RÉPUBLIQUE FRANÇAISE
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ADEME
AGENCE DE LA TRANSITION ÉCOLOGIQUE

HORIZONS

TRANSITION(S) 2050
DECIDE NOW ACT 4 CLIMATE

Executive summary

NEW EDITION 2024

AN UNPRECEDENTED structured...

Ambitions and goals of the Transition(s) 2050 analysis

Carbon neutrality by 2050 has become part of everyday language in climate policies. While its definition is more or less agreed on, the path to achieving carbon neutrality remains unclear, if not totally unknown to most decision-makers and citizens. Given the urgency of the climate situation, the changes to be made are of such magnitude that **it is vital to accelerate discussions, hence the publication of this work at the end of 2021, in anticipation of the debates on French energy and climate strategy, with four consistent and contrasting reference paths to take France towards carbon neutrality**

Since then, the French government has made progress on ecological planning, by consulting on a climate and energy trajectory. In this context, the ADEME scenarios are still relevant to provide food for thought and contribute to debate, insofar as they have been constructed on the basis of deliberately strong and contrasting assumptions which, by their gradation between sufficiency and innovation, illustrate specific paths that can serve as useful references and get decision-makers and citizens thinking about the model of society they wish to promote in order to achieve carbon neutrality.

Forecast for mainland France, they 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. These scenarios are inspired by the four IPCC scenarios presented in the 1.5°C special report in 2018[1].

The aim 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**.

1 https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15_Summary_Volume_LR.pdf

FORESIGHT exercise

Four years of cross-disciplinary expert work

ADEME has therefore carried out this unprecedented foresight exercise in order to facilitate the move to action. It is based on four years of preparatory work involving more than a hundred ADEME employees and regular discussions with a scientific committee. The assumptions and models were refined and enhanced through in-depth discussions with around a hundred or so partners and external service providers. Since the first publication in November 2021, ADEME has continued to develop this work through the publication of numerous special reports that focus on the impacts of the scenarios in more detail.

Method

For each scenario, ADEME constructed a coherent narrative, broken down into different economic sectors, using structuring variables; these narratives were then transformed into quantitative hypotheses in existing models or models created for the purpose; several successive iterations were necessary to verify, cross-reference and refine these quantifications.

This work highlights the interdependencies between sectors and gives each scenario a solid, coherent structure. In addition, it incorporates analytical advances in fields that have previously been little or poorly studied in climate forecasting. For example, the evaluation and availability of biomass, the evaluation of biological and technological carbon sinks, and the evolution of industrial production caused by changes in consumption.

The scenario descriptions cover the sectors of land-use planning, construction, passenger and freight transport, food, agriculture, forestry, industry, waste, digital and energy services (fossil fuels, bioenergy, gas, hydrogen, heat and electricity).

The parameters studied include:

- energy demand;
- impacts on the consumption of irrigation water, building materials, metals and materials for the energy transition, agricultural inputs, land use and atmospheric pollutants;
- waste production and management;
- energy production and the composition of the energy mix;
- energy imports and exports;
- the balance between greenhouse gases and biological and technological carbon sinks;
- carbon and materials footprints;
- macroeconomic impacts and impacts on certain sectors that are potentially significantly affected;
- adaptation to climate change.

This second publication (2024 edition) presents the key findings of this work, enriched by the main conclusions of the 16 special reports published since November 2021 (see page 15) which complement the initial summary. Without modifying the scenarios and their assumptions, they expand on the initial analyses, in particular on the environmental, technical, economic and social impacts of the different scenarios. Among these results, it should be noted that, while all the scenarios achieve carbon neutrality in 2050 in terms of national emissions, they have very different impacts, particularly on carbon and materials footprints (which include the impacts associated with the manufacture of imported products).

11 key messages

S1 Frugal generation
S2 Regional cooperation
S3 Green technologies
S4 Restoration gamble

01

The four pathways, each characterised by a consistent approach (see following double-page), enable France to achieve carbon neutrality across its territory by 2050 and reduce its carbon footprint. **They rely on varying degrees of human effort (especially S1) and technological progress (especially S4), suggesting that S2 and S3 are more balanced and achievable.**

02

Sufficiency, which involves questioning our needs and how to fulfil them while reducing their impact on the environment, **is the best way to move rapidly towards carbon neutrality** while reducing our dependence on fossil fuels. Sufficiency complements energy efficiency and helps to reduce the risks associated with climate change or a major geopolitical crisis such as the Russian-Ukrainian conflict.

03

Reducing energy demand, which is itself linked to demand for goods and services, and developing renewable energies are key factors in achieving carbon neutrality. With a reduction in final energy consumption of between 23% and 55% compared to 2015, it is possible to establish an energy supply made up of more than 70% renewable energies (RE) in all the scenarios. The share of electricity increases significantly in all cases.

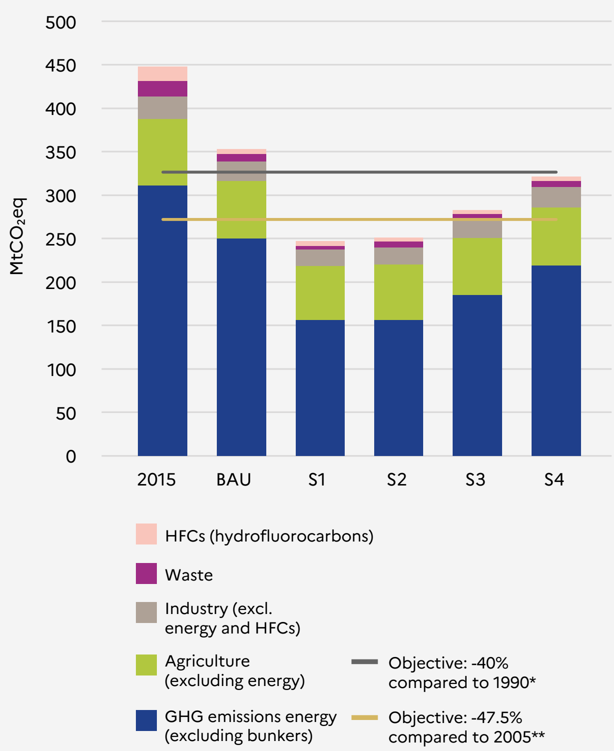
04

The carbon footprint (all greenhouse gases - GHGs)[2] is lower in 2050 for all scenarios than it was in 2015. The materials footprint also falls in S1, S2 and S3, and is at the 2015 level for S4. However, reductions in footprints are insufficient to achieve a trajectory that limits the rise in the planet's average temperature to +2°C, which would require GHG emissions to stabilise at an average of around 2tCO_2eq per capita worldwide in 2050[3].

05

Pressures on the environment increase from S1 to S4 and the environmental impacts are very different from one scenario to another. This is particularly the case for the cumulative quantity of GHGs over the thirty years of the exercise, but also for irrigation water, soil artificialization and atmospheric pollutants. **Achieving carbon neutrality at a territorial level by 2050 should not therefore be the only window of analysis and highlights the co-benefits of sufficiency, which reduces the various environmental pressures.**

Figure 1 *GHG emissions in 2030*



* Objective set in the French Law on Energy Transition for Green Growth (LTECV) of 17 August 2015.
** The objective of reducing French emissions by 47.5% in 2030 compared with 2005 corresponds to a target of 50% below 1990 levels. It is envisaged in the *Fit for 55%* package with the revision of the Effort Sharing Regulation (ESR).

06

In the four scenarios, industry is transformed not only to adapt to radically changing demand but also to decarbonise its production. This will require large-scale investment plans, including an increase in recycling, and an effort by society as a whole to support changing regions and train workers in new professions.

07

Our ability to adapt to climate change depends on the scenario: S1 and S2 appear more robust due to their energy sufficiency, whereas S4 seems riskier, with a very high consumption of resources. But in all the scenarios, it is water resources that become the central element in our ability to adapt.

08

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 uses of biomass, while preserving ecological functions such as biodiversity and carbon storage through a comprehensive approach to the bioeconomy.

09

Adapting forests and agriculture is becoming an absolute priority in the fight against climate change. The resilience of ecosystems is all the more crucial given that they are increasingly subject to the impacts of climate change. The extreme events already observed could lead to the collapse of certain natural environments and call into question the feasibility of all the scenarios.

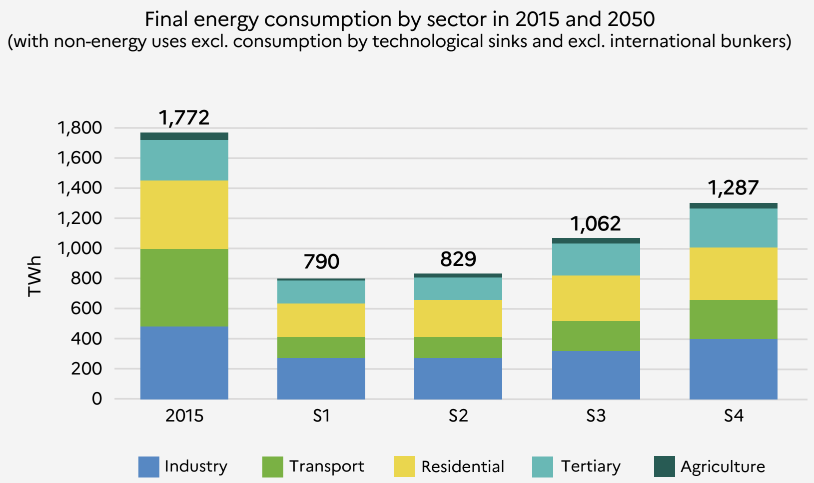
10

With the assumptions adopted, **none of the scenarios, including those that involve major sufficiency, lead to a long-term economic recession** compared to the current level of economic activity: three of the four scenarios even result in a higher level of activity in 2050 than the BAU scenario.

11

Social justice and transparency are at the heart of citizens' demands. They expect efforts to be shared equitably between all actors, including economic actors, and for the state to play a leading role. A renewal of democratic decision-making processes and the ways in which citizens participate is also required.

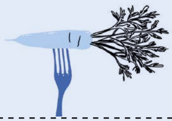
Figure 2 *Final energy consumption by sector (TWh)*



N.B. Electricity consumption of technological sinks is not included as it does not belong to any sector.

2 All four scenarios are carbon neutral in 2050 in terms of territorial emissions. The carbon footprint takes into account the impact of imported products.
3 Quantity of GHG in CO_2eq emitted per capita in a CO_2-neutral world in 2050 to meet the commitments of the Paris Agreement and keep the global temperature increase below 2 degrees Celsius.

SOCIETY IN 2050

		 **S1 FRUGAL GENERATION**	 **S2 REGIONAL COOPERATION**
LIFESTYLES	**Society**	• Search for meaning • **Frugality chosen but also imposed** • Preference for local • Nature protected 	• Sustainable changes in lifestyles • **Sharing economy** • Fairness • Preservation of nature enshrined in law
	Food	• Meat consumption reduced threefold • **Proportion of organic: 70%** 	• **Meat consumption reduced by half** • Proportion of organic: 50% 
	Housing	• Massive and rapid renovation • **Severe restrictions on new construction** (conversion of vacant housing and second homes into primary residences)	• Massive renovation, **gradual but profound changes in lifestyles** (growth in cohabitation and the size of housing adapted to household size)
	Personal mobility	• **Sharp reduction in mobility** • Distance travelled per person reduced by one third • Half of all journeys on foot or by bicycle 	• **Managed mobility** • Distance travelled per person reduced by 17% • Nearly half of all journeys on foot or by bicycle 
	Technology Relationship 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	• Massive investment (energy efficiency, renewable energy and infrastructure) • Digital technology in support of regional development • **Stable data centre consumption** due to stabilisation of flows
	Governance Scales of decision-making, international cooperation	• **Local decision making**, little international cooperation • Regulation, prohibition and rationing *via* quotas	• Shared governance • **Environmental taxation** and redistribution • National decisions and European cooperation 
	Region Rural-urban mix, soil artificialization	• Important regional role for resources and action • **"De-urbanisation"** in favour of medium-sized cities and rural areas	• **Demographic recovery of medium-sized cities** • Cooperation between regions • Regional energy planning and land policies
ECONOMY	**Macro-economy**	• **New prosperity indicators** (income gaps, quality of life, etc.) • Reduced international trade 	• Qualitative growth, **"re-industrialisation"** of key sectors in conjunction with regions • Regulated international trade
	Industry	• **Production as close as possible to needs** • 70% of steel, aluminium, glass, paper and cardboard, and plastics come from recycling	• Production of value rather than volume • **Dynamic local markets** • 80% of steel, aluminium, glass, paper and cardboard, and plastics come from recycling 

S3 GREEN TECHNOLOGIES

S4 RESTORATION GAMBLE

	S3 Green Technologies	S4 Restoration Gamble
LIFESTYLES		
Society	• **New technologies rather than reduced consumption** • Green consumerism for the benefit of populations with financial means, connected society • Services provided by nature are optimised	• Mass consumption **lifestyles safeguarded** • Nature is a resource to be exploited • Confidence in the ability to repair damage to ecosystems
Food	• 30% reduction in meat consumption • **Proportion of organic: 30%**	• Meat consumption almost unchanged (10% decrease), supplemented by **synthetic or plant proteins**
Housing	• **Large-scale demolition-reconstruction** of housing • All homes renovated but with low performance: only half to Low Energy Building (LEB) standard	• New construction **continues** • Only half of housing renovated to LEB standard • **Appliances multiply**, combining technological innovation and energy efficiency
Personal mobility	• Mobility managed with state support: infrastructure, large-scale teleworking, car-pooling • **Distance travelled per person increases 13%** • 30% of journeys on foot or by bicycle	• Sharp increase in mobility • Distance travelled per person increases 28% • People prioritise **speed** • 20% of journeys on foot or by bicycle
Technology Relationship to progress, digital, R&D	• Targeting of **the most competitive decarbonisation technologies** • Digital technology in support of optimisation • Data centres consume 10 times more energy than in 2020	• Innovation on all fronts • Capture, storage or use of captured carbon essential • Pervasive presence of the Internet of Things and artificial intelligence: **data centres consume 15 times more energy** than in 2020
Governance Scales of decision-making, international cooperation	• Minimal **regulatory framework** for the private sector • French government as planner • Targeted carbon taxation	• Supply-side support • Strong international cooperation focused on a few key sectors • **Centralised energy system planning**
Region Rural-urban mix, soil artificialization	• **Urbanisation**, competition between regions, functional cities	• Low regional involvement, **urban sprawl**, intensive agriculture
ECONOMY		
Macro-economy	• **Green growth**, innovation driven by technology • Regional specialisation • International competition and globalisation of trade	• **Carbon-based economic growth** • Minimal, targeted carbon taxation • Globalisation of the economy
Industry	• **Decarbonisation of energy** • 60% of steel, aluminium, glass, paper and cardboard, and plastics come from recycling	• Decarbonisation of industry relying on **carbon capture and storage** • 45% of steel, aluminium, glass, paper and cardboard, and plastics come from recycling

OVERVIEW of the 4 scenarios

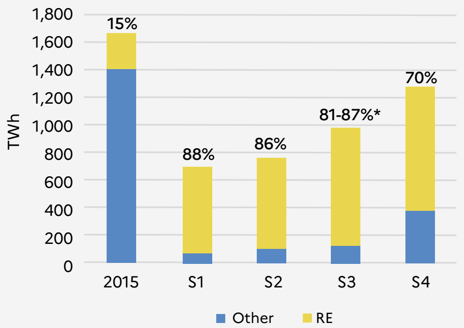
S1 Frugal generation ¦ **S2** Regional cooperation ¦ **S3** Green technologies ¦ **S4** Restoration gamble

ENERGY

4 different energy mixes for 2050

MORE THAN 70% RE IN ALL SCENARIOS

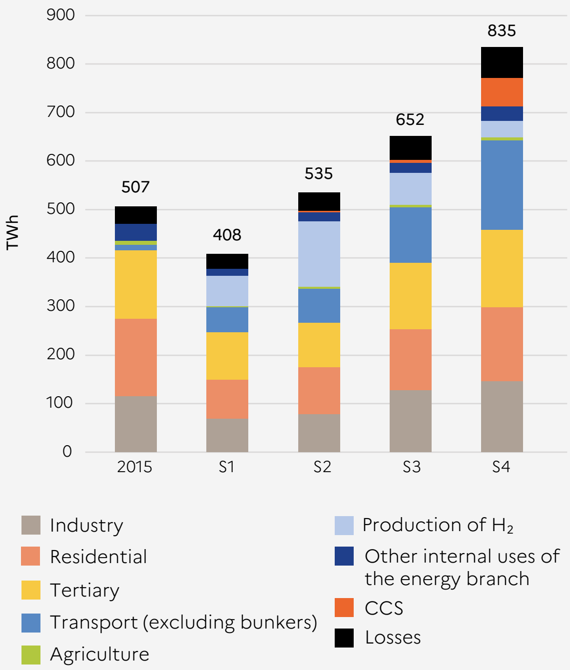
Energy consumption and share of RE in gross final energy consumption in 2015 and 2050



*Values dependent on industrial policy choices to develop offshore wind or nuclear power.

ELECTRICITY CONSUMPTION ON THE RISE, DRIVEN BY THE ELECTRIFICATION OF ENERGY USES

Total electricity consumption in 2050



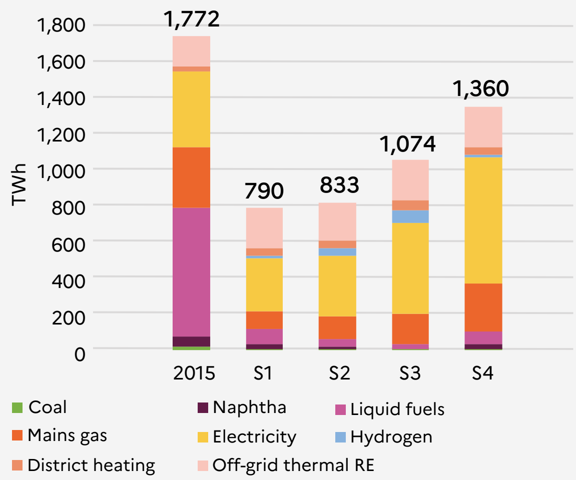
A GROWING PROPORTION OF ELECTRICITY

VIRTUAL DISAPPEARANCE OF FOSSIL FUELS

SOME RESIDUAL GAS CONSUMPTION

A DECREASE IN ENERGY DEMAND

Final consumption demand by carrier in 2015 and 2050
(incl. non-energy uses and excl. international bunkers)



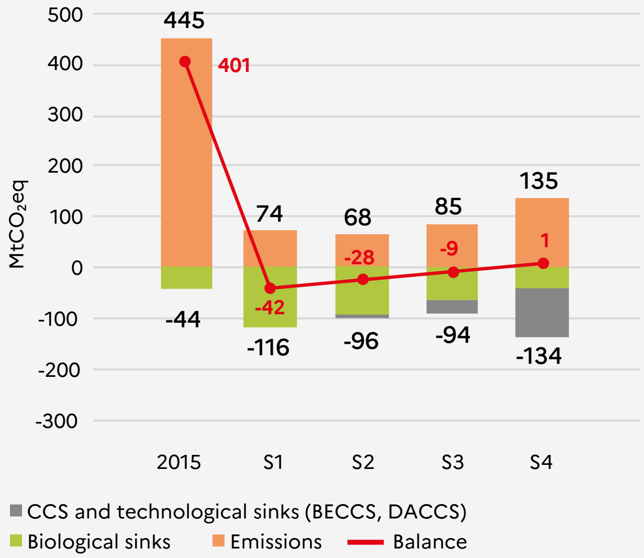
N.B. Final energy consumption does not take into account intermediate energy used in the manufacture of other energy or non-energy carriers, such as hydrogen. By way of illustration, the electricity consumption (not shown in this graph) used to manufacture hydrogen for energy purposes is 62 TWh, 135 TWh, 65 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 the consumption by technology sinks, which is not allocated to a specific sector. The difference from the gross final energy consumption comes from consumption for non-energy uses.

CLIMATE

The major role of biological sinks in achieving neutrality in France by 2050

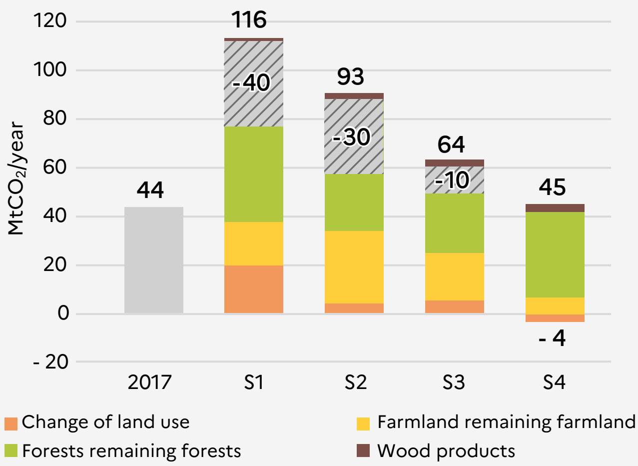
FOUR NEUTRAL SCENARIOS IN 2050, WITH VARYING DEGREES OF RELIANCE ON CARBON SINKS

Balance of emissions and sinks of CO_2 in 2015 and 2050



GROWTH OF BIOLOGICAL SINKS IN S1 AND S2 DUE TO FORESTS AND CHANGES IN FARMING PRACTICES

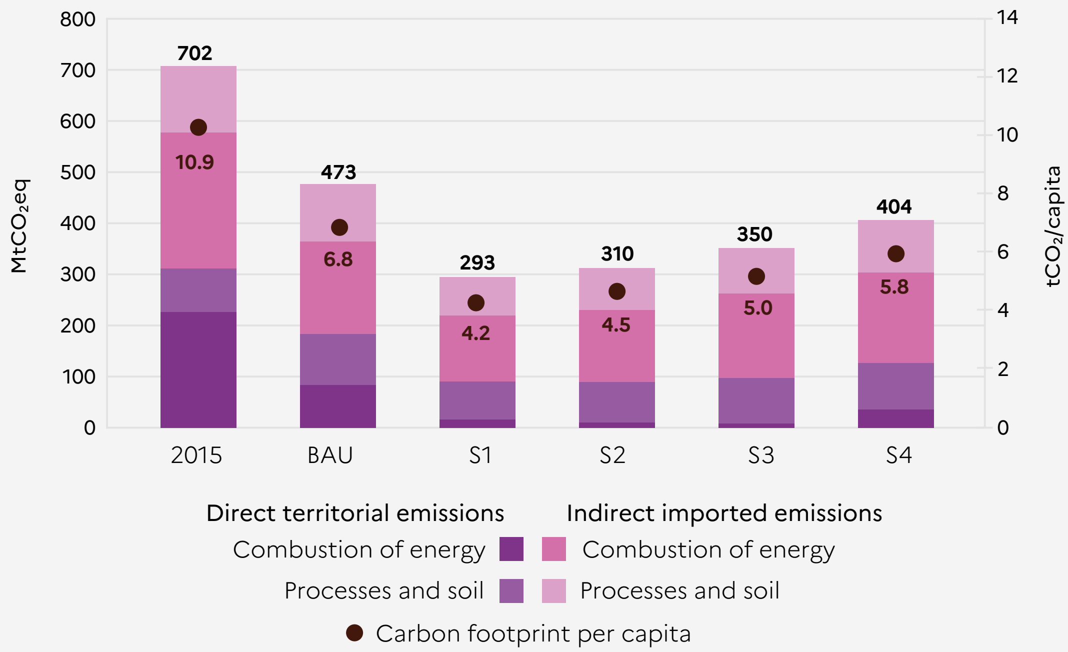
Natural carbon sinks in biomass and soil in 2017 and 2050



N.B. The sink value in 2017 is given as a reference, however, it was not calculated using the same method as for the scenarios but on the basis of values from the national inventory carried out by CITEPA, with the addition of carbon sequestration in forest soil and dead wood.

A CARBON FOOTPRINT THAT DECREASES BUT REMAINS ABOVE "2 TONNES OF GHG PER CAPITA", WITHOUT ANY MAJOR EFFORT FROM OTHER COUNTRIES

Composition of carbon footprint in 2015 and 2050 projection by scenario



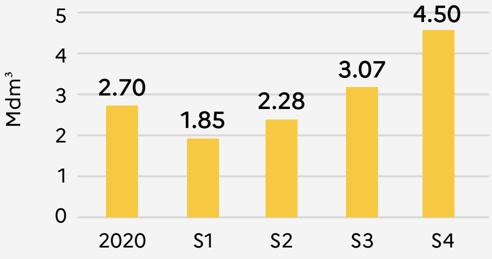
N.B. In terms of footprint, territorial emissions are expressed excluding emissions linked to the production of exports.

RESOURCES

Contrasting pressures on resources

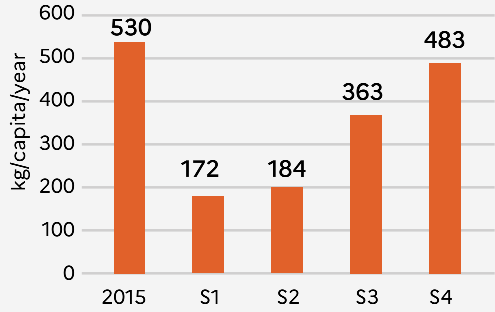
2 SCENARIOS REDUCE THE USE OF IRRIGATION

Water requirements for irrigation in 2020 and 2050



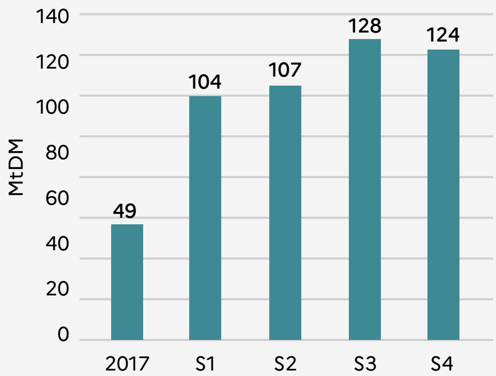
LESS HOUSEHOLD AND SIMILAR WASTE

Household and similar waste collected in 2015 and 2050

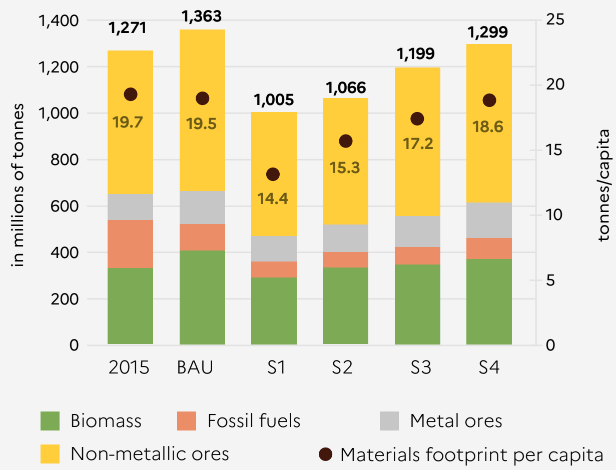


USE OF BIOMASS MULTIPLIED BY AT LEAST 2

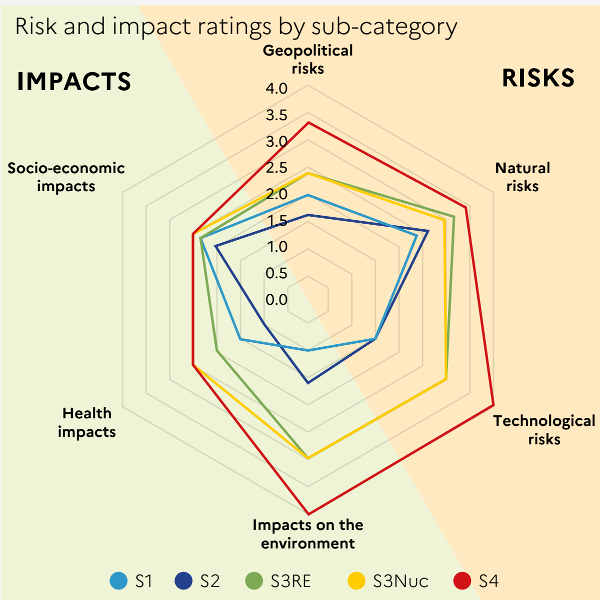
Biomass for non-food uses in 2017 and 2050



FRANCE'S MATERIALS FOOTPRINT IN 2015 AND PROJECTION FOR 2050 BY SCENARIO



RISKS AND IMPACTS LESS MARKED WITH SUFFICIENCY



S3 presents two electricity generation options: with (S3Nuc) or without (S3RE) additional nuclear power

6 ISSUES for debate

#1 Sufficiency: how far should it go?

It is easier to decarbonise energy if the demand is lower. Reducing demand is determined by two factors: the sufficiency approach, i.e. questioning lifestyles and consumption patterns in order to control demand for goods, energy and services; and energy efficiency, which uses technologies to reduce the amount of energy required for production. But the potential for energy efficiency comes up against physical limits and, above all, the limits of available technologies.

So there's no escaping the issue of sufficiency.

S4, the only scenario that abandons this lever, leads to a headlong rush that seems risky: unable to decarbonise energy, society is reduced to spending huge amounts of energy to extract CO_2 from the air. The technological and economic challenge is enormous.

S3, which continues current trends, relies on technologies to increase the potential of energy efficiency, so that moderate sufficiency is sufficient. This supposes an effective balance between the development of these technologies and an increase in consumption. However, the time required to develop these technologies delays the reduction in emissions, leading to a significant outstanding balance over the transition period.

S1 and S2 opt for greater emphasis on sufficiency by changing the logic of socio-economic development with reduced consumption and more sustainable lifestyles that favour social links over the accumulation of material goods, corresponding to aspirations that are increasingly expressed in our societies. S1 and S2 develop sufficiency of energy use (walking or cycling, favouring local shops, etc.), dimensional sufficiency (reducing the weight of vehicles, etc.) and cooperative sufficiency (more communal housing, renting equipment that is used infrequently rather than buying it, etc.). This sufficiency helps to ensure that carbon neutrality is achieved: residual emissions are more easily offset by natural carbon sinks and the fall in emissions is sufficiently rapid to ensure that the sum of emissions over the entire transition period remains moderate. It also makes it possible to reduce carbon and materials footprints, environmental impacts and, indirectly, to make our society more resilient to climate or geopolitical risks.

However, sufficiency goes against the predominant way of thinking in the consumerist culture of the modern world. It is often perceived as a deprivation and proves to be divisive: what is seen as a deprivation for a given generation or individual may, on the contrary, appear perfectly normal to another. However, the large-scale implementation of sufficiency policies requires rapid and far-reaching social transformations, which may meet with strong resistance. S2 overcomes this difficulty by seeking social consensus through open governance, but this slows the pace of transformation. S1, which has much stronger and faster sufficiency targets, inevitably has to resort in parallel to constraints via regulation or rationing via quotas, which requires a major effort in terms of explanation and compensation to make it acceptable. The difficulty of achieving this runs the risk of creating strong and even violent divisions within society.

Finally, **sufficiency cannot be separated from the issue of inequality**: on the one hand, current lifestyles seem to accommodate inequalities in access to products and services; on the other, the choice of sufficiency requires a real effort to be made in terms of fairness, as reductions in consumption should not be imposed on low-income households.

#2
Can we rely solely on natural carbon sinks to achieve neutrality?

The four scenarios show that carbon neutrality cannot be achieved without natural CO_2 sinks (plants, soil and products[4]), because their potential is so much greater than that of technological sinks (CO_2 capture and storage). However, the analysis must take account of the estimates published in 2023 on the forest carbon sink, which are more unfavourable than those forecast in the simulations (2020-2021).

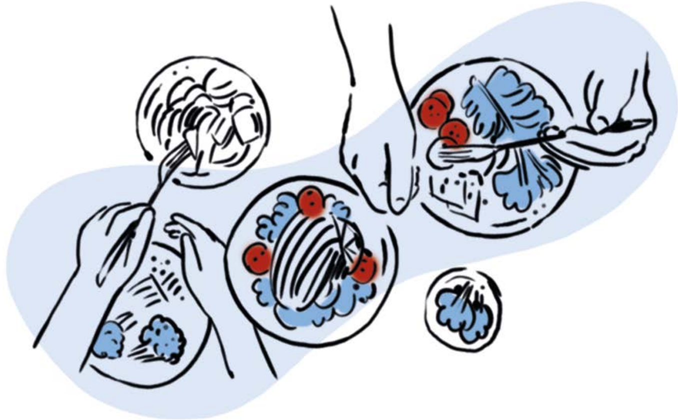
In S1 and S2, the scenarios with the most sufficiency, these agricultural and forestry biological sinks can be maximised and are sufficient (or almost sufficient in S2) thanks to a low demand for energy, which makes it possible to limit biomass extraction (particularly from forests). It is therefore possible to maintain a balance between using biomass to decarbonise, providing services to people (leisure, materials, etc.) and low exploitation of forests to preserve the services provided by nature (biodiversity, water quality, etc.). Agriculture, with the development of agro-ecology and "sequestration practices" (agro-forestry, grasslands, etc.), and the very low level of soil artificialization due to controlled urbanisation, also help to preserve the "sink" function of soil. 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 use of natural environments reduces the potential of sinks: technological sinks therefore become necessary.

While S3 achieves a satisfactory balance between natural and technological sinks that enables their cost to be kept under control, S4 is obliged to deploy technologies for direct capture of CO_2 from the air. These technologies consume a lot of electricity and are not currently mature; it is uncertain whether they will be mature in time and at what cost. In both scenarios, all or part of the captured CO_2 has to be stored underground, which raises acceptability issues.

Sufficiency, biomass management and natural sinks are therefore closely linked. But natural sinks are fragile and vulnerable to climate change. Without the massive sufficiency efforts that are made in S1, the other scenarios need to consider other strategies, such as:

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



#3
What is a sustainable diet?

Food is one of the world's major challenges, with food requirements expected to double by 2050. In France, food is responsible for a quarter of the country's carbon footprint and is at the centre of many health and environmental issues, in particular, the preservation of biodiversity, soil and water quality. Food is also at the heart of social customs.

The proportion of animal protein in meals is one of the most important factors in the environmental impact of food. For example, the amount of farmland required (in terms of footprint) to feed the average French person is four times greater for a meat-rich diet than for a purely plant-based diet.

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

With the exception of S4, which relies on the technological capture of CO_2 from the air, all the other scenarios require a shift to lower meat consumption, with an emphasis on quality rather than quantity. This has multiple co-benefits, such as freeing up farmland in France and abroad, facilitating the conversion of farming systems to organic farming and favouring less intensive systems (grassland systems), relocating production and promoting regional resilience, and reducing impacts on ecosystems (imported deforestation). The first three scenarios nevertheless show that different agricultural and food models are possible, provided they are developed in a way that is consistent with the other dimensions of the transition.

4 The oceans, another major natural sink, could not be taken into account in this exercise, but this does not have a significant impact on the general conclusions.

#4
Soil artificialization, energy poverty, renovation: is there another economic model for construction?

Residential and tertiary buildings currently account for almost half of the country's energy consumption and almost a quarter of its GHG emissions. Their construction consumes 51 million tonnes of materials a year and directly contributes to soil artificialization. In social terms, housing accounts for 30% of household budgets, energy poverty affects more than 5 million households and poor housing affects 4 million people.

In addition to this, **recent trends have led to the proliferation of household equipment and an increasing use of building space** (reduction in cohabitation, vacant housing and offices, growth in second homes).

In S1 and S2, it is possible to reduce the impact of buildings not only through large-scale effective renovation but also by abandoning the dream of the single-family home in favour of shared living spaces that respect each person's privacy, offering a friendlier environment, and developing the sharing of rooms or equipment (e.g. washing machines) between several flats, the conversion of second homes into main residences, and sufficiency in the use of electrical and digital equipment. However, such societal changes will not be easy. S3 and S4 rely more on technology and new construction (especially S3, which includes Haussmann-style demolition and reconstruction), with very high materials and energy consumption (cement and materials production), requiring new quarries or extensions that are increasingly unacceptable to local populations.

The choices made in the building sector have consequences for the industrial model: the mass consumption of cement and steel greatly increases emissions from industry. The S1 and S2 models, based on renovation, go hand in hand with a more restrained industrial model based on the circular economy. In social terms, the jobs created in the massive renovation of housing, which requires anticipating the need for new skills and training, could more than compensate for the loss of jobs in the new-build industry.

#5
Towards a new industrial model: is sufficiency harmful for French industry?

In contrast to the thinking of the past thirty years, it is now widely accepted that **relocating industry in France is vital for the economy and its resilience, particularly in light of the consequences of the COVID-19 crisis and the Russian-Ukrainian conflict. However, this relocation is not a simple matter in a world of globalised trade and will not be without impact.** The competitiveness of industry will be developed with two levers, activated to a greater or lesser extent depending on the scenario: a new industrial model favouring quality over quantity and based on the circular economy (S1 and S2); or a more quantitative model, but with decarbonised processes and energy (S3 and S4).

In S1 and S2, industry is having to review its business model, with production of materials and consumer goods falling in tonnage (-38% in S1 and -26% in S2) as consumers (individuals, businesses and local authorities) become more frugal. This will involve high-quality products that are more expensive but durable, eco-designed, repairable, reusable and recyclable. It will also require the development of a "functionality economy", i.e. the sale of a service rather than a product, which combines material and energy savings to create a circular economy. These scenarios also limit the risk of "carbon leakage" by avoiding the relocation of heavy industries to countries with lower carbon taxes; in S2, this goes as far as re-industrialisation (improving the trade balance) for certain targeted sectors whose production is decarbonised.

In S3, industrial production is down slightly (-14% in tonnage). It remains stable in S4, but with a deterioration in the balance of trade in heavy industry sectors, potentially leading to "carbon leakage". The industrial challenges then lie in energy efficiency and the decarbonisation of energy (renewable energy or carbon capture and storage).

In all cases, these changes must be accompanied by:
- large-scale investment plans, both for the mass deployment of mature technologies and for the emergence of breakthrough innovations in industrial processes, given that energy efficiency and decarbonisation become key factors in competitiveness.
- ambitious employment and training policies and support for areas affected by industrial change.

This raises the issue of the role of public policy in supporting these changes, whether in terms of support schemes or regional planning.

#6

Water: a major challenge in adaptation to climate change[5]

Water is essential to the life of plants, animals and humans. It is indispensable to the economy and throughout the world. Up until recently, except for during occasional heatwaves, water has been sufficiently abundant in France for all services, but this has been less and less the case since the turn of the century, and this decline is set to become more pronounced. Periods of dry weather occur year on year, and even in the winter, for example at the start of 2023.

Since 2018, around 300,000 hectares of forest have been affected by dieback, largely linked, according to the ONF (French National Forests Office), to a lack of water. This means less production of wood as a carbon sink and as a reserve of biodiversity, less materials and energy, and more risk of fire and attacks from pathogens or insects. The same is true in agriculture, with declines in production and yields depending on the crop and region.

Solutions for adapting to climate change, in particular those based on nature, make it possible to better manage water resources and limit urban heat islands thanks to plant life and evapotranspiration.

Saving water, like saving energy and raw materials, is therefore becoming a major challenge for societies, through reconciling sufficiency of use, the fight against waste, technological efficiency, and the adaptation of plant varieties and growing practices, which is not without difficulties for the various parties involved. These changes take time and need to be supported.

Consequently, the more sufficiency-oriented scenarios, S1 and S2, taking all uses together, are the most resilient in the face of this scarcity. This is particularly true for irrigation water consumption, which remains lower than in 2015, but does not guarantee that there will not be any problems. On the other hand, S3 and S4, with their focus on developing supply, consume more irrigation water (up 66% on 2015 in S4). S4 moves in the direction of greater liberalisation, with the possibility of a water market in the long term: the economic, environmental and social consequences are still difficult to grasp in their entirety and potentially risky. From this point of view, water will be one of the major challenges in adapting to climate change.

Limitations and outlook for further development

As with any foresight exercise, there are some limitations:

- **The effects of climate change** on the functioning of infrastructures, systems and organisations, as well as on behaviour, are mainly taken into account for the agricultural, forestry, buildings, transport infrastructure and electricity grids, due to the lack of reference work and modelling tools for other sectors;

- Comparing scenarios based on very different driving forces might suggest that they benefit from the same **level of expertise and feedback**. However, knowledge of sufficiency and carbon sinks is far less developed than that of energy efficiency or renewable energies, which have been the subject of studies and research for several decades;

- **The assessment of impacts on biodiversity** suffers from methodological difficulties due to a lack of knowledge and the fact that the data for the exercise is not precisely localised. However, this does not mean that potential impacts on biodiversity are not taken into account;

- **The "rest of the world" is considered as a whole** that follows the same path as mainland France and, as such, is not modelled on a detailed basis.

5 https://librairie.ademe.fr/energies-renouvelables-reseaux-et-stockage/5440-prospective-transitions-2050-feuilleton-adaptation-au-changement-climatique.html

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EXECUTIVE SUMMARY TRANSITION(S) 2050

"**Transition(s) 2050. Decide now. Act 4 climate**" is a foresight exercise that presents four consistent, contrasting paths to achieving carbon neutrality in France by 2050. They aim to link the technical and economic dimensions with reflections on the transformations in society that they imply or are likely to cause.

This new edition of the executive summary provides an overview of the main conclusions to be drawn from all the work that makes up Transition(s) 2050, i.e. the November 2021 edition and the 17 special reports published since that date. The 11 key messages emerging from this work and the 6 issues raised invite the reader to consider the challenges that need to be addressed to achieve carbon neutrality by 2050.

This is the product of more than four years' work by ADEME, in conjunction with external partners, with a view to informing the decisions to be taken in the coming years. The aim is not to propose a political project or "the right" trajectory, but to bring together technical, economic and environmental aspects so as to raise awareness of the implications of the societal and technical choices that will result from the paths that will be chosen.

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