TRANSITION(S)
2050
DECIDE NOW
ACT 4 CLIMATE
Executive Summary
An unprecedented, structured forward-looking exercise

Ambition and goals of the Transition(s) 2050 exercise
Carbon neutrality by 2050 is now part of the common language of international, European and national climate policies. While its definition is more or less agreed on, the way to reach it is still unclear, if not totally unknown for most decision-makers and citizens. However, given the climate emergency, the changes to be made are of such magnitude that it is essential to accelerate discussions now, given the time required to make decisions in a democratic framework, as well as the time required to implement them.

ADEME does not intend to propose “the” right pathway, because the route that will be decided is the result of political choices to be made in the face of multiple uncertainties and in line with a project for society as a whole. Therefore, on the eve of the 2022 presidential election and ahead of the collective deliberations on the French Energy and Climate Strategy, ADEME has chosen to submit for debate four coherent and contrasting “type” scenarios to take France towards carbon neutrality. These four carbon neutrality pathways are compared with a Business as Usual (BAU) scenario that sees current trends continuing to 2050.

Forecast for mainland France, the scenarios are based on the same macroeconomic, demographic and climate change data (+2.1°C in 2100). They all lead to carbon neutrality for the country, but take different routes and correspond to different societal choices. The logic of the four scenarios is inspired by the four IPCC scenarios presented in the 1.5°C Special Report of 2018.1

The goal of this exercise is therefore:

- to build “outline scenarios” that are internally consistent;
- to illustrate the range of possible long-term options for achieving carbon neutrality and explore the various implications;
- to inform essential short-term decision-making.

Two years of cross-disciplinary expert work
To facilitate the move to action, ADEME has carried out this unprecedented forward-looking exercise based on two years’ work and the involvement of about a hundred ADEME employees as well as regular discussions with a scientific committee. The assumptions and models were refined and enhanced through in-depth discussions with a hundred or so partners and external service providers, specialists in different fields, as well as two webinars organised in May 2020 and January 2021, each of which brought together nearly 500 participants to discuss the intermediate results.

Method
For each scenario, ADEME built a coherent narrative, broken down by each economic and social sector, using structuring variables; these narratives were then transformed into quantitative assumptions in existing models or models created for the occasion; several successive iterations were necessary to verify, cross-reference and refine these quantifications.

This work has highlighted the interdependencies between sectors and helped to give each scenario a solid and coherent structure. In addition, it incorporates analytical advances in areas that until now have been little or poorly studied in climate forecasts. For example, evaluation and availability of biomass, evaluation of biological and technological carbon sinks, and changes in industrial production induced by changes in consumption.

The scenario descriptions cover the construction sector, passenger and freight transport, food, agriculture, forestry, industry, waste and energy services (fossil fuels, bioenergy, gas, hydrogen, heat and electricity).

In particular, the parameters studied cover:
- energy demand;
- consumption of irrigation water, building materials, agricultural inputs and land use;
- waste generation and management;
- energy production and the composition of the energy mix;
- imports and exports;
- the greenhouse gas balance and biological and technological carbon sinks.

This first publication presents the major findings of the work, but some results of modelling that could not be started until after the final results from the sectoral scenarios will be presented in the form of a series of publications between January and March 2022. This is the case for the electricity mix, materials and greenhouse gas footprints, and macroeconomic impacts, which are only presented qualitatively in this publication.

Four “type” paths, consistent and contrasting, to lead France towards carbon neutrality.

1 https://www.pcc-cty.fr/assets/pdf/article/22/2018/05/1815_4PM_version_report_LR.pdf

9 key messages

01 The four pathways presented, each internally consistent, enable France to achieve carbon neutrality in 2050. But all are difficult and require orchestrated planning of changes, involving the State, regions, economic players and citizens.

02 Achieving neutrality is based on overcoming some major challenges, both human (behavioural changes) and technological (carbon sinks in particular). All scenarios therefore involve a degree of risk. But not all of them have the same environmental, social and economic consequences.

03 For all scenarios, it is imperative to act quickly. The socio-technical transformations to be carried out are of such magnitude that they will take time to produce their effects. During this decade, a profound transformation must be planned and undertaken in our consumption patterns, land use planning and development, technologies and productive investments.

04 Reducing energy demand, itself related to the demand for goods and services, is the key factor in achieving carbon neutrality. This reduction ranges from 23% to 55% compared with 2015 depending on the scenario, each scenario being based on a different balance between reduced consumption and energy efficiency.

05 Industry will have to transform itself, not only to adapt to a profound change in demand but also to decarbonise its production. This will require large-scale investment plans and an effort by all of society to support the regions undergoing change and to train employees in new professions.

06 The biosphere is one of the main assets in this transition, combining three strategic levers: carbon storage, biomass production and greenhouse gas reduction. It is therefore essential to maintain a balance between food and energy use of biomass, with preservation of ecological functions such as biodiversity and carbon storage, through a comprehensive approach to the bio-economy.

07 Adaptation of forests and agriculture is therefore becoming an absolute priority in combating climate change. The resilience of ecosystems is all the more crucial as they are increasingly being affected by the impact of climate change.

08 The pressure on natural resources varies considerably from one scenario to another. This is particularly the case for irrigation water or building materials, where the volumes consumed vary by a factor of two between certain scenarios.

09 In all scenarios, more than 70% of the energy supply in 2050 is based on renewable energy and electricity is the main energy carrier. However, to limit the pressure on resources, this can in no way justify wasting energy.
### Lifestyles in 2050

#### Society
- Search for meaning
- Frugality chosen but also imposed
- Preference for local sourcing
- Nature protected

#### Food
- Reduced by a factor of 3
- Share of organic: 70%

#### Housing
- Massive and rapid renovation
- Strong limits on new construction (conversion of vacant housing and second homes into primary residences)

#### Personal mobility
- Strong reduction in mobility
- Distance travelled per person reduced by one-third
- Half of all journeys on foot or by bicycle

#### Technical relationships to progress, digital, R&D
- Organisational and technical innovation
- Prevalence of low-tech, reuse and repair
- Digital collaboration
- Stable data centre consumption due to stabilisation of flows

#### Governance
- Decision-making, little international cooperation
- Regulation, prohibition and rationing via quotas

#### Region
- Rural-urban mix – land degradation

#### Macroeconomy
- New prosperity indicators (income gaps, quality of life, etc)
- Contraction in international trade

#### Industry
- Production as close as possible to needs
- 70% of steel, aluminium, glass, paper, cardboard and plastic sourced from recycled materials

### Generation in 2050

#### Frugal Generation
- Sustainable changes in lifestyles
- Sharing economy
- Fairness
- Preservation of nature enshrined in law

#### Regional Cooperation
- Meat consumption halved
- Share of organic: 50%

#### Green Technologies
- Massive renovation, gradual but profound changes in lifestyle (growth in caarbonisation and the size of housing adapted to household size)
- Managed mobility
- Distance travelled per person reduced by 17%
- Nearly half of all journeys on foot or by bicycle

#### Restoration Gamble
- Targeting of the most competitive technologies to decarbonise
- Digital technology in support of optimisation
- Data centres consume 10 times more energy than in 2020

### Economy

#### Macroeconomy
- Green growth, innovation driven by technology
- Regional specialisation
- International competition and globalisation of trade

#### Industry
- Decarbonisation of industry relying on carbon capture and storage
- 45% of steel, aluminium, glass, paper, cardboard and plastic sourced from recycled materials
OVERVIEW of the 4 scenarios
S1 Frugal Generation  |  S2 Regional Cooperation  |  S3 Green Technologies  |  S4 Restoration Gamble

ENERGY
4 different energy mixes for 2050

REDUCED ENERGY DEMAND
Final energy consumption by sector in 2015 and 2050 (excluding non-energy uses and excluding international bunker fuel)

MORE THAN 70% RENEWABLE ENERGY IN ALL SCENARIOS
Energy consumption and share of RE of gross final energy consumption in 2015 and 2050

A GROWING SHARE FOR ELECTRICITY
VIRTUAL DISAPPEARANCE OF FOSSIL-FUEL ENERGIES
SOME RESIDUAL GAS CONSUMPTION REMAINS

Final energy demand by vector in 2015 and 2050 (with non-energy uses and excluding international bunker fuel)

Note: final energy consumption does not take into account energy used as an intermediate in the manufacture of other energy or non-energy carriers such as hydrogen. By way of illustration, the electricity consumption (not shown in this graph) used to manufacture hydrogen for energy use is 62 TWh, 135 TWh, 61 TWh and 33 TWh respectively in S1, S2, S3 and S4. The difference between consumption demand and the graph of energy demand by sector is due to consumption by technological carbon sinks, which is not allocated to a specific sector. The difference with gross final energy consumption results from consumption for non-energy uses.

CLIMATE
The major role of biological sinks for achieving neutrality in 2050

FOUR NEUTRAL SCENARIOS IN 2050, WITH VARYING DEGREES OF RELIANCE ON CARBON SINKS
Balance of CO₂ emissions and sinks in 2015 and 2050

GROWTH OF BIOLOGICAL SINKS IN S1 AND S2 DUE TO GROWTH OF FORESTS AND CHANGING AGRICULTURAL PRACTICES
Natural carbon sinks in biomass and soils in 2017 and 2050

RESOURCES
Differing pressure on resources

2 SCENARIOS LIMITING THE USE OF IRRIGATION
Water requirements for irrigation in 2020 and 2050

LESS HOUSEHOLD AND SIMILAR WASTE
Household and similar waste collected in 2015 and 2050

USE OF BIOMASS DOUBLED OR MORE
Use of biomass for non-food uses in 2017 and 2050
ISSUE #1

Sufficiency: how far should it go?

The lower the demand, the easier it will be to decarbonise energy. However, reduction in demand is determined by two factors: sufficiency, i.e. re-examining lifestyles and consumption patterns to control the demand for goods and services; and energy efficiency, which makes it possible to reduce the amount of energy required for their production. But the potential for energy efficiency comes up against physical limitations and especially the limits of available technologies.

So we cannot escape the question of sufficiency. S4, the only scenario not to incorporate this lever, leads to a headline rush that seems risky, unable to decarbonise energy production. Society is reduced to using huge amounts of energy to remove CO₂ from the atmosphere. The technological and economic gamble is enormous.

S3, which is an extension of our current lifestyles, relies on technologies to increase the potential for energy efficiency, so that we can make do with only moderate sufficiency. This implies achieving an effective balance between development of these technologies and increased consumption. But the time taken to develop these technologies delays emission reduction, leading to a high overall emission balance during the transition period.

In S1 and S2 there is greater adoption of sufficiency by changing the principles of socio-economic development: reduced consumption, more rational lifestyles that prioritise social links over the accumulation of material goods, aspirations that are being expressed increasingly in our societies. S1 and S2 thus develop sufficiency in energy use (walking or cycling, preferring local shops), size sufficiency (reducing the weight of vehicles and cooperative sufficiency (communal housing, renting equipment that is used infrequently rather than buying it). This sufficiency secures the achievement of carbon neutrality. Residual emissions are more easily offset by natural carbon sinks and the drop in emissions is fast enough to ensure that total emissions during the transition period remain moderate.

However, sufficiency is at odds with the dominant way of thinking in the consumer culture of the modern world. It is often perceived as a hardship and proves to be divisive: what seems to be a hardship for a given generation or individual may be accepted as a matter of course by another. However, implementing policies of sufficiency on a large scale requires rapid and major social transformation, which may meet with strong resistance. S2 overcomes this difficulty by seeking a social consensus through open governance, but this slows down the pace of transformation. S1, with much stronger goals for sufficiency in a much shorter time, inevitably has to resort in parallel to coercion via regulation or rationing via quotas, requiring a lot of explanation and compensation to gain acceptance. The difficulty in achieving these goals runs the risk of strong or even violent divisions within society.

Finally, sufficiency cannot be considered in isolation from inequality: on the one hand, current lifestyles seem to have adapted to inequality in access to products and services; on the other, the choice of sufficiency requires a real effort for a fairer society, as reduced consumption cannot be expected from the least well-off.

ISSUE #2

Can we rely only on natural carbon sinks to achieve neutrality?

The four scenarios show that achieving carbon neutrality cannot be achieved without natural carbon sinks (plants, soils and forests) because their potential is very high compared with technological sinks (carbon capture and storage).

In the scenarios with the most sufficiency, S1 and S2, these agricultural and forestry biological sinks can be maximised and are sufficient (or almost sufficient in S2) due to low energy demand, which allows biomass harvesting to be limited (forests in particular). It is therefore possible to maintain a balance between exploitation of biomass to decarbonise, provision of services to people (recreation, materials, etc.) and low exploitation of forests to preserve the services provided by nature (biodiversity, water quality, etc.). Agriculture, with the development of agroecology and “sequestration practices” (agroforestry, grasslands, etc.), as well as the very low level of land degradation due to controlled urbanisation, also preserves the “sink” function of soils. But this requires changes in our lifestyles that may not be consensual.

In S3 and S4, the level of emissions to be offset increases and the greater exploitation of natural environments reduces the potential of sinks: technological sinks therefore become necessary.

But their potential is limited: while S3 achieves a satisfactory balance between natural and technological carbon sinks, keeping their cost under control, S4 is forced to deploy technologies for direct capture of CO₂ from the air. This consumes a lot of electricity, is not yet mature, and its cost is unknown even if it were to become mature in time. In both these scenarios, some or all of the captured CO₂ must be stored underground, which raises questions of acceptance.

Sufficiency, biomass management and natural sinks are therefore intimately related. But natural sinks are fragile and vulnerable to climate change. Without the enormous sufficiency exercised in S1, the other scenarios should not therefore preclude reflecting on the need for:

- an active policy to develop agricultural and forestry sinks to increase their resilience, with likely co-benefits for biodiversity and climate change adaptation;
- the development of carbon capture, utilisation and storage technologies, to avoid relying solely on natural sinks whose development potential remains uncertain.

ISSUE #3

What is a sustainable diet?

Food is one of the world’s major challenges, with an expected doubling in food requirements by 2050. In France, food is responsible for a quarter of the carbon footprint and is at the centre of multiple health and environmental issues, particularly preservation of biodiversity, and water and soil quality. Finally, food is also at the heart of our social practices.

The proportion of animal protein in the diet is one of the most important factors in the environmental impact of food production. As an example, feeding the average French citizen with a meat-rich diet requires four times more agricultural land (in terms of footprint) than a purely plant-based diet.

The four scenarios show that diet cannot be considered in isolation from other issues affecting the biosphere: what contribution is expected from biomass for material and energy production? What role do we want natural carbon sinks to play? How can agriculture adapt to climate change, which is already affecting it?

Apart from scenario S4, which relies on technological capture of CO₂ from the air, all the other scenarios require a move towards less consumption of animal protein while prioritising quality meat in the average French diet. This has multiple co-benefits: freeing up agricultural land in France and outside France, facilitating conversion to organic farming and favouring less intensive systems (grassland systems), relocalisation of production and encouraging regional resilience, and reducing our impact on ecosystems (imported deforestation). The first three scenarios show, nevertheless, that different agricultural and food models are possible, provided they are developed in conjunction with the other dimensions of the transition.
Towards a new industrial model: is sufficiency harmful for French industry?

In contrast to the past 30 years, it is now widely accepted that the traditional model of industrial expansion has led to over-consumption and over-production, with a negative impact on the environment and society. The issue of sufficiency, which is the idea of using resources only as needed, is increasingly being recognised as a key factor in the transition to a more sustainable economy. However, the introduction of sufficiency into the industrial sector is not straightforward, as it challenges established business models and market structures.

The choices made for the construction industry have consequences for the whole economy. In the past, the construction sector has been a driver of economic growth, but its impact on the environment has been significant, with high consumption of materials and energy (production of cement and steel strongly increases construction industry emissions). In S1 and S2, based on renovation, we see an impact of 8% on the production of reduced tonnage of materials and consumer goods (-38% for S1 and -26% for S2). This reduction is due to the sufficiency shown by consumers (individuals, companies, and local authorities). This will be achieved through high-quality products, more expensive but durable, eco-designed, repairable, reusable, and recyclable. But also through the development of new materials and energy saving technologies, and the emergence of new business models, such as the sharing of rooms or shared living spaces, respecting each person’s privacy but in a more open and collaborative environment.

In S3, industrial production is slightly down (-14% in tonnage). It remains stable in S4, but with a worsening trade balance in heavy industry sectors, potentially leading to “carbon leakage”. The industrial challenges are then in energy efficiency and energy decarbonisation (renewable energies or carbon capture and storage). In all cases, these developments must be accompanied by ambitious employment and training policies and support for certain targeted sectors with decarbonised production.

As with any forward-looking exercise, certain limitations remain:

- The effects of climate change on the operation of infrastructure, systems and organisations as well as on behaviour are mainly taken into account for the agriculture, forestry, construction and electrical energy sectors, due to a lack of benchmarking work or modelling tools for other sectors;
- The juxtaposition of scenarios built on very different driving forces may suggest that they benefited from the same level of expertise and feedback. However, knowledge of sufficiency is much less developed than that of energy efficiency or renewable energy, which have been studied and researched for several decades.
- The assessment of the consequences on biodiversity based on methodologies due to a lack of knowledge and the fact that the source of the data for the exercise is not precisely located geographically. Nevertheless, concern for biodiversity is not absent from the work;
- The “rest of the world” is considered as a whole which takes the same route as mainland France and, for this reason, is not modelled in a detailed way.

Next steps in this work

This work is just the first part of a series of publications that will be published between January and March 2022. The collection will then form a whole, which will be put into perspective during the Grand Défi Ecologique (the "Great Environmental Challenge"), an event organised by ADEME on 29 and 30 March 2022 in Angers.

This series of publications will cover the following subjects:

- Analysis of the electricity generation mix
- Materials for the Energy Transition
- Macroeconomic assessments including employment and investment
- Analysis of changes in lifestyle, conducted through a qualitative study of views and perceptions of the scenario narratives by 31 French people from different backgrounds
- Footprint of materials, greenhouse gases, resources and consumer goods
- Land use and soil quality
- Adaptation to climate change
- Analysis of the impact on some key sectors, in particular: “new construction”, “energy systems”, “proteins” and “last mile logistics”
- Robustness and vulnerability to shocks
- Air quality
- Regions (in the form of a guide to help regions with forward planning)
- Digital...
EXECUTIVE SUMMARY
TRANSITION(S) 2050

“Transition(s) 2050. Decide now. Act 4 climate” is a forward-looking exercise describing four consistent and contrasting pathways to carbon neutrality in France in 2050. The pathways aim to link the technical and economic aspects with consideration of the societal transformations that they assume or provoke.

The following sectors are considered in detail: those related to consumption (land development, building, mobility and food); those forming the production system (agriculture, forestry and industry), those forming the energy supply (gas, cooling and heating, biomass, liquid fuels and hydrogen); those that constitute resources (biomass and waste) and carbon sinks. Wherever possible, these sectors are also analysed for their impact on water, soils, materials and air quality.

This publication is the result of more than two years’ work by ADEME, in interaction with external partners, to inform decision-making in the coming years. For the aim is not to propose a political project or “the” right pathway, but rather to bring together technical, economic and environmental knowledge to raise awareness of the implications of the societal and technical choices that the chosen paths will entail.

This document is published by ADEME.

Find the ADEME scenarios online at www.transitions2050.ademe.fr/en
Photo credits: ADEME, Getty Images
Illustrations: Stéphane Kiehl
Editorial and graphic design: bearideas
Registered copyright: © ADEME Éditions, January 2022

The digital version of this document is conform to Web content accessibility standards, WCAG 2.1, and is certified ISO 14289-1. Its design enables people with motor disabilities to browse through this PDF using keyboard commands. Accessible for people with visual impairments, it has been tagged in full, so that it can be transcribed vocally by screen readers using any computer support. It has also been tested in full and validated by a visually-impaired expert.