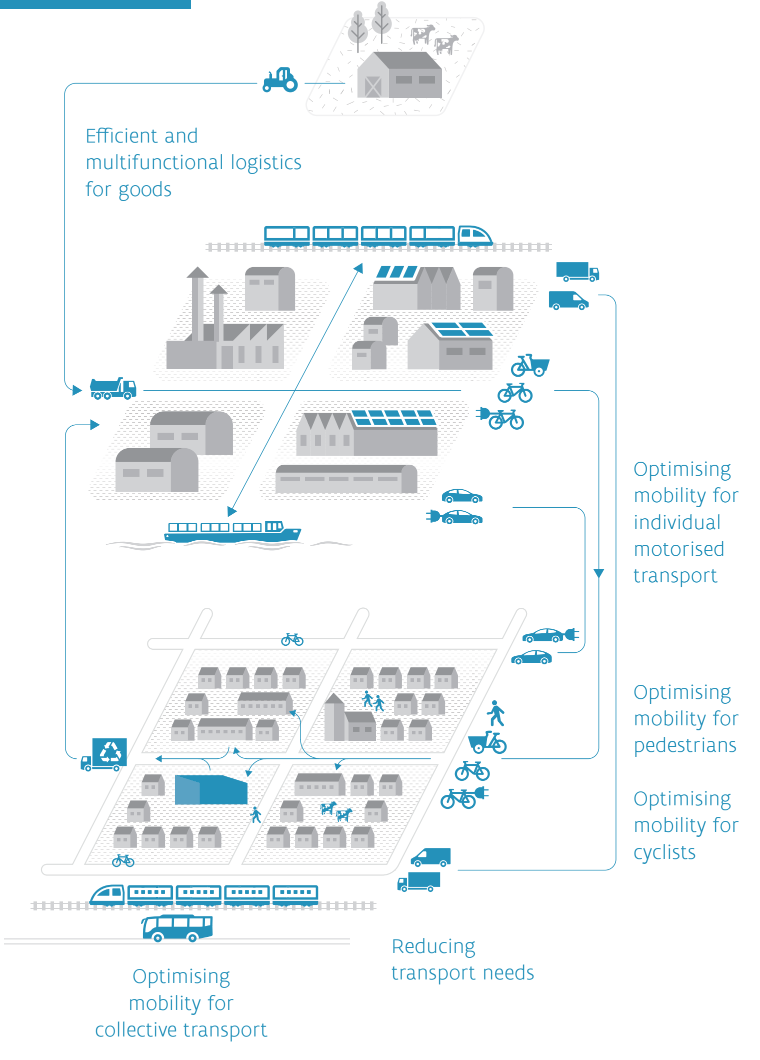
To implement solutions for more sustainable societal systems, the space in Flanders must be ingeniously used and organised. Due to the large amount of space already occupied, the fragmentation of, and the many claims on, the remaining space, well-thought-out choices across the various systems are vital. Those choices must literally give space to, and enable, the sustainability transitions of the various societal systems.

Space is therefore not to be considered as a separate system that exists alongside other societal systems. It is, however, an essential condition to bring about system transitions in the areas of energy, mobility and food.

The figures on the following pages show how solutions for the three societal systems can be viewed from a spatial perspective.

For the **mobility system**, the link with space is clear and direct. By organising and optimising the space, we can avoid and shorten trips, which could further motivate people to opt for more environmentally friendly alternatives. Public transport, for example, is a crucial pillar of a sustainable mobility system and greatly depends on the spatial organisation. Sustainable public transport thus calls for a dedicated lane, which requires sufficient space and an adequate infrastructure. A sufficient number of people must use public transport to make it affordable. Therefore, a sufficiently high concentration of dwellings and destinations is needed around the stops of the network, which in turn requires spatial measures. The modal shift in freight transport requires strategically located regional logistic hubs that are easily accessible by water and railways.

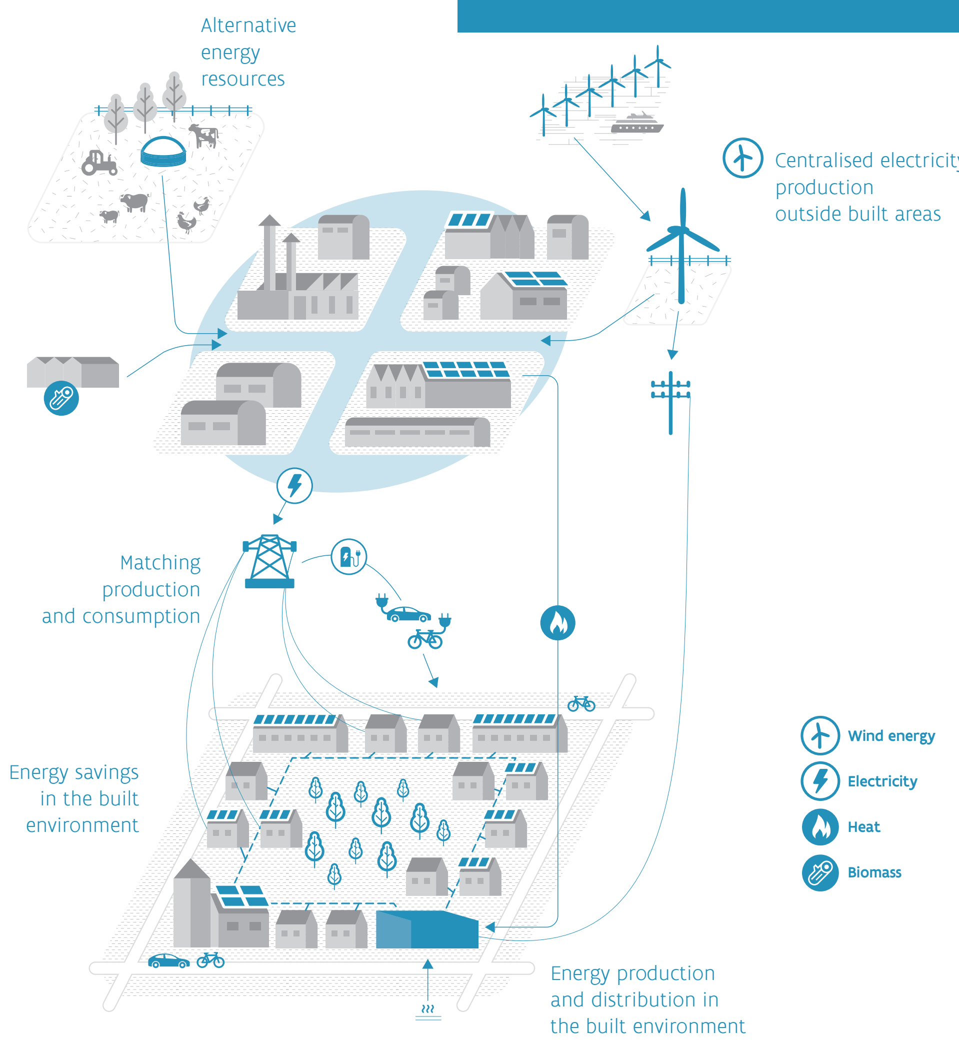
## SPATIAL STRATEGIES MOBILITY SYSTEM




To: Provincie Oost-Vlaanderen, *Maak Ruimte voor Oost-Vlaanderen 2050*

For the **energy system** the link with space is also clear. Space affects each of the solution paths. Spatial aspects are important prerequisites for achieving a more sustainable energy supply and energy use in the built environment, for bringing about a sustainable energy supply, and certainly also for matching supply and demand. Wind turbines, for example, are getting bigger and more productive due to technological developments. This has implications for their integration with surrounding landscape. Also heating grids in urban areas have a major spatial component. The installation of heating grids requires not only sufficient underground space, activities with surplus heat must also be smartly sited in the vicinity of locations with sufficient heat demand.

## SPATIAL STRATEGIES ENERGY SYSTEM

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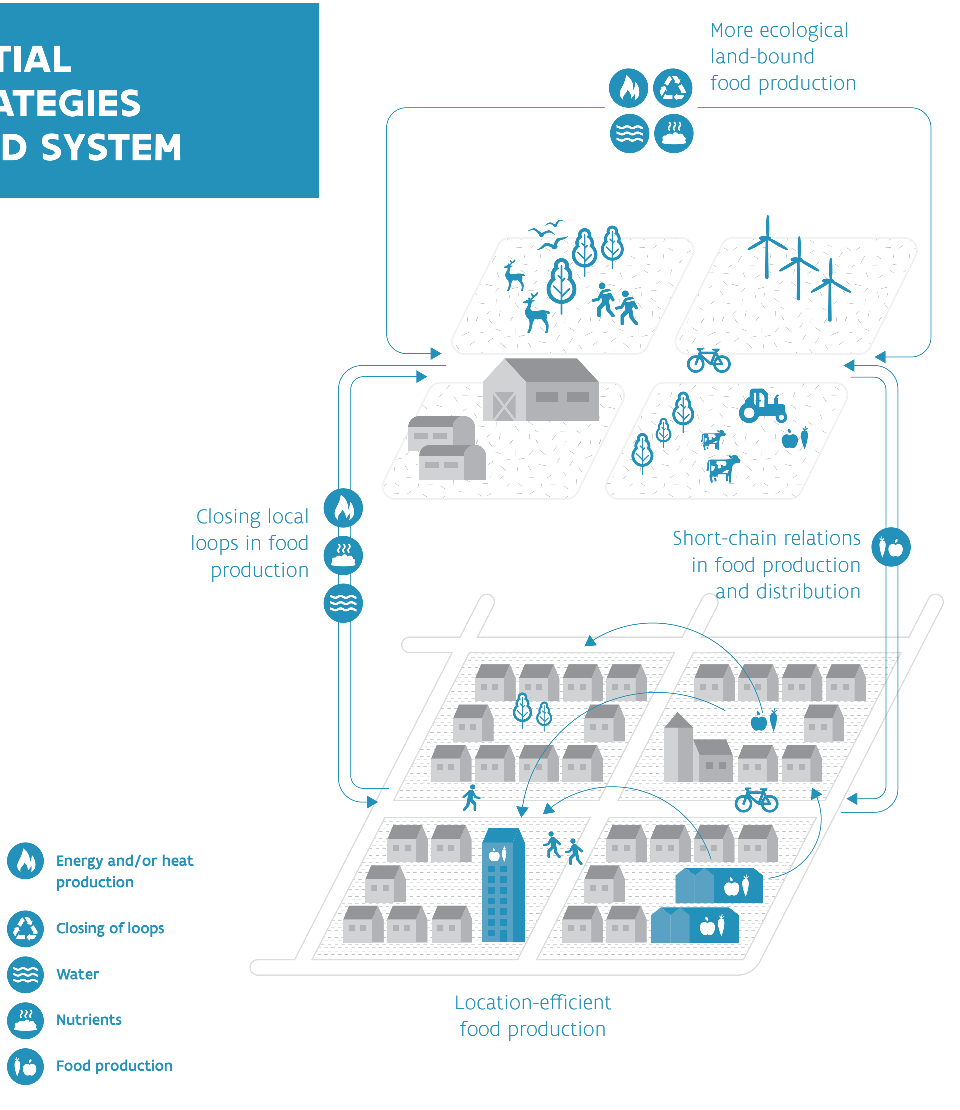
The transition to an ecological **food system**, too, requires spatial support. For example, it is necessary to preserve sufficient unfragmented open space for food production and provision of multifunctional services such as water infiltration, water buffering and agricultural water management. In many cases, access to affordable farmland also complicates the rollout of other production models such as forms of agro-ecological agriculture. This applies in particular to newcomers who want to start out as young farmers and do not yet have any land at their disposal. Also short-chain relations between producers and consumers benefit from short distances or proximity between the food production location and the users (in the built environment). And the spatial clustering of non-land-bound food production allows loops to be closed more effectively.

## SPATIAL STRATEGIES FOOD SYSTEM

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## Four levels of spatial action

The spatial strategies discussed in this chapter comprise a wide range of measures that can be taken from a spatial perspective. These measures are situated at four levels of spatial action: location policy, spatial networks, spatial organisation, and the use of the space. The different ways of acting on space apply to varying degrees to the selected spatial strategies as discussed below.

- **Location policy**, a basic principle of spatial planning, ensures that the right function is located in the right place. Thus, the purpose is to protect and strengthen the open space in relation to agriculture, recreation and the provision of social services. At the same time, activities such as living, economic activity and working are to be clustered in cities and villages. Other economic activities are combined into poles, which constitute the building blocks of the economic fabric.

- Whereas location policy looks at the actual functions, **networks** focus on the relations between locations and functions. The key element here is the development and enhancement of those relations. This also requires hard infrastructure as support for the networks, such as transport infrastructure and distribution networks for energy and other utilities. According to Beleidsplan Ruimte Vlaanderen (BRV; Spatial Policy Plan Flanders), there are four networks that steer a sustainable spatial policy: public transport, the road network, the network of cycle routes, and the energy distribution network.

Networks and locations reinforce each other. Each location can be assigned a specific network or node value, such as accessibility with a given transport mode, or connection to energy networks. They help determine the development potential of the location, which is addressed by the location policy. Conversely, networks are only really useful if they support a sufficient number of relations. They must therefore connect locations with a sufficiently high usage rate.

- **Spatial organisation** denotes the concrete design and layout of space. This involves both buildings and open space, but also transport and other network infrastructure. Key principles at this level are compactness, intense space usage, multiple space usage and image quality. In many cases, multiple use can be made of space by interweaving activities.

### MULTIFUNCTIONAL SPACE: COMBINING FUNCTIONS

One of the sustainable spatial organisation principles is '**interweave where possible, separate where necessary**'. Space occupancy and organisation should preferable develop interwoven, bringing functions together. Interweaving, such as integrating specific undertakings in residential areas, is based on the idea that functions reinforce each other. In this way, societal added value is created (just think of closing loops as part of a circular economy), the number of journeys is reduced, and short trips by bike or on foot are encouraged.

However, not all functions can be combined in the same location. High-risk activities cannot, or only to a very small extent, be interwoven. Allowing certain functions can also impair the development opportunities for other functions. Here, the principle 'separate where necessary' applies. Reserving space for non-interweavable activities constitutes a separate challenge in the spatial organisation. They can, for example, be grouped in economic poles that are easily accessible by sustainable modes of transport.

- Spatial planning and organisation as a whole is focused on the effective **use of the space**. Eventual user behaviour can be stimulated and steered via spatial strategies, but not determined directly. This is the area of 'soft' principles such as the specific activities carried out in the space, but also travel behaviour, use and exchange of raw materials, and cooperation between functions.

## Towards eight spatial strategies for more sustainability

To allow solutions for a sustainable energy, mobility and food system to be integrated from a spatial framework, we proceeded as follows:

1. In a first step, we analysed which solutions within the individual systems can be implemented from a spatial perspective. This step was illustrated in the figures below 5.1 for the various societal systems: the reader views the ecologically sustainable solutions and the way in which they can be facilitated, by looking through spatial glasses as it were.
2. The range of spatial strategies thus obtained for the various systems were then supplemented and compared with literature and subsequently grouped into a list of 25 strategies.
3. Rating the spatial strategies based on their environmental impact, state of play, innovative character and feasibility resulted in a selection of priority spatial strategies across the various societal systems. The eight selected strategies are by no means the only ones that are relevant to sustainability transitions of the societal systems. They are, however, the priority strategies and they all go to the core of sustainable spatial policy.
4. Finally, we zoomed in on each of the priority strategies. Special attention was paid to the potential environmental benefits in each of the three societal systems, for the actors and instruments, and for the levers that improve the chances of success of the spatial strategies. The actors were each time considered at three different levels (macro, meso and micro).

The eight selected spatial strategies are:

- Developing a polycentric network of cores and poles with a sustainable public transport network as carrier.
- Clustering dwellings and facilities in cities and well-equipped cores.
- Protecting the open space from improper use by 'hard' functions.
- Clustering supra-local activities in multimodal poles.

- Facilitating spatial interweaving of activities and facilities in cores.
- Spatial differentiation of agricultural activities in the open space.
- Integrating renewable energy production into the open space.
- Supporting the exchange of residual streams and the construction of heating grids.

## 5.2 Develop a polycentric network with sustainable public transport

In a polycentric network, the focus is on the relations between cores, economic poles and open space, the network that they make up, and the infrastructure as the sustainable backbone of the network. A polycentric network is based on the specificity and complementarity of the different cores and poles. Core strengthening also implies a judicious selection of which level of facilities is appropriate for which core, and therefore also the choice whether or not a core has to be strengthened. This strategy therefore focuses first of all on the strengthening of the core, which is equipped with a package of daily amenities. More periodic facilities are reserved for the major cities with a high node value, or distributed over a network of smaller, complementary cores.

In this strategy, the various cores are closely interconnected by a high-quality public transport (HPT) network. Spatial development takes place according to the principles of transit-oriented development (TOD): fully aligned with collective transport axes. A high-quality public transport network requires corridors with nodes, around which concentrations of highly dynamic activities are established. Such a network in turn supports the development of an efficient energy grid. In between the corridors, maximum space is available for an ecological and productive landscape that can be used for nature, food and renewable energy production, water storage and infiltration.

### What are the potential environmental benefits?

In this strategy, journeys are avoided or shortened, which forms the foundation of a sustainable **mobility system**. For movements between nodes, HPT represents an attractive alternative to the car. A HPT network allows better bundling of journeys. This leads to higher traveller potential and more efficient investments in the network. Combined with an increased potential for journeys on foot and by bike, an environmentally friendly alternative to the car is created.

In the **energy system**, too, a polycentric spatial development leads to greater efficiency and reduced costs. The clustering of activities and buildings at nodes creates a higher building density and compactness, thereby reducing heat demand. It also offers more opportunities for energy exchange and heating grids. The smaller occupied space in the outlying area frees up space for renewable energy production.

It also creates more opportunities for the **food system**. Agriculture receives more space and can more easily enter into synergies with other open space functions such as nature and water. This strengthens the development of a more ecological food production. The polycentric network also supports the creation of economic poles that can accommodate agro-industry.

## Which actors and instruments are involved?

At **macro-level**, the Spatial Policy Plan Flanders provides an objective basis for making choices on whether of not to densify and develop cores or to phase-out development options and to preserve open space. The combined effect of node value and level of facilities results in a node map. In the decree Basisbereikbaarheid (Basic Accessibility), the distance and operating rule based on the dwelling (origin) will be replaced by a new principle that focuses on the main destinations. This will also imply the creation of transport regions at meso-level. An important precondition for optimal operation of the polycentric network is that it does not stop at the regional boundaries. De Lijn (at Flemish level) and the NMBS (at federal level) are both responsible for the installation, maintenance and operation of the public transport networks in Flanders and Belgium.

At **meso-level**, a key role is reserved for the provinces, for example in preparing provincial structure and mobility plans and recently also the spatial planning policy memoranda. In the transport regions, the mobility policy will be implemented in practice by the transport regional council, which, in addition to the municipalities, is composed of De Lijn and the Department of Mobility and Public Works. In the future, each transport region will be required to prepare their own mobility plan, which will also define the additional network and the customised transport.

At **micro-level**, cities and municipalities are responsible for the majority of decisions concerning spacial planning and mobility. Municipalities have access to a wide set of instruments, including the municipal spatial structure plan, the mobility plan and all instruments linked to the licensing and enforcement policy. The framework of the transport regions could also promote the alignment between municipalities.

## What barriers could impede this strategy?

Introducing large-scale changes to the built environment is a long-term process. To arrive at a polycentric network of compact cores and poles around public transport stops, spatial planning needs to be managed more vigorously. In Flanders, there is an oversupply of land for living and working which is often not located in the vicinity of a public transport node or near a core with sufficient daily facilities. This situation was perpetuated in the regional plan and evolved into an acquired right of land owners. The oversupply of already allocated land makes it difficult to manage spatial developments from a network logic.

This peripheralisation is further amplified at fiscal and financial level, for example by the system of company cars and the lower land prices in the countryside. At policy level, there appear thus far to be few concrete stimuli for effective intervention to reverse this trend.

Finally, the budget for public transport has declined in recent years. Except for Brussels and Antwerp, the focus is mainly on efficiency gains rather than on new investments in, for example, additional lines or stations.

### WHAT LEVERS SHOULD BE USED TO DEVELOP THIS STRATEGY?

Flanders has an ever-growing congestion problem and also experiences difficulties in meeting its climate targets. Public support for an overarching and more radical strategy that could make the difference, grows as the problems become more urgent. A polycentric network based on a high-quality public transport network could offer significant added value to society, also in environmental terms.

The high cost of the growth in the periphery is a lever. Making scattered dwellings accessible and connecting them to utilities costs society significantly more. The maintenance costs for vast networks of roads, sewers and water pipes are increasing and lead to financing problems for local authorities.

The transport regions to be created could serve as a new framework for cooperation between municipalities on mobility and spatial planning. The transport regions could be the long-awaited forum where local authorities can discuss a joint mobility plan, both with each other but also with higher policy levels.

## 5.3 Cluster dwellings and facilities in cores

The purpose of this strategy is to concentrate the growth of hard functions into cores. It deals with living, facilities that support living - such as shops, physicians and local recreation - and functions that are 'interweavable' with living, such as schools and small-scale economy that does not cause any inconvenience. Clustering is intended to guarantee the proximity between these functions, to more efficiently organise public services and the use of collective facilities such as shared mobility and public transport, and to protect the open space. Outside these cores, growth is excluded and eventually hard functions - such as dwellings or companies in a flood plain - can be moved to cores.

Clustering preferably occurs in cores that are already well-equipped with amenities and easily accessible by public transport. There is as yet no clear framework for this. The implementation of this strategy for less well-equipped cores, for example, needs to be further clarified. Supra-local cooperation will in any case be important.

Core strengthening should contribute to the quality of life of residents and users. Infill prevents the spatial expansion of the core, and reduces additional space occupancy. Quality can be improved by eliminating vacant building spaces and by stimulating multiple use of underutilised buildings, by more compact and/or communal living, and by replacing low-quality functions such as open car parks. Core strengthening can only succeed if cores are attractive. The focus must therefore be on improved road safety, better environmental quality, sufficient green areas, well-developed amenities and affordable housing. This requires a better framework for core strengthening. Municipalities must be supported with instruments to qualitatively steer private developments and set up core-strengthening projects themselves.

## What are the potential environmental benefits?

Core strengthening is a crucial prerequisite to achieve the environmental and climate objectives across the three systems. It leads to sustainability of the **mobility system** in two ways. The best way to reduce the environmental impact of mobility remains the avoidance of trips. Creating proximity via clustering and interweaving of living, daily amenities and workplaces, reduces the need to travel. It enables journeys with a low environmental impact, for example by bike, that are even faster than travel by car. The switch to private car alternatives thus contributes to energy savings. In addition, clustering increases the potential for (cost-)efficient collective mobility solutions and offers opportunities for efficiently organised logistics and sustainable shared mobility.

Densification also benefits sustainability of the **energy system**. In cities and cores, more compact projects with stacked living and working units are possible, which is ideal for building heating energy savings. Moreover, clustering helps to make the distribution of energy and the investment in new forms of energy supply, such as the construction of heating grids, more efficient. In addition, interweaving of different functions increases the probability of a diversity of users, enabling better matching of demand and supply. Finally, core strengthening also frees up space for sustainable forms of energy production outside the cores, without any additional space being required.

The concentration of hard functions in cores helps alleviate pressure on the open space. As a result, there will be more space in the **food system** for sustainable land-bound food production. Moreover, clustering of housing in cores promotes opportunities for short-chain relations. In this way, a sufficient number of users can be reached to market locally/regionally produced food.

## Which actors and instruments are involved?

At **macro-level**, the Ruimtelijk Structuurplan Vlaanderen (RSV; Spatial Structure Plan for Flanders) introduced the idea of clustering in 2000 and a new set of instruments with spatial implementation plans (RUPs). Spatial development remained, however, largely dominated by the system of granting permits on the basis of old plans such as the Gewestplan (Regional plan).

The Vlaamse Codex Ruimtelijke Ordening (Flemish Spatial Planning Codex) also governed the acquisition of permits independently of the policy plans. The Beleidsplan Ruimte Vlaanderen (BRV; Spatial Policy Plan Flanders) maintains and reinforces the focus on clustering and efficient land use, but the instruments to implement the policy are not yet in place.

At **meso-level**, the provincial administration is responsible for the preparation of the policy plans, the provincial RUPs, the monitoring of strategic projects and applications for developments in residential expansion areas. Provinces work, in varying degrees, to prepare provincial policy plans on space. Furthermore, they guide municipalities in their planning processes. There are already quite a few informal, supra-local partnerships that are supported and coordinated by the provinces.

The majority of decisions in the field are taken at **micro-level** through licensing, possibly preceded by a planning initiative. Only a limited number of municipalities use a development regulation on housing typology as a way of steering densification to the right locations and thereby stimulating core strengthening. In a number of locations, there are interesting initiatives such as non-regulatory assessment frameworks for projects in general or for housing typology.

## What barriers could impede this strategy?

In policy, local interests and solutions still often prevail over solutions that support the goal of raising the spatial organisation to a higher level. It is also not evident, especially for local administrations, to let qualitative core strengthening prevail over previously granted building rights. Furthermore, core strengthening - generally complex projects involving many local residents, stakeholders, physical barriers and constraints - often has to compete with 'easy' developments at the outskirts of the cores and in the open space. Growth through densification also meets with opposition out of fear for major metropolitan problems and nuisance. Moreover, there is as yet no clear vision on the strengthening of village centres: which should be strengthened, which not, and how? In some cases, municipalities have no clear decisions from the higher authorities as to which cores they want to strengthen and develop, and which not. Municipalities also have insufficient knowledge of the instruments that can be deployed for sustainable core strengthening.

Furthermore, there is still a lack of insight into the nature of the demographic challenges of the next decades. These will consist primarily of dealing with an ageing population, which leaves us facing the tremendous challenge of building compact dwellings in centrally located locations. If not, the cost of elderly care will increase significantly.

### WHAT LEVERS SHOULD BE USED TO DEVELOP THIS STRATEGY?

In recent years, we have seen a tentative shift in the discourse on space: from scarcity of building land to the intention to abandon opening up any new areas for building. Many cities no longer accept the consequences of dispersed housing and take measures in the area of mobility. Ageing of the population can also be used to communicate the advantages of core strengthening. Initiatives like carsharing, bikesharing and co-housing are gaining ground and call for compact cores.

Flemish cities have been focusing strongly on core strengthening over the past two decades. Large and medium-sized cities have heavily invested in upgrading their centre and station environment. Smaller cities and municipalities are slowly following suit, for example, by commissioning a Bouwmeester Scan. The provinces are also increasingly supporting this policy.

It is essential to create a link between the long-term cluster policy and the daily flow of licence applications through an adequately spatially differentiated licensing framework. The government could impose additional requirements on private development projects that enhance the quality of the cores. A challenge in the longer term is to compensate for suboptimally located land and premises within the cores. A more vigorous land policy, either at local level or within supra-local structures, can have a facilitating effect. It allows for affordable projects in the cores via strategic public purchases of land and premises.

## 5.4 Preserve open space

This strategy deals with the challenge of preserving the remaining open space for open space functions: agriculture, nature, water management and sustainable energy production. In the longer term, it could even be envisaged to remove 'hard' functions from the open space. This implies a twofold task.

On the one hand, the solution consists in stopping further encroachment on open space by functions that do not belong there from a spatial-ecological point of view and that can be clustered in cores or economic poles. This involves dwellings, economic activity, trade, amenities and hard recreation. To protect open space functions, expansion of zone-foreign functions is excluded and occupancy of farming land by, for example, gardens or hobby activities, limited. The remaining stock of scattered building land for living and economic activity must also be withdrawn. Projects for defragmentation of the open space are therefore an integral part of this strategy.

On the other hand, a positive spatial approach is needed, such as clustering and densification in cities and well-equipped residential cores (see also 5.3 "Clustering dwellings and facilities in cores"). However, there must also be an attractive policy for open space functions: this will require closer cooperation among open space actors. Appropriate instruments for the design of the open space are already in place. The necessary resources can ensure that these too are applied on an area-specific basis. Also model projects that create win-win situations in the field through cooperation among authorities, owners and users, may prove inspiring. The challenge is to ensure that more land is designated correctly (through planning compensation or other solutions) or acquired, in order to create opportunities for the open space functions.

## What are the potential environmental benefits?

The **food system**, and agriculture in particular, are under heavy pressure from space occupancy in the open space. A policy aimed at eradicating the assumption that unbuilt land in open space will still be developable in the future, could reduce the land value for agricultural use. This would also create opportunities to make ecological and multifunctional forms of land-bound agriculture more feasible. Moreover, this spatial strategy contributes to other environmental policy goals such as integrated water management and preserving space for ecological networks.

The phase-out of scattered developments and activities is also essential for a more sustainable **mobility system**. Less scattered housing reduces the need for transport, as developments are located, and interwoven, in cities and well-equipped cores. The short distances within the cores encourage walking and cycling. Cost-effective implementation of public transport is only possible in compact cores. Clustering economy in cities and cores further creates support for new logistics solutions such as urban distribution centres.

The phase-out of scattered development also benefits the **energy system**. Less scattered housing and concentration of hard functions in cities and large urban centres reduce energy demand. Distribution networks can be shortened and also lead to fewer losses. Less scattered housing promotes the construction of heating grids. Preservation of open space offers opportunities for renewable energy production.

## Which actors and instruments are involved?

At the **macro-level**, the surplus of designated residential, residential expansion or reserve residential areas on the regional plans have adversely affected the preservation of open space. To change designations in order to protect open space, planning compensations are used, but these are very complex and expensive. The generic rule licensing has enabled the maintenance and expansion of zone-foreign functions and has given rise to an insidious transformation in the agricultural area. Many old agricultural buildings thus received a new use that no longer corresponds to the designation. A number of strategic open space projects lead to locally supported solutions. However, such projects are, for the time being, confined to considerations between the various open space users (water management, agriculture, nature). The BRV can offer new opportunities. However, the tension between spatial policy objectives and conflicting generic regulations remains a point of concern. Thus, the derogations provided for in the recent Codex trein can be used sustainably for qualitative core strengthening in cities and residential cores. However, they also allow the further densification of scattered housing in the open space.

The impact of the provinces at **meso-level** must not be underestimated. They play a decisive role in the advice on and approval of local spatial plans. This authority has probably led to a significant number of spatial plans being steered in the right direction, in accordance with the principles of the RSV. But the provinces also play a role in 'exception planning'. This makes it possible, for the purpose of preservation of open space, to regularise undesired situations or authorise and modify the designation of undesired developments in the open space, such as zone-foreign companies or residential expansion areas. Apart from planning and licensing, the province strongly profiles itself as an actor that supports and coordinates supra-local strategic projects aimed at cohesive open space areas. It also participates in research into new instruments for equalisation between municipalities.

At **micro-level** – the municipal level – decisions are made on the majority of concrete projects in the field. Just as with core strengthening, the regional plan provides the main basis for licensing in municipalities. The licensing practice varies widely. In addition, many cities and municipalities work on local strategic projects for the open space. Many municipalities are currently examining what a desirable densification policy should look like. Both the development of these visions and their translation into licensing frameworks constitutes a major challenge. The use of reparcelling with planning exchange and tradable development rights as instruments to relocate building opportunities within the municipality to appropriate locations, is attracting growing interest.

## What barriers could impede this strategy?

The importance of open space is clearly recognised in policy plans, but the historical planning system remains an obstacle to an effective open space policy. Zoning plans indicated a reserve of building opportunities. The Flemish licensing system also repeatedly eroded spatial planning. Moreover, there is no comprehensive investment policy for the outlying area.

The pressure from large landowners on policy makers is significant and has contributed to the idea that high land prices are the result of scarcity of building land. Also the wish of individuals to build their own home and the idea of owners having self-determination over their land, are deeply rooted in our societal thinking. Furthermore, many developments in the open space are not licensed and are often not licensable either. Some 80 per cent of the activities in former agricultural buildings are estimated to be unlicensable. No structural enforcement is forthcoming. Moreover, there is the persistent conviction that additional developments such a subdivision project or a new industrial site are a source of income for the local level, which is not immediately confirmed by the figures.

The government deploys various instruments that (inadvertently) stimulate the attractiveness of living and working in a scattered housing environment. Examples are the municipal fund that encourages also rural municipalities to grow or the assessment of the cadastral income which makes scattered living cheaper. Land positions of authorities such as land of social housing companies, also stimulate encroachment on open space.

### WHAT LEVERS SHOULD BE USED TO DEVELOP THIS STRATEGY?

There is growing support to counter the encroachment on new open space. Water management, for example, gains in importance with each flooding. That we need space for water storage and that building on high-risk land is not justified, appears to have become an accepted principle. Also from an elderly care perspective, it is becoming clear that scattered building is not desirable. The upcoming oversupply of large dwellings with garden could further ease the pressure to continue to subdivide land. The importance of compact building for the purpose of energy efficiency and the installation of heating grids is gradually being recognised. Also the importance of (heritage) landscape and identity is growing in recent planning processes at meso-scale.

At the same time, there is increased opposition from cities to continue to bear the consequences of scattered housing. This leads to the introduction of traffic-restricted zones, circulation plans and low-emission zones. This evolution will stem the scattered siting of 'hard' functions such as living and companies, in favour of centrally located developments in the immediate vicinity of public transport and amenities. However, the effects of scattered housing appear not to have sunk in yet, and it is important to ensure that the public debate is continued. This will also give real opportunities to the instruments for a sound open space policy.

In addition to existing open space instruments (including land use, regional landscapes, unpaving fund, etc.), two groups of instruments still to be developed, are essential: Firstly, the discussion on an equalisation mechanism has started whereby municipalities not eligible for core strengthening nevertheless receive income. This can be done, for example, via a radical open space policy. A second group of instruments focuses on the relocation of building rights, for example, via a system of tradable development rights (TDR) or reparcelling with planning exchange. An important lever to implement these ideas in practice is the creation of supra-local systems that allow cooperation between municipalities. Pilot projects such as Regionet Leuven and the start-up of the transport regions, are promising.

Finally, a large-scale reallocation operation will be needed to defragment open space and to withdraw designated but not sustainable building land. A first step towards the regulation on signal areas has been made and the intentions to introduce a forest registry: such interventions must be regulated and financed.

## 5.5 Cluster supra-local activities in multimodal poles

This strategy examines how non-interweavable economic activities can be addressed from an environmental perspective. If these activities are too large-scale or cause too much inconvenience (mobility, noise, air pollution, odour pollution), they must be clustered in multimodally accessible industrial sites. The latter are carefully selected for accessibility via public transport, by rail, water and road, and, where possible, even by air. Their excellent accessibility allows them to take up a strategic position as 'poles' within regional spatial planning.

At the highest level are the strategic (intern)national growth poles for which a number of important supra-local functions qualify. They are easily accessible via a broad range of transport modes. Other poles should preferably be located near cities or in highly dynamic corridors, for example along a major rail- or waterway. What is important here is the principle that companies that are interweavable, such as offices, small-scale services or high-tech small-scale manufacturing industry, in principle do belong in the cities and well-equipped residential cores.

Job-intensive activities are located around public transport hubs, whereas functions generating a high number of logistic movements are best located in highly dynamic corridors. For passenger transport, the importance of easy access by bike via high-quality connections such as bicycle highways, also increases. In this strategy, industrial sites are only further expanded and supported if they have such multimodal access.

An additional focal area is the spatial organisation of the economic poles themselves. By stacking functions, sharing infrastructure and getting away from the practice that every company provides space on its own plot for possible future expansions, the use of space can be reduced significantly. This frees up extra space for more economic activity or open space. The collective provision of facilities ensures a high level of spatial efficiency. Finally, clusters of companies also make it easier to exchange residual streams and reduce their environmental impact.

## What are the potential environmental benefits?

In the **mobility system**, travel related to work and economy play a key role. In Flanders, almost three-quarters of trips to work are made by car. More than 80 per cent (according to tonne kilometre) of freight transport takes place by road. Rail and inland navigation account for only 20 per cent. Clustering economic activities around multimodal hubs reduces the average travel distance for passengers and goods. It creates additional possibilities for collective transport from and to industrial sites and increases the share of sustainable transport modes. Companies that can use rail or waterways are clustered by priority in sites with adequate access. This provides opportunities for shared logistics and higher load factors.

Also for the **energy system**, clustering can reduce the environmental impact. Compact building on an industrial site with high 'spatial efficiency' reduces the demand for heat. Smart clustering of heat producers and consumers could stimulate the use of residual energy streams. The spatial clustering of large users will also make investments in renewable energy production more attractive.

Just like the clustering of residential areas, the clustering of economic activities leads to less fragmentation and occupancy of the open space. This offers additional opportunities for both energy and food production in the open space. We will therefore notice the indirect positive effect on sustainability of the **food system**.

## Which actors and instruments are involved?

Policy at **macro-level** is currently focused on the selection, allocation and development of industrial areas. The RSV distinguishes a number of types of regional business areas based on function and required infrastructure. At present, the Flemish government is working on a new categorisation, called 'segmentation', which should allow for several types of location environments, including more interwoven locations in highly urbanised areas.

The **meso-level** will probably play an important role. The provinces play an important role in spatial economic policy. Since the RSV became effective, they have been responsible for the policy on industrial sites for their territory. The Regionaal Sociaal-Economische Overleg-comités (RESOCs; Regional Social-Economic Dialogue Committees) are an important consultation structure on socio-economic policy. The provincial development companies play a key role in the activation and supervision of projects for industrial sites and their development.

Important partners at **micro-level** are the municipalities as initiators for a spatial policy on economy, where appropriate, focusing on the selection, designation and development of a local industrial site. For the cities, the municipalities are also involved in the planning processes for regional industrial sites. In a number of cities, there are municipal pilot projects aimed at reintegrating economic activities into the residential fabric. Until recently, the municipality was a key actor in the licensing policy; since the introduction of the environmental permit this role has been partly shifted to the provinces.

## What barriers could impede this strategy?

The idea that there is scarcity of commercial land promotes the development of industrial sites. In some areas, however, there is actually an oversupply of commercial land. As a result, new commercial land is sometimes offered to companies that do not actually belong there.

Municipal financing is based in part on the number of companies and their employment, and on the local tax income that they generate. This often hampers a more regional policy with more clustering in correctly accessible locations.

To facilitate cooperation and circular economy through clustering, insight is needed into the business logic. This requires intense, area-specific coordination, which is often lacking today. There is generally also a big difference in time perspective between the managers of industrial sites (who look a few years ahead) and the location policy, which should span at least several decades. Moreover, many companies believe it is important to own spare land. They see it as an investment and a guarantee of expansion opportunities. This makes it difficult to set up a policy on economical use of space and clustering.

### WHAT LEVERS SHOULD BE USED TO DEVELOP THIS STRATEGY?

In spatial policy, awareness is growing that industrial sites outside the residential cores are not the only possible option. A more flexible approach whereby a long-term vision at regional level is developed in collaboration with economic partners, is slowly gaining ground. Intermunicipal companies and provincial development companies can support this approach, develop supra-local economic policy (vision building) and ensure the management (land policy). This is best done in the form of a flexible, project-based approach in regions where there are opportunities for area-specific cooperation. New instruments such as reparcelling with planning exchange, may help to exchange poorly located sites for better located areas. A system of equalisation between municipalities is a key condition, but is not yet operational.

Recent amendments to the Flemish Spatial Planning Codex now make it possible to link mitigating measures to a land-use plan. Such measures may be the reuse of water, exchange of energy, joint use of infrastructure, or management of waste streams. This makes it easier to enforce environmentally friendly measures via a regional implementation plan.

Area-specific supra-local pilot projects where municipalities, provinces and economic actors work together, are the key to success. A regional broker can supervise the process from vision building to implementation in sustainably organised industrial sites. Subsidies on project basis are a good instrument to let developers focus on sustainable solutions. Also the growing attention to energy and climate at European level creates opportunities for strategic projects. Companies are also increasingly interested in participating in projects on shared services, such as shared car parks, bundled logistics and collective energy services.

## 5.6 Interweave activity in cores

Offices, large retailers, and above all the manufacturing industry and workshops are increasingly moving out of the cores to peripheral locations, main roads or industrial sites. Reasons include land prices, accessibility (by car) and problems with environmental pollution and nuisance.

This strategy collects measures to make cities and large cores more productive and to reintegrate economic activity into the urban fabric. This also applies to new forms of (high-tech) food production. In this way, living and working are brought closer together. Job-intensive activities are best concentrated in the vicinity of public transport network nodes.

There is need for a good practice that enables the interweaving and smooth integration of these activities in the city. This involves both the creation of a sustainable (mobility) infrastructure and a logistics networks, and the creation of an urban manufacturing and entrepreneurial culture.

## What are the potential environmental benefits?

This strategy contributes significantly to a more sustainable **mobility system** by reducing commuter traffic, by far the largest traffic flow in Flanders. This reduction is even greater when the strategy is combined with an explicit core-strengthening location policy for housing. Shorter commute distances are also better suited to trips on foot or by bike. Urban centres and large residential cores of municipalities are also places where there is a greater supply of collective transport, because it can serve companies, facilities such as schools, and residents simultaneously. Interweaving therefore supports also collective passenger transport. Finally, freight transport can also be reduced by moving services or smaller forms of production closer to the market. This also promotes the organisation of urban distribution (centres).

The potential impact of this strategy on the **energy system** is situated mainly in matching energy demand and supply. It allows more efficient energy distribution to be organised via heating grids.

In this strategy there is less need for use of open space for industrial sites. This can free up space for a more sustainable **food system**. If also food production is interwoven in the cores, new short-chain relations and opportunities can be created to utilise urban residual streams (see also 5.7 "Spatially differentiate agricultural activities").

## Which actors and instruments are involved?

At **macro-level**, public support for innovative projects with attention to interweaving of activity, is important. One example is the instrument 'Pilootprojecten Terug in Omloop'. Not only the financial incentive but also the visibility gained by the projects is important.

At **meso-level**, the RESOCs, the consultative bodies at regional level between the local social partners and the local administrations of the province and the municipalities, could play a role by developing regional pacts. Interweaving can be a focal point of such pacts.

At **micro-level**, a counter of area managers and company managers can help with the search for a suitable business location or expansion opportunity. In addition to obvious financial, organisational and spatial criteria, social objectives such as interweaving can play a role. Multifunctional, interwoven projects can be actively supported. Conventional planning instruments such as the allocation plan (RUP) can play a central role.

## What barriers could impede this strategy?

The most structural barrier to the implementation of this strategy is situated at the discourse level. Within the classical economic discourse, relocating the manufacturing economy to industrial sites is logical, based on the lower land prices and more evident expansion possibilities. However, confidence in the economic feasibility of a small-scale interwoven economy is low. This is further accentuated by the deficit in experience, network and awareness of the manufacturing economy among investors, property owners and the government.

At local level, the policy for interweaving these activities is also insufficiently developed. Zoning plans and other local policy instruments impose restrictions on the siting of the manufacturing industry. Also nuisance-related legislation may have a restrictive effect.

### WHAT LEVERS SHOULD BE USED TO DEVELOP THIS STRATEGY?

The proximity of sufficiently trained staff and a sales market in the cities constitutes a major asset. Transport costs can thus be significantly reduced. Due to the growing importance of on-demand production, the production process can be better tuned to the local market. It pays for companies to have the market nearby, especially with respect to the expected developments in the circular economy. There seems to be a trend towards a civic economy where companies and economic activities forge closer ties with their environment and pay increased attention to collectivity.

The comprehensive facilities in the field of trade and commercial services in cities and large cores plead in favour of interwoven activity. Shops, schools, childcare, hospitality and an attractive public space in the work environment support the activity and create a much more pleasant atmosphere for employees than does a parcel in an industrial site. Locations in the core are often easier and multimodally accessible. There is better public transport service and a better supply of shared mobility.

Interweaving in cities and large cores also provides more opportunities to share knowledge. Due to the strong relation between the knowledge economy and the high-tech manufacturing economy, the two should preferably be located close to each other. Technological innovation also reduces production-related nuisance. In the meantime, societal appreciation for 'manufacturing' is growing. The time therefore seems ripe to reintegrate certain forms of production into city life. It would appear that companies, supported by the government, will be the first to make a switch.

## 5.7 Spatially differentiate agricultural activities

Agriculture exists in many forms. For example, some agricultural activities in the open space do not use, or hardly use, any soil. They account for nearly 15 per cent of the total agricultural area in Flanders. Just think of certain forms of horticulture and a large part of intensive livestock farms such as pig and chicken farms. Spatial policy does not differentiate between all forms: the agricultural open space policy is, in principle, accessible to any form of agriculture.

This strategy aims to spatially differentiate agricultural activities and food production, for the purpose of achieving a more sustainable alignment with the surrounding landscape and the local environment. The relation between agriculture and environmental impact is now governed exclusively by environmental legislation. Various ways of differentiation are possible. For example, a distinction can be made between a low dynamic network of smaller residential cores surrounded by a green belt of land-bound agriculture and nature, and a high dynamic network of intensive agriculture with use of resources and agro-industry.

Also a distinction based on environmental load and vulnerability could be a valid criterion. Agriculture continues to a occupy a central place in the open space, but is spatially located on the basis of the local environmental pressure, which increases societal acceptability. Environmentally harmful activities are thus brought together in locations where the impact on the environment is smaller. Less environmentally harmful agriculture can be located in or nearby vulnerable areas. These are, for example, areas with a high nature value, priority areas for infiltration and flooding or priority areas for groundwater extraction.

Certain forms of food production can again be reconnected to the urban fabric and the end consumer. This is possible, for example, in the form of urban agriculture or agricultural parks on the outskirts of the cores.

Finally, activities can be differentiated according to land dependency. Agricultural activities with no or little land use, such as horticulture businesses, can be clustered in rural industrial sites.

## What are the potential environmental benefits?

Conventional agriculture in Flanders enjoys a high level of productivity due to the intensive use of (external) resources. This puts high pressure on the environment and the surrounding landscape. This spatial strategy supports different sustainable solutions for the **food system**, such as the development of location-efficient food production, the closing of loops, and the organisation of short-chain relationships. Clustering of specific non-land-bound activities also generates more space for ecological food production in the open space. At the same time, the strategy reduces the impact of agricultural activities on the water system and nature. It allows for the creation of zones where both are protected, supported and developed.

Spatial differentiation allows highly dynamic functions with a high local environmental impact to be concentrated in zones with a higher carrying capacity and lower ecological vulnerability. Clustering creates opportunities for better monitoring, efficient collective water treatment, use of rainwater and treated wastewater, and better management of waste and residual streams. Clustering of highly dynamic forms of food production can also reduce the logistics flow and the environmental impact of traffic movements. By routing traffic over a supra-local transport network, the **mobility system** becomes sustainable and the viability of cores in the low dynamic network can be improved.

Short-chain relations between urban space and agriculture (parks) in the open space around it also offer opportunities for greenery and recreation in locations where urbanisation pressure is high. This provides significant added value for the quality of living in the city. These zones could also provide important ecosystem services such as water buffering/infiltration and reduction of the heat island effect.

## Which actors and instruments are involved?

At **macro-level**, designation and licensing policy plays a crucial role in the spatial use of agriculture in Flanders. It is a rather defensive policy of generic designations and delineations with respect to the other open space functions such as nature and recreation. The relatively new Landbouweffectenrapport (Agricultural Impact Report) can be a valuable instrument to assess the impact of spatial development on agriculture. It is, however, not sufficiently clear to what extent it is used.

At **meso-level**, in the delineation process for the natural and rural structure in Flanders (completed in 2009), thirteen outlying area regions were defined, based on spatial-physical conditions. This was complemented with a spatial vision for agriculture, nature and forests. Unlike the transport regions, these outlying areas no longer seem to play any role of significance for spatial policy. Alongside the important role for the provinces, such as the provision of an agricultural counter, there are also seventeen Regional Landscapes. They work mainly around nature conservation, landscape, regional identity and nature recreation, and work structurally together with farmers.

At **micro-level**, reference can be made to the instruments for the strategy 'Preserve the open space from inappropriate use by 'hard' functions' (see 5.4 "Preserve open space").

## What barriers could impede this strategy?

The delineation discourse must be abandoned in order to arrive at new spatial concepts and synergies for food production and open space. Relocating farms is often not obvious because of the traditional ties between farmers and their environment.

This is further complicated by the high land prices. The average price for one hectare of agricultural land has tripled between 1995 and 2005, and continues to rise. This increases the pressure for more efficient production and decreases the margin for drastic reforms such as relocation. There is also a fundamental tension between the interests of an individual farmer versus the collective interest of the sector. Older farmers rely on the proceeds from the sale of agricultural land for non-agricultural activities, thereby making it difficult for starting farmers to gain access to land. Apart from land price thresholds, there is no set of legal planning instruments to spatially differentiate agricultural activities.

The clustering of specific agricultural activities on the urban fringe - in the interest of short-chain relations - clashes with the even higher land prices. Moreover, the clustering of agricultural activities with a higher environmental impact could create the perception that inconvenience to the surrounding area is increasing. Aspects such as odour nuisance, light pollution (horticulture), noise pollution (transport) and visual inconvenience play a role in this respect.

**WHAT LEVERS SHOULD BE USED TO DEVELOP THIS STRATEGY?**

In contrast to other spatial strategies, this strategy still lacks maturity and a number of essential thresholds relating to, among other things, discourse, land price and fragmentation, remain to be eliminated. However, differentiation according to the dynamic character and the environmental load offers opportunities to reduce the environmental impact and reinforce the social and landscape role of agriculture and food production. Also the development of relations between agriculture parks and urban areas can play an important role in the revaluation of the food system.

Clustering agricultural activities may meet with local opposition. This can be solved by focusing, on a collective level, on efficient and technologically advanced emissions reduction and the closing of loops. Adequate monitoring, transparent communication and local participation are critical success factors. For example, residents can participate in the concrete siting of buildings and the installation of buffer zones in the context of visual inconvenience and odour nuisance. The provinces can take the lead in this matter.

## 5.8 Energy production in the open space

To meet energy demand in Flanders on the basis of locally produced renewable sources, each spatial opportunity, also in the open space, must be fully utilised. This may not compromise other open space functions (food production, nature, water, recreation, etc.).

In the open space, the main purpose is to install wind energy and, to a lesser extent, deep geothermal energy or hydropower in locations where this is possible. Wind turbines take up little space, but require a buffer area where building is not allowed, so as to prevent any inconvenience caused by rotor noise and cast shadow. The open space, and therefore primarily the agricultural area, is a suitable environment. Spatial integration and preservation of the landscape quality are two challenges in this respect. This strategy also implies the matching of energy demand and supply. It is therefore crucial to think about the way in which mixed consumers can better be organised into networks.

### What are the potential environmental benefits?

Installing wind turbines in agricultural area contributes to a more sustainable **energy system**. The additional income for farmers could be significant. In this way, the energy transition can play a role in the economic viability of sustainable, local food production. The environmental gain of this strategy cannot be viewed in isolation from a (spatial) policy aimed at reducing energy use by instruments such as core strengthening (see 5.3 "Cluster dwellings and facilities in cores").

Also biomass (from energy crops and forestry management) and PV panels along roads or railways can be a source of renewable energy. Biomass as a renewable energy source remains controversial in Flanders. The specific cultivation of biomass for energy generation, whereby biomass enters into competition with food production, raises serious questions. From an environmental perspective - but also from a spatial point of view - it does not constitute a valid alternative to wind or solar energy or geothermal energy. It could, however, be a partial and temporary solution for the energy transition.

Also for the use of residual streams from the **food system** and wood residues, allowance must be made for the value retention cascade, where reuse of materials has priority over energy production.

## Which actors and instruments are involved?

At **macro-level**, a circular on 'an assessment framework and framework conditions for the erection of wind turbines' was drawn up in 2014. Since 2017, the environmental permit has been in force, which combines the old planning permission and environmental permit into one procedure. At policy level, much is also expected from the Fast Lane initiative of the Flemish government, which investigates where wind turbines can best be installed to avoid inconvenience.

At **meso-level**, the study Energielandschap Vlaanderen calculated the maximum potential for renewable energy production, based on seven landscape types. Provinces and intermunicipal companies are important supra-local actors in onshore wind energy projects.

At **micro-level**, local government is considered the key actor in the planning, coordination and implementation of wind projects. New instruments include the energy or climate plans under the Mayor Covenant. Another option is to set up a local 'wind team', which acts as a steering group to supervise projects and assists in monitoring the entire process. Other key stakeholders are the landowners (tenant, leaseholder, etc.). The Windgids (2017) provides a roadmap for wind projects that are implemented by a project developer or the local government.

## What barriers could impede this strategy?

Fragmentation of the open space and urban sprawl constitute a barrier for wind turbines in the open space. Renewable, decentralised energy production in fact requires more space than conventional central energy generation. This is a challenge for Flanders in particular.

Lack of openness and communication during the implementation of projects and lack of facilities for participation sometimes lead to local opposition to the installation of wind turbines.

**WHAT LEVERS SHOULD BE USED TO DEVELOP THIS STRATEGY?**

To utilise the potential of energy production in the open space via wind, solar energy and biomass, land use will have to be addressed resolutely. Preserving the open space and preventing space from being used by other functions, are key elements. For the location of wind turbines, judicious siting must be fully taken into account. Spatial assessment instruments based on objective information can provide support.

In a spatial context, the hard link between land ownership and wind revenues prevents a more equitable distribution of revenue and expenses in wind turbine projects. The owner of the land receives a compensation from the operator/developer. Owners in the immediate vicinity do not benefit from this compensation, even though they experience the impact of the turbine and, as a result of the required distance between turbines, may no longer be able to install or have a turbine installed themselves. A system whereby a larger group of residents and landowners within a specific radius around the wind turbines can share in the revenue, could create additional support for projects.

The EU supports the creation of local energy communities as a new, cooperative structure that can be part of the local energy system. The framework for this is under development. The energy transition is an opportunity to organise the energy system more locally and transfer its ownership to society.

## 5.9 Support the exchange of residual streams and the installation of heating grids

Apart from spatial densification and proximity because of mobility, it is also possible to pursue clustering that is favourable from an energy perspective (energy oriented development). This offers opportunities for exchanging residual streams and installing (collective) heating grids, for example by combining consumers at short distance and having an energy demand that is spread throughout the day with one or or more producers of residual heat. The installation of energy grids implies that sufficient attention must also be paid to a suitable spatial structure in the underground.

### What are the potential environmental benefits?

In Flanders, heat accounts for around 60 per cent of gross final energy consumption, and as such is a major component of the **energy system**. An optimal development of heating grids respects the heat cascade. This means that consumers who need heat at high temperatures and pressures (such as public swimming pools or horticulture) are the first to be served. More energy-efficient buildings are then served with their residual heat. Maximum efficiency is achieved by adapting the spatial configuration of the heat users to that of the heating grid. By judiciously combining users with different profiles, efficiency increases because the thermal input is better distributed. An important aspect is the evolution from the current closed heating grids to open heating grids or fourth-generation grids. These are hybrid systems where different small-scale sources of different owners are combined. Such an open heating grid allows users not only to flexibly withdraw heat from the grid, but also to inject self-generated and unused heat into the grid at other moments. This technique is still in the test phase and requires extremely careful spatial planning.

A trial period on geothermal energy is still ongoing in Flanders. The exact potential of geothermal energy is therefore insufficiently known. Based on data collected in the Netherlands, the potential is estimated to be high, which can play an important role in the heat supply in Flanders.

Heating grids also allow the **food system** to be made more sustainable. They can contribute to the local closing of loops and increasing the energy efficiency of intensive sub-sectors such as horticulture. Collective heating grids and horticulture businesses that use each other's heat residues can increase the output of individual Combined Heat and Power installations (CHPs). The Flemish horticulture clusters have a large potential for this application due to the high concentration of businesses. Depending on the location and the heat demand, houses, schools and other facilities could also be connected to such a heating grid.

## Which actors and instruments are involved?

At **macro-level**, Warmtenetwerk Vlaanderen (Heating Network Flanders) is a key actor. The switch from gas to collective heating grids requires consultation with the gas sector. The Warmtekaart Vlaanderen (Heat Map Flanders) shows areas with high potential for the installation of new heating networks and the recovery of available residual heat. This is an important first step towards a heating vision at regional level.

Also the **meso-level** is important because the available heat sources vary from region to region and the potential is also determined by the building structure and density. Provinces and intermunicipal companies are crucial actors.

At **micro-level**, the local government is responsible for the planning, licensing and implementation of concrete heating networks, possibly in collaboration with neighbouring municipalities or in a private-public partnership. The Flanders Heat Map remains to be refined for the local level. A heat zoning plan is used to map the potential of heating grids in a given area, allowing a local heating vision to be developed, along with an associated action plan and instruments.

## What barriers could impede this strategy?

The installation of heating grids requires coordination among numerous actors. This makes the realisation much more complex than individual measures such as solar panels or heat pumps. Especially in existing districts, a heating grid implies both a significant infrastructural intervention and a modification within each individual dwelling. At present, heating grids are mainly installed at locations with a high heating potential, for example, located close to an incinerator or an industrial site. This has thus far resulted in a rather ad-hoc approach.

The current spatial configuration of Flanders is not conducive to a large-scale rollout of heating grids: a heating grid requires densification and interweaving. Because the energy transition will have to be initiated in the short term, the work will have to be carried out under suboptimal spatial conditions. Gas is also cheap at the present time, so that heating grids using other heat sources are less profitable for investors.

### WHAT LEVERS SHOULD BE USED TO DEVELOP THIS STRATEGY?

An important lever to promote the acceptance of heating grids and sustainable heat sources is a long-term vision and a concrete objectives and decision framework. The outlines of such a framework must be drawn first of all on the Flemish level. Alignment with the energy and renovation policy is crucial in this regard.

Heating grids are also financially attractive for all parties involved in the medium and long term. Locally, they provide significant economic added value. Experience has shown that entrepreneurs can also take the lead. Already completed or planned pilot projects could prove inspiring. Some companies could link heating grids to a quality criterion of corporate social responsibility. Useful use of residual heat could also be taken into account as energy saving by companies.

The spatial scope of application and the environmental potential increases enormously as soon as the step to fourth-generation open heating grids can be made. It will then become possible to combine several small-scale players into a single grid.

A heating grid can also lead to a comprehensive heat supply service. The consumer no longer needs to look after the maintenance of their system. This could be a valid argument to convince private individuals to sign up. It could also make a difference for the construction of social housing.

## 5.10 Conclusions

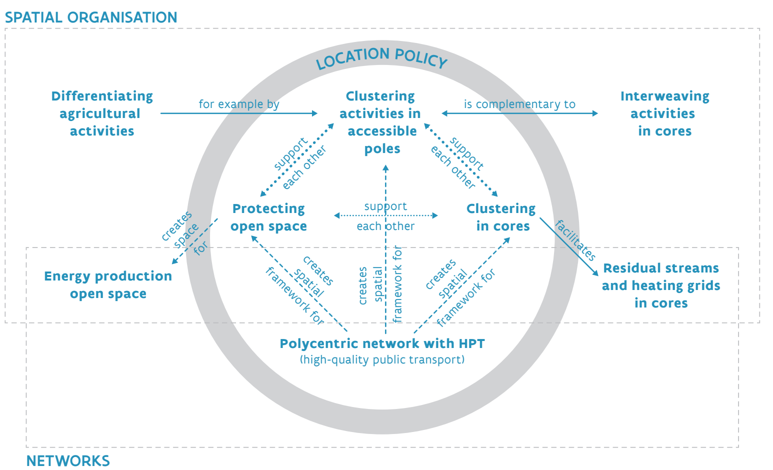
### Spatial strategies work together and at different levels

The eight selected strategies cannot be unambiguously linked to the levels of spatial action, but in each case a specific level prevails. The polycentric network with public transport as carrier is situated mainly at the level of regional networks. Clustering in cores, preserving open space and clustering of activity in poles are aimed mainly at location policy, although the implementation also involves the spatial organisation of functions (see figure below). The use of space applies to all spatial strategies.

Interweaving of activity, clustering of agricultural activities, energy production in the open space and residual streams in cores are situated primarily at the level of spatial organisation. Also location policy and networks play a role, but at a lower level than the previous three strategies.

The eight selected priority strategies are not the only ones, but they do form a coherent whole. The strategy of the polycentric network with the public transport network as carrier constitutes the spatial framework that is implemented by the other three strategies on location policy. These three strategies are complementary: by clustering activities in cores and poles, the open space is simultaneously preserved, and vice versa. Together these four strategies within the circle constitute the foundation of a sustainable spatial policy. They are also an essential condition for the realisation of the other four spatial strategies.

## COHESION AND RELATIONS BETWEEN THE SPATIAL STRATEGIES UNDER STUDY




BUUR cvba, shiftN, Background document *Ruimte als integrerend platform voor milieuoplossingen*

Moreover, the eight strategies have an important impact on the sustainability of the energy, mobility and food societal systems. This impact may be direct,or sometimes indirect. Thus, the environmental impact of the mobility system cannot be reduced significantly if no efforts are made towards a better spatial planning based on clusters around cores and poles.

Also the environmental solutions for the energy system are to a large extent determined spatially. Minimising energy use for space heating and mobility is only realistic if buildings are sited more compactly. Similarly, the local production of renewable electricity will only be feasible by reserving sufficient space for energy production. This, too, requires an important turnaround in spatial policy.

In the food system, many environmental solutions are related to eating behaviour and the distribution of food. However, substantial environmental benefits are possible by siting agricultural activities more judiciously, for example by taking into account the local carrying capacity of the natural systems such as soil, water and nature.

The selected spatial strategies also reveal synergies between the societal systems. Preservation of the open space can thus contribute to a more ecological food production, but also promote the production of renewable energy and the closing of loops. However, attention also needs to be paid to possible trade-offs.

## Levers for a sustainable space

When zooming in on priority spatial strategies, a number of similarities in barriers and levers can be identified that are crucial to approaching the sustainability transitions in the different societal systems in an integrated manner.

### A switch in thinking and discourse is needed

Some of the most persistent barriers to a sustainable spatial policy are situated at the level of the institutional discourse and traditional thought patterns. There is still not enough attention being directed to the societal added value of a better spatial planning, especially in the area of the environment and sustainability. There also remains a gap between the formal spatial policy at higher level, which increasingly incorporates sustainability principles, and its implementation in the field. This was clearly shown by the analysis of the strategies related to steering the growth of 'hard' functions such as dwellings, facilities and economic activity. Whereas all policy levels put forward the clustering of hard functions and the preservation of the open space as policy principles, there was hardly any change to the practice in the field.

Mentalities among policy makers and society explain this tension. Thus, people often think in terms of scarcity. This led to the so-called hectare policy: so many extra hectares for industrial sites, so many for living. As a result, the potential of more efficient land use was not tapped. There is also the discourse of sense of entitlement. Once building rights have been acquired, they are believed to be perpetual, even if they are found not to be appropriate from a societal point of view.

This discourse has thus far not met any real opposition. There is no strong coalition of actors who safeguard the interests of the open space in an integral manner, so that there is little opposition to the fragmentation of the open space. There has also not been enough close collaboration between spatial planning and actors from the environmental sector. Moreover, there is still often insufficient knowledge about the exact impact of a spatial strategy on the environment. Yet the strategies discussed show how they can fundamentally contribute to the sustainability of societal systems. The broad societal added value of the eight discussed spatial strategies (but also of the other strategies connected with them) must be examined and used more in-depth, also by actors involved in environmental policy.

### From generic to well-considered plan-based

Flemish spatial regulations provided for various derogations. They allowed for developments that may seem justified in a particular case, but which cumulatively resulted in a transformation that prevents the policy objectives from being achieved. There is therefore urgent need for a harmonisation of the policy objectives for space and the factual framework for projects and permits.

The plan-based resolution of errors in the old licensing framework - such as the indication of too many building opportunities, also in poorly located areas - is greatly complicated. A realistic solution for the correction of errors in the licensing framework is therefore necessary. Fees and compensations will play an important role in this respect. However, the principle that any building permit that was ever granted must be compensated at the current market value, is no longer tenable. It also ignores the factual oversupply in various places.

### From top-down and local to supra-local

In nearly all spatial strategies, the importance of vision building and project approach at supra-local level was highlighted. This also means that a Flemish generic framework should determine the overall principles and strategies, but not the actual details. Supra-local also means that municipalities often do not have the appropriate level of scale to make concrete choices in the area of spatial policy. Many systems such as trade, housing markets, recreation, activity and energy production have long ceased functioning at local level. Open space functions such as agriculture, water systems and nature and ecological structures have never done so at all. Supra-local cooperation will therefore be essential in shaping sustainable spatial strategies. Examples are projects for open space policy, partnerships for the siting of industrial sites, for mobility policy in transport regions or for energy production and distribution in energy regions. Various authorities can take the initiative: provincial departments, development companies, intermunicipal companies, but, where appropriate, also the Flemish Region or the municipalities themselves.  Also actors outside the public sector must be involved more closely. In addition, there is a need for supra-local actors who, as ‘regional brokers’, know the region and the actors, contact them and bring them in contact with other. They can play an important role by revealing win-win situations and encouraging parties to work together.

## Model projects as inspiration and driving force

For each spatial strategy there are already Flemish model projects where different public authorities, together with local initiators, owners and users, develop a supported vision and concrete implementations. Financial support by the Flemish and provincial governments constitutes a vital factor as the source for financing of coordinators and of the study and start-up costs. As pilot projects, they are an important lever. However, also more conventional open space projects such as land use, urban policy and strategic projects remain relevant.

It is important to continue working with pilot and model projects and to broadly communicate on them, both with local authorities and with the population. An inventory of easily accessible information on spatial pilot projects in Flanders appears necessary. It could provide initiators with an insight into the path travelled, the lessons learned and the instruments used.

## A new discourse is developing and seeks to be implemented

A great number of levers point at a sustainable perspective and growing attention to the importance of spatial strategies. Examples include the water challenge, the emerging energy debate, the challenge of an ageing population and the mobility problem, all of which cannot be properly solved without core strengthening. Unfortunately, the spatial debate is still too fragmented. There is as yet no coalition for a sustainable Flemish spatial policy aimed at the clustering of activities in the right place and with appropriate forms of interweaving that lead to a reduced environmental impact. The inertia of the spatial structure and the rigidity in spatial policy are still deeply rooted in the three societal systems that we studied in the *Environmental Outlook 2018*.

The recently emerging sustainability discourse is spatially translated into the priority strategies from this study. Systems thinking and an integrated view of sustainability are more and more central to this discourse. Space, systems, human activities, environmental impact and even mental models and world views are analysed together and used as inputs for a more robust and integrated environmental policy. Translating the conceptual framework into broadly supported and implemented policy is crucial in this respect. This requires quite a few more steps, including in the area of cooperation, model projects, and instruments.

## Missing but promising instruments

The available set of instruments include various tools for the development of spatial priority strategies. A number of instruments are still missing and will need to be developed in detail in the coming years:

- exchange systems for land and land value (designation and building rights);
- equalisation systems between municipalities, including the evaluation of ecosystem services;
- an active land policy with a realistic compensation system, aimed at the repurchase of poorly situated land and the purchase of strategic land within the cores;
- planning instruments for the spatial differentiation of agricultural activities;
- regulatory incentives for the development of energy networks (microgrids).

If the discourse develops favourably, it will increasingly attract societal and political support. This will make it possible to effectively deploy various spatial instruments to ensure system transitions towards sustainability.

## Differences between systems

The extent to which the relationship between spatial strategies and environmental solutions has pervaded public debate, differs for the three systems.

While the link between spatial planning and the mobility system has long been known and apparent in policy visions and the transport regions, it is only slowly penetrating the public debate. This debate still focuses too strongly on the opposition between investments in road traffic versus collective transport, and on innovations in vehicles and infrastructure.

The awareness that the energy system is a spatial theme has only recently taken hold. This is particularly the case for renewable energy production (wind energy and biomass) and the search for local answers to energy distribution and storage challenges. As energy is moving up on the social agenda, it is also pervading the spatial debate.

Finally, the link between spatial planning and the food system is the least developed one. How agricultural activities are spatially organised, what landscape role they play, whether a sustainable location policy can be implemented: these are issues that have hardly entered spatial policy visions or the public debate. In addition, a number of essential instruments are missing to adequately steer food production in the spatial domain.

6

# INSIGHTS FROM THE *ENVIRONMENTAL OUTLOOK 2018*

**The evolution of the environmental indicators as reported by MIRA raises a number of questions: many favourable trends are beginning to slow down, the impact on people, nature and the economy remains significant, and some environmental indicators are even showing a negative trend. Moreover, our societal systems such as energy, mobility, and food are also under pressure from global megatrends such as demographic developments and climate change. These findings prompted MIRA to further study the transitions of, and the solutions for, these three societal systems, together with (practice) experts. In addition, we examined how this transition could be supported from a space perspective.**

**By looking at environmental problems from a system perspective, the *Environmental Outlook 2018* provided many new insights. In this chapter, we bundle our insights and findings across the three systems, looking for overarching levers that could enable system interventions for sustainability. These levers could be the basis for a new, system-oriented policy that devises integrated solutions for the purpose of evolving towards a sustainable Flanders by 2050.**

## 6.1 The need for transition

The dominant regimes within each of the societal systems (energy, mobility and food) have proved to be quite efficient during the past few decades. This is true for both the conventional energy supply based on fossil and nuclear fuels, mobility based on fossil fuels, and the industrialised food production. These regimes, in their respective systems, ensure a supply that is permanently available, reliable and (for the majority of inhabitants) affordable. However, internal tensions and external societal developments place the systems under pressure to change. In other words, the systems are subjected to transition impulses.

The functioning of the three societal systems generates undesired effects on the environment, climate, health and quality of life. Growing public awareness of these issues leads to changing expectations for the three systems, thereby inducing them to change. In addition, megatrends such as demographic developments, scarcity of resources, and climate change, are accompanied by the necessity to adapt societal systems.

There are also internal tensions that put pressure on the systems. This internal pressure is particularly noticeable in the mobility system. One example is the congestion problem that is becoming more acute every year. Within the food system, the internal tension is reflected, for example, in tight margins and income uncertainty for farmers. The energy system for its part depends to a large extent on imported resources.

The regime is also under pressure from new niches. They are emerging in each of the three systems, in various stages of development. They are often still experiments, but in some cases they have already witnessed a broader, albeit still very early, breakthrough. Niches in the energy system include PV systems (prosumers) and the growing share of wind energy. While still limited in absolute numbers, these renewable alternatives show clear growth. Niches in mobility such as the electric bike and car- and bikesharing systems challenge conventional thinking on individual mobility. Examples in the food system include organic food, reduced meat consumption and the rapidly increasing attention to avoidance of food waste. None of these niches is currently threatening the existing, dominant regimes. However, the great diversity is steadily resulting in a broad range of more sustainable alternatives within each of the above-described systems.

## 6.2 Systems in different phases of transition

The study of the behaviour of societal systems shows that transitions can go through a number of phases. An initial focus on the optimisation of regimes and first experiments in emerging niches can change into an acceleration phase and result in a tipping point being reached, and eventually lead to a phase-out of certain elements of regimes and the institutionalisation of certain new niches. This results in a new stable condition of the system, as the co-existence of transformed (parts of) existing regimes and new niche regimes.

As described earlier, each of the three societal systems is undergoing a certain transition impulse. There are, however, differences regarding the status of the transition. In the energy system, an irreversible process with a clear and supported final goal seems to have been initiated. A significant momentum has been reached. In the food system, by contrast, there does not appear to be any real sense of urgency for structural changes, despite the pressure exerted on the system by sustainability issues, societal developments and emerging niches. Unlike the energy system, there is hardly any sign of an institutionally driven transition. Also within the mobility system, no fundamental change is thus far visible, as witnessed by the ever-increasing number of car kilometres and the very limited modal shift. The point at which automobility will be thoroughly challenged, appears to be still a long way off. What we do see, however, is the beginning of some awareness of the societal cost of congestion and the emission of air pollutants, and of the increasingly scarce open space and the space usage within cities. The growing awareness in cities leads to a change in climate and mobility plans. Air quality also appears to be a major carrier for local advocacy and progressive policy instruments such as low-emission zones.

Differences are also noticeable in the extent to which the regime adapts. In the food system, adjustments are implemented mainly on a step-by-step basis, primarily via the technological improvement of the environmental performance. Existing organisations, structures and institutions are still the starting points, with growth and efficiency as dominant paradigms. For mobility, too, there is a comparable focus on technology-driven optimisation of the regime based on motorised vehicles. This is reflected in particular attention to improved flow, infrastructural modifications and more efficient engines. Only in the energy system does the regime appear to be preparing itself for structural change, as illustrated by the search for fundamentally new business models.

## 6.3 Resistance to change

In each system we notice resistance to change. The dominant regime wants to restrict new niches. The underlying intention is to preserve the own institutions and to slow down emerging alternatives. Due to the resistance and inertia of the system, the need for structural system change is insufficiently recognised and the transition is therefore slow to take off.

World views, norms and values appear to be persistent components of the existing regimes that put up resistance to the internal and external pressure. In the food system, the emphasis is on efficient, export-oriented food production, convenience and abundance. In the energy system, there remains a big gap between energy awareness and behaviour, and there is the persistent belief in affordability and supply security based on non-renewable sources. In the mobility system, there is a deeply rooted car-centric culture, based on comfort, that has also become embedded in spatial planning and wage policy.

Infrastructure is another major source of inertia. Infrastructure comprises both energy and road networks and the facilities for food production and processing.  In each of these cases, a comprehensive infrastructure has been built up over a longer period of time which can only be modified slowly and at significant cost. The infrastructure is also closely interwoven with the spatial aspect and is often considered as sunk costs: costs that were made in the past and that are only to a limited extent reflected in the usage costs.

Also the current regulations are largely based on the existing regimes, and therefore show inertia. In the energy system, the current regulations do not allow, for example, to organise energy communities with local energy sharing. In the mobility system, regulations often work to the advantage of cars. In the food system, regulation in, for example, the field of food safety can stand in the way of specific new sustainable alternatives.

## 6.4 Levers for a system reconfiguration towards sustainability

A number of niches explicitly focusing on sustainability have already developed. However, they appear not to have been developed sufficiently or broken through in the various systems in order to speak of a turnaround. Their presence and growth is undeniable, but their favourable impact on the environment remains rather limited for the time being. It is becoming clear that the classical approach, which focuses only on aspects or components of systems, is inadequate to initiate the desired turnaround (in time). A complete reconfiguration of our societal systems is necessary and must comprise both technology, infrastructure, knowledge and rules, practices and customs, thought patterns, values and world views.

From the foregoing it also appears that each societal system has its own specific identity, is in a different stage of the transition, and does not have an equally clearly defined ultimate goal. There are, however, a number of general levers to be found across the different societal systems. They are briefly summarised below, with reference to their significance for each of the three systems. Attention is paid to their similarities, but also to the differences to be taken into account by policy from a system perspective.

Space is an integrating lever to initiate and enable the transition of the three societal systems. A number of spatial strategies are of fundamental importance to maximise the environmental potential of solutions for the energy, mobility and food systems. At the basis lies a sustainable and polycentric public transport network. This allows compact cores (living and working) and economic poles (working) to be realised and connected with each other via sustainable mobility. As a result, remaining open space can be preserved and extended, which is necessary to support a transition towards a sustainable energy and food system.

To implement these spatial strategies without any shifting, there is need for a reconfiguration of the space and a turnaround in the dominant spatial discourse. Traditional thinking is now determined, among other things, by thinking in terms of scarcity (so many hectares necessary for living and companies) and a focus on individual right of ownership. This puts a brake on opportunities for economical and future-oriented land use and the societal and environmental benefits that can thus be achieved. A turnaround in this dominant discourse is necessary to implement spatial and environmental solutions in practice, from the highest to the lowest spatial level.

## Develop and implement a long-term strategy

Throughout the three societal systems, we have seen that a broadly supported long-term vision with clear objectives could steer the transitions to more ecological sustainability. However, visions alone will not work. Their consistent implementation in regular policy is crucial for them to be effective. In practice, this must be reflected in the choices that are made, such as in the allocation of research fundings, in tax and subsidy mechanisms, in regulations, in communication and in educational programmes. Moreover, a long-term vision must allow for flexibility and devote attention to the avoidance of lock-ins. Systems theory in fact teaches us that it is impossible to accurately predict the behaviour of systems in transition. A robust societal system must be able to respond to unexpected developments and also learn from them. Vision development in the longer term is therefore not a strictly linear process. The sustainable finality should be clear, but the concrete transition path must allow for dynamic adjustment.

For the transition to sustainability within the **energy system**, there are clear objectives and an end result: a low-carbon society. Long-term visions have been mapped out at supra-regional level. The Paris Agreement is an agreement to keep global temperature rise below 2°C (with regard to the pre-industrial period) and to even strive to limit it to 1.5°C. For the European Union, this means an 80 to 95 per cent greenhouse gas emissions reduction by 2050 as compared to 1990 levels. The objectives laid down by the EU with 2030 as horizon are a concrete translation of these targets. It constitutes a clear framework within which national and regional authorities must shape their policy.

The need for a more integrated long-term vision is felt for the **mobility system**. Visie 2050 (Vision 2050) of the Flemish Government is focused on the transition priority of a 'smoother, safer and more environmentally friendly transport system'. It sees the transition in the energy system and in housing policy as being closely connected with the mobility system, and provides for alignment with the Spatial Policy Plan Flanders. However, this integration remains to be defined in greater detail. Consistent and steering policy - including forms of deterrence - will be necessary to bring about the modal shift away from the dominance of car and truck. Various solutions can provide environmental improvements provided sufficient allowance is made for rebound effects that could cancel out the desired effects. Suitable attention to this aspect in policy measures will therefore also be crucial to effectively utilise the environmental potential of innovations.

For the **food system**, a concrete long-term strategy that can be translated into consistent policy is not yet in place. The vision developed by the The New Food Frontier – a network of fifty thinkers and doers on sustainable agriculture and food – could be a first step in this direction. Sufficient support among the various actors is of paramount importance, but should not prevent the government from making guiding choices and putting forward binding targets. The ambition of the conventional agri-food chain and of policy to continue to focus on growth and export, is a barrier to the development of transition paths that bring the system within the ecological capacity. Support of innovation and reconversion, and sustained focus on dialogue and cooperation are necessary to reduce opposition.

Just as the preceding policy plans, the BRV provides a sustainable long-term vision for the Flemish **space** by 2050. We see, however, that during the past decades a number of lower-level interventions were possible that run counter to the formal objectives. For example, space occupancy in the open space has increased and the delineation of agricultural land was unable to prevent that in some locations agricultural activity was replaced with other functions such as living, horsification and activity. Above all, there was primarily a detailed vision on urban space policy, whereas for smaller, more rural cores it was not sufficiently clear what the policy objectives were exactly. The inertia of space and the cumulative results of earlier policy choices and possible derogations put a brake on the opportunities for sustainability transitions in the three societal systems. For the energy and mobility system, visions have already been developed at levels smaller than the Flemish ones. Examples are the energy landscapes, the definition of transport regions, and the core maps. Whereas the spatial character of the energy system slowly enters the public debate, this is still only to a very limited extent the case for the mobility system. For the food system, a similar regional spatial approach remains to be developed and there is as yet no sign of a public debate on sustainable location policy for agriculture. It is still not clear how the vision of the BRV will be translated into an adapted set of instruments and allocation of resources.

## Innovation: develop, exchange and transfer knowledge

Various forms of innovation – technological, but also social (behaviour) and economic (new business models) – will play a substantial role in the transition of societal systems.

For the current transitional phase in the **energy system**, innovation is of paramount importance. Further technological progress is expected in the field of renewable energy and energy storage, including battery technology. Also the further digitisation and availability of large amounts of data open up opportunities for further energy saving through behavioural change and better energy efficiency, as well as the necessary matching of energy demand and supply. All of this requires the training of a sufficient number of highly skilled personnel and the development of new business models for energy services.

For the **mobility system**, too, further research and innovation is necessary for the further development of solutions. For instance, synchromodality and an approach to logistics from the vision of a physical internet could play an important role in the area of (ecological) sustainability. For autonomous vehicles, however, it is not yet sufficiently clear what their effect on mobility demand and environmental impact will be; further research and experiments are needed. Considering the importance of mobility and logistics in Flanders, it is crucial to participate in international research and demonstration projects. Behavioural change, finally, benefits from the development of tools allowing for a more objective comparison between the costs of mobility alternatives, taking also into account the total cost of ownership.

More research into system innovations in the **food system** can help to break the path dependency of the system. Examples of system innovations are agro-ecology, multifunctional agriculture, new production systems with minimal land use, alternatives to animal production, and bio-refinery. Not only technical-scientific but also socio-economic (new distribution and business models) research is necessary, This should preferably be practice-oriented and be carried out in close collaboration with the actors involved. Low-regulation zones could create experimentation space to further develop new practices and technologies. A smooth transfer of results to the field is crucial.

Knowledge building is also necessary at the **spatial planning** level. The impact of spatial strategies on the environment is often insufficiently known. Also, more knowledge and expertise is necessary at the local level, including the way spatial instruments can be used as a reference framework for sustainability-oriented policy. This can ensure that interventions in the field are better aligned with generic long-term objectives at a higher (Flemish) level. Also pilot projects are essential for knowledge building and can be a lever to replace old concepts with new insights. Broad communication on such projects, also towards non-experts, is necessary.


Zone A
Zone A
2

## Mobilising resources

The transition to sustainability requires a significant mobilisation of resources to allow the broader acceptance of alternatives.

The current state of the transition in the **energy system** provides a good opportunity to activate the savings of citizens. This is possible by stimulating investments with high return in energy saving and renewable energy applications such as PV systems. Cooperative initiatives can ensure that also a broader section of the population can benefit from the dividends from investments in renewable energy. Support and any forms of subsidisation can, limited in time, promote the upscaling and breakthrough of innovative concepts or technologies.

Public investments in appropriate infrastructure appear to be a key factor in the transition of the **mobility system**. Examples are cycling paths that are sufficiently adapted to new niches such as (fast) electric bikes, but also charging and fuelling facilities and parking infrastructure for sustainable alternatives such as shared systems and BiTiBi facilities (Bike-Train-Bike). Also the further expansion of the public transport network as backbone for future mobility services (Mobility as a Service) requires significant investments. It is an essential component of the sustainable mobility system of the future.

Affordable farmland is a prerequisite for making the **food system** more sustainable. It allows small-scale, less intensive and multifunctional forms of agriculture to find their place in the mix of production methods. But it also contributes to more viable margins in the agricultural sector as a whole. In addition, it is essential that support and subsidy systems focus more on system innovations for sustainability, both in the conventional regime and in emerging niches. Resources do not need to be provided by the government alone. Banks could, for example, take into consideration sustainability criteria when granting loans, and cooperation between producers could help to share costs.

From a **spatial** perspective, much is expected from the local level, also through participation in supra-local cooperation. The distribution of resources among (large) cities and rural areas is, however, not always sufficiently adapted to properly facilitate such cooperation. An equalisation mechanism, where the income of municipalities is based, for example, on a range of ecosystem services, could also be financially interesting for rural municipalities to preserve open space.

## Guarantee socially correct prices and distribute costs

To speed up the desired transitions, pricing based on sustainability will be an important lever. External societal costs will then have to be reflected at least in part, in the prices.

The economic promotion of sustainable alternatives by making the use of fossil fuels more expensive ('tax shift geared towards sustainability') is considered an important step towards creating a greater market share for renewable forms of energy. For the **energy system**, much is expected from the proposal to introduce a $CO_2$ levy for the non-ETS sectors. The introduction of dynamic electricity tariffs is an important factor to arrive at a better matching of demand and supply. Such variable tariffs are an incentive for end users to use electricity at moments when it can be produced or supplied at low cost.

Also for ecologically sustainable solutions in the **mobility system**, pricing is considered essential. At present, the price of passenger and freight transport insufficiently reflects the societal costs, as a result of which the majority of efforts remain stuck in the non-sustainable regime of road transport. By pursuing correct prices driven by policy, a framework is created for the transition to more sustainable mobility. It encourages transport users to make sustainable choices about the number of journeys, logistics processes, mode of transport, and vehicle technology. A pricing policy that confronts individuals and companies with the social consequences of their individual transport choices could be introduced at urban, regional or federal level, with Europe playing a role in defining the outlines of such a policy.

In the **food system**, it is of great importance to distribute the costs of sustainability in a fair manner across the entire chain, including consumers. Correct food prices should also reflect (external) environmental and social costs. Retail and the hospitality sector can help increase the consumer's readiness to pay by improving the marketing of sustainable products. The range of short-chain selling can be extended by innovative logistic models. In addition, a correct compensation is needed for the other societal services provided by agriculture, such as biodiversity, water storage and care for the landscape. Such compensation can be integrated into the food price, but alternative financing models (such as landscape funds) and modification of support mechanism are also possible.

In the **spatial** area, the scarcity discourse persists, even though in many cases it is no longer based on actual conditions. Locally, there is sometimes an (unmarketable) oversupply. This scarcity thinking leads to unfair competition of building and densification opportunities outside cores and in open space, at the expense of sustainable densification within cores. The costs of living outside cores (including for the construction and maintenance of sewers and roads) are borne by society and/or the local government. There are also not enough incentives to interweave activity in cores, or to make economical use of space on industrial sites. A stronger focus on the early debate on societal implications and costs of the use of new open space could lead to a trend break and put an end to the classical discourse.

## Create sustained public support

To enable the transition to succeed, the adoption of sustainable alternatives by a sufficiently broad segment of the population is crucial. This requires sustained attention to creating and perpetuating sufficient public support.

In the **energy system**, this can be achieved via a sustained focus on the increasing positive recognition of 'ecological modernisation', such as advanced insulation and the use of low-energy and renewable technologies for electricity and heat supply in the built environment. This positive dynamic could provide an impulse to more sustainable energy use in the built environment. Also the promotion of participation in energy cooperatives or other forms of cooperation for energy production, energy storage and energy efficiency could create additional public support. It could also to some extent counter opposition against wind energy projects (nimby effect) by actively involving citizens early on through empowerment and financial participation.

Visible and inspiring (foreign) examples can contribute to behavioural change and change in attitude in the **mobility system**. City distribution trial projects are currently ongoing in several European cities. Examples are Bristol, but also CityDepot in Hasselt. It is essential to sufficiently highlight the significant health effects of the modal shift to (electric) cycling, but also of the phase-out of conventional fossil-based mobility (particulate matter). Also a better awareness of the total cost of ownership and of the external societal costs of mobility choices could promote public support for more sustainable transport modes.

In the **food system**, public support for sustainable eating patterns can only be increased by changing the entire food environment. Numerous actors can help to turn sustainable food into the new normal. Examples are retail, hospitality, catering, civil society organisations and education, but also influencers such as famous cooks, athletes and media figures. In addition, the distance between producer and consumer can be shortened via short-chain selling, so that proximity and transparency can also alter perceptions of (the value of) food. The importance that consumers attach to convenience represents a separate challenge. Supporting new logistics models can make a difference in this context. To strengthen support among (future) farmers, transfer of knowledge and inspiring practice examples are of great importance. It is also essential to assess the success of the food system against sustainability and resilience, instead of evaluating it only in terms of efficiency.

**Spatial** intervention in a densely populated and diffuse built environment like Flanders is particularly sensitive to (lack of) public support. The societal debate about where individual and societal responsibility begins and ends, must be conducted in an open manner. Properly designed, full-fledged participation by citizens at various spatial levels can play an important role in this respect. Only when an adequate public debate has taken place, instruments for a better open space policy will have a real chance of succeeding.

## Support cooperation and networking

Societal changes require cooperation among a large number of actors, both within and outside the various systems. Furthermore, due to the importance of new technology in the transition to more sustainability, facilitation by third parties is essential for the efficient adoption of innovations.

Within the **energy system**, a facilitating role is reserved for third parties in various areas. For example, potential is seen in the role of 'heat broker', who links sources to potential customers and brings the respective parties together to search for solutions that benefit all parties involved. Also third parties providing a comprehensive service could be entrusted with the coordination of energy-efficient renovation projects, thereby contributing to a higher (ecological) renovation rate. In matching energy demand and supply, a commercial role can be reserved for 'aggregators' capable of trading the flexibility of industrial, commercial or household electricity users on the energy market.

Integrators in the **mobility system** can ensure the provision of (sustainable) mobility solutions (Mobility as a Service) where different transport modes are integrated via digital interfaces in an efficient manner for the user. In logistics, too, third parties can play a facilitating role as broker in the optimal deployment of different transport modes based on a comparison of (real-time) information about supply, characteristics and concrete logistic requests.

For the **food system**, cooperation between a wide group of actors is required for the transition to more sustainable food production and processing. These are not just the stakeholders, both conventional and new, within the food chain itself but also, for example, sectors such as the chemical and pharmaceutical sectors, regional actors involved in multifunctional services provided by agriculture, and consumers. Targeted investments in networks, in matchmakers that bring the interested parties together, and in facilitation and mediation, could be helpful in this respect.

From a **spatial** perspective, none of the three societal systems is the most relevant at the highest or lowest level, more often than not they are situated at the intermediate level. For the implementation of spatial strategies, the supra-local level is crucial for vision development and cooperation at the level of concrete projects. It is as yet not clear how supra-local cooperation can be structurally organised and embedded.

## Stimulate policy integration

The development of a long-term vision and its translation into consistent policy choices requires coordination and alignment of the various policy areas involved. Furthermore, sustainability transitions within the various societal systems are, sometimes strongly, connected with each other. The link between the mobility system and the energy system appears to be particularly intensive. Sustainable electric transport implies renewable electricity generation. Moreover, the growth of electric driving holds both challenges and opportunities for the matching of electricity demand and supply. Also the need for linking sustainable alternatives within the food system with the other systems is apparent from the attention to short-chain relations, more energy-efficient production methods in horticulture and the link between onshore wind turbines and (agriculture in) the open space. Sustainability within each individual system therefore seems inconceivable without the other systems co-evolving coherently in the same sustainable direction. A spatial vision geared towards sustainability will be an important integrating factor and also a crucial prerequisite.

Alignment between different policy areas, policy levels and the wide availability of data are of great importance for a sustainability transition of the **energy system**. Changes in the usage of space that benefit sustainability in the field of energy, such as densification of cores and change in land use, will have to be integrated at different decision levels.

For the **mobility system**, too, an integrated policy with a distinct spatial component is of crucial importance. Mobility is in fact closely connected with where we live, work, shop and relax. Also the connection with industrial policy is apparent from the importance of the spatial embedding of regional logistics hubs. In the area of mobility, in addition to an overarching vision at the Flemish level, local authorities play an important role as catalyst for, for example, the concrete introduction of systems for shared mobility, low-emission zones or city distribution systems.

To allow a supported, steering long-term strategy on a sustainable **food system** to be consistently integrated into the policy of the different policy levels and areas (such as agriculture, environment and nature, health, economy and education), cooperation and coordination are needed. This could be realised through an integrated food policy.

**Spatially**, there is twofold need for policy integration. Firstly, integration is needed at the various levels, with better integration between the Flemish level (sustainable spatial vision development) and the (supra-)local level at which this vision is implemented in practice. A better role assignment, but above all a better alignment and consistent implementation of the overarching vision, remains essential. Secondly, there is need for better integration and alignment of spatial policy and environmental policy. Sustainability goals are in essence shared goals that must also be considered and elaborated as such. The current integration based on advice during existing processes, such as licensing procedures, has proven inadequate. Environmental policy instruments, for example, appear to focus primarily on the effects of individual spatial projects without placing them in a broader systemic change. The 'newer' themes of energy, food and water offer additional opportunities for a stronger integration. The first two in particular still have difficulties in finding their place within spatial policy.

# BACKGROUND DOCUMENTS

The *Environmental Outlook 2018* compiles information from the seven background documents on which it is based. VMM-MIRA wishes to explicitly thank the researchers and all the members of the expert panels for their valuable and enthusiastic contribution to this extensive study.

***Wat milieu-indicatoren ons (niet) vertellen: een meta-analyse***

- Bob Peeters, Hugo Van Hooste, Johan Brouwers, Sander Devriendt, Igor Struyf, Erika Vander Putten, Floor Vandevenne, Marleen Van Steertegem (MIRA, VMM)

***Naar een diagnostiek van systeemverandering***

- Pieter Valkering, Erik Laes (VITO/EnergyVille)
- Yves De Weerdt (VITO Transition Platform)
- Philippe Vandenbroeck (shiftN)
- Frank Nevens (UGent)

***Horizonscanning***

- Annick Gommers, Katelijne Verhaegen (KENTER)
- Merel Claes, Jo Goossens (shiftN)

***Oplossingsrichtingen voor het energiesysteem***

- Erik Laes, Pieter Lodewijks, Nele Renders, Marlies Vanhulsel, Pieter Vingerhoets (Sustainable Energy and Built environment (SEB), VITO/EnergyVille)
- Jo Goossens, Kris Ooms (shiftN)

***Oplossingsrichtingen voor het mobiliteitssysteem***

- Inge Mayeres, Bruno Van Zeebroeck, Sebastian Vanderlinden (Transport & Mobility Leuven)
- Kris Bachus, Luc Van Ootegem (HIVA, KU Leuven)

***Oplossingsrichtingen voor het voedingssysteem***

- Jonas Van Lancker, Marianne Hubeau, Fleur Marchand (Landbouw en Maatschappij, ILVO)

***Ruimte als integrerend platform voor milieuoplossingen***

- Miechel De Paep, Kristine Verachtert (BUUR cvba)
- Jo Goossens, Philippe Vandenbroeck (shiftN)

You can read and download the background documents (in Dutch, with English summary) via **en.milieurapport.be/publications**.

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## ABOUT VMM – MIRA

The Flanders Environment Agency (VMM) plays a vital role in integrated water management. It measures and monitors the quantity and quality of water, manages water systems, collects a levy on water pollution and groundwater extraction, advises on environmental permits and ensures the planning and supervision of the treatment infrastructure. The VMM acts as the government organisation for water. Furthermore, the VMM monitors ambient air quality, draws up the air emissions register and makes policy proposals.

The coordination of the Flanders Environment Report (MIRA) is the responsibility of the VMM. MIRA provides the scientific foundation for environmental policy. The task of MIRA was laid down in the decree containing general provisions on environmental policy of 5 April 1995, and is threefold:

- a description, analysis and evaluation of the current state of the environment;
- an evaluation of the environmental policy conducted to date;
- a description of the expected environmental developments in case of an unchanged policy and a changed policy according to a number of scenarios that are thought relevant.

The MIRA reports are widely publicised. More information about the Flanders environmental reporting and the MIRA publications at **www.milieurapport.be**

# **Environmental Outlook** 2018

## Solutions for a sustainable future

Conventional environmental policy is reaching its limits. Many environmental indicators are improving, but various positive trends are clearly slowing down. Other indicators illustrate the important impact on humans, nature and the economy. Moreover, megatrends such as demographic changes, increasing shortages of raw materials and resources, and climate change put today's societal systems under pressure. A system-driven approach is needed to bring about the transition to a more sustainable Flanders. Such an approach looks at the behaviour of large societal systems in transition and then develops integrated solutions at system level.

Europe and Flanders want to evolve to an ecologically more sustainable society by 2050. How can we make that ambition come true? The *Environmental Outlook 2018* presents an in-depth analysis of the energy, mobility and food systems. It looks at a broad range of solutions and innovations, with their environmental impact and possible *trade-offs* and *co-benefits*. It zooms in on potential levers: measures, innovations or trends that could support and speed up the desired solutions. Special attention is given to the Flemish space, which, as a supporting and resilient platform, will have to facilitate the various societal transitions. The findings and insights of this report are meant to serve as a scientifically based source of inspiration for policy makers and all societal actors who are looking to help shape the transition to a sustainable society.

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