

ECO2050 VISION

The Future of Luxembourg's Economy by 2050



2023

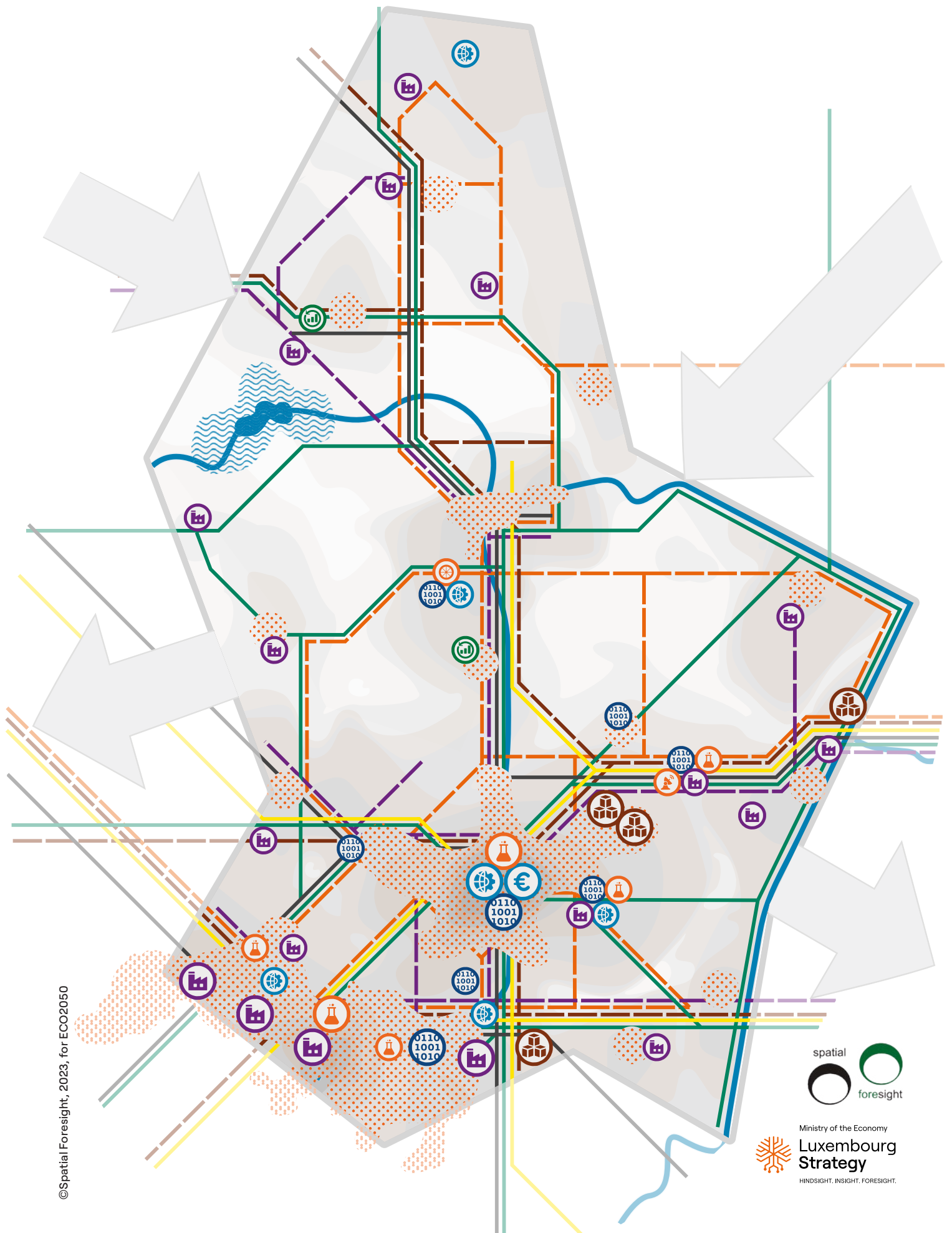
Ministry of the Economy



Luxembourg
Strategy

ECO2050

Current situation of economic activity in 2023



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Main specialised and localised economic sites and activities

-  Existing and projected zones of economic activity (PSZAE)
-  Facilitator(s) of the circular economy
-  Research & Development (R&D)
-  Audiovisual and telecommunications zone
-  Automotive zone
-  Major multinational company/companies zone
-  Finance and FinTech
-  Data and Cloud infrastructure
-  Logistics hubs (rail, air, river, road) and reverse logistics

Main networks of economic importance

-  Railway
-  Motorway
-  Cycle network (commuting/transport)
-  Natural gas network
-  Main fibre optic network
-  Electricity network
-  Cross-border cooperation

Land occupation and use

-  River
-  Dam protection zone
-  Lake
-  Urban areas and Centres of Development and Attraction (CDA) (PDAT)
-  Density of employment /km²

Introductory Remarks



Luxembourg has experienced extraordinary economic and demographic growth for almost 70 years. Its rate of population growth, which has seen an increase of 150,000 residents, or +30%, over just 12 years (2010–2022), is unrivalled by any other country in the world. As a result, the country's various systems and infrastructures – transport, housing, education, health and the environment – are overstretched.

The current context, marked by a new geopolitical order, an accelerating climate emergency and the goal of achieving carbon neutrality by 2050, leads us to question this model. This is not a new question: it is a discussion that has been going on in Luxembourg for at least 15 years, under the term 'qualitative growth', and which resurfaces in the media every time demographic forecasts for our country are published and every time an industrial project fails to materialise. It is also a question that is not specific to our country, but which is similarly being asked in all developed countries, in Europe and beyond, and which can be summed up as follows: how can we combine economic prosperity, social wellbeing and the preservation of the planet?

It is clear to me that the dominant global economic model, based on fossil fuels, linear modes of production and consumption, the intensive use of resources and high levels of pollution, is unsustainable. This view is now widely shared.

First and foremost, it is shared at the European level: the Fitfor55 roadmap, the Net Zero Industrial Act and, before that, NextGen EU are all aimed at achieving a low-carbon, digital economy in a Europe that maintains control of its industrial sovereignty. EU legislation aimed at creating a 'right to repair' is also being prepared.

I also think that this view is shared at the national level in Luxembourg: the results of the public consultation conducted between December 2022 and January 2023 with some 650 participants, as well as the many public discussions with stakeholders, show that the vast majority of people taking part in the dialogue are of the opinion that profound changes need to be made to our economic model.

Luxembourg Strategy was born out of my desire – having taken office as Minister of the Economy just a few weeks before the emergence of the COVID-19 crisis – to give the Ministry a tool for foresight and reflection, in order to support its decision-making in building a resilient, but also competitive and inclusive economy by 2050.

The strategic Vision that you are holding in your hands aims to assist, by 2050, all actors in the economic sphere and civil society in their efforts to establish a Luxembourg economy capable of successfully managing uncertainties, polycrises and multiple simultaneous transitions. The way to achieve this will be found in a delicate balance between technological innovation and behavioural change, redundancy and simplification, digital skills and technical know-how.

The economy is a function of the resources at its disposal. Physical and territorial resources and skills are the key areas of scarcity in Luxembourg. There is an unprecedented need for additional resources and funding to completely transform our energy and production systems, against a backdrop of potentially shrinking supplies of cheap energy and basic raw materials.

In this global race, Luxembourg is at a disadvantage because its small size limits its ability to achieve economies of scale that could absorb the additional costs. On the other hand, our size can also be an advantage when it comes to reacting quickly and optimising local resources.

Luxembourg's economy boasts unrivalled strengths: international openness and access to the EU single market, its role as a gateway to Europe, its geographical position in Europe and potential for synergies with neighbours in the Greater Region, its traditional industrial structures and advances in manufacturing, the presence of global leaders, its multilingualism, its experience in low-carbon solutions, its state aid schemes and its high-performance R&D ecosystem. The ECO2050 Vision report aims to counter the weaknesses and highlight the strengths of the national economy,

in order to transform the transitions that lie ahead into economic and social opportunities. On the one hand, the economy has a crucial role to play in implementing the transitions by decarbonising its processes and producing the decarbonised goods and services of the future. On the other hand, consumer purchasing preferences have a direct influence on the products to be supplied by the economy. Similarly, the economy supports the country's essential infrastructure and people's basic needs, and contributes to the social protection of populations in the face of new uncertainties.

In order not to replace one vulnerability with another, priorities must be set in a way that makes intelligent use of technologies, avoiding rebound effects and an increase in dependence on critical materials, while making net gains in resource savings and combining technological innovation (supply) with behavioural change (demand). To respect the limits of biophysical resources, it will be necessary to reconsider the production volumes of certain non-essential goods, while ensuring the continuing provision of necessary services and making low-carbon technologies accessible to all. This will require an attitude of sufficiency in the consumption of energy and resources.

By being open and non-prescriptive, this Vision aims to give all enterprising forces the right framework conditions to act and prosper as they see fit, while working collectively towards a resilient economy and society.

The available room for manoeuvre at the national level is largely determined by the international and European framework. The Vision aims to support the implementation of existing and future economic strategies. Moreover, we are committed to continuity and continuous improvement. Many of these principles and long-term objectives were already present in the foresight strategic study 'The Third Industrial Revolution', from 2016. Since then, a number of projects have been implemented by companies with, where necessary, the support of Luxinnovation.

In order to be ready for all possible developments and to overcome divisions, we will have to be agile and have several strings to our bow: the economy will have to make savings, safeguard production factors, build up provisions and reserves, diversify, localise and globalise, all depending on the circumstances. It will be based on a mix of decarbonised energies and supply sources, and will combine technical and behavioural solutions, decentralised and centralised systems, and modern digital knowledge alongside traditional and manual knowledge.

In any scenario, betting on a stable climate is not a good idea. The ECO2050 Vision report complements the climate and energy policies already in place. It helps to reconcile the various transitions – energy, digital, economic, ecological and societal – and make them mutually beneficial.

In any scenario, if we want to retain our options and choices, we must follow the path of curbing the increase in our energy and material requirements. In any scenario, we have to respect the dual framework of, on the one hand, the planetary boundaries that must not be exceeded and, on the other hand, minimum socio-economic foundations that must be maintained. This must be our goal for a truly resilient, inclusive and competitive economic policy.

Franz Fayot,
Minister of the Economy

Prefaces



The European Union is firmly on the path to achieving climate neutrality and sustainability in the coming decades. Successfully completing this ambitious transition will not only enhance our resilience by limiting the risks posed by climate change and environmental crises, but also strengthen Europe's open strategic autonomy, including its long-term competitiveness and prosperity, social economy model, and ultimately, its global leadership in the new, net-zero economy.

But to make this a reality will require a concerted effort at all levels; local, national and European. And we need to address the challenges which we face today, be it the increasing impacts of climate change, the shifting geopolitical sands, or undergoing the digital transition.

With all these factors to consider, and with the world of tomorrow set to be even more challenging and complex, we as policymakers need to make the most of strategic foresight.

As a modern governance tool, foresight helps us to explore, anticipate and shape the future we want. Applying it in a strategic way leads to better, more coherent, anticipatory policymaking and will help us on our journey towards becoming the first climate neutral continent by 2050.

Since I took on responsibility for embedding foresight into EU policymaking in 2019, it has become increasingly clear how important it is that this effort is matched by our Member States. So I am thrilled to see Luxembourg joining those Member States that make full use of strategic foresight to shape their policies, with the ECO2050 Vision report serving as a prime example.

The report identifies many future challenges that need to be addressed jointly, such as increasing circularity, greening the digital transition, or boosting skills crucial to the green transition. Many of these coincide with the broader challenges for the EU as a whole, as we put forward recently in the Commission's 2023 Strategic Foresight Report.

For instance, a key challenge will be creating a green economy that promotes inclusive growth and wellbeing for all. That will require a different way of looking at progress and development. In other words, we need to look beyond Gross Domestic Product (GDP) as the only measure of economic growth and prosperity. This is why we have launched a new work strand in the European Commission on developing metrics for sustainable and inclusive wellbeing that can be used as a compass for future policymaking at all levels. We are glad to see the ECO2050 Vision report feed into those efforts.

Another key challenge will be strengthening Europe's resilience and open strategic autonomy, by managing the supply of critical raw materials and adopting a systemic long-term approach to avoid falling into a new dependency trap. This report provides insightful reflections on this topic coming as it does from a country with an extensive mining history, considering for example forward-looking possibilities like space mining, the potential of which Luxembourg is already embracing by putting in place an appropriate legal framework.

In conclusion, I would like to commend the work of all the contributors to the ECO2050 Vision report, which is an excellent example of strategic foresight, with its analysis leading to innovative policymaking ideas that will I'm sure prove their merit beyond Luxembourg's borders. It represents a valuable addition to the ongoing foresight work being done across Europe, giving policymakers at all levels inspiration as we seek a credible path towards green growth and enhanced wellbeing.

Maroš Šefčovič,
European Commission Executive
Vice-President for the European
Green Deal, Interinstitutional Relations
and Foresight



Many prefaces of this sort now begin with the alarming observation that our world is facing a multitude of unprecedented crises, the impact of which is intensifying due to the acceleration of the various transitions underway – climatic, digital, energy, technological – which are interlinked and, furthermore, exacerbated by the return of war to Europe. Polycrisis, perma-crisis, resilience – these are all buzzwords that illustrate the new context in which we find ourselves, marked by a loss of familiar reference points and the emergence of new questions, doubts and fears. But rather than remaining frozen by a sense of powerlessness or merely enduring the crises, we have the capacity to move forward decisively, to anticipate the long term, to be visionaries. ‘Business as usual’ is not an option, because we have no time to lose. If we want to avoid a situation where transitions develop beyond our control and reduce us to the role of mere spectators, we need to take ownership of the changes and turn them into opportunities. We need to be agile and flexible. We need to act responsibly, in the interests of future generations and a resilient society, because we want to preserve our socio-economic model that puts people at the centre of our thinking. This model lies at the heart of the famous ‘European way of life’, which defines the European Union and its citizens, and which is unique in the world.

The ‘ECO2050 Vision’ strategy is part of this proactive and determined approach, which is also the one chosen by the European Commission. Building a sustainable future by strengthening Europe’s competitiveness, its open strategic autonomy and its economic leadership, while increasing the wellbeing of its citizens and preserving our natural environment: these are the guiding principles of the Commission’s roadmap. The transformation we are aiming for is inclusive and equitable, and it makes Europeans into actors in the structural and systemic change we need in order to succeed in our future. Indeed, in our democratic, social and values-based Europe, competitiveness and inclusive wellbeing go hand in hand and are not mutually exclusive.

If we are to achieve our ambitious goals and accelerate progress towards the EU’s climate and energy objectives for 2030 and the transition to climate neutrality by 2050, we will need to equip Europeans to deal more effectively with all these challenges. This is the idea behind the European Year of Skills. It will also involve attracting massive strategic investment and improving the conditions of access for industry to the clean technology market in the EU. This is the goal of regulation for achieving ‘net zero’ industry.

The EU is at a key moment in its history which requires a joint impetus from political decision-makers and all actors in our society to enable it to occupy a leading position in the global race which has now begun, with no possible turning back. The ECO2050 Vision contributes to this call for joint action and confirms Luxembourg’s role as a reliable and valuable partner of the EU, more united and supportive than ever, in its ongoing quest for a more sustainable, resilient and equitable model.

Anne Calteux,
Representative of the European
Commission in Luxembourg

Prefaces



Luxembourg Strategy has embarked on an ambitious foresight exercise examining the possible futures of Luxembourg's economy up to 2050. This exercise has resulted in the emergence of a 'Vision' of the main directions that the Grand Duchy's economy should take to meet the major challenges of our time. This approach aims to inform the political choices that will be made.

The approach adopted by Luxembourg Strategy consists of two distinct and complementary phases. The first is what is known as exploratory foresight, because it aims to explore possible futures without taking any position and without prejudging what is desirable. This work of exploratory foresight involves examining major changes in the context in which the Grand Duchy is, and will be, situated, but it must also identify the major strategic choices that may be taken by actors in Luxembourg. Changes in the context should not dictate the country's conduct, but on the other hand it is risky to decide on this conduct without taking account of the world in which it finds itself. The main challenges for Luxembourg's economy lie at the interface between major internal and external dynamics. This intertwining of internal and external forces is undoubtedly even stronger in Luxembourg than elsewhere, owing to its highly service-orientated economy and the major role played by the finance sector.

The second stage in the process is the development of what is referred to here as a Vision, which proposes a way forward for the economy and for structuring strategies in a coherent way that responds to long-term challenges. This Vision is not a plan, but a proposal for aligning actors in the same direction, so as to set a course over the long term.

Some critics may question the usefulness of such an attempt at long-term reflection and orientation, in light of the great uncertainties that we currently face. But we should remember that foresight does not aim to predict the future, but rather to discern what can be said about it (let us not bury our heads in the sand, especially in the face of environmental challenges), what is fundamentally uncertain but nonetheless open to some conjecture, and what remains and will continue to be unpredictable. This approach should lead us to take responsibility for future developments that have already begun, but also to build resilient, robust strategies in future contexts that may be highly varied (which, in foresight work, are usually described in 'scenarios').

Exploratory foresight involves a process of intellectual reflection that can give rise to controversy between experts. The vision that emerges is different. It embodies the major orientations desired by the actors who have been involved in its development. The more rigorous and inclusive the foresight process, the more robust and shared the vision will be. Gradually, by working together on medium- and long-term futures, the actors build a shared culture regarding the major issues, which lays the foundations for a possible shared will to meet these challenges. But even if it is the result of a highly participative approach, the vision can rarely claim to be consensual. Its success will lie in providing a reference point for democratic debate on the major issues of the future.

François de Jouvenel,
Executive Director of Futuribles
International

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List of abbreviations

ABBL	The Luxembourg Bankers' Association	DMC	Domestic Material Consumption
AI	Artificial Intelligence	ECMWF	European Centre for Medium-range Weather Forecasts
AWG	Age Working Group	EEA	European Environment Agency
BAU	Business As Usual	EIB	European Investment Bank
CBAM	Carbon Border Adjustment Mechanism	EIG	Economic Interest Group
CDA	Centres of Development and Attraction	EPRS	European Parliamentary Research Service
CdC	Chamber of Commerce Luxembourg	EROI	Energy Return on Investment
CDM	Chamber of Skilled Trades & Crafts	ESA	European Space Agency
CEO	Chief Executive Officer	ESPAS	European Strategy and Policy Analysis System
CES	Economic and Social Council	ETS	Emissions Trading System
ChD	Chamber of Deputies	EU	European Union
CNP	National Productivity Board	EUROSTAT	Statistical Office of the European Union
COP	Conference of the Parties	EVs	Electric Vehicles
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation	FAO	Food and Agriculture Organization
CSDD	High Council for Sustainable Development	FEDIL	Federation of Luxembourgish Industrialists
CSL	Chamber of Employees Luxembourg	FJD	Luxembourg Federation of Young Business Leaders
CSR	Corporate Social Responsibility	FNR	Luxembourg National Research Fund
CSRD	Corporate Sustainability Reporting Directive	GDP	Gross Domestic Product
DATer	Department of Spatial Planning	GDPR	General Data Protection Regulation
		GNI	Gross National Income
		HCNP	High Commission for National Protection
		HDI	Human Development Index
		HECParis	<i>École des Hautes Études Commerciales Paris</i>
		HERA	Health Emergency preparedness and Response Authority
		HPC	High Performance Computers
		ICT	Information & Communication Technologies
		IEA	International Energy Agency
		IGSS	General Inspectorate of Social Security
		ILNAS	Luxembourg Institute of Standardisation, Accreditation, Safety and Quality of Products and Services
		IMO	International Maritime Organization
		IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services

IPCC	Intergovernmental Panel on Climate Change	R&D	Research & Development
IPCEI	Important Projects of Common European Interest	RETEL	Observatory on Labour Market and Employment
IPP	Index of Planetary Pressures	S1	Scenario 1 (Socio-economic sleepwalking)
IRA	Inflation Reduction Act	S2	Scenario 2 (Bio-regional circularity)
JRC	Joint Research Centre	S3	Scenario 3 (Techno-digital optimism)
KBR	<i>Klima-Biergerrot</i>	SAF	Sustainable Aviation Fuels
KIS	Knowledge-Intensive Services	SDG	Sustainable Development Goals
LISER	Luxembourg Institute of Socio-Economic Research	SIS	Societal Impact Company
MAVDR	Ministry of Agriculture, Viticulture and Rural Development	S&P	Standard and Poor's
ME	Ministry of State	SME	Small and Medium Enterprises
MEA	Ministry of Energy and Spatial Planning	STATEC	National Institute for Statistics and Economic Studies
MECDD	Ministry of the Environment, Climate and Sustainable Development	STEM	Science, Technology, Engineering and Mathematics
MEGA	Ministry of Equality between Women and Men	TEEB	The Economics of Ecosystems and Biodiversity
MTEESS	Ministry of Labour, Employment and the Social and Solidarity Economy	TIR	Third Industrial Revolution
MT	Megatrend	UEL	Luxembourg Employers' Association
NGFS	Network of central banks and supervisors for Greening the Financial System	UN	United Nations
NZIA	Net Zero Industrial Act	UNDP	United Nations Development Programme
OAI	Order of Architects and Consulting Engineers	UNEP	United Nations Environment Programme
ODA	Official development assistance	WEF	World Economic Forum
ODC	Observatory for Competitiveness	WEO	World Energy Outlook
OECD	Organisation for Economic Co-operation and Development	WHO	World Health Organization
OPC	Climate Policy Observatory	ZAE	Economic Activity Zone
OPSI	Observatory of Public Sector Innovation		
PCDS	Product Circularity Data Sheet		
PDAT	Master Programme for Spatial Planning		
PNDD	National Plan for Sustainable Development		
PNEC	Integrated National Energy and Climate Plan		
PNPN	National Plan for the Protection of Nature		
PSN	National Strategic Plan		
PV	Photovoltaic		

Executive summary

Strengthening the **resilience**, **inclusiveness** and **competitiveness** of Luxembourg's economy by 2050 is the objective assigned to Luxembourg Strategy by the Minister of the Economy. The future needs to be anticipated in order to meet this objective and fully embrace the economic, societal and environmental transitions that lie ahead. Full awareness of the risks and threats posed to Luxembourg's socio-economic model and business ecosystem – by rising inequality, slower growth relative to the eurozone, and the crossing of biogeochemical limits (with complex repercussions on the climate, ecosystems, biodiversity, and the quality and abundance of primary resources) – is essential for identifying and creating new entrepreneurial opportunities capable of preserving the quality of life for future generations and the attractiveness of the country as a whole.

Following the success of the strategic study 'The Third Industrial Revolution' (TIR2050), initiated in 2015 under the aegis of Jeremy Rifkin, the Ministry of the Economy set up Luxembourg Strategy with the task of equipping its policy-making with strategic foresight tools. As the future is fundamentally uncertain but not totally unpredictable, this approach proposes to draw up, on the basis of a limited set of plausible scenarios, **a foresight vision that is both relevant and robust – regardless of the future that emerges**. The practical aim of this rigorous, systemic approach is to make it easier for companies to take decisions today that are in tune with the economy of tomorrow, by means of a set of 'no-regrets' recommendations, identified collectively with the participation of a group of economic actors.

The strategic vision 'ECO2050 – For a resilient, inclusive and competitive economy' (referred to in this report as 'the ECO2050 Vision' or simply 'the Vision') that emerged from this exercise provides a compass to guide the various economic strategies towards greater coherence. The Vision is built on **10 building blocks** which, together, lay the foundations and form the structure of a new economy. These 10 major components of the Vision, which are mutually beneficial and reinforcing, are as follows:

1. **Strategic autonomy**, because boosting domestic production reduces dependence on imports and decouples the economy from shocks on international markets
2. **Circularity and sufficiency**, because saving energy and raw materials makes it easier to comply with environmental and financial constraints
3. **Focus on people, knowledge and wellbeing**, because societal and organisational innovation creates new business, attracts talent and preserves a high quality of life
4. **Reconciling the digital, ecological and social transitions**, because building a competitive economy that manages the environmental and social footprint of new technologies facilitates social and ecological progress
5. **Critical redundancy and strategic storage capacity**, because adopting multiple solutions and building up reserves of essential goods and services ensures greater resilience and adaptability for the economy
6. **Administrative simplification**, because improving the environment for entrepreneurs, investors and researchers by streamlining procedures boosts the economy by making it more agile
7. **Diversification of the economy**, because adapting key sectors to new challenges for the sake of the general interest strengthens the preservation of common goods and the capacity of the existing economic system to turn transitions into business opportunities
8. **Sustainable economic diplomacy**, because forging close diplomatic and commercial ties with partners who share the same ecological and social values pools strengths and assets, while strengthening the global governance of resources
9. **Sustainable and solid public finances**, because guarding against budget imbalances will help finance transitions and efforts towards greater sustainability
10. **Anticipation and speed**, because planning for the long term, constantly adapting to increasingly rapid change and keeping an eye on developments gives a comparative economic advantage by defusing threats and reinforcing opportunities

With its high level of dynamism, boldness and economic agility, Luxembourg has many assets that will enable it to play a leading and exemplary role in sustainable and social innovation. However, this project for the future calls for investment to be directed towards technological solutions and socio-economic models that are increasingly respectful of the environment and biodiversity, adapted to climate change and the increasing scarcity of resources, low in requirements for energy and raw materials, and at the same time capable of opening up new business opportunities in the transport, health, housing and agriculture sectors. While **technological innovation** has been and will remain a key factor in the dynamism and attractiveness of the national economy, this study shows that **behavioural change** will also be necessary to structure and strengthen the economy of the future – just as low-tech solutions will complement high-tech solutions.

The transitions that lie ahead present the **EU** with an opportunity to reindustrialise and reinvent its economic model so as to become less carbon-intensive, less energy-intensive, less polluting, more virtuous and more in tune with its values and skills. These transitions will require massive investment. In order to grow, the production and export of goods and services must reduce their environmental impact. At the same time, and despite the limitations imposed by its geography and its resource-poor subsoil, Luxembourg is betting on becoming a country of outstanding innovators in low-carbon technologies, goods and services. Thanks to their technical progress, Luxembourg's industry and craft trades are being called upon to support the technological and energy transitions, and to export their climate-friendly solutions and models. Adapting our economy to climate change and gradually decarbonising goods and services will enable new activities with high added value, whether in the context of renewable energies, climate services, recycling or the circular economy. Shorter supply chains that are less exposed to geopolitical uncertainties will facilitate the emergence of new productive economic sectors and new business models, supported by the fruits of research and innovation.

The stakes are high. According to the Vision, by 2050 the country should achieve the collective feat of better controlling its vital resources: less will be consumed and more generated and stored locally. Thanks to its integration in the **Greater Region**, the circular economy will enable the country to cover a large proportion of its essential needs locally with more durable, repairable and robust products. In urban areas, private cars and traffic jams will be replaced by an unrivalled network of low-carbon public transport, extending across the Greater Region. Lean administration, short distances and local services will support entrepreneurship, competitiveness and resilience. The financial centre will be recognised worldwide for its sustainable investments, and the **space sector** will be known for its contribution to sustainable development, both on Earth and in space. **Agriculture and forestry** will be preserved and biodiversity will recover, while continuing to contribute to the goal of carbon neutrality and the supply of food and raw materials. **Digitalisation and ecology** will not be in conflict with one another, but will be mutually beneficial. Infrastructure will be built to last longer and people will be protected from climate damage. The state of health will be improved, to the point of making Luxembourg a 'blue zone', in which longevity and quality of life are exceptionally high. Social relations will be healthy and inequalities low. The economy will no longer be based on the endless accumulation of objects, but on individual development and fulfilling jobs that are essential for successful transitions. By agreeing to simplify and to consume differently, we will create new opportunities.

This transformation is a project for the future, in which playing a part is necessary in order to benefit fully from it.

The purpose of this report is, firstly, to present the strategic foresight exercise that was carried out in consultation with a number of actors from the economic world, the general public and experts, in order to clarify the approach and illustrate its benefits for the economy and for the common good ([Chapter I](#)) and, secondly, to explain the nature of each of the 10 building blocks briefly mentioned above, which are the main components of the ECO2050 Vision ([Chapter II](#)). [Chapter III](#) summarises the 3 scenarios underlying the development of the ECO2050 Vision, and [Chapter IV](#) contains appendices presenting the main methodological and contextual components of the foresight exercise.

I Method

II The Vision

III Scenarios

IV Appendices

I. Method

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1. The foresight method at the service of the economy

Looking to the future is a fundamentally optimistic act.

Looking to the future on the basis of what is biophysically and socio-economically feasible is an act of **realistic optimism**.

According to the Organisation for Economic Co-operation and Development (OECD) and the Observatory of Public Sector Innovation (OPSI), **strategic foresight** is an organisation's ability to perceive, make sense of and act in the face of different emerging futures. It contributes to providing early warning of potential disruptions, envisaging different possible futures, building resilience in the face of disruption, making plans and strategies future-proof, and building a common language and a shared vision of success. By observing megatrends,¹ challenging existing assumptions and models of thinking, grounding decisions in science and interdisciplinarity,² and moving beyond short-termism, strategic foresight fosters a new way of looking at progress and managing business. Strategic foresight does not decide between different values, but rather reveals them.

Unlike forecasts and projections, foresight does not project the future from the present in a linear fashion. It attempts to take account of growing complexity and uncertainty by drawing up a number of **possible and plausible scenarios** (see also Appendix 1) and taking account of a multitude of viewpoints and variables. Some issues evolve rapidly, or even accelerate, and may reach tipping points after which it becomes too late to act.

Strategic foresight has its limits. It does not predict the future, solve problems, or anticipate the next crisis. It does not itself produce a strategy and it does not guarantee its own success. It is a complementary source of information, not the definitive basis for decision-making. It takes time and iterative work to establish foresight as a way of life and practice. It is not uncommon to find unrealistic expectations of foresight work, or to see its results under-utilised.³ Since it is not aimed at immediate operational action, its benefits are indirect and often difficult to attribute to foresight itself. Its work can generate an awareness that is uncomfortable, counter-intuitive, critical or contradictory in relation to current expectations and agendas, or challenging in relation to established ways of seeing things and working.

Is foresight scientific? To the extent that there is no data on the future, foresight is not a science of the future. Scenarios are not scientific in the sense that there is no – and never will be – data on the future.⁴ 'Through purposing, exploring, identifying implications, and taking strategic action, scenarios help us learn from the future to reframe and re-perceive our understanding of the present'.⁵

On the other hand, **foresight is a scientific endeavour** insofar as it orientates itself towards the scientific and academic work of dedicated organisations (e.g. the Intergovernmental Panel on Climate Change (IPCC), the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), the OECD, the International Energy Agency (IEA), the European Commission's Joint Research Centre (JRC)), draws on and cross-references numerous sources of scientific publications and academic research, generates its own scientific studies and surveys, organises collective intelligence exercises,

1 A megatrend is a long-term driving force that is observable today and will continue to have a global impact in the years to come. Typically, megatrends cover a time horizon of 10 to 20 years. However, their analysis is used to inform medium- and long-term strategic planning over the next 5 to 50 years. See OPSI (2023), [Towards a strategic foresight system in Ireland](#) and European Commission (2022), [Megatrend Hub](#), Competence Centre on Foresight. Luxembourg Strategy, in its preliminary work, has identified 12 megatrends relevant to Luxembourg; Luxembourg Strategy (2022), [Tableaux prospectifs](#), Ministry of the Economy.

2 European Commission (2023), [Supporting policy with scientific evidence](#), Competence Centre on Foresight.

3 This was the case, for example, of numerous pre-2008 foresight publications warning of the imminence of a financial crisis, pre-2016 publications warning of a rise in populism, and of pre-2019 publications warning of the possibility of a pandemic arising from the animal kingdom. OPSI (2023), [Towards a strategic foresight system in Ireland](#).

4 Jan E. Karlsen & Hanne Karlsen (2012), [Classification of tools and approaches applicable in foresight studies](#). In: Giaoutzi & Sapiro (Eds.), *Recent developments in foresight methodologies*. New York.

5 OECD (2020), [Back to the Future of Education: Four OECD Scenarios for Schooling](#).

uses plausibility tests and expert opinions, and works in a rigorous, multi-disciplinary, collaborative and fact-based way.⁶

Foresight seeks to challenge preconceptions, launch a debate and help to make better decisions. The aim is to draw lessons from the futures that can be imagined, so as to initiate a dialogue on the strategy to put in place to construct the future. What innovations, technologies, industries and skills for facing uncertainty are revealed by the scenarios created by foresight work? If foresight is to add value, it must retain its role of challenging existing values and mental models and questioning the 'common sense' attitude of inevitability.⁷

2. The 2022-2023 foresight process conducted by Luxembourg Strategy

Drawing on the experience of foresight studies conducted as part of the Third Industrial Revolution (TIR) initiative, the Ministry of the Economy set up Luxembourg Strategy in 2021, with the task of devising scenarios for the economic future up to 2050, and then using this foresight work as the foundation for developing a robust strategic economic vision to address all these possible and plausible economic futures.

In establishing Luxembourg Strategy, the Minister for the Economy called for a vision that could meet the objective of stimulating a **resilient, inclusive and competitive economy** by 2050.

Resilience is the capacity of a system to resist shocks, and then to regenerate and transform itself in order to better manage future disruptions.⁸ In its established sense, it refers to the capacity of a system (socio-economic or biophysical) to cope with disruptions while preserving its structures and functions, and also learning and transforming itself. An **inclusive economy**, according to the OECD, is one that allows for an equitable distribution of benefits across society and the creation of opportunities for all. For businesses, inclusiveness means maximising social impact as well as economic performance.⁹ In Luxembourg, **competitiveness** is conceived in a broader sense than that of 'increasing productivity in comparison with one's main trading partners in an open market economy'.¹⁰ The Luxembourg Economic and Social Council (CES) places the emphasis on other dimensions, defining competitiveness as 'the ability of a nation to durably improve the standard of living of its inhabitants, and to procure a high level of employment and social cohesion while preserving the environment'.¹¹

6 See the ChD & FNR (2023) conference, [Megatrends – shaping the future with scientific foresight](#).

7 Martin Müller, Executive Director Science Anticipator, Geneva Science and Diplomacy Anticipator, speaker at the Megatrends Conference, Cellule scientifique, ChD & FNR, Luxembourg, May 2023.

8 'Economic aspects of sustainability understood as managing the transformation of the economy to ensure it remains within the planetary boundaries, while being globally competitive and resilient', European Commission (2023), [Strategic Foresight Report 2023](#). In the field of risk management, resilience is defined as 'die Fähigkeit eines Systems, einer Gemeinschaft oder Gesellschaft, die potenziell Gefahren ausgesetzt ist, sich anzupassen, indem sie Widerstand leistet oder sich verändert, um ein akzeptables Funktions- und Strukturniveau zu erreichen und aufrechtzuerhalten. Dies wird durch den Grad bestimmt, in dem das Sozialsystem in der Lage ist, sich selbst zu organisieren, um diese Fähigkeit zu erhöhen, aus vergangenen Katastrophen für einen besseren Schutz in der Zukunft zu lernen und die Maßnahmen zur Risikominderung zu verbessern' (UN/ISDR, 2005), quoted by MECDD (2023), [Plan de gestion des risques d'inondation 2021-2027](#).

9 HEC Paris (2020), [Inclusive business. What it is and why it matters](#). Society & Organizations. The Europe 2020 strategy introduced a new common objective for inclusive growth: to reduce by 25% the number of Europeans living below the national poverty line and to lift more than 20 million people out of poverty by 2020. Since this target was not met, in March 2021 the Commission introduced a new overall target in the European Pillar of Social Rights Action Plan: to reduce by at least 15 million the number of people living in poverty by 2030. European Commission (2021), [The European Pillar of Social Rights Action Plan / ODC \(2021\), Bilan Compétitivité et Résilience](#). Ministry of the Economy, p. 75.

10 European Commission (1998): 'a country is internationally competitive if concurrently: its productivity increases at a rate which is similar to or higher than that of its major trading partners with a comparable level of development; it maintains external equilibrium in the context of an open free-market economy; and it realises a high level of employment', quoted by ODC (2020), [Historique](#). Ministry of the Economy.

11 Ibid.

To fulfil its mission, Luxembourg Strategy set up a collaborative foresight process involving an interministerial network, with the help of a consulting firm with expertise in collaborative scenario planning.¹² The method is the same as that used by the European Commission to design its open strategic autonomy policy, based on scenarios drawn up in advance by its JRC.¹³

Work on designing the scenarios and the Vision took place within a technical working group representing a diversity of national interests. It was steered by an interministerial committee. The project also received contributions from a circle of business leaders, a group of municipalities and a committee of national experts on foresight ([Appendix 6](#)).

The foresight work was launched in early 2022, and was divided into 4 stages:

- **Take stock:** creating an inventory of the sectoral strategies and scenarios that already exist for Luxembourg, as well as the existing strengths and weaknesses of the country's economy, such as its European character and its degree of innovativeness and agility
- **Zoom in:** identifying and analysing megatrends, drivers of change and bifurcations relevant to Luxembourg
- **Zoom out:** designing alternative future scenarios in response to uncertainty
- **Take position:** developing a vision in order to achieve the desired future

A year later, Luxembourg Strategy published three scenarios¹⁴ and a strategic economic vision, entitled ECO2050. The three scenarios can be summarised as follows:

- Scenario 1 (S1): **Socio-economic sleepwalking.** Continuation of the status quo and permanent transitions.
- Scenario 2 (S2): **Bio-regional circularity.** Simplification and economic slowdown.
- Scenario 3 (S3): **Techno-digital optimism.** Technological acceleration without behavioural change.

These **scenarios** are presented in detail in [Chapter III](#) and [Appendix 1](#) of this report. They are fictitious and often make for uncomfortable feeling. Their purpose is to reveal our values and to make explicit hypotheses about the future.¹⁵

'Even though certain scenarios are undesirable, the risks they present are plausible and independent of the strategic choices to be made. All scenarios must therefore be considered in order to prepare for all eventualities during the transition to a more resilient economy.'

Minister for the Economy, Franz Fayot,
General Meeting of the Federation of Luxembourgish Industrials (FEDIL) (16 March 2023)

The typology of the three scenarios used by Luxembourg Strategy is similar to many other scenarios developed at the international level ([Appendix 3](#)). Despite differences in method, the three ECO2050 scenarios are also consistent with those recently developed by Fondation IDEA in February 2023.¹⁶

¹² [4Sing](#), Foresight to Strategy for Security and Sustainability in Governance.

¹³ European Commission (2021), [EU's open strategic autonomy by 2040 and beyond](#).

→ Scenario 1: Green leadership
→ Scenario 2: Complex prosperity
→ Scenario 3: Economic growth above all
→ Scenario 4: Retreat inwards

See also European Parliament (2022), [EU Strategic Autonomy Monitor](#).

¹⁴ Luxembourg Strategy (2022), [Les scénarios d'avenir pour l'économie luxembourgeoise en 2050](#), Ministry of the Economy.

¹⁵ Ian Miles et al. (2016), [Foresight for science, technology and innovation](#). Springer International Publishing Switzerland.

¹⁶ These are the 3 scenarios used by Fondation IDEA:

→ The 'business as usual' scenario (GDP 2.8%/year)
→ The scenario in which the relative level of wealth falls back to that seen before the financial centre took off (scenario A)
→ The scenario of accelerating gains in apparent labour productivity (scenario B)

Fondation IDEA (2023), [Une vision territoriale pour le Luxembourg à long terme](#). Fir eng kohärent Entwécklung vum Land.

The work of Fondation IDEA draws on expert analysis and literature reviews, involves making its own calculations. Luxembourg Strategy's foresight scenarios are narratives of possible futures co-constructed by non-experts, and do not involve quantified projections or simulations.

Scenarios are beyond our control, and do not constitute strategies (see also [Appendix 1](#)). The ECO2050 scenarios are based on an interaction between collective perceptions, political choices and external trends. A **strategy**, on the other hand, relates to actions under our control, which is undertaken and to which resources are allocated. A strategy is not a strategic **vision**. A vision outlines the desired future. A strategic vision brings together strategic reflections on the possible responses to different future scenarios. Because of the many possible megatrends, disruptions and hazards, there is no guarantee that one of these scenarios will come true, just as there is no guarantee that any given scenario or combination of scenarios will come true, hence the need for a vision that is robust whatever scenario emerges (for all concepts related to foresight, see the Glossary at the end of this report).

Scenario ≠ Strategy ≠ Vision



SCENARIO - DEFINITION :

- Scenarios, in the plural, are concerned with the possible evolution of factors beyond our control.
- Scenarios are fictitious, they do not describe a desirable future situation, and they are not political manifestos.
- Scenarios bring together hypotheses about how the world (and in this case, Luxembourg) could change between now and 2050.

STRATEGY - DEFINITION :

- A strategy relates to the controllable actions, which can be decided to be undertaken in the face of these different possible futures.
- A strategy is operational and aimed at the short or medium term. It is equipped with a monitoring framework and resources for its implementation.
- A strategy is robust if it remains relevant regardless of the future that materialises.

VISION - DEFINITION :

- A vision is a fictitious construct that describes a long-term future as it could be, while anticipating all scenarios.
- A vision does not itself have an operational component (action plans, human and financial resources, indicators, etc.), but can be the basis for developing strategies.
- A vision is robust if it remains relevant regardless of the future that materialises.

After consulting the general public via an online survey (Dec. 2022 – Jan. 2023, results presented in [Appendix 4](#)) about the scenarios and their desired vision of the economic future, a draft strategic economic vision for the period up to 2050 was developed. Its aim was to help seize the opportunities and avoid or mitigate the risks revealed in the three plausible future scenarios.

PUBLIC CONSULTATIONS

ECO2050 BUILDING BLOCKS	PUBLIC CAMPAIGN (ECO2050) (Appendix 4), (12.2022-01.2023) ¹⁷	KLIMABIERGER-ROT (PNEC) (2022) ¹⁸	BIERGER-KOMMITTEE ¹⁹ & ILRES SURVEYS (PDAT) (2020, 2021) ²⁰
1 <u>Improving open strategic autonomy in order to renew national production</u>	<ul style="list-style-type: none"> → Sufficiency → energy dependence ↘ → energy requirements ↘ → Local production 	<ul style="list-style-type: none"> → Sufficiency → Planned obsolescence → 'PV ready' obligation for industrial buildings 	
2 <u>Extending circularity and sufficiency throughout the economy</u>	<ul style="list-style-type: none"> → Energy sufficiency → Bio-regional circularity 	<ul style="list-style-type: none"> → Sufficiency → Circularity → Bring per capita overconsumption of materials down to the European average 	<ul style="list-style-type: none"> → Land consumption ↘ → Sufficiency regarding land use → Living area ↘ → General Development Plan (PAG) without expansion of building areas → Multifunctional use of buildings, increased vertical mix and urban densification
3 <u>Putting people, knowledge and wellbeing at the heart of the economy</u>	<ul style="list-style-type: none"> → Future skills (technical & interpersonal) → Education on sustainable development → Citizen engagement 	<ul style="list-style-type: none"> → Awareness raising → Behavioural change → Coworking space → Voluntary environmental rehabilitation service 	<ul style="list-style-type: none"> → Intergenerational housing
4 <u>Reconciling the digital, ecological and social transitions</u>	<ul style="list-style-type: none"> → Better governance of vital materials 		
5 <u>Investing in critical redundancy, strategic storage and duplicated solutions</u>		<ul style="list-style-type: none"> → Energy storage → Programmed redundancy → 'Duebel-strosseschkeet' 	
6 <u>Simplifying procedures, shortening paths and facilitating transfers</u>	<ul style="list-style-type: none"> → Social and territorial simplification 	<ul style="list-style-type: none"> → 15-minute cities → Harmonisation of local planning regulations → Sustainable public procurement → Light, low-carbon public transport → Remote working 	<ul style="list-style-type: none"> → 15-minute cities: green spaces, public transport, nearby shops, healthcare and local services; parking; car-free neighbourhoods → Assessing the impact of construction on land and soils → Smaller shopping centres in urban areas accessible by public transport and soft mobility
7 <u>Diversifying the economy by adapting it to the challenges of the future</u>	<ul style="list-style-type: none"> → Industries of the future (engineering, ICT, health, crafts) 	<ul style="list-style-type: none"> → Green infrastructures → Public environmental rehabilitation programme 	
8 <u>Integrating new challenges into economic diplomacy</u>	<ul style="list-style-type: none"> → Better governance of vital materials → Promoting Luxembourg 	<ul style="list-style-type: none"> → Green shipping 	
9 <u>Ensuring sustainable and solid public finances</u>	<ul style="list-style-type: none"> → Importance of the financial centre → Promoting financial innovation → Investing to prepare for the future 	<ul style="list-style-type: none"> → Taxation of polluting vehicles 	<ul style="list-style-type: none"> → Taxation of empty properties and undeveloped building plots → Taxation of vacant building land
10 <u>Turning anticipation into a comparative economic advantage</u>	<ul style="list-style-type: none"> → Anticipation, adaptation and flexibility in the face of future challenges 		

Figure 1. Summary of citizen consultations on national long-term planning

¹⁷ Luxembourg Strategy (2023), Résultats de la campagne publique ECO2050. Ministry of the Economy.

¹⁸ PNEC refers to the Integrated National Energy and Climate Plan, ME (2022), Klima-Biergerrot: Rapport final.

¹⁹ MEA (2023), Biergerkomitee Lëtzebuerg 2050, nos recommandations au monde politique.

²⁰ PDAT refers to the Master Programme for Spatial Planning. DATer (2023). Residents' responses are in line with the objectives of the PDAT2023 project: 8 out of 10 in favour of limiting land consumption, 89% in favour of assessing the impact on land of future construction projects, and 97% consider green spaces in the city to be essential, Press release dated 7 February 2023.

From early 2023, presentations of the draft vision (see Figure 1) were given to a group of business leaders (CEOs), the Chamber of Employees Luxembourg (CSL), the Luxembourg Employers' Association (UEL), the Chamber of Commerce Luxembourg (CdC), the Chamber of Skilled Trades & Crafts (CDM), the Luxembourg Federation of Young Business Leaders (FJD) and a delegation of municipalities. This draft was also the subject of three presentations to the *Commission de l'Économie, de la Protection des consommateurs et de l'Espace* of the Chamber of Deputies (ChD) at the 'Megatrends and political foresight' conference co-organised by the Scientific Unit of the ChD and the Luxembourg National Research Fund (FNR) in May 2023, and to the CES's 'energy transition' working group in July 2023.

At the international level, the draft vision was discussed with the Strategic Foresight Unit and its Global Foresight Community, as well as with the OPSI of the OECD, the Foresight Network of the European Commission and the European Strategy and Policy Analysis System (ESPAS), hosted by the European Parliament.

The draft, improved by these exchanges, was presented and discussed publicly for the first time in June 2023 at a conference in Esch Belval.²¹ Consultations then continued, culminating in a final version of the ECO2050 Vision that takes account of the guidelines of the Interministerial Committee and the many comments received from economic and institutional actors. The final version of the Vision, which you have in your hands, has been available since September 2023.

The foresight process has therefore achieved its aim: to produce future scenarios and an associated strategic Vision. But a foresight process of this sort also brings its own rewards. Beyond the development of scenarios and a Vision, it provides a formative experience for all participants, since it involves the implementation of a new, anticipatory way of conducting strategic design and collective learning within public administration.

3. The bio-physical and socio-economic frameworks of the ECO2050 Vision

It is easier to draw up economic strategies and plans in times of abundance and low costs than in times of scarcity and rising production costs. Megatrends and publications indicate that the end of the age of cheap, abundant fossil fuels are being reached – which are the foundation of the current civilisation – and of non-renewable natural resources.²² The scientific consensus emphasises that the current model of economic development is contributing to the depletion of the planet's resources and that, by endangering its own habitat in this way, the human species is increasing the existential risks it faces.²³ The deterioration of the environmental and climatic context is likely to cause additional physical damage and material constraints, the management and repair of which will weigh heavily on public budgets. These aspects are generally underestimated in long-term macro-economic projections (see the [budgetary implications of climate inaction, building block 9](#)).

21 See the [Luxembourg Strategy](#) website.

22 An increase in resource scarcity is one of the 14 megatrends observed by the European Commission. See European Commission (2023), [Supporting policy with scientific evidence](#), Competence Centre on Foresight. In 2010, the International Energy Agency's (IEA's) annual World Energy Outlook (WEO) speculated that the global peak of conventional crude-oil production had taken place in 2006, when 70 million barrels were produced per day. This forecast was revised to the year 2025 in WEO 2022. See also Richard Heinberg (2007), [Peak Everything](#).

23 IPBES-IPCC (2021), [Co-sponsored workshop report on biodiversity and climate change](#), IPCC (2022), [Climate change 2022: Impacts, Adaptation and Vulnerability](#). Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. 'We are destabilizing the planetary systems we rely on for survival', see Pedro Conceição (2021), The next frontier: Human development and the Anthropocene, presentation by the United Nations Development Programme (UNDP) at the [Luxembourg Strategy Conference](#) on 15 November 2021.

Various analytical frameworks exist, and many valuable macro-economic studies have been carried out in Luxembourg. The ECO2050 Vision provides a complementary bio-physical and socio-economic perspective for the national economy. To do this, it draws on the concept of planetary boundaries developed since 2009.²⁴ In 2017 this was combined with the concept of essential social needs to produce a doughnut chart depicting shortfalls of the social foundation and overshoot of the ecological ceiling (Figure 2).

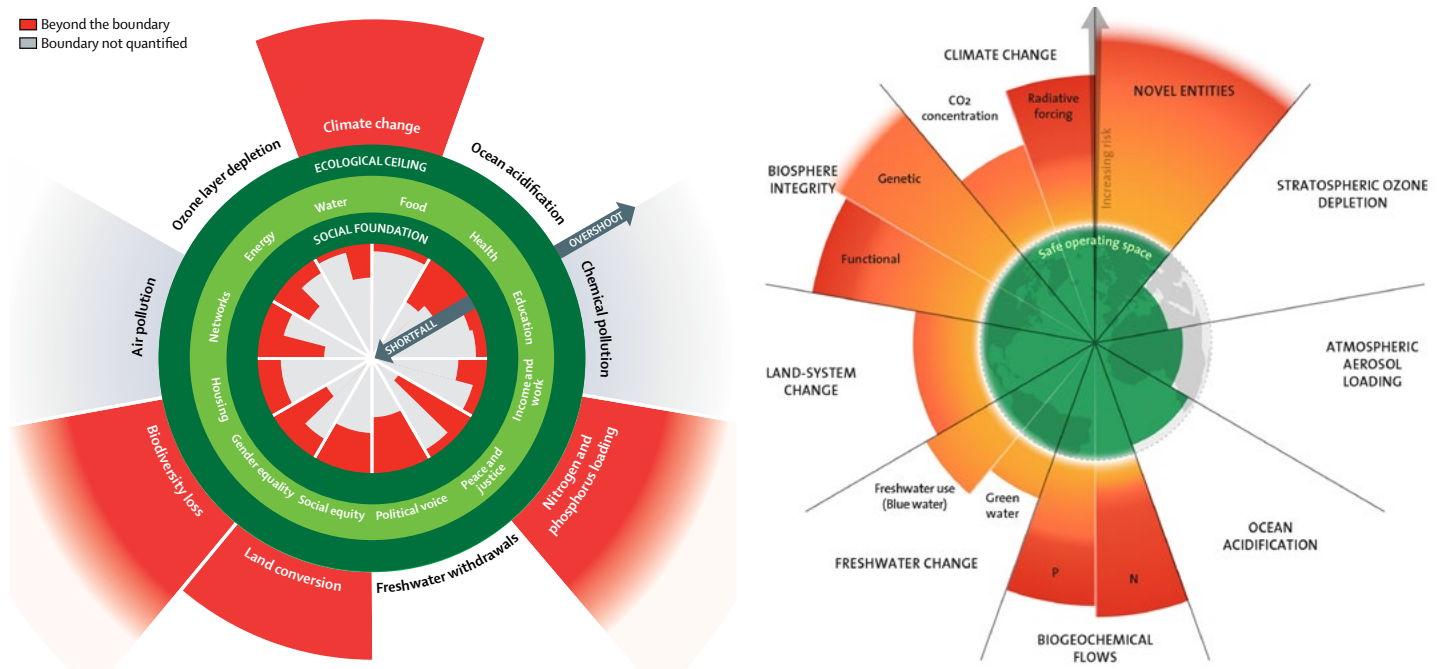


Figure 2. Shortfalls The Doughnut framework (in general) (left) and the planetary boundaries framework (right) (April 2022)²⁵

This doughnut chart is one of the most balanced and detailed analytic tools for enriching the understanding of resilience and ways of strengthening it.²⁶ It graphically shows the links between different socio-economic and biophysical indicators. It therefore appears to be an effective guide to strategic decision-making, and was chosen as the analytical framework for developing the ECO2050 Vision.

24 Johan Rockström et al. (2009), *Planetary Boundaries: Exploring the Safe Operating Space for Humanity*, Ecology and Society 14, no. 2. Will Steffen et al. (2015), Planetary boundaries: Guiding human development on a changing planet, Science.

25 The development of an equivalent doughnut chart for Luxembourg is underway and at the heart of discussions between the High Council for Sustainable Development (CSDD), the Luxembourg Institute of Science & Technology (LIST) and Luxembourg Strategy. The doughnut chart (Kate Raworth (2017), *A Doughnut for the Anthropocene: humanity's compass in the 21st century*, The Lancet Planetary Health, 1(2), pp. e48-e49) integrates the research of the Potsdam Institute for Climate Impact Research and the Stockholm Resilience Centre, which estimate that in 2023 humanity will have exceeded 7 of the 9 planetary boundaries (8 of which are quantified) (Johan Rockström et al. (2023), *Safe and just Earth system boundaries*, Nature, 619(7968), pp. 102-111). See also Andrew Fanning (2022), *The Doughnut Framework in Economics and its Application to the Case of Luxembourg*, presentation by the Doughnut Economic Action Lab at the Luxembourg Strategy conference on 17 October 2022. Stockholm Resilience Centre (2023), *All planetary boundaries mapped out for the first time, six of nine crossed*.

26 Other relevant indicators include the Human Development Index (HDI) adjusted for the Global Pressures Index (GPI) of the United Nations Development Programme (UNDP), the Sustainable Development Goals (SDGs) of the United Nations (UN), the EU Resilience dashboards and the Transitions performance index of the European Commission, the Better life Index of the OECD and other indicator sets from various initiatives (Happy Planet Index, Biodiversity Performance Index, Sustainable Development Performance Indicators, etc.).

Overall, a decline in **returns on investment** can be observed in many areas: technologies,²⁷ information & communication technologies (ICT),²⁸ energy,²⁹ minerals,³⁰ innovation,³¹ education,³² agriculture,³³ etc. According to Tainter, the more complex societies become, the more energy it takes to maintain that complexity, and the lower the marginal return on investment in complexity, which in turn creates social vulnerability.³⁴

The goal of reaching sustainable development objectives for all is becoming increasingly remote, and the very possibility of achieving all these objectives while respecting planetary boundaries is being called into question.³⁵ On a global scale, economic and demographic growth is slowing (see Figure 3),³⁶ national budget deficits are increasing³⁷ and inequalities in income³⁸ and carbon footprints are considerable.³⁹

Changes in global GDP and population

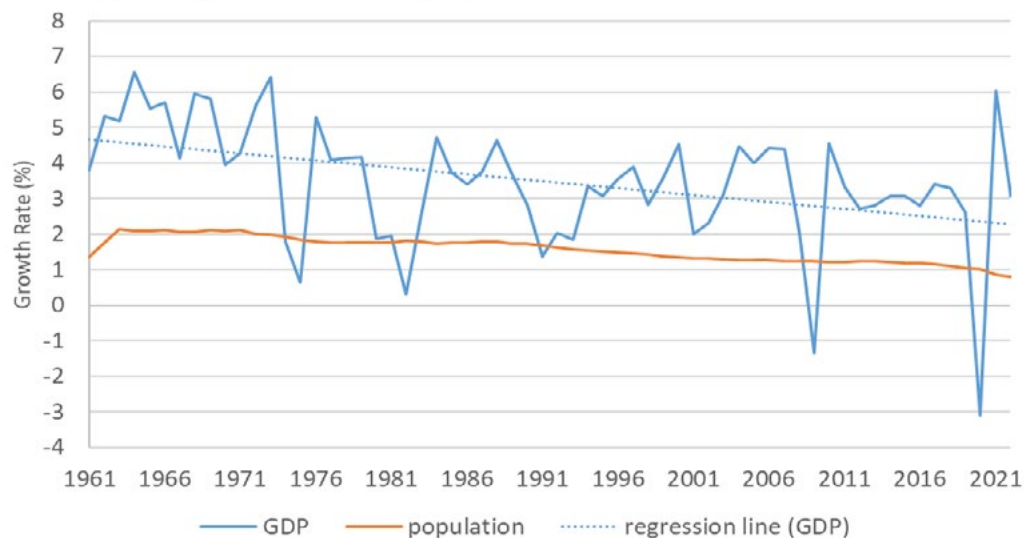
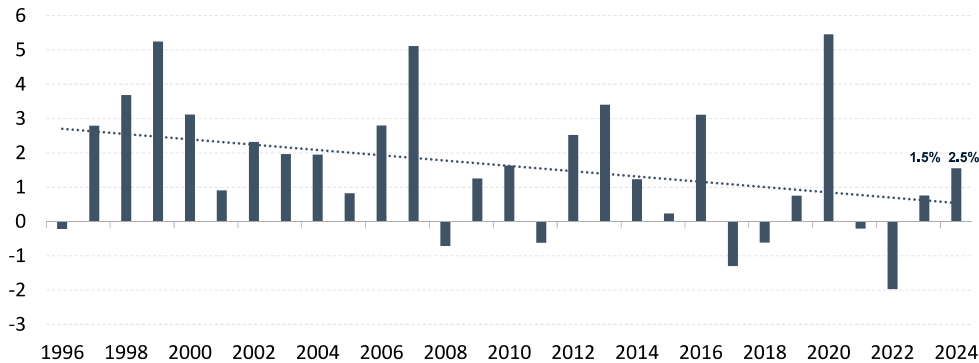


Figure 3. Change in global GDP and population growth rates (%) 1961-2022⁴⁰

- 27 'Post-Internet technological advances appear to have had less of an economic impact than previous technological revolutions', Fondation IDEA (2023), *Grands Défis*, p. 33, citing Robert J. Gordon (2015), *Secular Stagnation: A Supply-Side View*. *American Economic Review*, 105 (5): 54-59.
- 28 The high productivity due to the ICT boom has slowed since 2010, according to Robert J. Gordon (2012), *Is US Economic Growth Over? Faltering Innovation Confronts the Six Headwinds*, Working Paper 18315. National Bureau of Economic Research.
- 29 Iñigo Capellán-Pérez et al. (2019), *Dynamic Energy Return on Energy Investment (EROI) and material requirements in scenarios of global transition to renewable energies*; Jessica G. Lambert et al. (2014), *Energy, EROI and quality of life*, *Energy Policy* 64.
- 30 IIER (2016a), *What made us so rich in 250 years?* & IIER (2016b), *How energy and natural resources limits inhibit economic growth*.
- 31 'Long-run growth in many models is the product of two terms: the effective number of researchers and their research productivity. We present evidence from various industries, products, and firms showing that research effort is rising substantially while research productivity is declining sharply. (...) everywhere look we find that ideas, and the exponential growth they imply, are getting harder to find', Nicholas Bloom et al. (2020), *Are Ideas Getting Harder to Find?* *American Economic Review* 2020, 110(4).
- 32 According to various studies focusing on the reverse Flynn effect, the global intelligence quotient peaked in the mid-1970s.
- 33 Projections of peak agricultural land, FAO (2006), *World agriculture: towards 2030/2050*, OECD (2012), *OECD-FAO Agricultural Outlook 2012*, Deepak K. Ray et al. (2012), *Recent patterns of crop yield growth and stagnation*, *Nature Communications* volume 3, Article number: 1293.
- 34 Tainter (1988), *The Collapse of Complex Societies*, Cambridge University Press.
- 35 UN (2023), *Turn words into action to get world back on track for 2030 goals*. 'The BAU scenario indicates that the social and environmental SDGs cannot be achieved together, within the planetary boundaries', Jorgen Randers et al. (2019), *Achieving the 17 Sustainable Development Goals within 9 planetary boundaries*. *Global Sustainability*, Volume 2. 'Extreme poverty and hunger in the world have declined, access to basic services (electricity, water, health, education, etc.) and life expectancy have increased, as have living conditions in general. However, the poorest half of humanity's share of global income has changed little', Observatoire des inégalités (2022), *Les inégalités mondiales de revenu diminuent*.
- 36 André Sapir, *Journée de l'économie*, Chamber of Commerce Luxembourg, 17 April 2023.
- 37 On a global scale, public debt jumped by 76% between 2007 and 2022, and now exceeds annual world GDP according to S&P (2023), *Global Debt Leverage: Is a Great Reset Coming?* Standard & Poor's Global.
- 38 While income inequalities between the world's inhabitants have been falling for 20 years, inequalities within many countries are tending to increase. The share of income received by the world's richest 1% soared from 17% of total income in 1980 to 21% in 2000. This share fell slightly after 2008, but remained at a very high level (19%) in 2020. See Observatoire des inégalités (2022).
- 39 With a carbon footprint of 10tCO₂ eq. per person, the richest top 1% generate more greenhouse gas emissions (16.9%) than the poorest half of humanity (11.5%), who live on just 1.4tCO₂ eq. per person. Lucas Chancel (2022), *Global carbon inequality over 1990-2019*. *Nature Sustainability* 5, 931-938.
- 40 On average, over these 62 years, the GDP growth rate between 2 consecutive years is 3.5%. The slope of the regression line is -0.04%/year (with a 95% confidence interval of -0.06 to -0.02%/year). The slowdown remains statistically significant after excluding the observation for 2020 (COVID-19 crisis). World Bank (2023), *National accounts data on population and GDP growth*.

According to Luxembourg's National Institute for Statistics and Economic Studies (STATEC), the 'Luxembourgish exception' – the country's ability to achieve gross domestic product (GDP) growth rates well above those of its neighbours – is fading. It becomes more frequent to see years in which Luxembourg's economic growth is lower than that of the eurozone, and the trend of the historical gap in Luxembourg's favour is downward sloping:⁴¹



Source: STATEC, Oxford Economics (2023-2024: forecasts)

Figure 4. GDP growth differential between Luxembourg and the eurozone (%)

According to Fondation IDEA, growth is no longer 'free': 'Although the growth of recent decades has "materialised" in reality in defiance of underestimated projections, this is partly due to characteristics (availability of housing, cross-border labour, oversizing of certain infrastructures, etc.) that are gradually disappearing and which will be more constrained by environmental imperatives in the future.'⁴²

In Luxembourg, the National Productivity Board (CNP) noted in 2022 that 'the national economy has been faced with a **persistent quasi-stagnation of its total productivity** since the beginning of the millennium', albeit at a high level by international standards. This is not specific to Luxembourg, but can be observed across OECD countries.⁴³ After a steady decline in labour productivity from 2015 onwards, there was an increase in productivity in 2020 and 2021 thanks to the performance of the financial and insurance sectors. The contribution of information & communication technologies (ICT) to economic progress is losing momentum, with a significant fall in its labour productivity since 2012.⁴⁴ Labour productivity in manufacturing recovered well in 2021 and continues to improve.

Although Luxembourg has a high level of **resource productivity**, this has stagnated, such that figures from 2020 are close to the level of 2010. This led the CNP to conclude that the country has not succeeded in decoupling GDP growth from domestic material consumption (DMC): 'As for the evolution of energy productivity, it appears that the general trend over the last 20 years has been positive, both in Luxembourg and in the EU as a whole. Luxembourg has succeeded in decoupling its economic production from its energy consumption. This can be explained in part by the fact that Luxembourg's economy is based mainly on service activities, which generally consume less energy than industrial activities. From a climate perspective, however, the downside is that Luxembourg's economy is highly carbon-intensive, as the share of renewable energies in gross final energy consumption is relatively low (11.7% in 2020) and fossil fuels dominate energy consumption in Luxembourg. Because Luxembourg has to import the fossil fuels it consumes, dependence on these energy sources also represents a vulnerability for the country.'⁴⁵

Among the various scenarios analysed by the General Inspectorate of Social Security (IGSS) in its *Bilan technique du régime général d'assurance pension* (Technical Review of the General Pension

41 STATEC (2023), *Note de conjoncture 1-23: Une lutte contre l'inflation lourde d'intérêts*.

42 Vincent Hein (2023), *Préparer le Luxembourg au million d'habitants*, Paperjam out of the box.

43 The OECD's productivity database 1995 to 2019 highlights the general slowdown in advanced economies' labour productivity growth in the last two decades, in CNP (2022), *Rapport sur la productivité 2021-2022*.

44 IDEA (2023), *Grands défis: propositions en vue des élections législatives*, p. 28 & CNP (2022), *Rapport sur la productivité 2021-2022*, p. 18.

45 Ibid. Resource productivity is calculated by dividing GDP by domestic material consumption (DMC).

Insurance Scheme),⁴⁶ the basic scenario predicts that the **population** will grow only slightly to 770,000 by 2050 (reaching 785,000 in 2070). According to the European Statistical Office (Eurostat) (EUROPOP 2019 model), the number of net immigrants per year is expected to fall by around 50%, from around 10,200 per year at present to just 5,200, which would represent a break with the past. Real annual **GDP** growth is expected to average 1.8% between 2020 and 2070 (Working Group on Ageing Populations and Sustainability, AWG: 1.5% average 2022–2070), with a continuous downward trend from the early 2040s. National **employment**, driven by cross-border employment, is expected to show average annual growth of 0.6% between 2020 and 2070. Starting from a value of 2.5%, it is expected to decline rapidly, ending up with negative growth of -0.2% in 2070. **Labour productivity**, which determines real wage growth, is expected to increase by 1.2% on average between 2020 and 2070 (AWG: 0.8%).

Macroeconomic assumptions

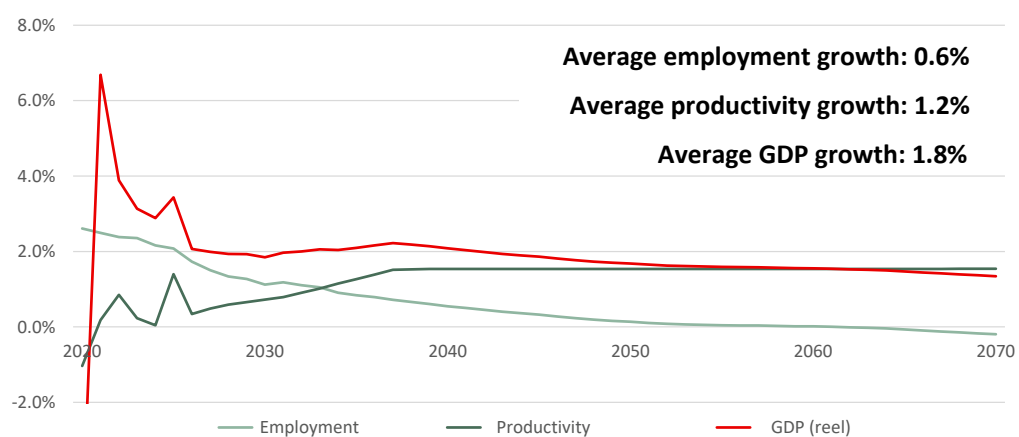


Figure 5. Change in economic growth and its components between 2020 and 2070 (%), (Baseline scenario, IGSS 2022)⁴⁷

In order to extend the basis for analysis and identify critical events, IGSS has developed several alternative scenarios that are more optimistic in terms of GDP growth, population growth, employment and productivity growth: ‘To summarise the projections, both contribution revenues and pension expenditures will increase until 2070, but expenditures will grow faster than revenues owing to demographic trends, including in terms of GDP. The “critical events” for the general pension insurance scheme are (i) the overall contribution rate being exceeded by the pure pay-as-you-go premium, (ii) the reserve falling below the legal threshold of 1.5 times the amount of annual benefits, and (iii) the reserve being exhausted. These three events are projected for 2027 (i), 2041 (ii) and 2047 (iii) respectively. The other alternative scenarios analysed by the IGSS show the same trends, with the years of the critical events being virtually identical.’⁴⁸

In February 2023, Fondation IDEA developed three economic and demographic scenarios to underpin its vision for the country.⁴⁹ The main parameters and results of the **‘business as usual’ scenario** are: GDP growth of 2.8% per year, annual growth in apparent labour productivity of 0.5%, maintenance of the current split between new immigrants (45% of needs) and new cross-border commuters (55%) in the supply of foreign labour, and continued gains in life expectancy and maintenance of the birth rate, resulting in a population of 1,092,456 inhabitants and 955,000 jobs (of which 452,000 fulfilled by residents and 503,000 by cross-border commuters) in 2050.

⁴⁶ IGSS (2022a), *Bilan Technique du Régime Général d’Assurance Pension – 2022*. Ministry of Social Security. The baseline scenario reflects the demographic and macro-economic assumptions made by the European Commission’s Working Group on Ageing Populations and Sustainability (AWG).

⁴⁷ IGSS (2022b), *Bilan Technique du Régime Général d’Assurance Pension*. Presentation of 26 April 2022.

⁴⁸ Ibid.

⁴⁹ Fondation IDEA (2023), *Une vision territoriale pour le Luxembourg à long terme*. Fir eng kohärent Entwécklung vum Land.

Fondation IDEA also tested two alternative quantified scenarios: that of a decline in the relative level of wealth in Luxembourg towards that observed before the financial centre took off (**scenario A**) and that of an acceleration in gains in apparent labour productivity (**scenario B**).

	GDP change	Productivity change	Jobs change	Population number	Jobs number	Commuters number
	2022-2050	2022-2050	2022-2050	2050	2050	2050
<i>Fil de l'eau</i>	2.8%	0.5%	2.3%	1,092,456	955,092	503,329
Scenario A	0.4%	0.4%	-0.1%	768,591	489,795	212,207
Scenario B	2.8%	1.5%	1.2%	948,457	714,827	341,911

Source: STATEC and Fondation IDEA

Figure 6. Economic and demographic development scenario for Luxembourg to 2050⁵⁰

The economic projections for Luxembourg produced by various authors therefore illustrate in quantitative terms what the foresight scenarios of Luxembourg Strategy outline in a schematic way (Scenario 1: continued growth; Scenario 2: slower growth; Scenario 3: accelerated growth). Taken together, these different scenarios and projections for Luxembourg's economy call for caution with regard to the future development of its performance. It is for these reasons, and also in light of the uncertainties associated with the transitions and polycrises of the current era, that the economic Vision developed by Luxembourg Strategy aims to outline a path that will prepare the economy for these three eventualities.

Many factors may explain this trend towards lower growth. These include the upward trend in the price of fossil fuels over the last 60 years⁵¹ and the projected long-term decline in their physical accessibility or in demand for these carbon-based energies. The stock of fossil fuels, which constitutes a 'one-time bounty', is the foundation of current consumer civilisation and industry. The energy density of fossil fuels and their historically high energy return on investment (EROI)⁵² have yielded cheap production costs and cheap machinery, enabling to build the current affluent society. This abundance of energy has facilitated progress, technological innovation and the production of consumer goods. However, scientists⁵³ are predicting a decline in this EROI, to the point that 50% of the final energy return will be required for producing energy. The energy needed for bringing about the energy transition is becoming increasingly scarce, while the world's energy needs continue to grow. Renewable energies are being added to total energy production, rather than replacing fossil fuels.

⁵⁰ Ibid. p. 7.

⁵¹ Our World in Data (2023), [Global crude oil prices, measured in US dollars per cubic meter](#). This data is not adjusted for inflation. Ross (2022), [Historical Oil Prices \(1968-2022\)](#).

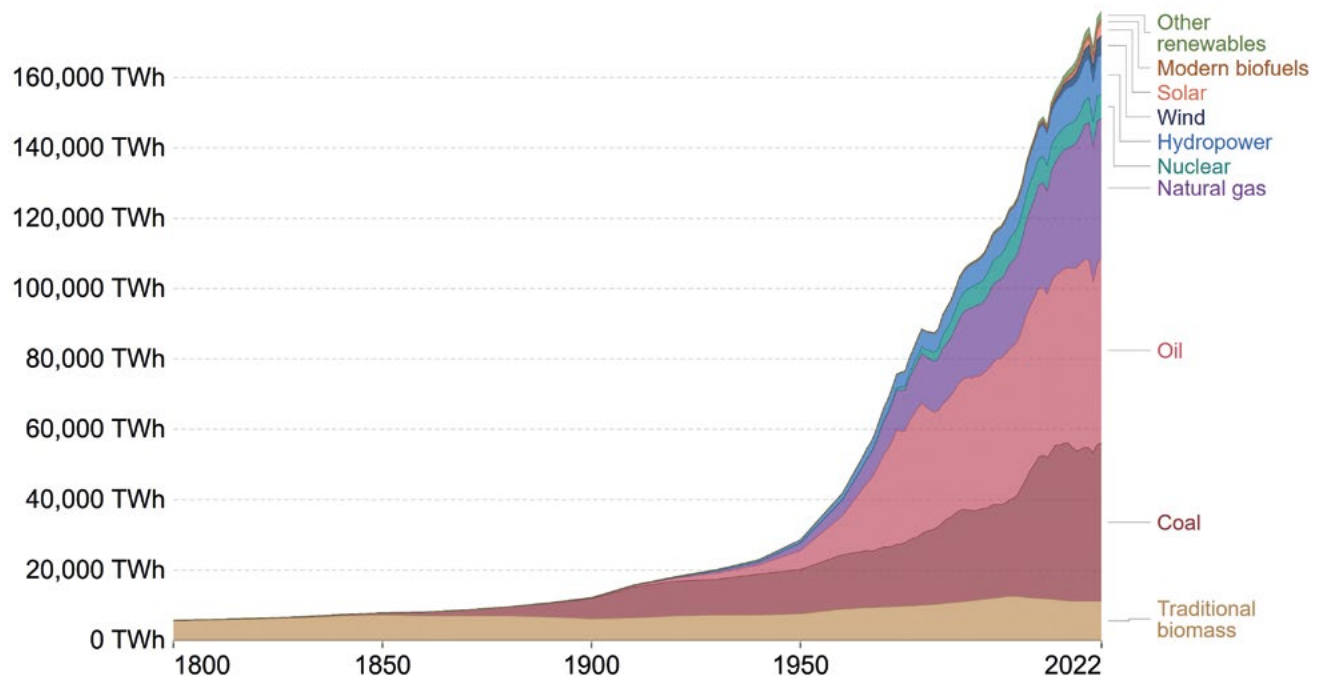
⁵² The concept of energy return on (energy) investment (EROI), proposed by Charles Hall and colleagues in the 1980s, quantifies the energy surplus (energy return) as a fraction of the effort required to generate the surplus (the investment) for a given activity. Charles Hall et al. (1981), [Energy Return on Investment for US Petroleum, Coal and Uranium](#); Mitsch, W., Ed; Elsevier: Amsterdam, The Netherlands.

⁵³ 'Our society can be described as a thermodynamic system that profoundly relies on abundant cheap energy sources such as petroleum to thrive. However, the rapid growth in use of this non-renewable fossil fuel has undermined its future availability, leaving little doubt that an all-oil liquids peak will take place in the next 10 to 15 years. By 2050, a proportion equivalent to half of the gross oil energy output will be engulfed in its own production. Given the societal dependence on oil and the difficulties in achieving a transition to low-carbon energies in time, such a peak is likely to have deep implications'. Louis Delannoy et al. (2021), [Peak oil and the low-carbon energy transition: A net-energy perspective](#), Applied Energy Volume 304 & Misra (2023), [Plummeting 'Energy Return on Investment' of Oil and the Impact on Global Energy Landscape](#), Journal of Petroleum Technology.

Global primary energy consumption by source

Our World
in Data

Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.



Source: Energy Institute Statistical Review of World Energy (2023); Vaclav Smil (2017)
OurWorldInData.org/energy • CC BY

Figure 7. Just one illustration of the 'Great Acceleration'⁵⁴

At the same time, global energy demand is projected to increase by 50% over the next 30 years,⁵⁵ owing to economic and demographic expansion and the energy transition, among other factors. The task of reconfiguring the entire energy systems to switch from dense, controllable fossil fuels towards renewable energies will carry a considerable, even staggering cost.⁵⁶

In the absence of sufficient reserves to compensate for the decline in existing oil production worldwide, the price of oil is tending to rise,⁵⁷ and with it the cost of the global energy transition, since fossil fuels are currently used to create new renewable energy capacity.⁵⁸ Beyond the controversy over whether or not the moment of peak oil (supply or demand) is imminent, there remain unanswered questions about the investment requirements and future costs of renewable energies, and the physical availability and economic profitability of the supplies of energy, materials, land and water that are needed to achieve the **energy transition**.⁵⁹

54 Will Steffen et al. (2015), *The trajectory of the Anthropocene: The Great Acceleration*. *The Anthropocene Review* 2 (1): 81–98.

55 OECD (2022), *Competition in energy markets*. Competition Policy Roundtable Background Note.

56 Jean Pisani-Ferry and Selma Mahfouz (2023), *Les incidences économiques de l'action pour le climat*, France Stratégie.

57 Gail Tverberg (2022), *Energy: The Interconnection of Energy Limits and the Economy and What This Means for the Future*, presentation at the Luxembourg Strategy conference on 17 October 2022.

58 The Shift Project (2021), *Pétrole: quels risques pour l'approvisionnement de l'Europe?*

59 'The global energy transition is not happening. A rebound in economic activity led to a roughly 4% increase in global energy demand, much of which was met by fossil fuels', REN21 (2022), *Renewables 2022 Global Status Report*.

The situation reveals, once again, that the major challenges currently faced are linked: a rapid accomplishment, in parallel, of not one but several **transitions – climatic, energy, material, logistical, digital, social, professional, economic, financial, administrative,⁶⁰ cultural and agricultural** – in order to avoid exceeding the carbon and biophysical budget available to humanity, while ensuring that these transitions are socially equitable and inclusive is needed.

In the framework of the European Semester, Luxembourg has defined the reduction of the risk of poverty or **social exclusion** as an objective of inclusive growth. However, on both indicators the situation in Luxembourg is deteriorating: in 2020, the at-risk-of-poverty or social exclusion rate was 20.9%, affecting around 125,000 people. The Luxembourg Institute of Socio-Economic Research (LISER) has observed a widening income gap between high and low earners in Luxembourg since 2000, with a relative poverty rate of 16% in 2019. Although low incomes have risen since 1985, they have risen much more slowly than median income, and also much more slowly than high incomes. The main risk factors for poverty are foreign citizenship, lack of education, unemployment and youth.⁶¹ These results are in line with Luxembourg Strategy's analyses, which show a steady increase in income inequality in Luxembourg between 1985 and 2019, approaching certain international thresholds.⁶² Furthermore, STATEC has identified a sharply rising sense of loneliness among young people aged 16 to 29. Moving towards a new model, it must be ensured that the population can live with dignity and that everyone can find their place in the new economy, by reducing the number of people threatened by insecurity or social exclusion.

In fact, rather than talking about sectoral transitions, bifurcations or mutations, there is a need for **systemic transformation**. This transformation lies at the centre of the project for the future, and it is essential to be part of it, both as actors and beneficiaries. This transformation will involve a shift in investment towards low-carbon and resource-efficient technologies, energies, processes and infrastructures. Additional and cumulative investment will be needed in mobility, agriculture, housing, infrastructure, adaptation to climate change, the social justice transition, water conservation and maintaining biodiversity.

Although the decline in biodiversity is a megatrend observed in particular by the European Commission,⁶³ this remains a blind spot for most companies, who see few direct links between this phenomenon and their own business case.⁶⁴ As the preliminary results of Luxembourg Strategy's RISK2050 study suggest, energy-intensive industries in Luxembourg perceive biodiversity loss and ecosystem degradation as only distant and indirect threats, mainly affecting the wellbeing and health of their employees and of society in general.⁶⁵

60 The OECD-OPSI [Anticipatory Innovation Governance](#) project develops and tests new approaches and conducts action research with governments and partners in this emerging area of anticipatory innovation practice.

61 LISER (2023), [Inégalités et pauvreté](#). Lëtzebuurger Land, 16 June 2023.

62 Luxembourg Strategy (2023), Evolution of the social foundations over time in Luxembourg and neighbouring countries. Ministry of the Economy. The Standardised World Income Inequality Database has provided continuous information since 1985 on the Gini coefficient (the measure of the extent to which the income distribution in a country deviates from a perfect distribution, where 0 denotes perfect equality and 1 denotes a situation of complete inequality in which one person would capture 100% of the income). According to Thomas Piketty (2014), [Capital in the Twenty-First Century](#) & Andrew L. Fanning et al. (2021), [The social shortfall and ecological overshoot of nations](#), *Nature Sustainability*, 5(1), pp. 26-36, a Gini coefficient of 0.3 indicates average or even low inequality (the situation in the United States in the 1970s). The measure of inequality in Luxembourg has risen from 0.24 in 1985 to 0.29 in 2019.

63 European Commission (2022), [Brief me on nature-based solutions](#). Knowledge Centre for Biodiversity. European Commission (2021), [Brief me on biodiversity and trade](#). Knowledge Centre for Biodiversity.

64 85% of the world's largest companies have a moderate to high risk of dependence on nature through their direct operations, S&P (2023), [How the world's largest companies depend on nature and biodiversity](#). Moreover, \$44 trillion of global economic value, representing more than half of global GDP (2019), is moderately or highly dependent on natural resources and ecosystem services such as pollination. WEF (2020), [New Nature Economy Report II – The Future Of Nature And Business](#).

65 The RISK2050 study, conducted by Luxembourg Strategy in collaboration with the University of Luxembourg, is due to be completed by the end of 2023. It aims to analyse the vulnerability of Luxembourg's economy to 3 main physical risks: (i) climate change, (ii) the decline in biodiversity and (iii) the increasing scarcity of resources.

This state of affairs is changing, however, as shown by a publication from the European Central Bank entitled *The Economy and Banks Need Nature to Survive*. It notes that 72% of the 4.2 million businesses in the eurozone are heavily dependent on at least one nature-related service, such as pollination, clean water, healthy soil or wood.⁶⁶ According to the European Commission, six major industries in Europe depend on nature, through their supply chains, for at least 50% of their turnover: chemicals and materials; aviation, travel and tourism; real estate; mining and metals; supply chain and transport; and retail, consumer goods and lifestyle.⁶⁷ In a recent article in *Le Monde*, a group of companies called on the French government to make the regeneration of living resources into the guiding principle of its planning laws.⁶⁸

66 Elderson (2023), *The Economy and Banks Need Nature to Survive*, European Central Bank & European Commission (2020), *The business case for biodiversity: the European Green Deal*.

67 European Commission (2020), *The business case for biodiversity: the European Green Deal*.

68 'Les activités économiques doivent contribuer activement à la restauration de la biodiversité', *Le Monde*, 31 July 2023.

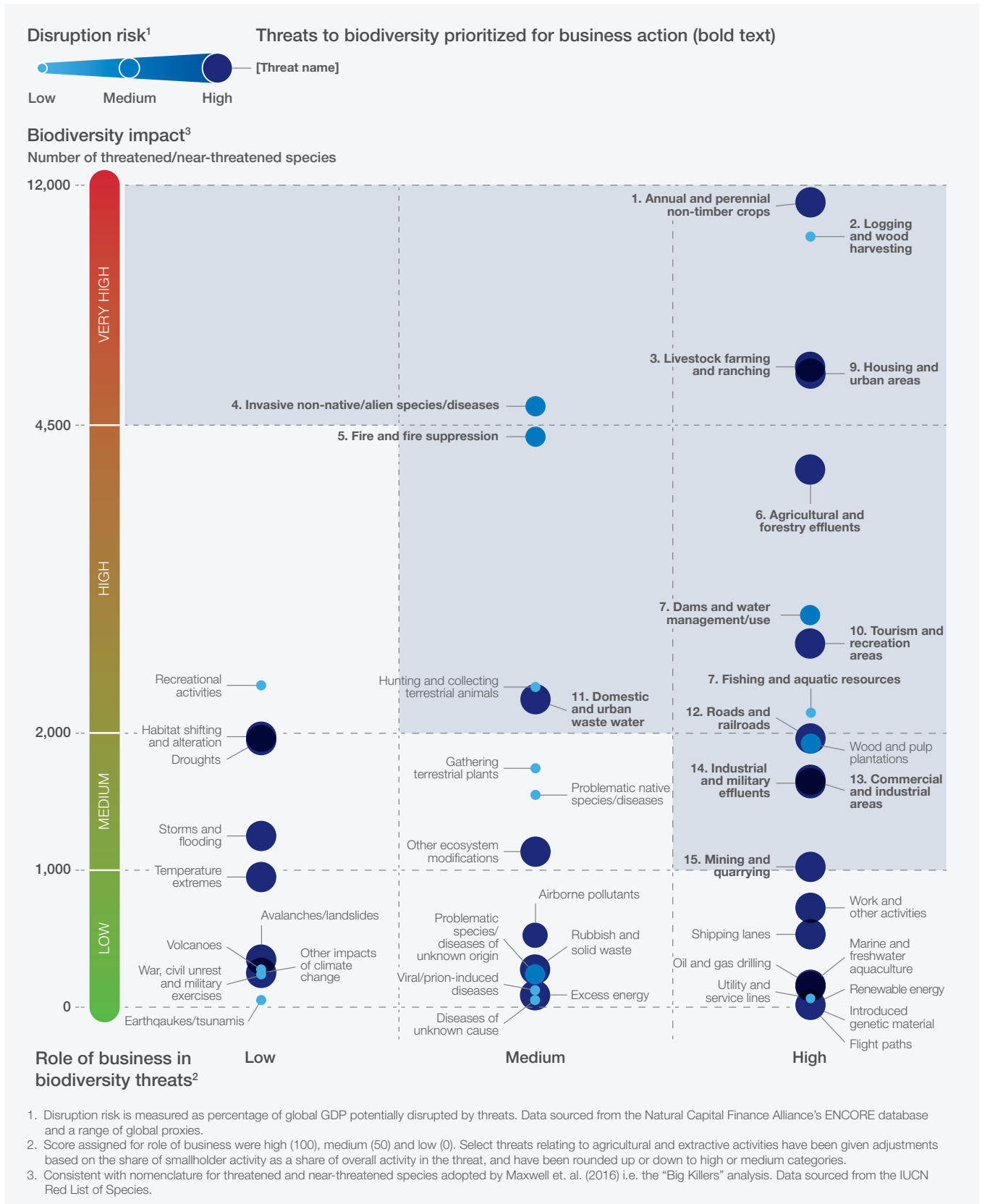


Figure 8. Threats to biodiversity prioritised following three criteria: their impact on biodiversity, the role of business in driving them, and their disruptive potential for business (2020)⁶⁹

69 WEF (2020), *New Nature Economy Report II – The Future Of Nature And Business*, p. 20. See also Finance for Biodiversity Foundation (2023), *Briefing paper – Top 10 biodiversity-impact ranking of company industries*.

Using a holistic approach, the ECO2050 Vision takes account of this socio-economic and biophysical context in order to achieve greater success in the multitude of transitions ahead of us, turning them into economic and business opportunities while helping to improve the quality of life for all.

The ecological transition refers here to the implementation of development trajectories that preserve or restore the viability of the planet. It involves transforming the way we produce, consume, work, travel, live and share economic wealth, while remaining within the limits of what the Earth can regenerate ([building block 3](#), [building block 6](#)).⁷⁰ It will also be necessary to ensure a continuous supply of vital goods and services (food, clean air and water, materials, medicines, shelter).

The climate transition is also concerned with maintaining the planet's habitability, specifically in relation to the challenge of climate change, by two means: reducing emissions until carbon neutrality is achieved, and adapting to the effects of ongoing climate change. This decarbonisation will require essential resources (metals, rare earths, etc.) that Europe lacks ([building block 1](#)). Carbon-intensive and resource-intensive goods (means of transport, housing, boilers, etc.) will have to be replaced by non-carbon-intensive and resource-efficient goods ([building block 2](#)). Many decarbonisation technologies do not yet exist, are resource-intensive, or are still extremely expensive. 'Climate change threatens all businesses, as all exist on Earth. However, some are more vulnerable than others. Impacts are expected to fall disproportionately on SMEs, including property damage and disruption to business operations, supply chains and infrastructure, leading to increased costs of maintenance and materials, and ultimately higher prices. However, climate action offers a wide range of new opportunities for businesses to develop products and services that help both reduce emissions and adapt to a warming world' ([building block 7](#)).⁷¹

Contrary to popular belief, Europe is the fastest-warming continent in the world, with an average rise of +1.2°C compared with pre-industrial levels.⁷² Water tables are low in Europe following several historically dry summers. Given the extent, density and sophistication of the man-made technosphere in high-income countries, greater economic value is at risk from physical damage resulting from climate extremes and the disruption of natural cycles than in less densely built and equipped regions.

The contraction of the physical basis of production can result in conflicts of use or provoke feedback loops between systems.⁷³ How is hydroelectricity, the source of half of Luxembourg's 'green' electricity, changing in the face of drought, declining river flows and the over-extraction of water? How can carbon be stored in furniture if the quality of woodland is such that it can no longer be turned into good-quality furniture? What impact do losses in agricultural and forestry yields have on the food and construction industries? How to maintain, or even increase, the carbon sink function of soils and forests if the soil is losing organic matter and moisture, and if 2 out of 3 trees are diseased or drying out, with the risk of them emitting more greenhouse gases than they absorb?⁷⁴ Should priority be given to biomass for construction, industry, energy, transport (biofuels and Sustainable Aviation Fuels (SAF)) or food, or to green hydrogen for heavy industry or fertilisers? Should increasingly scarce water supplies be reserved for cooling, electrolysis to produce hydrogen, irrigation of vegetables or vines, or for livestock? How to meet everyone's basic needs in a context of ecological overshoot?⁷⁵ What are the cereals of the future, which will provide resistance to ecosystem and climatic degradation? How can local mineral resources be extracted in an environmentally-friendly way? How can natural resources be adapted to climate change if they have already been weakened? How to protect workers from the negative effects of climate extremes, and protect economic activities from physical damage (storms, floods, landslides, etc.)?

⁷⁰ Chamber of Commerce Luxembourg (2023), [Accélérer les transitions écologique et énergétique](#).

⁷¹ European Commission (2023), [Conséquences du changement climatique pour les entreprises](#).

⁷² Copernicus (2023), [European State of the Climate Report](#), Copernicus Climate Change Service, 20 April 2023. The Arctic is currently the region experiencing the greatest increase in temperature.

⁷³ Luxembourg Strategy (2023), [RISK2050 study](#), Ministry of the Economy.

⁷⁴ Munch (2023), [Sécheresse, scolytes, incendies: comment les forêts du Grand Est sont devenues une 'source' de CO2](#), France bleue, 19 June 2023. The capacity of French forests to absorb CO2 is collapsing, according to the Académie des Sciences (2023), [Les forêts françaises face au changement climatique](#).

⁷⁵ 'The BAU scenario indicates that the social and environmental SDGs cannot be achieved together, within the planetary boundaries', Jorgen Randers et al. (2019), [Achieving the 17 SDGs within 9 planetary boundaries](#). Global Sustainability, Volume 2.

What are the consequences for the economy and finance of the loss of biodiversity?⁷⁶ It is necessary for the state to provide the framework conditions for anticipating these challenges.

These constraints are particularly pronounced in Luxembourg, which imports almost 90% of its energy and food, and whose soil and water are precious resources that are subject to numerous competing uses and human pressures.

The **societal transition** ([building block 3](#), [building block 4](#), [building block 6](#)) poses the most difficult questions, as it is concerned not only with social, economic, behavioural, psychological, organisational and political barriers and opportunities, but also with the complex interaction of these aspects with one another and with the technical and biophysical aspects.⁷⁷ Neither technology nor public policy measures can be designed independently of users, their practices and the communities in which they live. Changes in behaviour and lifestyle are therefore essential to the deployment of the climate, energy and ecological transitions.⁷⁸ **Social justice transitions** involve supporting these other changes through social policies that protect the most vulnerable and fragile members of society. The term **socio-economic transitions** covers initiatives to strengthen an ecologically sustainable economy and thus address the structural scarcity of resources and environmental problems, particularly those linked to the use of fossil fuels and global warming.

There is another vital resource that must not be left out of the equation: **time, a non-renewable resource, constitutes a hard limit**. Transitions take time, and time is extremely pressing in the race to address environmental changes and the rapid pace of technological and digital change. The tension between moving quickly to respond to the urgency of the situation and taking the time required to make the right choices will have to be managed. To do this, work must be performed on two levels: both technological and infrastructural choices must be analysed, to make sure the right path is taken in the long term, in order to avoid lock-in and path dependencies that will significantly increase costs in the future.⁷⁹ This requires to step back and analyse, focus on the essentials, learn from past mistakes, adopt a systemic approach, address technological and societal developments in the long term, change scale and make provision for the unknown.

‘The only viable solution is not to restrict our desires, but to change them.’

Gaspard Koenig, Chairman, GénérationLibre

The ECO2050 approach is therefore firmly based on biophysical limits and socio-economic needs, which guarantees the feasibility of the Vision. This approach calls for a **systemic** view of all national policies and strategies in order to establish whether their joint and simultaneous implementation is realistic, given the resources and means available. It calls for a strong role for public authorities in orchestrating the transitions and distributing the effort and benefits fairly. The difficulty lies in the coherence and coordination required to accomplish the transitions in record time: achieving one transition at the expense of another, or wasting time indulging in illusions about what is feasible and financeable, or shifting vulnerabilities from one sector, region or generation to another must be avoided. It is key to steer the economy towards achieving all the transitions, quickly, fairly and justly, so that their objectives converge with those of the living world.

⁷⁶ 85% of the largest international companies have a moderate or high risk of dependence on nature through their operations according to S&P (2023), [Nature positive](#) & the capacity of French forests to absorb CO2 is collapsing, according to the Académie des Sciences (2023), [Les forêts françaises face au changement climatique](#).

⁷⁷ See the publications of the [Environmental innovation and societal transitions Journal](#).

⁷⁸ ADEME (2021), [Analyser les pratiques sociales pour favoriser la transition énergétique et écologique](#). ADEME Research Newsletter n° 33.

⁷⁹ Path dependency is seen as a process that has the property of staying on a particular path, so that past decisions and contingent events pre-determine what further steps may be taken. Technologies, policies, or governance modes are locked-in. Self-reinforcing mechanisms contribute to their reproduction and diminish the range of likely alternatives. Susanne Hanger-Kopp et al. (2022), [Defining and operationalizing path dependency for the development and monitoring of adaptation pathways](#), Global Environmental Change, Volume 72.

4. Link between the ECO2050 strategic Vision and the TIR2050 strategic study

The TIR2050 strategic study, carried out in 2015 with the help of the futurist Jeremy Rifkin, and the ECO2050 Vision are not economic strategies, but strategic reflections aimed at enriching the debate and examining the possible responses to different future scenarios. TIR is based on one of two quantified scenarios drawn up by experts, while ECO2050 is based on 3 non-quantified scenarios drawn up by a multidisciplinary working group of non-experts.

In contrast to the TIR strategic study's assumption of a rapid and sustained fall in energy prices due to the advent of renewable energies,⁸⁰ the ECO2050 Vision assumes a possible increase in energy and materials prices, and consequently in production costs and sale prices.⁸¹ This precaution is explained by the ECO2050 Vision's desire to respond with 'no regrets' to three possible futures: a 'business as usual' future of continuing economic and demographic growth (S1), a future of slowing economic and demographic growth (S2), and a future of high economic and demographic growth (S3). Nor does the Vision take it for granted that the virtualisation of processes will lead to a dematerialisation of the economy, since the material and energy footprint of digitalisation and automation⁸² is set to increase ([building block 4](#)).

TIR, and more recently the invasion of Ukraine, have raised awareness around the vital importance of energy for society, the economy and industry. The COVID-19 crisis has also raised awareness of the importance of greater independence when it comes to basic supplies. Today, climate and energy targets are legally binding in Luxembourg and the EU. Added to this are targets for reducing material consumption, biodiversity loss and the amount of land taken over by construction (artificialisation) – subjects that are relatively neglected in TIR.

⁸⁰ Jeremy Rifkin (2014), *The Zero Marginal Cost Society*. St. Martin's Griffin

⁸¹ Electricity prices in Europe have been rising since 2008 for households and industry (5% from 2008 to 2019). European Commission (2020), [Study on energy prices, costs and their impact on industry and households](#), DG Energy. The Council of the EU explains the extraordinary increase in energy prices since 2021 by the following factors: the 2021-2022 increase in gas import prices, extreme weather conditions resulting in more energy consumption for cooling and constraints on nuclear and hydroelectric production, increase in demand for liquefied gas, greater gas consumption by Asia following its economic expansion, and the cessation of gas deliveries by Russia in 2022. Council of the EU (2023), [Energy prices and security of supply](#). A weak signal (see [Glossary](#)) can be observed concerning the recent reversal of the historical trend of falling renewable energy costs, with a relative increase in these costs detectable since 2021 under the combined effect of supply constraints, soaring fossil fuel energy costs, the strengthening of the European electricity grid and international freight, inflation and rising interest rates, and a reduction in subsidies for renewable energies. IEA (2022), [Renewable Energy Market Update - May 2022](#). Several observers are talking about a wind energy crisis, particularly regarding offshore wind: BloombergNEF (2022), [Wind - 10 Predictions for 2022](#), Procurement Resource (2022), [Wind Energy Price Trend and Forecast](#), Bloomberg (2023), [World's Biggest Wind Power Projects Are in Crisis Just When World Needs Them Most](#) & Financial Times (2023), [Soaring costs threaten offshore wind farm projects](#). 'In Europe, new investment in wind farms actually fell by more than 40% in 2022 compared to 2021, as did new wind turbine orders', Watson Institute (2023), [Letting Europe's Energy Crisis Go to Waste: The Ukraine War's Massive Fossil Fuel Costs Fail to Accelerate Renewables](#).

⁸² Anne Faure (2021), *Transition numérique : le cas français. Autour du rapport Soutenabilités ! Orchestrer et planifier l'action publique*. Présentation France Stratégie. [Conférence Luxembourg Stratégie](#). 17 October 2022.



Figure 9. International and national biophysical targets for 2030 and 2050

As a result, the window of opportunity has narrowed since 2015. Nonetheless, many of the measures outlined in TIR are still present and even amplified in the ECO2050 Vision: the circular economy, greater energy autonomy through the use of renewable sources, energy efficiency and storage, the interconnected economy, ‘digital for sustainability’ and sovereign infrastructures, sustainable finance, new business and consumption models, reducing the need for mobility, and capitalising on the gains offered by the collaborative commons.

In 2021, 5 years after the launch of the strategic study, the three historical partners in the TIR process – the Ministry of the Economy, the CdC and IMS Luxembourg – carried out an assessment of how the situation had evolved.⁸³ On the one hand, this assessment showed that many measures have been implemented, were progressing, had changed name or direction, or were not attributable only to the impetus provided by TIR. On the other hand, it became clear that much remains to be done. The TIR scenario for national electricity production is now proving to be too conservative.⁸⁴ Be that as it may, even the measures whose quantitative targets proved to be out of date (e.g. that 100% of new car registrations should be electric by 2025, or that 100% of agriculture should be organic by 2050) have had the benefit of stimulating debate and awareness of the issues at stake, and of speeding up initiatives in these areas.

The TIR process was beneficial and pioneering in Luxembourg, in that it allowed to look far into the future and to bring sectors together in a common approach. It focused our minds and enabled to converge towards a shared, intergenerational, multi-sectoral vision. It has also certainly been one of the triggers for completing or clarifying existing strategic planning tools, whether in the field of the data-driven economy, manufacturing industry, sustainable finance or the circular economy.

As a result, at the point of taking stock of TIR in 2021, Luxembourg Strategy was created to broaden and deepen the foresight approach undertaken in that strategic study, with the aim of accelerating the transition towards a sustainable and resilient economy. Luxembourg Strategy’s method is different, as it is based on the observation of megatrends, the identification of uncertain bifurcations and the collaborative development of scenarios for possible futures, in order to develop

⁸³ IMS Luxembourg et al. (2021), *État des lieux de 49 mesures stratégiques*, Ministry of the Economy.

⁸⁴ The TIR/Fraunhofer ISE scenarios forecast a need for almost 1,100 MW of national ‘green’ electricity generation in 2040. In 2020, the PNEC target scenario was 2,500 MW. Michels (2022), *Energy Transition @ Creos, a view to 2040*. *Conférence Luxembourg Stratégie*. 18 October 2022.

a strategic vision that responds to those scenarios. Both exercises are ‘home grown’ in the sense that they are based on existing knowledge and expertise in Luxembourg. Both TIR and ECO2050, with certain differences, were organised into working groups and steering committees made up of the main economic actors, businesses, government departments and intermediary bodies, and both of them engaged with civil society. ECO2050 also drew on the knowledge of all the departments and administrations of the Ministry of the Economy, thematically focused observatories,⁸⁵ national and international foresight expertise and local authorities.

The sectoral scope of the ECO2050 Vision coordinated by Luxembourg Strategy is narrower than that of TIR. Whereas the TIR study provides a detailed, 400-page list of concrete measures and actions, the ECO2050 approach is more modest and remains at the level of general principles and objectives. The Vision does not advocate one technology over another. It seeks to remain neutral while laying down certain basic principles and criteria to be respected in the choice of solutions, including those of **resilience** and **precaution**, which in themselves favour a diversity of compatible technological choices rather than **technological exclusivity**.

ECO2050 takes the position that the various transitions call for **strengthening national physical production**, whether through industry, crafts, agriculture or forestry, and not dismantling the industrial heritage. Increased dependence on imports, an exclusive return to protected local crafts and a move towards self-sufficiency are all things to be avoided. Overhauling production and energy systems will require major efforts from both industry and crafts, as well as considerable investment. It will provide jobs for a new generation of trained and motivated employees. In the ECO2050 Vision, value creation is derived from increasing people’s capabilities and wellbeing: this will not be achieved through the pursuit of an endless accumulation of objects, or by increasing screen time or continually degrading the living environment, but rather by fostering a taste for effort and satisfaction with a job well done.

5. The ECO2050 Vision: a ‘no regrets’ response to the three possible economic future scenarios

The Vision is structured by the 10 building blocks summarised below, and has its origins in the 3 economic scenarios for 2050 (S1, S2, S3) developed under the coordination of Luxembourg Strategy during 2022–2023.

1. Improving open strategic autonomy in order to renew national production

An economy that is less dependent on imports and shocks on international markets is an asset, whatever happens in the future (S1, S2, S3). Preserving, securing and optimising the critical physical factors of production – energy, materials, land and water – will make it possible to continue to produce, to set up new activities, to anticipate possible falls in consumption and supply (S2), and to take advantage of changes in consumer preferences (S2), a possible intensification of high-tech and digital activity aimed at exports (S3), or a development of green and low-tech industry aimed at the regional market (S2).

⁸⁵ There are 17 observatories monitoring megatrends in specific domains in Luxembourg. These include the observatories for Competitiveness, Spatial Development, Equality, Children, Youth and School Quality, the Natural Environment, Employment (RETEL), the Civil Service, Price Formation, Housing, Mobility, SMEs, Climate Policy, Social Policy, Health, and Labour and Social Cohesion.

2. Extending circularity and sufficiency throughout the economy

Circularity and sufficiency contribute to greater autonomy in production and consumption, as well as to decarbonisation and efficiency in the use of resources, thus responding to energy and material constraints, the widening of the economy's environmental footprint (S1, S3), lack of resources, including financial resources, and the potential weakening (S3) or shrinking (S2) of the EU.

3. Putting people, knowledge and wellbeing at the heart of the economy

Societal and organisational innovation can be a lever for developing business creation, employment and social cohesion and for meeting new social needs. It is a question of mobilising, training, converting, attracting, retaining and inspiring skills and vocations in a context where there is a mismatch between supply and demand for skilled labour, in order to bring about transitions. S2 features an emphasis on Knowledge-Intensive Services (KIS), combining both old and new forms of knowledge, regarding both manual and digital processes. S3 features an emphasis on staying at the cutting edge of high-tech and data-driven innovation.

4. Reconciling the digital, ecological and social transitions

While digital technologies can facilitate the emergence of a more economical future, they also have a significant environmental footprint and shape social relations. The aim is to limit the destabilising effects of transitions on social cohesion (S1, S3) and to limit the environmental footprint of digital innovation (S1, S3) by harnessing its potential for supporting social progress and the ecological transition.

5. Investing in critical redundancy, strategic storage and duplicated solutions

To make the economy more resilient in the face of shocks and able to recover more quickly from disruptions, it is necessary to create reserves and strengthen the resilience of critical infrastructures (S1, S2, S3). This will make it easier to manage price changes and the smooth functioning of these infrastructures in a context of energy, material, food and water constraints, increasing physical risks and rising geopolitical tensions (S1, S3).

6. Simplifying procedures, shortening paths and facilitating transfers

Improving the working environment for entrepreneurs, investors and researchers by streamlining procedures will also bring about a change in corporate culture, making it easier to attract young recruits and talent. This longstanding ambition must be given absolute priority and substantial resources in order to keep up with the timetable for transitions. Simplification is relevant in the face of increasing complexity (S1) or hybrid transformation (slowdown) of the system (S2), as well as in a context of exacerbated competition between systems (acceleration) (S3).

7. Diversifying the economy by adapting it to the challenges of the future

Strengthening community assets and adapting them to environmental changes (climate, biodiversity, increasing scarcity of resources) is of general interest (S1), and also represents an economic opportunity (S2, S3). A lowcarbon economy is capable of producing, selling and exporting climate-friendly, low-carbon and resilient goods and services (S3), while meeting the vital needs of the population (S2). In healthcare, for example, costs can be reduced and quality increased thanks to digitisation (S3).

8. Integrating new challenges into economic diplomacy

Forging strong diplomatic and trade links with other countries that share the same values will be a valuable asset for successfully accomplishing the various transitions. This is justified in a context of international uncertainty (S1, S2, S3) concerning the distribution of scarce resources and the decarbonisation effort, technological interference with climate change (S3), and the role of the economy (S2), and also in the context of the uncertain development of artificial intelligence (AI) dominated by large multinational companies (S3).

9. Ensuring sustainable and solid public finances

The transitions will have a substantial cost in all scenarios (S1, S2, S3), affecting the means for financing the welfare state. The avoidance of financial imbalances can be achieved through anticipation, making savings by promoting the health, environment and wellbeing of citizens (S2), fossil fuel taxation (S1), reallocating public funds to resilient investments, building up reserves (S1), blended finance (S3) and sustainable finance (S2), and specialising in 'green' financial products and skills (S2).

10. Turning anticipation into a comparative economic advantage

Long-term planning and early warning systems make it possible to identify vulnerabilities and opportunities upstream and to react at an early stage, in order to reduce their potential for destabilising the transitions. Anticipation will make it possible to identify (before other competing actors) labour shortages (S1, S3), disruptive technologies (both high- and low-tech) (S2, S3) and markets of the future. It will facilitate the strategic trade-offs that need to be made in the face of conflicts over the use of limited resources (S1, S3), while also helping to avoid stranded assets (S1), to accelerate transformations (S2, S3), and to reduce the costs associated with the transitions.

ECO2050 FUTURE SCENARIOS

ECO2050 BUILDING BLOCKS	SCENARIO 1 (S1) PERMANENT TRANSITIONS	SCENARIO 2 (S2) SIMPLIFICATION AND ECONOMIC SLOWDOWN	SCENARIO 3 (S3) TECHNOLOGICAL INNOVATION WITHOUT BEHAVIOURAL CHANGE
1 <u>Improving open strategic autonomy in order to renew national production</u>	<ul style="list-style-type: none"> → import dependencies & trade shocks ↓ → Cope with an \uparrow in constraints (energy, materials, food, water, etc.) 	<ul style="list-style-type: none"> → import dependencies & trade shocks ↓ → Benefit from greater resource sufficiency → Take advantage of a low-tech intensification aimed at the Greater Region market 	<ul style="list-style-type: none"> → import dependencies & trade shocks ↓ → Cope with an \uparrow in constraints (energy, materials, food or water) → Make the most of a high-tech intensification targeted at export
2 <u>Extending circularity and sufficiency throughout the economy</u>	<ul style="list-style-type: none"> → Cope with an \uparrow in constraints (energy, materials, food or water)... → ...and an \uparrow in the ecological footprint → Focus on efficiency to minimise the rebound and crowding-out effect 	<ul style="list-style-type: none"> → Cope with the potential shrinkage of the EU → Focus on sufficiency and behavioural change to avoid the rebound and crowding-out effect 	<ul style="list-style-type: none"> → Cope with an \uparrow in constraints (energy, materials, food or water)... → ...and an \uparrow in the ecological footprint... → ...and the weakening of the EU → Focus on recycling to minimise the rebound and crowding-out effect
3 <u>Putting people, knowledge and wellbeing at the heart of the economy</u>	<ul style="list-style-type: none"> → Maintain Luxembourg's attractiveness to the workforce of the Greater Region → Digital start-ups 	<ul style="list-style-type: none"> → Strengthen the attractiveness of the craft industry and hybrid poly-activity in the face of the need for manual work → Physical start-ups 	<ul style="list-style-type: none"> → Stay at the forefront of innovation in the new technologies sector (high-tech, data, etc.) → Out-sourcing tasks → AI start-ups
4 <u>Reconciling the digital, ecological and social transitions</u>	<ul style="list-style-type: none"> → Limit the ecological footprint of digital innovation → Limit the destabilising effects of transitions on social cohesion 	<ul style="list-style-type: none"> → Limit the destabilising effects of transitions on social cohesion 	<ul style="list-style-type: none"> → Limit the ecological footprint of digital innovation → Limit the destabilising effects of transitions on social cohesion

ECO2050 FUTURE SCENARIOS

ECO2050 BUILDING BLOCKS	SCENARIO 1 (S1) PERMANENT TRANSITIONS	SCENARIO 2 (S2) SIMPLIFICATION AND ECONOMIC SLOWDOWN	SCENARIO 3 (S3) TECHNOLOGICAL INNOVATION WITHOUT BEHAVIOURAL CHANGE
5 <u>Investing in critical redundancy, strategic storage and duplicated solutions</u>	<ul style="list-style-type: none"> → Ensure the continuity of basic functions for a growing economy and population → Cope with an \uparrow in physical risks and geopolitical tensions 	<ul style="list-style-type: none"> → Ensure the continuity of basic functions for a sluggish economy and population → Improve recovery from biophysical and socio-economic shocks 	<ul style="list-style-type: none"> → Ensure the continuity of basic functions for a strongly growing economy and population → Cope with an \uparrow in physical risks and geopolitical tensions
6 <u>Simplifying procedures, shortening paths and facilitating transfers</u>	<ul style="list-style-type: none"> → Continue efforts in a context of increasing complexity → Address urban sprawl → Friend-shoring 	<ul style="list-style-type: none"> → Continue efforts in the context of a hybrid transformation (slowdown) → Decentralisation and 15-minute cities → Near-shoring 	<ul style="list-style-type: none"> → Continue efforts in the face of heightened competition between systems (acceleration) → Metropolisation → Off-shoring
7 <u>Diversifying the economy by adapting it to the challenges of the future</u>	<ul style="list-style-type: none"> → Continue diversification in existing sectors 	<ul style="list-style-type: none"> → Focus diversification on the carbon industry and nature services → Adapt common goods and services to crises 	<ul style="list-style-type: none"> → Focus diversification on the carbon industry and carbon services → Adapt common goods and services to crises and export them
8 <u>Integrating new challenges into economic diplomacy</u>	<ul style="list-style-type: none"> → Manage international uncertainty linked to the distribution of scarce resources, decarbonisation efforts, etc. → Protect against loss of competitiveness 	<ul style="list-style-type: none"> → Manage international uncertainty linked to the role of the economy → Protect against the development of protectionism 	<ul style="list-style-type: none"> → Manage international uncertainty linked to the distribution of scarce resources, decarbonisation efforts & the role of multinationals (AI, etc.) → Prevent confrontation
9 <u>Ensuring sustainable and solid public finances</u>	<ul style="list-style-type: none"> → Carbon tax → Future fund → Green financial centre 	<ul style="list-style-type: none"> → Strong demand on the public sector to finance transitions → Make savings by promoting health, the environment and wellbeing 	<ul style="list-style-type: none"> → Strong demand on the private sector to finance transitions → Taxation on digital services
10 <u>Turning anticipation into a comparative economic advantage</u>	<ul style="list-style-type: none"> → Identify labour shortages → The destabilising potential of resource constraints \downarrow 	<ul style="list-style-type: none"> → Identify labour shortages → Anticipate disruptive (low-tech) technologies 	<ul style="list-style-type: none"> → Identify labour shortages → the destabilising potential of resource constraints \downarrow → Anticipate disruptive (high-tech) technologies

Figure 10. The building blocks of the Vision and their origins in each of the 3 ECO2050 possible scenarios

6. Next steps: using foresight to strengthen strategic coherence and robustness

The ECO2050 Vision is a representation of a desirable future, in anticipation of the 3 possible future scenarios (see the presentation of the scenarios in [Chapter III](#) and [Appendix 1](#)). The Vision is essentially open, iterative and non-prescriptive, and proposes a convergent and coherent framework for action, aimed at accomplishing a shared ambition for a more resilient, inclusive and competitive economy. Aside from their use in fulfilling this ambition, the scenarios and the Vision provide **a ready-to-use public space for foresight reflection**, which any national actor can use to help design their own monitoring systems, projections, strategies, investment plans or policies. The range of foresight products that Luxembourg Strategy has made available to the public also includes tables for monitoring megatrends, national sectoral strategies, and both national and international scenarios.⁸⁶

The Vision focuses on the economy and its interaction with the various transitions of the current era. It outlines the long-term development of the various strategies that the Ministry of the Economy defines in the shorter term. However, it is not a mere compendium of the strategies and policies already in place, since that would deprive it of its innovative and visionary character, and since that is done elsewhere.⁸⁷ The Vision updates and extends the foresight element of the project initiated in 2015 in Luxembourg by the TIR strategic study.

The Vision is not an operational strategy with quantified objectives. The Vision does not say what the future should be, but what the future could be, in anticipation of the 3 scenarios, if economic actors take up the necessary means. It is based on the observation of megatrends and the pooling of collective imaginations. It is not based on a quantified diagnosis of the economy, macro-economic projections of its future state, a prior assessment of existing strategies or a literature review. No calculations have been made specifically for the Vision. At the end of the collaborative foresight process, internal expertise from the Ministry of the Economy, comments from other ministries and partners, sectoral studies, macro-economic projections and existing scientific publications were taken into account to reinforce the thematic approach of the Vision, its systemic and multidisciplinary character, and the robustness of the assumptions on which it is based.

There is a solid basis for the weak signals and emerging trends listed in the Vision, the figures and data that are explored, and the ideas, hypotheses and new concepts that are put forward. These are all the result of in-depth horizon scanning (see [Glossary](#)) and cross-referencing of numerous publications and foresight studies, with an emphasis on the most recent in order to benefit from the latest perspectives. In the interests of transparency, a detailed list of references is provided in the footnotes.

As a result, the Vision can be read in two ways:

- A more 'visionary and conditional' reading, without recourse to the footnotes
- A more down-to-earth reading, extrapolating the lessons to be learnt from the signals that have already been observed and the trends that have already been documented, which are listed in the footnotes

Finally, a foresight mapping exercise was undertaken, illustrating the hypothetical change in the geographical deployment of future economic activities in the area over the next 27 years (see [maps of economic activities in 2023 and 2050](#), at the very beginning and end of this report), and the potential territorial impacts of the Vision were assessed, taking into account the principles of the Master Programme for Spatial Planning (PDAT2035/2050) ([Appendix 7](#)).

⁸⁶ Luxembourg Strategy (2022), [Tableaux de suivi prospectifs](#). Ministry of the Economy.

⁸⁷ See, for example, the [Programme National de Réforme \(PNR\) 2022](#), which takes stock of the policy responses to the major economic and social challenges facing the country.

The foresight exercise led to an exploratory vision consisting of 10 axes, or **10 building blocks for constructing ECO2050**. Each building block is justified with reference to plausible future scenarios (Figure 10). The building blocks are interconnected and reinforce one other (**internal coherence**): for example, circularity contributes to greater material self-sufficiency; efficiency and sufficiency complement technical progress; and transitions are an opportunity for greater motivation at work.

Internal consistency between the 10 building blocks of the ECO2050 Vision

Far from being independent of one another, the building blocks interact to form a veritable network. Improving strategic autonomy goes hand in hand with the application of sufficiency or investment in critical redundancy and storage, since renewing national production, adapting circular practices and diversifying supplies all help to reduce dependence on imports while minimising the ecological footprint.

Placing people and knowledge at the heart of the economy supports the reconciliation of the digital, ecological and social transitions insofar as investing in education and innovation prepares the workforce and industry to meet the challenges of tomorrow. Adopting a sustainable economic diplomacy strategy supports the ambition to improve Luxembourg's open autonomy by securing its partnerships in the green economy and technologies.

Finally, measures to ensure the sustainability of public finances and to anticipate transitions strengthen all the other building blocks, since they all require significant investment, with a good understanding of emerging sectors and challenges.

Economic models based on circularity and sufficiency make it easier to reconcile the digital, ecological and social transitions. Indeed, any reduction in the need for raw materials reduces the pressure on ecosystems and the scale of the societal, organisational and industrial transitions to be achieved.

In terms of **external coherence**, thanks to the representation of the various ministries within Luxembourg Strategy (Appendix 6), solid links have been created with international and European commitments, as well as with the national policies and laws that will guide national development in the coming decades, and which will have an impact on the economy. The various building blocks of the Vision combine in a variety of ways to facilitate the achievement of the Sustainable Development Goals (SDGs) set out in the National Plan for Sustainable Development (PNDD 2030): carbon neutrality, promotion of renewable energies, energy efficiency (PNEC 2030),⁸⁸ protection of biodiversity and the water cycle and adaptation to climate change (PNPN3 2030), sustainable mobility (PNM2035), and gradual reduction in land artificialisation (PDAT 2035/2050).⁸⁹ However, the Vision does more than simply facilitate the materialisation of the existing legislative and strategic framework. While it highlights the **synergies** to be exploited, it also brings to light certain dilemmas and **antagonisms** (e.g. between digitalisation or the creation of new settlements and respect for biophysical limits, between financing pension and social security systems and transitions) and outlines certain new ways of overcoming them (Figure 11).

88 The 2030 objectives of the Integrated National Energy and Climate Plan (PNEC), updated in July 2023, are:

- To reduce greenhouse gas emissions by 55% compared with 2005 (for sectors not covered by the European Emissions Trading Scheme)
- To achieve 37% renewable energy in final consumption (up from 25% in the previous PNEC)
- To improve energy efficiency by 44% (compared with a range of 40–44% in the previous PNEC)

89 PNPN: National Plan for the Protection of Nature; PNM: National Mobility Plan; PDAT: Master Programme for Spatial Planning.

NATIONAL PLANS

ECO2050 BUILDING BLOCKS	TIR2050	PNDD2030 (ODD)	PNEC2030/2050 ⁹⁰	PDAT2035/2050
1 <u>Improving open strategic autonomy to renew national production</u>	<ul style="list-style-type: none"> → Wind power, solar energy, biomass, biogas, geothermal energy, heat pumps → Efficiency/Storage → Energy supply security → Agricultural energy 	<ul style="list-style-type: none"> → Diversify and ensure an inclusive economy with a promising future (PNDD4) → Halt environmental degradation and respect the capacities of natural resources (PNDD7) 	<ul style="list-style-type: none"> → Energy efficiency → Energy supply security → Innovation, competitiveness and research → PV, biogas, geothermal, green H2, heat pumps → Aid for transition → Voluntary agreements and energy audits 	<ul style="list-style-type: none"> → Land artificialisation → Development in appropriate locations → Preserve natural resources
2 <u>Extending circularity and sufficiency throughout the economy</u>	<ul style="list-style-type: none"> → Sustainable, passive construction → Training in circular practices → Materials databases 	<ul style="list-style-type: none"> → Promote sustainable consumption and production (PNDD3) 	<ul style="list-style-type: none"> → Circular economy → Changing lifestyles → Geo- and bio-sourced materials 	<ul style="list-style-type: none"> → Circular & dense ZAEs → Sufficiency regarding land use → Multi-storey & multi-use construction
3 <u>Putting people, knowledge and wellbeing at the heart of the economy</u>	<ul style="list-style-type: none"> → Energy self-consumption → Mobility as a service → Limit the need for mobility (sufficiency) → Flexible working, coworking → Innovative eco-start-ups → STEM → Innovative business models (including agricultural) → The sharing economy 	<ul style="list-style-type: none"> → Ensure social inclusion and education for all (PNDD1) 	<ul style="list-style-type: none"> → Training for transitions → STEM 	<ul style="list-style-type: none"> → Experimentation and pilot projects → Socio-territorial cohesion
4 <u>Reconciling the digital, ecological and social transitions</u>	<ul style="list-style-type: none"> → The Energy Internet 	<ul style="list-style-type: none"> → Halt environmental degradation and respect the capacities of natural resources (PNDD7) 	<ul style="list-style-type: none"> → Energy-efficient data centres 	<ul style="list-style-type: none"> → Carbon neutrality
5 <u>Investing in critical redundancy, strategic storage and duplicated solutions</u>	<ul style="list-style-type: none"> → Energy storage 	<ul style="list-style-type: none"> → Protect the climate, adapt to climate change and ensure supplies of sustainable energy (PNDD8) 	<ul style="list-style-type: none"> → Energy storage 	<ul style="list-style-type: none"> → Territorial resilience → Green infrastructure

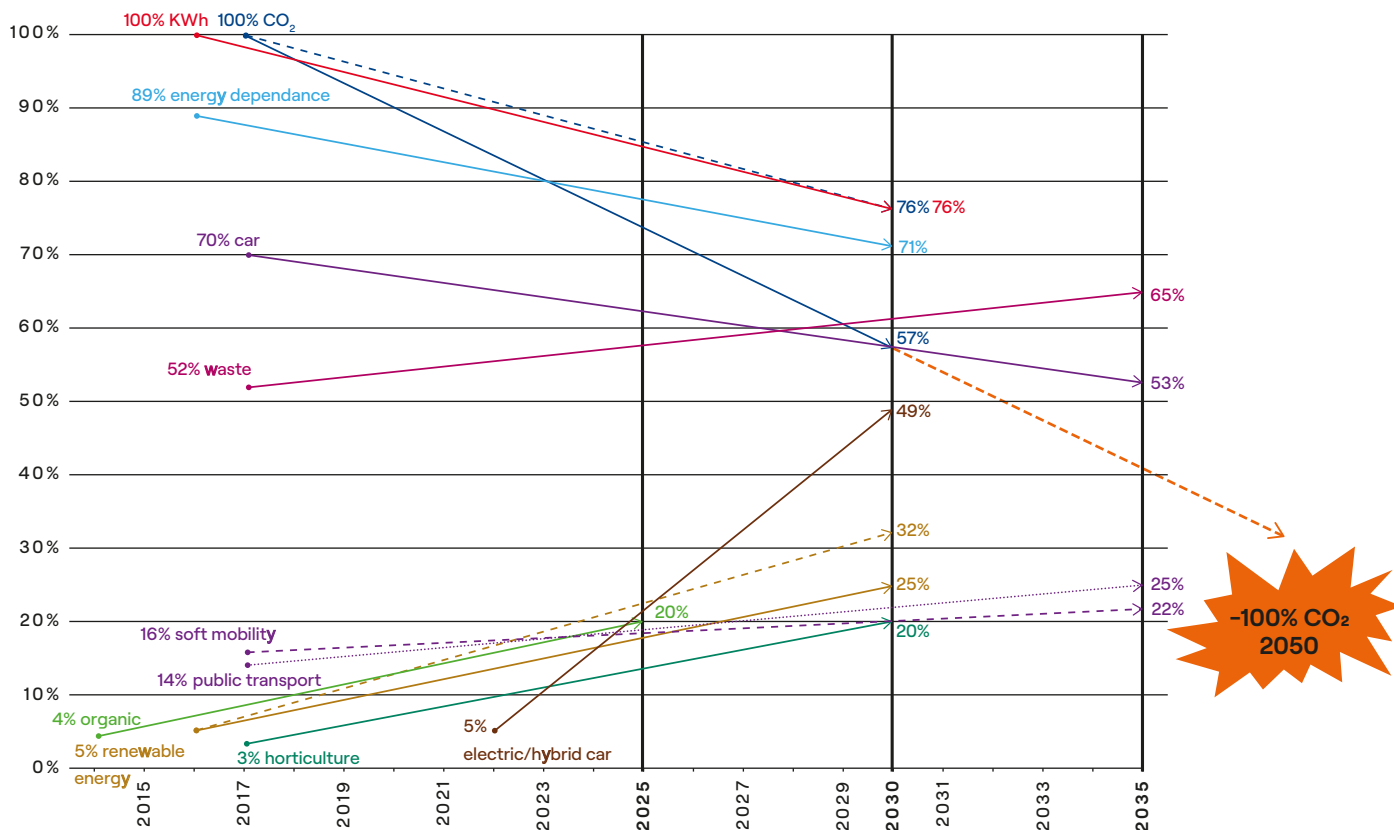
⁹⁰ MECDD (2023), *Mise à jour du Plan National intégré en matière d'Énergie et de Climat*. Presentation to ministers, 23 March 2023. The proposals listed here are both those for new measures and those for measures that have been strengthened compared with PNEC2020. The items in bold refer to the key 5 dimensions of PNEC 1 and 2: decarbonisation (including renewable energies); energy efficiency; security of energy supply; the internal energy market; and innovation, competitiveness and research.

NATIONAL PLANS

ECO2050 BUILDING BLOCKS	TIR2050	PNDD2030 (ODD)	PNEC2030/2050 ⁹⁰	PDAT2035/2050
6 <u>Simplifying procedures, shortening paths and facilitating transfers</u>	<ul style="list-style-type: none"> → Smart districts → Multiple modes of transport → Cycle paths → Urban planning 		<ul style="list-style-type: none"> → 15-minute cities → Light, low-carbon public transport → Procedures to be eliminated, reduced, accelerated or facilitated → Long-term contracts and contracts for difference → Harmonisation of town planning rules → Internal energy market → Renewable energy generation in GR and EU 	<ul style="list-style-type: none"> → 15-minute cities → Light, low-carbon public transport → Cross-border cooperation and governance
7 <u>Diversifying the economy by adapting it to the challenges of the future</u>	<ul style="list-style-type: none"> → Technological innovation → Electrification of mobility → Logistics → Smart grid → Energy renovation → Robotics, augmented reality, internet of things → Product as a service → Automotive campus and self-driving cars → High performance computers → Organic farming and energy 	<ul style="list-style-type: none"> → Ensure the necessary conditions for a healthy population (PNDD2) → Diversify and ensure an inclusive economy with a promising future (PNDD4) → Halt environmental degradation and respect the capacities of natural resources (PNDD7) → Protect the climate, adapt to climate change and ensure supplies of sustainable energy (PNDD8) 	<ul style="list-style-type: none"> → Decarbonisation → Green infrastructure, agroforestry, sustainable forest management → Local timber → Energy renovation → Electrification of mobility → Low-carbon freight and logistics → Consequences of global warming on health/agriculture → Monitoring of emissions and efficiency 	<ul style="list-style-type: none"> → Carbon neutrality → Green infrastructure → Preserve natural resources → Sufficiency regarding land use → Experimentation
8 <u>Integrating new challenges into economic diplomacy</u>		<ul style="list-style-type: none"> → Contribute, on the global stage, to the eradication of poverty and coherence in policies for sustainable development 	<ul style="list-style-type: none"> → Climate and biodiversity negotiations 	
9 <u>Ensuring sustainable and solid public finances</u>	<ul style="list-style-type: none"> → TIR investments: +/- 2% GDP/year for 35 years → Fintech → Digital economy → Microfinance 	<ul style="list-style-type: none"> → Ensure sustainable finances (PNDD10) 	<ul style="list-style-type: none"> → Carbon taxation → Sustainable finance and carbon finance → Subsidise carbon industry investment & ↘ carbon investment risk 	<ul style="list-style-type: none"> → Anticipation makes public finances more efficient
10 <u>Turning anticipation into a comparative economic advantage</u>	<ul style="list-style-type: none"> → Monitoring of technology trends 			<ul style="list-style-type: none"> → Territorial foresight

Figure 11. Summary of the different national long-term plans

The 3 scenarios and the corresponding ECO2050 Vision allow the Ministry of the Economy to strengthen the **coherence of new and existing strategies**. In addition to the 12 existing economic strategies, ECO2050 also takes account of the other **existing national sectoral strategies** (Figure 12). In all, there are around 50 such strategies in Luxembourg, with varying timeframes, drafted by experts in the respective fields with the aim of generating momentum and improving sectoral planning.



CO₂ EMISSIONS

- European target: -40% from 2005-2030. For 2017-2030 (index 100 for 2017): -24%pt.
- National target: -55% from 2005-2030. For 2017-2030 (index 100 for 2017): -43%pt.

FINAL ENERGY CONSUMPTION

- Target: 40-44% increase in energy efficiency compared to the 2007 EU PRIMES. For 2017-2030 (index 100 for 2016): -24%pt., from 47,000 GWh to 36,000 GWh.

DEPENDANCE ON ENERGY IMPORTS

- Target: reduce dependency from 90% in 2015 to 60% in 2040. For 2016-2030: -18%pt.

MODES OF TRANSPORT FOR HOME-WORK JOURNEYS

Targets for 2017-2035 (modes of transport as proportion of total journeys):

- 17%pt. reduction in the use of private cars
- +11%pt. increase in the use of public transport
- +6%pt. increase in the use of soft mobility

ORGANIC FARMING

- Target : 2025 20%. For 2014-2025: +16%pt.

ELECTRIC/HYBRID CARS

- Target: 49% of all cars by 2030. For 2022-2030: +44%pt.

RENEWABLE ENERGIES

- European target: 32% by 2030. For 2016-2030: +27%pt.
- National target: 25% by 2030. For 2016-2030: +20%pt.

RECYCLED HOUSEHOLD WASTE

- Target: 65% by 2035. For 2017-2035 : +13%pt.

HORTICULTURE

- Target: 20% by 2030. For 2017-2030: +17%pt.

Figure 12. Quantified targets for sectoral strategies adopted in Luxembourg (2021)⁹¹

⁹¹ Luxembourg Strategy provides an inventory and description of the more than 50 national sectoral strategies in Luxembourg, with a view to facilitating their coherent implementation. Luxembourg Strategy (2022), *Tableaux de suivi prospectif: les stratégies nationales*. Ministry of the Economy.

The 3 scenarios and the ECO2050 Vision can be a useful tool for all ministries whose strategies interact with the economy, and all companies seeking to define and update their own strategies (see participants in the ECO2050 process, [Appendix 6](#)). It is in everyone's interest to see these different strategies working together in a world with limited resources. The scenarios can be used to establish whether a proposed policy or strategy will prove to be robust in the face of a range of plausible futures. The Vision is intended to be capable of developing organically in different directions, and being continually improved. Future strategic initiatives that take the Vision as their framework will then be able to reinforce it, as well as making it broader and deeper. The scenarios and the Vision can be used to test robustness, to stress-test existing sectoral strategies and to develop them further. For each future policy or strategy, it will be useful to ask the following questions:

- Is it robust whatever future scenario emerges?
- In what respects is it consistent with the strategic economic Vision?
- Does it share the same assumptions as the Vision?
- Does it fit within the budget for available biophysical resources?
- Does it meet people's expectations in terms of social protection?
- To what extent does it clarify and/or extend the scope of the Vision?
- In what respects does it highlight shortcomings in the Vision that should be remedied?

It is part of Luxembourg Strategy's mission to support economic actors seeking to define or update their own strategies in the light of ECO2050. In addition to the use of the scenarios and the ECO2050 Vision by other bodies independently of their initial purpose, other foresight methods may be useful to companies, public authorities, territorial communities or individuals. These methods include (see also the [Glossary](#)):⁹²

- **Forecasting:** developing a better understanding of future technologies, skills or behaviours to inform investment or strategy today.
- **Horizon Scanning:** monitoring and analysing emerging trends, weak signals and potential developments to strengthen a systemic approach and anticipate risks and innovations.
- **Black Swans:** preparing for the next disruption that will challenge current certainties and significantly disrupt forecasts and plans. (The black swan event designed as part of ECO2050 is called 'Red Queen', see [Appendix 2](#)).
- **What if:** asking 'what if?' questions to explore the potential consequences of hypothetical events or decisions in order to better anticipate outcomes and make strategies more adaptive.⁹³
- **Visioning / Incasting:** using the ECO2050 Vision to align current actions and decisions with long-term goals aimed at bringing about a desired future. By integrating the perspectives of key stakeholders, strategies become more realistic and convincing.
- **Windtunneling (stress testing):** using ECO2050 scenarios to assess how certain strategic decisions would turn out when confronted with extreme conditions or major changes.
- **Backcasting:** defining a future objective, then determining and scheduling the trajectories, concrete actions, resources, deadlines and preliminary stages needed to achieve it.
- **Causal layered analysis:** examining different layers of understanding (cultural, symbolic, etc.) as a group to stimulate a change in values or worldviews, which is indispensable for bringing about a genuine transformation.
- **Foresight studies:** undertaking a study on the likely evolution of a given parameter or theme. Luxembourg Strategy provides a physical risk matrix and an adaptation plan for the economy (RISK2050 study), as well as an analysis of the tipping points determining national social transitions in Luxembourg (SOC2050 study).⁹⁴

92 Luxembourg Strategy (2023), [Glossaire](#). Ministry of the Economy.

93 See, for example, the definition proposed by the European Parliamentary Research Service (2023), [What if](#).

94 Luxembourg Strategy (2023), [Étude RISK2050](#). Ministry of the Economy & Luxembourg Strategy (2023), [Étude SOC2050](#). Ministry of the Economy.

The Vision thus offers a subsidiary strategic space, sufficiently concrete to serve as a clear and stable framework for economic actors, and sufficiently open so that each actor and each sector can deploy the means it deems appropriate in order to achieve the common goal: to transform ourselves within a generation.

In the next stage, it will be possible to simulate the effects on the national accounts, as well as on the socio-economic and biophysical domains, and to complete the macro-economic modelling of decarbonisation carried out by STATEC as part of the PNEC.

Finally, it is important to point out that the ECO2050 Vision is not a static piece of work that ends with its publication. Rather, it is a living document that needs to be revisited and adapted regularly, in response to the many internal and external developments that influence it.

I Method

II **The Vision**

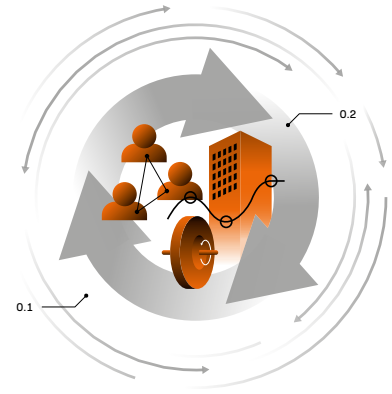
III Scenarios

IV Appendices

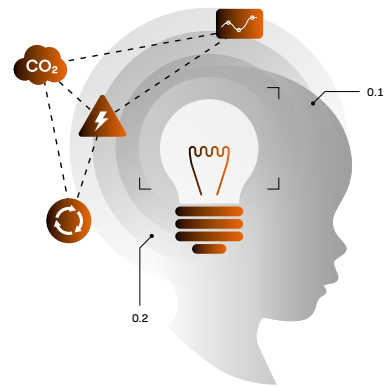
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The result of the ECO2050 consultative foresight initiative is a strategic vision structured around 10 building blocks. These 10 mutually beneficial and enabling building blocks are constructed around future-proof principles. The Vision emphasises that technological innovation has been and will remain a key factor in the dynamism and attractiveness of Luxembourg’s economy. Behavioural change is also necessary and the two are complementary in strengthening the economy. According to the principles of redundancy and precaution, hightech digital solutions and low-tech manual solutions complement each other, as do green and grey infrastructures and climate mitigation and adaptation. Other virtuous principles applied in all the scenarios considered include: autonomy, efficiency, sufficiency, wellbeing, transmission, cohesion, regeneration, circularity, proximity and preference for using local resources, simplification, diplomacy, multilateralism and anticipation. The 10 building blocks of the ECO2050 edifice are listed and illustrated on the present page, then detailed in the following pages:



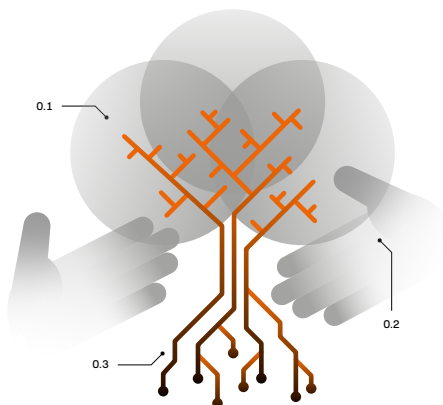
#2 Extending **circularity** and **sufficiency** throughout the economy



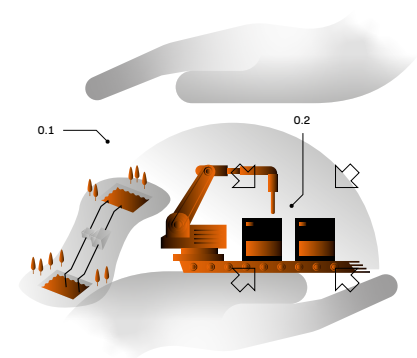
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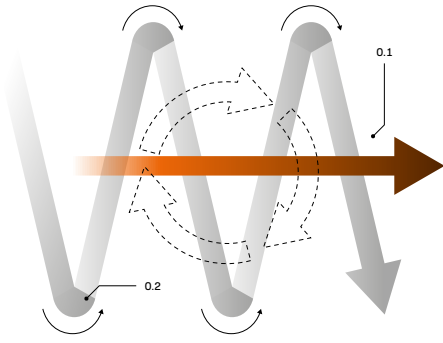
#1 Improving open strategic **autonomy** in order to revitalise national **production**



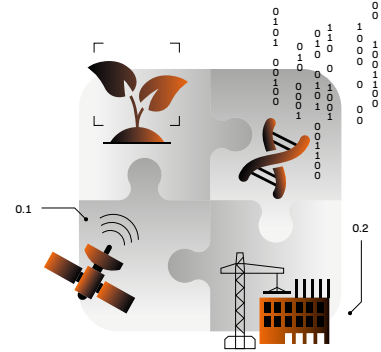
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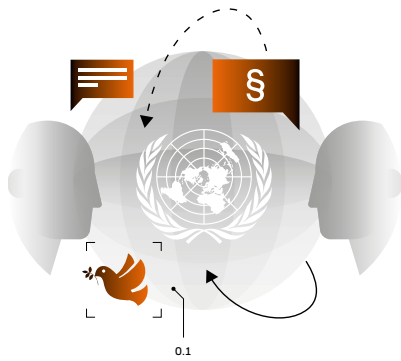
#5 Investing in critical **redundancy**, strategic **storage** and duplicated solutions



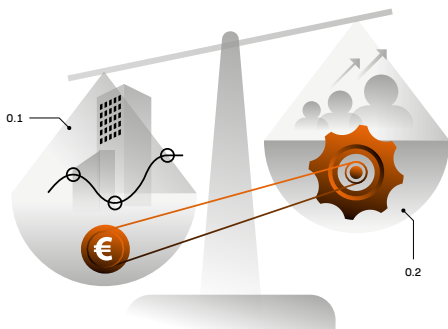
#6 Simplifying procedures, shortening pathways and facilitating transfers



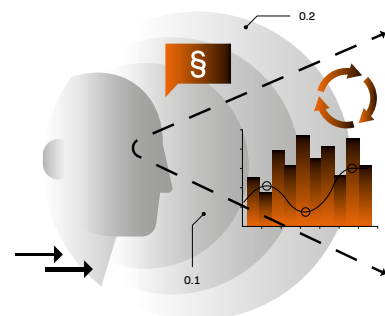
#7 Diversifying the economy by adapting to the challenges of the future



#8 Integrating new challenges into economic diplomacy



#9 Ensuring sustainable and solid public finances



#10 Turning anticipation into a comparative economic advantage



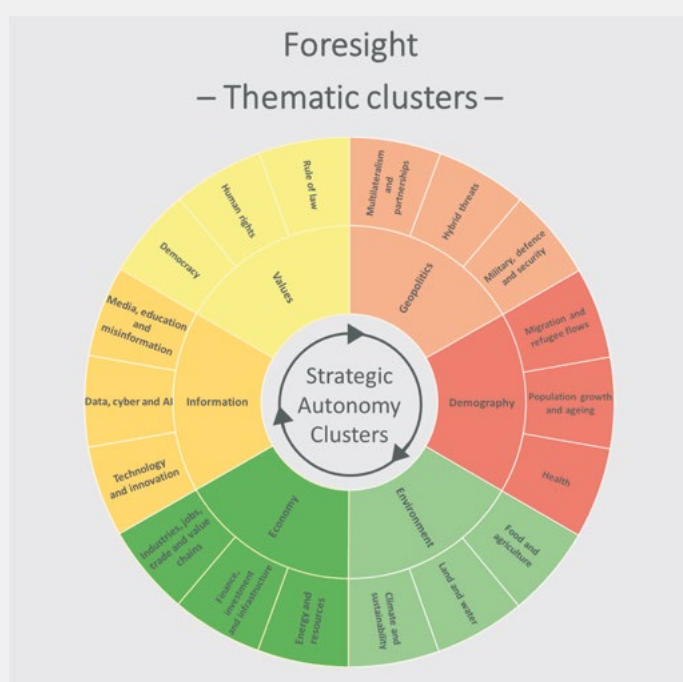
#1

Improving open
strategic **autonomy**
in order to revitalise
national **production**

Given the uncertainties of the various transitions and the vulnerabilities of supply chains in a period of international economic and political tension, an economy less dependent on imports and international market shocks is an asset for successfully managing these transitions.

The COVID-19 crisis has underscored the importance of maintaining essential resources and activities, including supply chains, within national, regional and European territories. Far from being unique to Luxembourg, the postCOVID-19 quest for greater autonomy and supply security is reflected in numerous economic future scenarios⁹⁵ (see [Chapter III](#) and [Appendix 3](#)) and forms the official policy of the EU:

EXAMPLE : EU STRATEGIC OPEN AUTONOMY



The 360° strategic autonomy wheel

illustrates policy areas in which the EU aims at more strategic autonomy, as well as the links between them. The wheel can help to understand links, set priorities and view potential conflicts. More autonomy in the digital green economy will, for example, require vast quantities of ‘rare earth’ materials, making the EU more (instead of less) dependent on imports. Reductions in energy consumption achieved through digitalisation of the economy (for example by reducing transport) will be partly offset by the increase of energy consumption by electronic devices and data centres. The wheel cannot solve such dilemmas, but can help to identify them.

Source: EU Strategic Autonomy Monitor, European Parliament, July 2022

The European Commission recently published its proposal to establish a framework to ensure a secure and sustainable supply of raw materials to support ecological and digital transitions and bolster the EU’s **resilience**. The regulatory dimension will potentially be structured around four main pillars:

- Defining the EU’s action priorities and objectives
- Enhancing the EU’s oversight, risk management and governance concerning critical raw materials
- Strengthening the EU’s critical raw material value chain (extraction, refining, processing, recycling) in a global context
- Ensuring fair and sustainable conditions of competition throughout the single market

Additionally, the European Commission has published a regulatory proposal for establishing a framework to encourage ‘net zero’ industry (Net Zero Industry Act (NZIA)). This aims to improve the **resilience and competitiveness** of ‘net zero’ technology production in the EU and to make the energy system safer and more sustainable, with the goal of ensuring that the Union’s overall production capacity for strategic ‘net zero’ technologies nears or meets at least 40% of the Union’s deployment needs by 2030. If approved, the regulation would also expedite progress towards the EU’s 2030 climate and energy goals as well as the transition to climate neutrality, and additionally

#1 Improving open strategic autonomy in order to revitalise national production

boost the competitiveness of European industry, creating high-quality jobs and bolstering the EU's efforts to become energy independent.

The business environment is likely to become increasingly competitive, with advantages going to countries which have resources and can offer the best energy prices. Given this, how can the material and energy autonomy of national production be improved while controlling costs? Which sectors or resources hold the most strategic interest, or have highest potential for replacing imports with domestic production, given the strengths and needs of Luxembourg's economy? How can a small nation with limited natural resources position itself in Europe amid what is increasingly becoming a global race for scarce resources and secure, sustainable and affordable energy (the **energy trilemma**)?

Successfully navigating these transitions will require **strong industry**,⁹⁶ relative technological and material sovereignty, and solid integration into international value chains. **Industrialists and craft workers** – whether longstanding, newly established, or yet to come – must be able to provide the goods and services required for these transitions, producing tools, parts, components, processes, and low-carbon and efficient technologies for both the domestic market and export. However, the OECD notes that production growth has been stagnant in the OECD zone since the 1970s.

In line with ongoing European regulations on decarbonising industry, energy independence and the supply of critical raw materials, Luxembourg will **navigate these transitions by revitalising industrial and craft production** and mitigating its dependencies. This can be achieved through the following means:

- A. **Assessing and prioritising sectors** where greater autonomy is possible
- B. **Preserving the biophysical base** in order to produce more sustainably and locally
- C. **Accelerating transitions** in resource-intensive production sectors
- D. **Securing and diversifying** basic supplies for production

A. Assessing and prioritising the potential for open strategic autonomy

Luxembourg, as an open and interconnected economy, has a low degree of strategic autonomy and relies on imports for its essential needs. Strategic autonomy related to supply is not the same thing as self-sufficiency. Rather, it is the ability to ensure the continuity of at least the most essential activities, even if one or more major suppliers fail as a result of geopolitical conflict, protectionism, pandemic, war, resource scarcity, pollution and so on.

A more precise understanding of the potential for self-supply and local production (TIR) for essential areas (energy, resources, land, water, food) will make clear how far it is possible to limit dependency. To give an example from food production, Luxembourg is capable of fully meeting its own beef and dairy requirements, and produces 60% of the pork it needs.

According to the EU Strategic Autonomy Monitor, Maslow's hierarchy of needs provides a useful tool for defining the essential needs which are of particular interest when seeking greater autonomy: most of these are found at the bottom of the pyramid and involve basic needs and interests, such as access to water, food, housing, healthcare, and security and defence, for which energy, resources and space are essential.

⁹⁶ Pierre Pailler (2023), *Franz Fayot, de la résilience à la relance*. Paperjam 17 February 2021.


Maslow's hierarchy of needs	Areas of strategic autonomy
 <p>Self-actualization desire to become the most that one can be</p> <p>Esteem respect, self-esteem, status, recognition, strength, freedom</p> <p>Love and belonging friendship, intimacy, family, sense of connection</p> <p>Safety needs personal security, employment, resources, health, property</p> <p>Physiological needs air, water, food, shelter, sleep, clothing, reproduction</p>	<p>EU identity, autonomous democratic federation, global role model</p> <p>EU as a normative power, values</p> <p>EU multilateralism/partnerships</p> <p>EU military security</p> <p>EU economic independence (supply chains)</p> <p>EU health security; EU energy security; EU food and water security</p>

Figure 13. Areas of strategic autonomy correlated with Maslow's pyramid, EU Strategic Autonomy Monitor 2022⁹⁷

Other essential goods for companies include semi-conductors, rare metals, batteries, active pharmaceutical ingredients, etc.⁹⁸ In the case of semi-conductors, the challenge is not to produce in Europe all the semi-conductors required across the continent, but to have sufficient production capacity that essential activities can be maintained in the event of a breakdown in external supplies.

In assessing the potential for autonomy, it is key to also consider the potential for strategic relocation or the establishment of new activities, which is a focus of the *Compatibiliteits-check* implemented by the Ministry of the Economy. This should take into account the interests of both the industrial and craft sectors.

The degree of foreign control over national companies is another aspect of economic autonomy. It is particularly pronounced in the manufacturing sector, where 34% of companies, 52% of gross added value and 53% of jobs are in the hands of foreigners.⁹⁹

B. Preserving the biophysical base in order to produce more locally

Preserving basic natural resources is essential for increasing local production and gaining autonomy for basic supplies. This involves reducing energy, material, space and water needs in production and avoiding rematerialisation. This can be achieved through technology, innovation and reducing consumption. Several strategies can be combined:

- Accelerating the **efficiency** of industrial processes (TIR and PNEC)
- Enhancing resource and energy **productivity** (TIR and PNEC)
- Increasing **research and development** (R&D) into autonomy
- Protecting against **rematerialisation**, the **rebound effect** and the **crowding-out effect**
- Promoting **sufficiency** in industrial processes and consumer behaviours
- Bringing **overconsumption** in line with the European average
- Investing in the **regeneration** of natural resources needed for production
- Optimising **domestic** resources (PDAT, Climate Platform)
- Incorporating **time**, a limited resource, into technological decision-making

To reduce the supply of fossil fuels, a priority should be to reduce demand for them. This was also projected by TIR for 2050. Reducing needs benefits autonomy, but also the energy and carbon transitions: when the total amount of **energy** required is reduced, less fossil fuel energy will need to be replaced by renewable energy, and fewer emissions will need to be avoided to achieve carbon neutrality, which in turn eases pressure on budgets. The energy demand reduction policies (by

97 European Parliament (2022), *EU strategic autonomy 2013-2023. From concept to capacity*. EU Strategic Autonomy Monitor

98 European Commission (2021), *In-depth reviews of strategic areas for Europe's interests*. European Industrial Strategy.

99 Eurostat (2023), *Foreign-controlled enterprises statistics – inward FATS*.

#1

Improving open strategic autonomy
in order to revitalise national production

voluntary agreement) of the EU and Luxembourg had already seen results before the energy crisis resulting from the invasion of Ukraine. The updated PNEC currently anticipates a further reduction in gross final **energy** consumption from roughly 45,000GWh in 2022 to 32,000GWh in 2030 and 29,000GWh in 2050.¹⁰⁰ At the same time, local electricity production is expected to increase, and dependence on the import of electricity is projected to decrease, from 80% today to close to 60% by 2050.¹⁰¹

This is all the more remarkable given that Luxembourg's population continues to grow¹⁰² and that the energy transition itself will be resource- and energy-intensive and requires significant investment. Electrifying the energy system is a slow process, which will require new material and financial resources on a vast scale: new wind turbines and solar panels, base production and storage plants, electric vehicles, electrolysers, heat pumps, liquefied natural gas tankers (since hydrogen tankers do not yet exist), pylons and high-voltage lines, and batteries. Solar panels, wind turbine blades and batteries require significant amounts of minerals and metals per unit of kWh generated or stored. In 2018, the OECD announced an increase in the cost of electricity due to the shift from controllable to intermittent energy sources.¹⁰³ This was confirmed by France Stratégie.¹⁰⁴ Bloomberg estimates that, to achieve carbon neutrality, 152 million kilometres of transmission cables will be needed, equivalent to the average distance between the Earth and the Sun.¹⁰⁵ According to Slameršak (2022), the additional energy needed to achieve the low-carbon transition could amount to between 10% and 34% of available energy. Most models overlook the energy investments involved in constructing and operating power plants using renewable energy, and their implications for the entire energy system.¹⁰⁶

Under the combined effect of the energy and digital transitions and the expansion of construction, individual transport and the consumption of goods, the demand for material and mineral resources is set to double by 2060.¹⁰⁷ To achieve the goals of the Paris Agreement, metal production could increase twelvefold by 2050.¹⁰⁸ The challenge is to ensure that decarbonisation does not result in a net increase in material and energy needs. Both the OECD and the IEA emphasise the risk of rematerialisation and potentially even the recarbonisation of energy generation, and therefore also of the production of goods and services.¹⁰⁹ A rapid transition to a fully renewable electrical system worldwide by 2060 could lead to a substantial rematerialisation of the economy, increasing the risk of hitting 'peak materials'.¹¹⁰

100 PNEC(1) for 2020, p. 181/207 and PNEC(2) updated in 2023, presented on 26 March 2023, MECDD. STATEC projections for the PNEC(2): Compared with the projections made for 2030, Luxembourg has set itself the target of consuming 44% less final energy (which amounts to a target of reducing final energy consumption by 30% compared with 2005 levels). ODC (2021), *Bilan de la compétitivité*. Ministry of the Economy.

101 Laurent Braun et al. (2023), *Projections du STATEC pour le nouveau PNEC: Autres activités économiques*. STATEC, Mesurer et modéliser la transition écologique, 19 May 2023.

102 Luxembourg had a population of around 640,000 in 2021, with a meteoric growth rate of over 2% between 2011 and 2019 and a population increase of 250,000 over the last 30 years. In 50 years, from 1970 to the present day, the population has almost doubled.

103 OECD (2018), *The Full Costs of Electricity Provision*, p. 17.

104 Jean Pisani-Ferry and Selma Mahfouz (2023), *Les incidences économiques de l'action pour le climat*, France Stratégie.

105 BloombergNEF (2023), *A power grid long enough to reach the sun is key to the climate fight*.

106 Aljoša Slameršak et al. (2022), *Energy requirements and carbon emissions for a low-carbon energy transition*. Nature Communication 13, 6932.

107 OECD (2019), *Global Material Resources Outlook to 2060, Economic Drivers and Environmental Consequences*.

108 Copper8 (2019), *Metal demand in the energy transition*.

109 'An energy system powered by clean energy technologies differs profoundly from one fuelled by traditional hydrocarbon resources. Building solar photovoltaic (PV) plants, wind farms and electric vehicles (EVs) generally requires more minerals than their fossil fuel-based counterparts. A typical electric car requires 6 times the mineral inputs of a conventional car, and an onshore wind plant requires 9 times more mineral resources than a gas-fired power plant. Since 2010, the average amount of minerals needed for a new unit of power generation capacity has increased by 50% as the share of renewables has risen', IEA (2022), *The Role of Critical Minerals in Clean Energy Transitions*, World Economic Outlook Special Report. OECD (2023), *Supply of critical raw materials risks jeopardising the green transition*, 11 April 2023.

110 Iñigo Capellán-Pérez et al. (2019), *Dynamic Energy Return on Energy Investment (EROI) and material requirements in scenarios of global transition to renewable energies*.

Despite the dominance of the tertiary sector in the national economy, **domestic material consumption** (DMC) is significantly higher than the average for OECD countries, at 24t/per capita (2020).¹¹¹ Given that domestic material extraction is very low (4t/per capita), the gap is filled by imports, primarily composed of construction materials, scrap metal and other metal products.¹¹²

Aside from energy and materials, what is the situation in Luxembourg regarding the supply of water and land, which also potentially constrain national production?

In terms of **land area**, 12.4% of Luxembourg's territory is artificialised (2021), making it one of the most urbanised countries in Europe.¹¹³ Between 1990 and 2020, building volume in Luxembourg doubled.¹¹⁴ Luxembourg also has some of the highest land resource prices and the most sustained construction rates, driven by population growth and housing shortages. Trade and industry directly use 1.2% of land and depend indirectly on technical and transport infrastructures which take up 4% of land. Economic, residential, agroforestry and recreational land uses often compete with these sectors. More than elsewhere, Luxembourg's land is a scarce resource that must be managed with the utmost care (see the [maps of economic activities in 2023](#) and [2050](#) at the beginning and end of this report, as well as [Appendix 7](#)).¹¹⁵

With regard to **water**, continental Europe is undergoing aridification.¹¹⁶ The European continent is directly experiencing the effects of climate change: a lack of precipitation leading to chronic droughts, heatwaves (the summer of 2022 was the hottest ever recorded), declining groundwater levels, receding glaciers and polar ice, increased risk of forest fires, rising surface water temperatures, declining soil moisture and reduced river navigability. In France, the availability of renewable water has decreased by 14% over the past two decades compared to the previous ten years, and is expected to further decline by 30% to 40% by 2050. None of the predictive scientific models suggest the situation will improve.¹¹⁷ The negative impacts on production systems (energy, industry, logistics, food) will need to be integrated into long-term infrastructural planning.

To successfully manage these transitions, proven technologies should be prioritised or those that are still being developed? The **time** needed for developing and commercialising new technologies and reconfiguring energy systems is often underestimated. It can take several decades for a technology to mature.¹¹⁸ It must be carefully chosen between established technologies and those not yet developed. Given the limited time available to achieve the transitions, a balance must be struck between innovation and improving existing technologies. Deploying existing, repairable and robust clean technologies on a large scale may offer advantages over focusing exclusively on new technologies.¹¹⁹

Beyond questions about the maturity of these technologies, businesses are also grappling with concerns about their availability on the national and European markets, investment costs, implementation challenges, the availability of trained personnel and innovation opportunities.

111 OECD (2020), [Environmental performance Luxembourg](#). EEA (2019), [Europe's material footprint](#). 8th Environment Action Programme.

112 Marco Bianchi et al. (2023), [Regional monitoring frameworks for the circular economy: implications from a territorial perspective](#), *European Planning Studies*, 31:1, 36-54.

113 According to the 2018 European LUCAS survey, only Malta exceeds Luxembourg's rate of artificialisation, with the EU average standing at 4.2%. Eurostat (2018), [Occupation des sols – Comparaison européenne](#). Lucas survey.

114 TVK et al. (2021), [Métriques du quotidien: matières et coalitions de l'alimentation et de la construction](#). Luxembourg in Transition, TVK, first pre-report, p. 11.

115 According to the functional approach to land use, the sum of urbanised and road surfaces, i.e. artificialised surfaces, corresponds to 12.4% of Luxembourg's land. DATer (2022), [Couverture et utilisation du sol au Luxembourg](#). Ministry of Energy and Spatial Planning.

116 ECMWF (2022), [European State of the Climate](#), Summary 2022.

117 Martine Valo (2023), [Le plan 'eau' d'Emmanuel Macron mise sur la sobriété et l'innovation technologique](#), *Le Monde*, 21 March 2023.

118 Robert Gross et al. (2018), [How long does innovation and commercialisation in the energy sectors take? Historical case studies of the timescale from invention to widespread commercialisation in energy supply and end use technology](#). *Energy Policy*, Volume 123, pp. 682-699.

119 Gaston Trauffer (2023), [What we can learn from the US Inflation reduction Act – Time to rethink EU Climate Policy](#), *FEDIL Echo*, 12 April 2023.

#1

Improving open strategic autonomy in order to revitalise national production

The **rebound effect** occurs when more of a good or service is consumed because it has become more efficient. Whenever an innovation allows to consume while using less energy or material, there tends to be an increase in consumption. The **Jevons paradox** occurs when the rebound effect is so strong that it offsets the energy or resource savings brought about by a technology. Direct effects occur when efficiency gains result in reduced resource prices and a resulting increase in demand – for instance, as cars become more fuel-efficient one drives more miles. Indirect effects arise when the same efficiency gains boost purchasing power, which is diverted to other products with potentially worse environmental impacts: for instance, buying a heavier SUV-type vehicle. This efficiency dilemma is clearly visible in the fact that primary energy consumption in the EU-27 is not changing significantly, despite a rapid reduction in the energy intensity of the economy.¹²⁰ To avoid such unforeseen consequences, innovation and technological advancements must be complemented by other economic, social and behavioural measures such as effective citizen communication and awareness-raising, regulatory tools and/or appropriate taxation if they are to be effective.¹²¹

The production apparatus may struggle to meet both the demand for new products for these transitions and existing demand for conventional consumer goods. Given the desired speed of transitions and constraints on natural and human resources, the industry may face a **crowding-out effect**. Choices must be made, trade-offs between supply and demand must be considered, and priorities must be set or revised.

To guard against a **crowding-out effect** (building block 1) and to free up energy, materials, water, or land for the production of essential goods and services, other production could be reduced. It would be prudent to discourage the use of certain **non-essential or overconsumed goods and services**, particularly those with a high ecological footprint. These include products which are overconsumed and harm our health (fast food, sugary soft drinks, social networks, chemical products, disposable plastics, immersive video games), or devices that replace what was previously done manually or offer services that were previously considered unnecessary. Other examples include mass air travel, fast fashion, long distance food imports, luxury products, some single-use plastic packaging and utensils, heated terraces and urban sprawl. Methods to disincentivise these include better informing consumers, implementing the **Klima-Biergerrot (KBR) proposals on planned obsolescence**, and addressing food waste and advertising that encourages such consumption.

¹²⁰ EEA (2021), *The Jevons paradox for energy consumption in the EU-27, 1995-2019*.

¹²¹ Freire González (2022), *The Jevons Paradox and Rebound Effect: Are we implementing the right energy and climate change policies?* OECD Forum network.

Rematerialisation, rebound effects, crowding-out effects and overconsumption are all factors that can either diminish or increase the physical base of production. Investing in the preservation and **regeneration** of natural resources could greatly reduce the pressure on these resources so that they can continue to enable production. This pressure will increase as environmental crises intensify. This results in a new need, **to adapt these resources to the effects of climate change and biodiversity loss**.

Given these constraints, reducing resource needs through efficiency and sufficiency, technological innovation, applied research, and increasing resource **productivity** can improve economic **competitiveness**, industrial supply security and the viability of an energy transition. However, the transitions will not be achieved through **technology and innovation alone**.¹²² A coordinated effort towards **sufficiency** is essential; without it, the revitalisation of industrial policy might not be financially viable.¹²³

EXAMPLE : SUFFICIENCY IN INDUSTRY

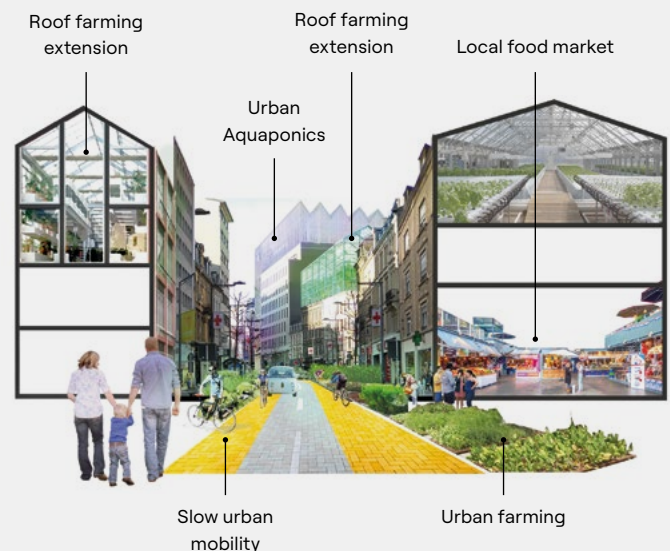
Defining Sufficiency:

Limiting the production and consumption of goods and services to a level that is 'sufficient' and not superfluous. 'A set of measures and daily practices that avoid demand for energy, materials, land and water, while delivering human wellbeing for all within planetary boundaries.' (IPCC, 2022)¹²⁴

'A reduction in resource consumption that does not result from efficiency gains in the use of resources'. (FRANCE STRATEGIE, 2023)¹²⁵

In industry, this can mean:

- Decreasing waste production and increasing the rate of **incorporation of secondary materials**
- Developing **'made in Luxembourg'** products
- Producing fewer goods and services that are not essential for the transitions, and more goods and services that are
- **Bringing together facilities that produce and consume waste heat**
- Sizing: building and equipping smaller, lighter vehicles, more modular housing
- Supplying components for **self-construction**
- **Extending the lifespan of equipment**
- Reducing lighting



Integrated hubs localising production with consumption, Beyond Luxe (2021), Luxembourg in Transition
Source: <https://luxembourginttransition.lu>

122 'Sustainability cannot be achieved by technological innovations alone, but requires a continuous process of institutional and behavioural adjustment'. Mario Giampietro and Kozo Mayumi (2018), *Unraveling the Complexity of the Jevons Paradox: The Link between Innovation, Efficiency, and Sustainability*. Frontiers in Energy Research.

123 Aude Pommeret (2023), *Rapport Thématique Sobriété*. In: Jean Pisani-Ferry and Selma Mahfouz (2023), *Les Incidences économiques de l'action climatique*. France Stratégie & National Academy of Technologies of France (2023), *Matières à penser sur la sobriété*. Summary of the 2022 Seminar of the National Academy of Technologies of France.

124 IPCC (2022), *Climate Change 2022: Mitigation of Climate Change*, p.31.

125 Jean Pisani-Ferry et Selma Mahfouz (2023), *Les incidences économiques de l'action pour le climat*, France Stratégie, pp.41-42.

#1

Improving open strategic autonomy in order to revitalise national production

ENGIE estimates that the adoption of practices of sufficiency could mean that global energy demand falls by 28% by 2050.¹²⁶ According to the National Academy of Technologies of France, sufficiency is necessary for progress, and progress is necessary for sufficiency. One example is **low-tech** – that is, low-tech solutions and de-complexified products that are easy to repair and maintain, with intelligent, technologically and behaviourally innovative designs.¹²⁷ Other examples of possible savings include reusing wastewater and pricing limited resources progressively, with the rate increasing with volume consumed in order to discourage ‘comfort’ consumption.¹²⁸ In general, the aim is to distinguish between **uses that are necessary** and those that are **convenient**, and to eliminate over-consumption in the latter case. For Luxembourg, the KBR has called for per capita overconsumption of materials, energy, land and water to be brought down to the EU average, and Climate Platform has asked the PNEC to further investigate the question of on sufficiency in order to curb overconsumption.¹²⁹

Industrial sufficiency in the use of materials is not currently covered by the draft EU regulations contained within the Critical Raw Materials Act (CRM Act). The National Academy of Technologies of France is calling for a global, equitable, urgent approach to this issue, coordinated at national and intra-community level.¹³⁰ **Sufficiency, behavioural change, low-tech and circularity** (building block 2) together provide a set of tools for increasing national production.

C. Accelerating the transition of resource-intensive production sectors towards more sufficient systems

The transitions will require considerable investment, and even a new industrial revolution, which will have to be financed by a dynamic economy. The national tradition of industrial production must be continued and transformed. To **accelerate the transition** of industrial sectors that use large quantities of energy,¹³¹ materials, space or water, the state must increase its current efforts, through measures such as:

- Introducing a tax system and dedicated aid to fulfil the **industry decarbonisation roadmap**, in compliance with EU law
- **Supporting and advising companies**, particularly through **Luxinnovation** and **Klima-Agence**, as they transition and implement PNEC measures
- **Monitoring the effectiveness of state aid** in achieving resilience, inclusiveness and competitiveness

The national greenhouse gas reduction targets for industry and construction set out in the PNEC are very ambitious (-40% in 2030 compared with 2021). Based on emissions of 407kt CO₂eq in 2021, STATEC projects that a 131% increase in emissions from manufacturing production (including construction and excluding the Emissions Trading System (ETS)) between now and 2050 would be largely offset by large-scale energy efficiency gains (-193%) and fuel switching (-25%).¹³²

¹²⁶ ENGIE (2023), [What is energy sufficiency?](#)

¹²⁷ Philippe Bihouix (2022), [Face aux tensions sur les ressources, miser sur les low-tech?](#), presentation by the AREP group at the [Luxembourg Strategy conference](#), 17 October 2022.

¹²⁸ Martine Valo (2023), [Le plan 'eau' d'Emmanuel Macron mise sur la sobriété et l'innovation technologique](#), Le Monde, 21 March 2023.

¹²⁹ MECDD (2023), [Avis de la plateforme pour l'action-climat et la transition énergétique relatif à l'avant-projet de la mise à jour du PNEC du Luxembourg pour la période 2021-2030](#). Final version of 11 July 2023.

¹³⁰ National Academy of Technologies of France (2023), [Matières à penser sur la sobriété](#). Summary of the 2022 Seminar of the National Academy of Technologies of France.

¹³¹ For the EU Commission, energy-intensive industries include: raw materials, manufacturing of products with high environmental impact: chemicals, iron and steel, forest-based products, plastics, refining, cement, rubber, non-ferrous metals, fertilisers, etc. European Commission (2023), [Energy Intensive Industries ecosystem and LSP\(s\)](#).

¹³² Laurent Braun et al. (2023), [Projections du STATEC pour le nouveau PNEC: Autres activités économiques](#). STATEC, [Mesurer et modéliser la transition écologique](#), 21 April 2023.

To support Luxembourg's industry as it strives to decarbonise by 2050, to meet its 2030 climate targets, to contribute to Luxembourg's 2030 energy targets, and to meet the requirements of the EU's Emissions Trading System (ETS), the Ministry of the Economy drew up a **roadmap in 2023 for decarbonising Luxembourg's manufacturing industry** by 2040/2050, working in close collaboration with the Ministry of Energy and Spatial Planning (MEA) and the Ministry of the Environment, Climate and Sustainable Development (MECDD). The industrial sector (both ETS and non-ETS) has already reduced its emissions from 3,300kt CO₂eq (2005) to 1,900kt CO₂eq (2021),¹³³ even though emissions from the sector rose by 21% from 2020 to 2021 as a result of COVID-19 counter-shock.¹³⁴

To further support businesses in their efforts to decarbonise, **business support schemes** will be extended, made conditional, and targeted more directly. State aid to businesses has a significant steering effect. By supporting innovation and encouraging businesses to protect the environment and the climate, it gradually helps to make the economy more sustainable and more digital. Having given out almost €1 billion in state aid over the period 2018–2022,¹³⁵ the government will increase and focus its financial support for businesses for the decades to come.

'Choices [must be made]: we will have to redefine aid to so that it encourages investment in energy efficiency, emissions reduction and circularity. Gone are the days when technologies of the past were supported in just the same way as climate-friendly innovation.'

Minister of the Economy Franz Fayot, *Carte blanche*, Paperjam (June 2023).

D. Securing and diversifying basic supplies

To give industry and SMEs more **secure access** to competitively priced energy and raw materials at national, regional and European level over the long term, supply sources will be diversified. A greater proportion will be produced and extracted locally, including by companies themselves. The collection and re-use of secondary materials can be structured according to their trading area in the Greater Region or beyond. Craft production already operates for the most part on the basis of national and inter-regional supply and processing chains. Local resource use will be optimised on a case-by-case basis for companies that do not rely mainly on imports. Finally, strategic reserves will be built up at national and regional level ([building block 5](#)).

To illustrate the process of **strategically securing and diversifying** national production, the following measures can be identified. Some of these are already provided for in other long-term strategic documents, particularly the PNEC.

Energy types will be diversified. It will be necessary to develop options other than electricity, including geothermal energy, solar energy, biogas and district heating networks (supplied by these sources and by industrial heat). The government will support industry in generating more **energy** on-site. The PNEC aims to encourage the installation of solar panels on every suitable roof on industrial buildings. Such support could be extended to geothermal energy, mutual heating networks and self-consumption. To bring electricity prices down, industrialists are also calling for greater attention to demand management and local storage capacity.¹³⁶

Research and industry will help meet the **scientific and technological challenges** posed by this transition, particularly in terms of alternative technologies and materials, resource sufficiency

¹³³ Laurent Braun et al. (2023), *Projections du STATEC pour le nouveau PNEC: Autres activités économiques*. STATEC, Mesurer et modéliser la transition écologique, 19 May 2023.

¹³⁴ MECDD (2022), PNEC presentation. Interministerial Committee for Climate Action, Meeting of 6 September 2022.

¹³⁵ For all the different financial support measures, the Minister of the Economy granted a total of €906 million to businesses over the period 2018–2022, through different types of aid (subsidies, advances, guarantees (managed by the State Treasury), etc.). More than half of this (51.7% or €469 million) was granted in the form of aid to companies for investments in Luxembourg totalling €1.5 billion. Aid for environmental protection alone amounted to €95 million and generated investment of €404 million. Ministry of the Economy (2023), *Franz Fayot a fait le point sur les aides étatiques aux entreprises*. Press release 9 February 2023.

¹³⁶ FEDIL (2023), *National Climate and Energy Plan – Update 2023*, note, p. 10.

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and the robustness and interconnectedness of energy networks and systems with a high level of renewable use. Basic and interdisciplinary research will analyse the value chains of critical minerals and consider what substitutes might be possible ([building block 2](#), [building block 3](#)).

To successfully bring about a large-scale shift to electric energy, the expansion of mines around the world is essential, as are gains in efficiency, sufficiency, innovation and metal recycling in Luxembourg itself.¹³⁷ The state can promote **geological prospecting** for resources in Luxembourg, the Greater Region and the EU, in compliance with physical and regulatory constraints and existing environmental, health and social standards. There will be a call for R&D and new digital technologies to provide precise, efficient, non-invasive and non-chemical methods of exploration and resource extraction, as well as remediating sites at the end of their life. These methods must be economical in terms of energy, land and water.¹³⁸ Renaturation and rewilding offer opportunities for developing these areas and generating 'ecopoints'.

This will require digitising geological maps and visualising geoscientific data in three dimensions. France provides an example of the strategic, economic and technical monitoring of metals: in 2022 the French Observatory of Mineral Resources (OFREMI) was set up to help secure supplies of critical metals. The Observatory monitors the global value chains of strategic metals and the current and future supply needs of the French industrial sector, and produces the risk analyses required for all investment decisions.

To geographically diversify dependencies, European **holdings** can be acquired in companies outside the EU to gain access to raw materials or semi-finished and finished products. At an international level, **commercial agreements** and strategic partnerships can be created in order to group investments and secure dedicated supplies. **Electricity supply contracts** are becoming increasingly long-term, with their deployment facilitated by a risk reduction system (PNEC).

At the EU level, European innovations and technologies will be better protected (e.g. the Carbon Border Adjustment Mechanism (CBAM)) and Europe will cease to be an incubator for the US and China. The integration of the borderless internal market will be completed, enabling future technologies to achieve **critical mass within a large single market**.

137 IHK Bayern (2017), [Leitfaden zur Rohstoffsicherung](#).

138 WEF (2020), [New Nature Economy Report II – The Future Of Nature And Business](#), Ch. 2 on Nature positive metals and minerals extraction.



#2

Extending
circularity and **sufficiency**
throughout the economy

Europe has relatively few naturally occurring resources and raw materials. In terms of production sovereignty, it has much to gain by building a **truly circular and sufficient European economy**. In fact, the Rifkin Study argued that Luxembourg could become Europe's first circular nation by 2050, an objective that remains desirable.

The circular material use rate in Europe was only 11.7% in 2021. According to EUROSTAT's data and definitions, Luxembourg's rate has been falling since 2010, dropping to 9.9% in 2020.¹³⁹ For Luxembourg, different calculation methods result in different rates. If only domestic reuse of secondary materials is taken into account, the rate is 4%. If imports of secondary materials are also taken into account, the circular material use rate rises to 31% for Luxembourg's economy, which imports scrap metal and metal waste on a massive scale for the steel industry.¹⁴⁰ The large number of cross-border workers, who contribute to the consumption and disposal of materials, make it difficult to compare Luxembourg with other countries.

At a global level, **the circular economy is currently stagnating or even declining**. It accounts for only 8% of the world's economic activities and flows.¹⁴¹ For instance, the widespread, linear use of plastic (an extremely useful material) since the 1950s is now causing major environmental pollution problems, particularly in the seas. Yet its overall recycling rate is currently 6%, and the volume of production is estimated to triple by 2060.¹⁴²

So the question is, how to move the national circular economy forward?

First, let us go back to basics.

Circularity broadly follows the 5Rs approach. Broadly speaking, this means **refusing** overconsumption, **reducing** waste volume, **reusing** materials, extending the life of products and avoiding waste, **repairing** instead of throwing away, reconditioning and consuming differently, using resources more smartly, and **recycling** residual waste. Notably, recycling is considered here as the option of last resort.

The circular economy distinguishes between two main cycles: **the technical cycle and the biological cycle**. In the technical cycle, products are kept circulating through reuse, repair, refurbishment and recycling. In this way, materials are kept in use and do not become waste. In the biological cycle, biodegradable materials are returned to the soil and decomposed through processes such as composting and anaerobic digestion. This allows the soil to regenerate nutrients, which can then be used to create new biodegradable materials, ensuring that the cycle continues.

In the future, the focus will need to be not only on recycling materials, but also on **reusing** products without going through the waste chain. As a result of Luxembourg's high domestic consumption of materials and imports of biomass in the form of food, residents on average produce more waste and throw away more food than their peers in the EU. There therefore are ample opportunities for reducing waste volume and, thereby reducing the need to recycle.

139 This indicator measures the proportion of materials recycled and reintroduced into the economy – thus saving the extraction of primary raw materials – as a proportion of overall material usage. The rate of circular use of raw materials, also known as the circularity rate, is defined as the ratio of circular use of raw materials to overall use of materials. The overall use of materials is measured by adding the aggregate domestic consumption of materials (DCM) and the quantity of circular use of materials. Eurostat (2023), [Circular material use rate](#).

140 Marco Bianchi et al. (2023), [Regional monitoring frameworks for the circular economy: implications from a territorial perspective](#), European Planning Studies, 31:1, 36–54.

141 'Circularity gap widens as extraction increases. A rise in raw material extraction has led to a fall in the circular share of the world economy from 8.6% in 2020 to 7.2% in 2023, according to a study by Deloitte and specialist consultants Circle Economy, whose figures are based on the volume of materials being recycled for a second life. A more circular economy would lead to a 1/3 reduction in current extraction levels, say the report's authors', Circle Economy (2023), [The Circularity Gap Report](#).

142 Plastic production has risen from 0 to 450 million tonnes between 1950 and the present day. Fuelled by economic and demographic growth, it is expected to multiply by a factor of 3 by 2060, OECD (2023), [Global Plastics Outlook to 2060](#).

#2

Extending circularity and sufficiency throughout the economy

Residual organic waste and wastewater are potential sources of energy and biological nutrients, which should be recycled in the form of biogas and digestate, producing compost or fertilisers that can be returned to the soil in order to maintain the fertility necessary for food production.

Sufficiency consists in a reduction in the consumption of resources that does not result from efficiency gains in the use of these resources.¹⁴³ This involves limiting the goods and services produced and consumed to a level that is sufficient but not superfluous. The Vision invites to move away from the logic of linear accumulation that prevails today. Sufficiency includes all policy measures and everyday practices that avoid any initial demand for natural resources while ensuring everyone's wellbeing within planetary boundaries.¹⁴⁴ Sufficiency is one of the megatrends observed by the European Commission, which considers that: 'efficiency applied to production and consumption will not be enough to halt environmental degradation, as past rebound effects have shown. An absolute decrease of consumption, especially for high-consuming classes [...] must be achieved.'¹⁴⁵

Efficiency and sufficiency are different concepts. To take an example from the energy sector: **energy efficiency** describes a system's energy consumption in relation to the service provided (a TV rated A++ consumes less energy than the same TV rated A+), whereas **energy sufficiency** aims to consume as little energy and raw materials as possible while ensuring reasonable comfort. If a television rated A++ is 139cm diagonally and a television rated A+ is 80cm diagonally, then the smaller TV will consume less energy, despite its lower efficiency rating. Sufficiency means choosing the 80cm model rather than the 139cm model, not only because it consumes half as much electricity in absolute terms, but also because its construction uses three times less materials and energy (and therefore less grey energy).¹⁴⁶

Circularity and sufficiency contribute to greater autonomy in production and consumption, as well as to the decarbonisation of production and the efficient use of resources. Carbon neutrality can not be achieved without circularity and sufficiency. According to the **Circular Economy Strategy Luxembourg report**, co-published in 2021 by the Ministry of the Economy, 'better control of raw material and product flows reduces the dependence on suppliers, contributing to resource productivity and greater security of supply for both businesses and Luxembourg as a country, as well as lower costs for waste management'. Similarly, the climate platform observed that '[in the face of] climate change and geopolitical or health issues, Luxembourg has had to deal with a continuing shortage of building materials. The transition to more holistic management of resources and flows of products and raw materials is therefore becoming essential'.¹⁴⁷

The widespread application of the principles of circularity and sufficiency throughout the economy and society can be promoted by the following actions:

- A. **Accelerating and extending the implementation of existing circular strategies**
- B. Reducing the **land and material footprint** of the economy
- C. Developing and structuring **circular industries**, innovating and substituting materials

143 Jean Pisani-Ferry and Selma Mahfouz (2023), *Les incidences économiques de l'action pour le climat*, France Stratégie.

144 IPCC (2022), *Climate Change 2022: Mitigation of Climate Change*.

145 European Commission (2023), *Sufficiency*. Competence Centre on Foresight. The IPCC defines sufficiency policies as 'a set of measures and daily practices that avoid demand for energy, materials, land and water while delivering human well-being-for-all within the planetary boundaries' in IPCC (2022), *Climate Change 2022: Mitigation of Climate Change*, p. 31.

146 Energie-Environnement.ch (2023), *Stratégie énergétique 2050 de la confédération helvétique*.

147 MECCD (2023), *Avis de la plateforme pour l'action-climat et la transition énergétique relatif à l'avant-projet de la mise à jour du PNEC du Luxembourg pour la période 2021 – 2030*. Final version, 11 July 2023.

A. Accelerating and extending the implementation of existing circular strategies

For the World Bank, circularity must become the dominant approach in European economies and evolve into a whole-of-government agenda.¹⁴⁸ **To unleash the full potential of circularity and sufficiency** and make them mainstream in the economy and society, the specific reasons that prevent them from becoming widespread must be better understood.

In Luxembourg, businesses report that responsibility for the circular economy is scattered among institutions, and that there is a mismatch between ambitions and the resources made available. They call for circular principles to be integrated into public procurement, which has remained 'linear' (building block 6). Others argue that individual companies and the state cannot succeed alone, as municipalities and the local ecosystem play a crucial role: 'Municipalities should go beyond traditional waste management policies and take advantage of their proximity to citizens, manufacturers, retailers, service providers and research institutions to channel local resources for the deployment of circular innovations throughout the value chain of priority sectors and products'.¹⁴⁹

According to the *Baromètre de l'Économie* for the second half of 2021, the main obstacles to implementing circular principles are lack of time, lack of technical solutions, lack of manpower and lack of budget or return on investment. The lack of natural resources and high land prices do not help matters.¹⁵⁰

Price certainly discourages circularity. The ECO2050 Vision is based on the hypothesis that, in the face of increasing prices, shortages and delivery delays for raw materials, circularity will become an economic necessity. To encourage the circular economy the state can act to make reuse, recycling, repair, reconditioning and reconstruction more competitive than manufacturing from scratch. To do this, it can offer **innovation, training and support** on the one hand, and on the other, **regulation, standardisation** (e.g. the right to repair, warranties, shelf life) and **subsidies** (e.g. specific state aid, zero-interest loans, reduced VAT, *Reparaturbonus*, and subsidies for reusing materials on the same building site).

The aim is to increase pace and scale in order to **accelerate and generalise the implementation of circular economy strategies** in Luxembourg. An initial strategy was launched in 2021, drawn up under the supervision of the Ministry of the Economy, the Ministry of Energy and Spatial Planning and the Ministry of the Environment, Climate and Sustainable Development. This was followed by the 'Economic Activity Zones (ZAE)' toolkit and the Ministry of the Economy's *Guide pour la conception durable des ZAE*, as well as the *Leitfaden Gestaltung Aktivitätszonen* jointly adopted in 2022 by the MEA and the Ministry of the Economy.

The government has put in place a range of instruments to encourage, strengthen and broaden the circular economy. To support businesses, **Luxinnovation** provides tools and support in the form of mapping. It has specific initiatives on sustainability enablers, the wood cluster and *Holzhaft*, start-up ecosystems and creative industries, together with its 'Fit4sustainability' programme and its 'circularity' materials assessment programme. The **Klimapakt fir Betriber** supports SMEs undertaking energy transition and climate action. In its assessment of the PNEC, the climate platform has proposed that the **Klimapakt fir Betriber** should include targeted support measures aimed at the transition to a circular economy. Craft workers are key actors in the transition to a circular economy, and the craft industry stands out for its good practices in terms of waste management and the use of local materials.

148 World Bank (2022), [Squaring the circle: Policies from Europe's circular economy transition](#).

149 Marco Bianchi et al. (2023), [Regional monitoring frameworks for the circular economy: implications from a territorial perspective](#), *European Planning Studies*, 31:1, 36-54.

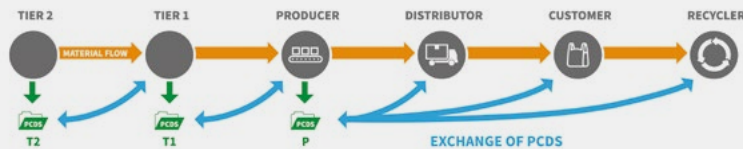
150 Ibid.

#2 Extending circularity and sufficiency throughout the economy

Terra Matters and the **Luxembourg Institute of Standardisation, Accreditation, Safety and Quality of Products and Services (ILNAS)** are two other key actors in the move towards circularity. ILNAS has a role to play in monitoring the market for certain secondary products. The **Neobuild** economic interest group (GIE) specialises in technological innovation in the sustainable construction sector.

EXAMPLE : CIRCULARITY, TERRA MATTERS

- The GIE Terra Matters, created in February 2023, aims to promote and support the transition to a circular economy by developing, managing and promoting the '**Product Circularity Data Sheet**', a circular data management system for materials and products initially launched by the Ministry of the Economy.
- This new public-private partnership brings together the Ministry of the Economy and the CdC.
- The main tasks of this GIE are:
 - Promoting and supporting businesses as they transition to a circular economy;
 - Supporting the development and provision of the PCDS as a technical solution and providing associated value-added services;
 - Managing and promoting the ecosystem around the PCDS;
 - Collaborating in the design and development of industry standards to provide reliable data on the circular characteristics of materials and products;
 - Collaborating with partners to develop and apply the PCDS.



Source: <https://pcds.lu>

Alongside technological innovation, achieving the goals of the circular economy will also require innovation in the **business model** used (e.g. moving from selling to letting, from owning to sharing) and social innovation (new ways of interacting or connecting businesses and people).

The new Circular Economy Action Plan (2020) and the new legislative initiatives on **eco-design and the right to repair** (2023) could change the situation. As one of the cornerstones of the European Green Deal, the Circular Economy Action Plan provides for various initiatives corresponding to the different stages in the life cycle of products, from design to promoting circular economy processes, encouraging sustainable consumption and ensuring that the resources used remain in the EU economy for as long as possible.

The EU's circular economy plan is currently confined to waste and makes no provision for the production or import of non-renewable raw materials such as metals, plastics or minerals. The Vision proposes to extend the scope of the plan to regulate not only waste generation but also product design and manufacture. At the EU level, it should be compulsory for new equipment and goods, whether imported or produced domestically, to contain high levels of recycled materials. This would provide an equivalent of the **CBAM for materials**.

Outside pressure is necessary but not sufficient. Many initiatives aimed at encouraging repair, reuse and recycling are mainly the result of national decisions and the pooling of resources at the regional level. Much can be done to increase the volume of economically profitable materials to be processed by structuring the activities and actors involved in the sector ([building block 6B](#)).

B. Reducing the land and material footprint of the economy by economising, densifying and recycling

The United Nations Environment Programme (UNEP) estimates that 8% of the world's energy consumption comes from the extraction and production of **virgin metals** – that is, those extracted directly from deposits as opposed to those produced by recycling. The same processes also contribute to greenhouse gas emissions. UNEP has also shown that, statistically, available deposits are becoming depleted and that energy consumption increases inversely with their metal content. Finally, it has demonstrated that producing recycled metal requires considerably less energy. By limiting needs and recycling materials that are already present in the region, it is possible to limit the risk of **criticality** for metals. This offers a double reward: reducing dependence on metal imports, and also reducing the negative externalities associated with extraction, processing and transport (e.g. on health, the natural environment, water and air quality, biodiversity, and the landscape). Recycling metals is essential to transition to new forms of energy (which is a metal-intensive process) and reduce pressure on primary supplies.

Making new products typically has a greater physical impact than reusing existing ones. New buildings, even those which are most efficient, require energy, land, steel, glass and concrete. The strategic advantage of the widespread adoption of circular and sufficient principles is that there is a strong potential for using materials that are already present domestically. This reduces the dependence of the manufacturing industry and households on new materials and products, whose relative cost in economic and environmental terms is increasingly high.

According to national spatial planning policy, it is essential to develop an economy that takes account of ecological limits. The PDAT 2035/2050 offers a territorial perspective by identifying those areas that should be developed and those that should be preserved, and by defining objectives for reducing the artificialisation of land and for cross-border cooperation. This makes it possible to identify sites for business parks at an early stage and to encourage the multifunctional development of those business parks.

#2 Extending circularity and sufficiency throughout the economy

Why limit land artificialisation?

- Limiting urban sprawl and therefore transportation needs
- Reducing CO₂ emissions
- Limiting the increase in expenditure on networks (transport, energy, sewers, drinking water, etc.)
- Limiting global warming
- Protecting landscapes and biodiversity
- Limiting flood risks
- Preserving farmland
- Preserving a carbon-absorbing substrate
- Maintaining social cohesion



Figure 14. Why the PDAT recommends limiting land artificialisation¹⁵¹

Reconciling a reduction in artificialisation with industrial relocation can be achieved through more circular land use. The concept of the **15-minute city** (KBR26), combined with the widespread use of attractive public transport, which frees up space in cities that was previously occupied by private cars (Luxembourg has 900,000 parking spaces, more than the country's population), would enable shops and workshops to be relocated to urban centres. The **Compatibilités-check** initiated by the Ministry of the Economy is another tool for identifying, early on in the process of setting up business, companies that can meet national constraints.

The application of the **ZAE toolbox** and the **Guide pour la conception durable des ZAE** produced by the Ministry of the Economy will be generalised and extended (see [map of economic activities in 2050](#) at the end of this report). The aim is to reduce the need for **new construction materials** by recycling concrete and other construction materials, to encourage the re-use of existing ZAEs and industrial buildings in order to reduce the rate of **new construction**, to avoid or compensate for the need for new land (PDAT2023), and to de-seal car parks and the areas around them.

Particularly promising are **multi-use** or **multi-storey** approaches to ZAEs, where applicable. This involves stacking productive functions, and using any vacant space to add complementary functions to the main productive function on a case-by-case basis, including:

- Food (greenhouses, market gardening, composting, aquaculture, beekeeping)
- Energy (solar energy, thermal energy, biogas)
- Water (rainwater collection and storage)
- Carbon and ecological (fruit trees, willows and hedges, ecological corridors, green roofs)

The **Leitfaden Gestaltung Aktivitätszonen** provides the necessary guidelines and refers to the need to provide, from the planning stage onwards, for the remodelling or conversion of sites to new uses. Particular attention should be paid to the development of agri-food sectors in business parks or urban areas. In addition, zoning areas could be made denser and more profitable through the temporary or permanent use of 'empty spaces' in ZAEs by SMEs that do not need large sites.

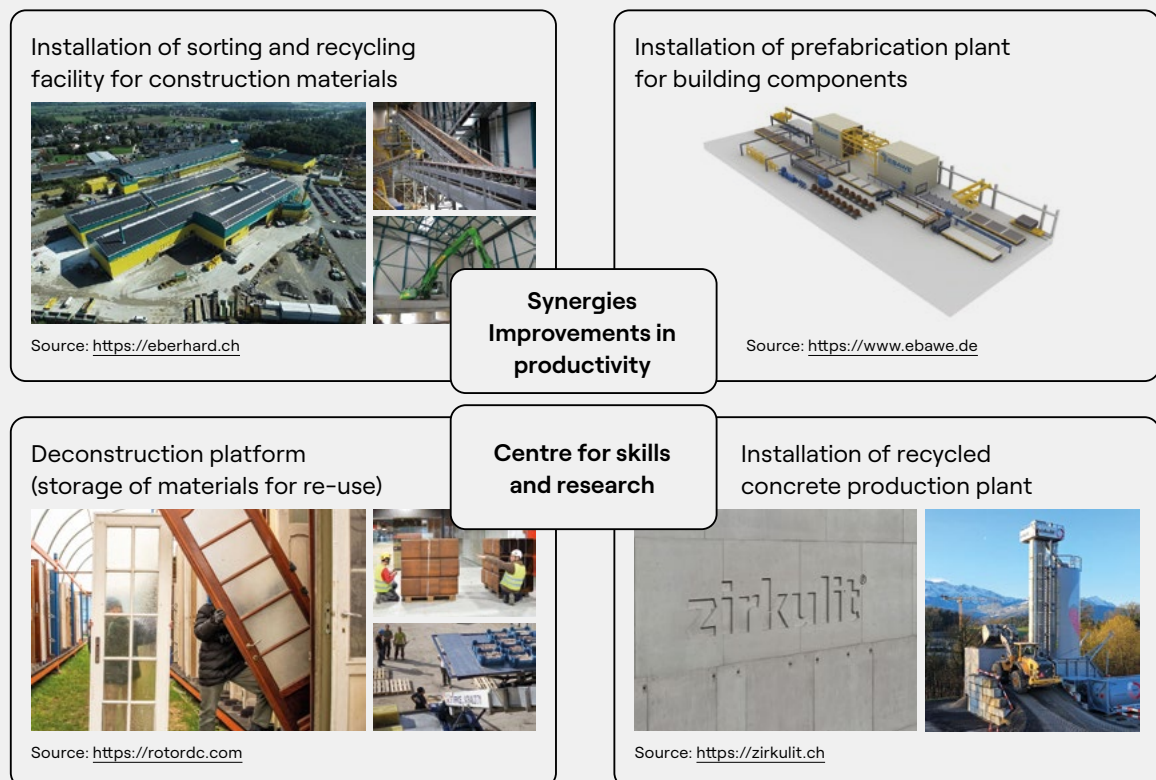
¹⁵¹ MEA (2023), Master Programme for Spatial Planning (PDAT) and Luxembourg in Transition (LIT). Institut Grand-Ducal: [Matinée-Débat: Vision pour le territoire luxembourgeois](#). 1 July 2023.

C. Developing and structuring circular industries, innovating and substituting materials

The development of circular logistics infrastructures can be achieved by setting up a platform for demolition and the **recycling of building materials**. In line with a circular economy strategy, the aim is to set up a physical and digital market for construction materials (concrete, wood, steel, crushed stone, etc.) and to support the necessary infrastructure, particularly for the reuse and recycling of concrete in a sustainable construction cluster. There is strong interest from private actors in the construction sector to move in this direction. A specific national ZAE dedicated to sustainable construction, the *Wertstoffhaff*, will be created (see the [maps of economic activities in 2023](#) and [2050](#) at the beginning and end of this report).

The *Wertstoffhaff* will support 'cradle-to-cradle' approaches and target activities involving concrete production in order to exploit synergies. It will potentially bring together activities involving the reuse of materials and preparations for reusing and recycling materials (an integrated centre), and allow for the sharing of land, machines and specific installations (optimisation) between relocated companies seeking synergies (e.g. prefabrication of construction components). A net surface area of 10 hectares would be required, close to the size of the largest 'reservoirs' of demolition and construction projects, to reduce material transportation requirements. The *Wertstoffhaff* would help reduce the volume of excavated soil that needs to be landfilled (there is a chronic shortage of landfill space in Luxembourg) and would enable related activities (concrete recycling, construction of prefabricated elements, and demolition).

EXAMPLE : THE WERTSTOFFHAFF SUSTAINABLE CONSTRUCTION CLUSTER



#2

Extending circularity and sufficiency throughout the economy

The same concept could be applied to the manufacturing of tools, spare parts, agricultural machinery and anything else that could help towards the transitions.

To reduce conflicts of use and limit the land footprint of economic activity, the Vision brings together initiatives to turn built-up areas into reservoirs of materials for reuse (urban mining) and food production sites (urban farming).¹⁵² To this end, it will be necessary to provide storage and sorting areas for demolition materials awaiting reuse, as well as infrastructures and circuits for processing and commercialisation. The possibility of relocating other economic activities compatible with housing directly into urban areas is being studied. The aim is to shorten the distance between homes and workplaces and to encourage retail in town centres.

If they are to be economically viable, promising sectors within the **Greater Region** should be structured with a view to achieving greater scale, following the example of existing initiatives: the Arla dairy cooperative, which is based in Pronsfeld in the Eifel region, processes German, Belgian and Luxembourg milk; BIO-OVO is a crossborder (Luxembourg, Germany, Belgium) group of egg producers; the *Eist Uebst a Geméis* label operates on a cross-border basis between Germany and Belgium; *La Provençale* supplies restaurants in the Greater Region with fresh produce; and the *De Verband* agricultural cooperative, based in Perl, operates across the Greater Region. Other projects include an abattoir in Thionville which operates with participation from Luxembourg, and a metacluster for environmental technologies in the Greater Region.¹⁵³

Luxembourg's craft workers are essential partners in the circular transition and the regionalisation of supply chains. Circularity cannot develop in society or the economy without drawing on the know-how of the craft sector, and without the efforts made by the craft, technical, manual and agri-food sectors. The future creation of 'resilient and sustainable strategic value chains', establishing design, manufacturing, operation and maintenance processes in the Greater Region, could offer new opportunities for craft industries through new forms of cooperation, particularly in terms of local circular value chains, by means of projects to return components or materials to the economic sectors that need them. According to the CDM, the establishment of new value chains within the Greater Region, which is a natural catchment area for craft industries, is an important avenue to develop in the future in order to minimise risk.¹⁵⁴

Research and the craft sector are investing in wood and earth construction. By 2050, existing construction methods will be complemented by self-build housing based on prefabricated wood panels using materials from the Greater Region. **Geo- and bio-sourced materials** (PNEC) and ultra-light materials will be promoted, as will eco-design and waste return schemes. Return schemes for glass and, in the future, other products will be organised across borders based on actual areas of purchase and consumption. The lifespan of all products, starting with essentials such as batteries, solar panels and wind turbines, will be gradually extended.

¹⁵² MECCDD (2019), *Stratégie Nationale Urban farming Luxembourg*. Le Luxembourg, une Smart Nation.

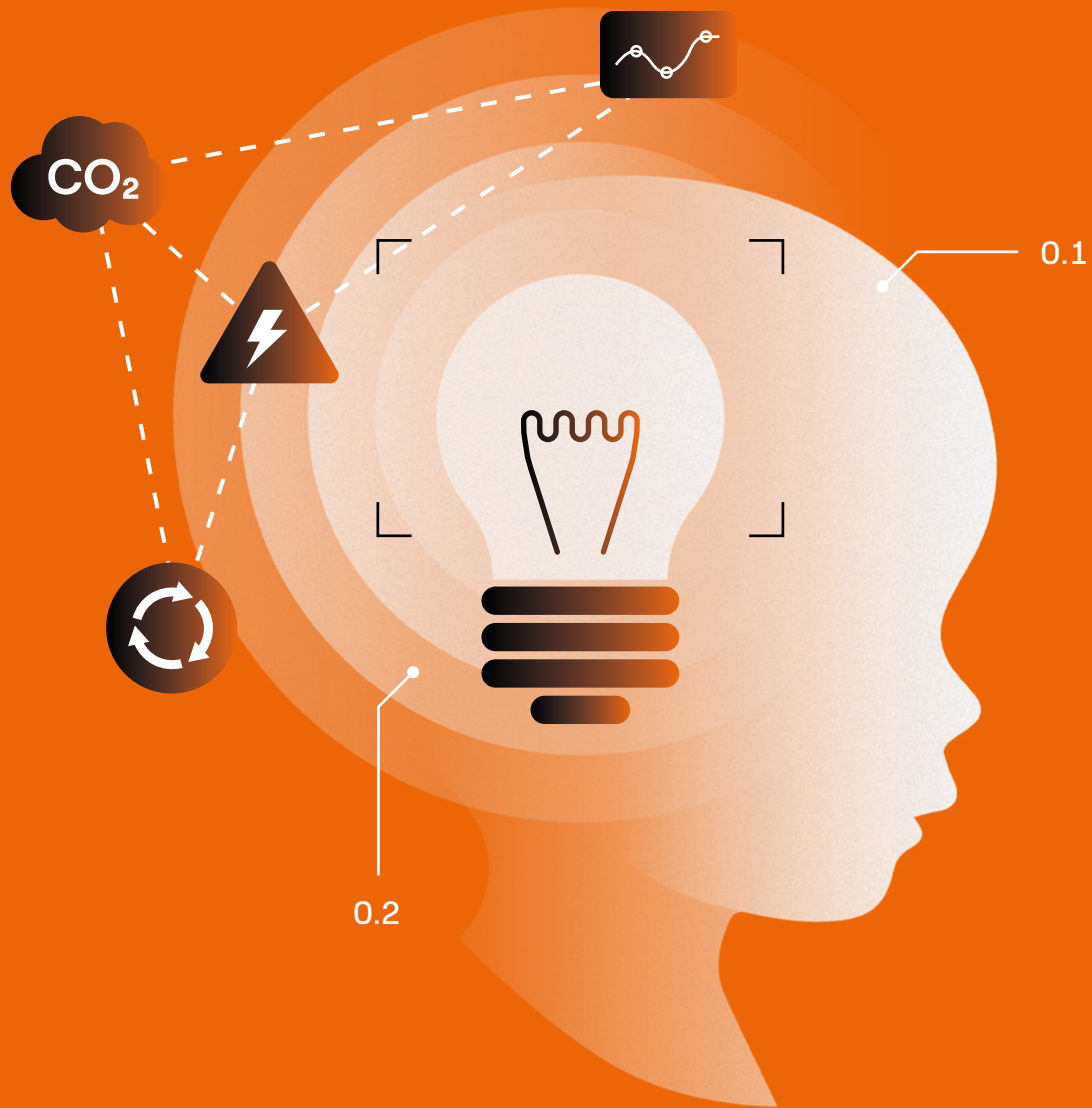
¹⁵³ Chamber of Commerce (2023), *Workshop compétitivité #1 sur l'éco-innovation*.

¹⁵⁴ Chamber of Skilled Trades & Crafts (2023), Position statement (following the exchange between 'Luxembourg Strategy' and the members of the Commission of the Centre de Promotion et de Recherche (artisanat) at the Chamber of Skilled Trades & Crafts on 27 April 2023). 10 July 2023.

Solar panels and wind turbines were first installed at the end of the last century and gained momentum from the 2010s onwards. Looking to the future, there appears to be an opportunity by 2030 for collecting, processing, reusing and reselling large quantities of the critical metals contained in such equipments when reaching their end of life.¹⁵⁵ On the circular model, a local industry for recycling solar panels and wind turbines, including their digital components, should be developed as soon as possible in order to give them a second life and enable them to continue producing electricity.

Markets for secondary materials will need to be strengthened. The creation of a fully integrated, resilient and borderless **internal market** will also be essential to facilitate access to and re-use of raw and secondary materials, and to enable the technologies of the future to achieve critical mass within a large single market. Technological (high-tech and low-tech) and behavioural solutions will need to be used together in order to fill any gaps in circularity and sufficiency. Positive discrimination in favour of robust products and 'circular' public procurement will provide additional incentives for circularity ([building block 6](#)).

¹⁵⁵ Energy Transitions Commission (2023), [Financing the Transition: supplementary report on the Costs of Avoiding Deforestation](#).



#3

Putting **people**, **knowledge** and **wellbeing** at the heart of the economy

Maintaining material capital and investing in technical innovation is one thing. But to achieve successful transitions, cooperation and cultivate social capital must also simultaneously be strengthened. Human action has great potential to reduce emissions.¹⁵⁶ But human action can also be marked by injustice and inequality, which can limit society's progress towards thorough decarbonisation by 2050.

For all these reasons, the Vision focuses on the many facets of social, societal and organisational innovation: **lifelong learning, work quality and job retraining, knowledge and know-how, research and excellence, a culture of entrepreneurship and stimulation of actors' personal interests, poly-activities, and the social and solidarity economy.**

Social and societal innovations refer to innovations that encourage transition without being primarily technologybased, and that involve society, business and governance (for innovation in governance see also [building block 10](#)). These innovations have a relatively high greenhouse gas mitigation potential, can be implemented rapidly (i.e. achievable before 2030), and have low implementation costs relative to purely technological innovations.¹⁵⁷ They can therefore complement technological solutions to achieve transitions more quickly and at lower cost.

The aim of **social innovation** is to develop new responses to social needs that are poorly or inadequately met. It aims to provide practical, effective solutions to issues that are often complex, and which neither the state nor the market can address on their own. These innovations concern products and services, as well as organisational and distribution methods. Examples include shared housing projects, energy communities the fight against food waste. The Social Business Incubator – run by the Ministry of Labour, Employment and the Social and Solidarity Economy (MTEESS) – and Luxinnovation offer expert, personalised support for socially innovative entrepreneurial activities.¹⁵⁸

This approach involves changing lifestyles, sharing and pooling resources, reducing obligatory travel, reducing demand for space, materials or food, and decentralising energy production and consumption. Microcredit, food cooperatives, deposit systems and fair trade are good examples of social innovations.¹⁵⁹

To place people, knowledge and wellbeing at the heart of the economy, three levers for change can be proposed:

- A.** Building a **new generation** of workers capable of leading the transitions
- B.** Combining old and new **knowledge**, promoting scientific culture and cultivating excellence
- C.** Promoting **new business and management models** (organisational innovation)

¹⁵⁶ Targeting demand could potentially bring down emissions by up to 70% by 2050. 'Demand and services: potential to bring down global emissions by 40-70% by 2050. Walking and cycling, electrified transport, reducing air travel, and adapting houses make large contributions. Lifestyle changes require systemic changes across all of society. Some people require additional housing, energy and resources for human wellbeing'. Yoav Aziz et al. (2022), *Climate Change 2022, Mitigation of Climate Change*.

¹⁵⁷ Sigit Perdana et al. (2023), *Expert perceptions of game-changing innovations towards net zero*. Energy Strategy Reviews. Volume 45. & Fergani (2018), *Scenario archetypes of the futures of capitalism. The conflict between psychological attachment to capitalism and the prospect of its dissolution*. Futures. Volume 105.

¹⁵⁸ Luxinnovation (2023), *Le premier appel à projets visant à promouvoir l'innovation sociale au Luxembourg*. Press release, 5 April 2023.

¹⁵⁹ Other possible applications are:

- Alternative forms of car use (car sharing, ride-sharing, etc.)
- Alternatives to car use (e-bikes, mobility-as-a-service, etc.)
- Reduced demand for mobility (home-working, teleconferencing, etc.)
- Alternative dietary preferences (flexitarian/reduced meat diet, etc.)
- Urban food production (growing food at home, community farming, etc.)
- Producer-consumer relationships (local food distribution, food box deliveries, etc.)
- Reduced demand for food (food waste, reduction, etc.)
- Inter-connectivity for optimised usage (smart appliances, LED, smart homes, etc.)
- Optimisation of thermal performance for buildings (e.g., smart heating controls)
- New service providers (energy service companies, energy aggregators, third-party financing)
- Integrating consumers into grids (demand response, time-of-use pricing, electric vehicle-to-grid, etc.)
- Decentralised energy supply (solar energy with storage, micro-wind turbines, etc.)

Sigit Perdana et al. (2023), *Expert perceptions of game-changing innovations towards net zero*. Energy Strategy Reviews. Volume 45.

#3

Putting people, knowledge and wellbeing
at the heart of the economy**A. Building a new generation of workers capable of leading the transitions**

Relocating parts of production closer to us and successfully achieving the digital and ecological transitions will require to address a shortage of skills and labour. This is a difficult task, comparable in Luxembourg only to the conversion of jobs in the steel industry into service sector jobs during the final quarter of the last century – a transition that was managed very well.¹⁶⁰

By their very nature, transitions need people who believe in them and can contribute to them. Today, as in the past, it is a matter of building a new generation of workers and jobs capable of leading the transitions. 'The project is complex but exciting. Rethinking the major emissions sectors, mobility, buildings, cities, agriculture, ... There are lots of jobs involved. It calls for young people's creative imaginations'.¹⁶¹ To achieve this, it is necessary to invest constantly in education, training, transmission and awareness-raising, and to promote wellbeing, civic engagement and productivity at work.

A major campaign to raise awareness of careers in ecosystem production and regeneration – in the industrial, craft, environmental and agriculture sectors – could help to attract people to these careers. Both new and old skills must be mobilised, and craft, technical and manual trades, distinguishing between those that can be done remotely and those that cannot, must be promoted.. In a world of consumerism producers are needed. Following the example of the *Léierbud*, a school of production should be created.

Foresight can help to identify and anticipate over the long term the jobs which reflect megatrends and are required for transitions. In Luxembourg, ADEM is the body which anticipates future labour needs and possible disruptions in the labour market. A number of studies have described the jobs of the future.¹⁶²

¹⁶⁰ Luxembourg is an illustration of creative destruction: in 1960, out of a population of some 300,000, 40% of the working population was employed in the steel industry. Between 1974 and 1985, the workforce in the steel industry halved, from 25,000 to 12,000 steelworkers. Between 1975 and 1973, the banking sector saw its workforce grow from 2,000 to almost 6,000. In 2000, the financial sector employed 23,000 people, a figure very close to the number of jobs lost in the steel industry. In 2001, STATEC stopped using the category of 'ouvrier' (manual worker) in its reports.

¹⁶¹ Pierre Veltz (2023), *Économie désirable*. Presentation at the [Luxembourg Strategy conference](#), 5 June 2023.

¹⁶² Luxembourg Strategy (2023), public campaign. Adem Luxembourg (2021). OECD (2023), [OECD Skills Strategy Luxembourg: Assessment and Recommendations](#), OECD Skills Studies. Chamber of Commerce (2023), [Rapport éco-innovation Report](#), Ministry of the Economy. CDM (2023), [30 propositions de l'Artisanat](#).

EXAMPLE : FUTURE JOBS FOR LUXEMBOURG

→ Luxembourg Strategy, Report on the results of the public campaign (2023):

IT (both software and hardware), healthcare and nursing, engineering (all specialisations), crafts, technology, data analysis, education, public services, research and science, the environment, the circular economy, agriculture/agronomy/food, finance, ESG assessment, environmental compliance, communication, climate risks.

→ OECD Skills Strategy Luxembourg (2023):

Advanced manufacturing, healthcare, creative sector, digital sector, green sector, science, information and communication technologies, technicians, finance and insurance.

→ ADEM, Sector studies in collaboration with UEL (2021):

IT (both software and hardware), business engineering, installation and maintenance of industrial and exploration equipment, industrial engineering and R&D, management and marketing of digital products, data analysis and management, green finance, construction (planning and management functions, operational profiles for sites, etc.), logistics and support activities (human resources, commercial strategy, legal advice).

'Clean energy jobs now outnumber fossil fuel jobs.'

IEA's first World Energy Employment Report, 2022

The **job transition** is well under way. Although there has been an impressive increase in 'green' jobs, particularly in efficient construction, in Luxembourg and elsewhere,¹⁶³ there is an acute shortage of qualified personnel in certain fields involved in transitions, particularly in circular construction, green finance, sustainable energy engineering, agro-ecology and agri-food. As well as jobs in digitisation and automation, other transition-related professions are found in professional, practical, environmental and technical fields, including low-tech areas. New jobs will be created in environmental restoration, maintaining natural carbon sinks, adapting to climate change, societal innovation, the social and solidarity economy, local food production, processing and sale, natural air conditioning, demolition, and do-it-yourself (DIY). Furthermore, the CdC's *Retail Report 2023* notes that DIY shops have been considerable growth in sales since the COVID-19 lockdowns.

LinkedIn's 2022 *Global Green Skills Report*¹⁶⁴ points out that demand and supply for jobs related to the environment, energy and climate change have increased by 8% and 6% respectively, leading to a positive number of net transitions into these jobs. It even finds that workers will accept lower pay to join companies whose values match their own.

The OECD's **National Skills Strategy** study, published in February 2023, concludes that, in order to achieve successful transitions in Luxembourg, establishing pathways for skills enhancement and requalification is crucial, enabling working people and young people to move towards greener jobs. On the basis of this analysis, the MTEESS is currently preparing a Skills Plan to support businesses' needs for skilled labour through continuing training. The new **continuing training support plan** will be aimed primarily at SMEs (with fewer than 250 employees), with even more favourable rates for small businesses (with fewer than 50 employees). This programme will support forward-looking management of employment and skills. Measures to **retain employees and develop loyalty** also play a key role in the human resources strategies of SMEs, particularly small businesses.

¹⁶³ 'Clean energy jobs now outnumber fossil fuel jobs', see IEA (2022), first 'World Energy Employment Report'.

¹⁶⁴ LinkedIn (2023), *Global Green Skills Report 2023*.

#3

Putting people, knowledge and wellbeing
at the heart of the economy**B. Combining old and new knowledge, high- and low-tech skills, scientific culture and multilingualism**

In line with the principles of the Vision, rather than pitting digital and manual, academic and professional careers, soft and hard skills against each other, it would be better to capitalise on all the skills needed for the transitions and for achieving the ECO2050 Vision. Hybrid skills are needed: recycling involves mechanisation and digitalisation, and low-tech professions also make use of digitalisation. Digitalisation is useful for arduous tasks, rare specialisations, and for cutting costs through automation. Digital jobs should be combined with interpersonal and team-building skills.

The government is assisting companies and workers in the transition, **retraining and requalification** of jobs from high-impact to low-impact activities, and supporting companies that upgrade their skills and train their staff, taking into account the specific needs of each group (young people, women, senior citizens).

To train the next generation of workers, full use should be made of the potential and know-how of **senior citizens** (aged 55–64), whose employment rate in Luxembourg is one of the lowest in the OECD. The number of people aged 65 and over is set to double by 2050. The aim is to invest in training senior citizens over the age of 50 'to enable them to increase their productivity in their basic profession, to retrain in another profession, and to facilitate the transmission of their know-how to younger generations'.¹⁶⁵

Societal innovation also involves making work more flexible, and encouraging life-long learning and the **pursuit of multiple activities**. For those who feel they have a vocation, it should be possible to alternate between different occupations and economic sectors, between phases of activity and inactivity (career breaks, part-time work),¹⁶⁶ or combining a main domestic job with seasonal manual outdoor work (e.g. harvesting, forestry work, *Drauwelies*). Companies and workers could agree to work over a reference period adapted to their respective needs, with a timetable suited to fluctuating workloads and employee absences (*Jores-aarbechtszäit*). In order not to lose the skills capital accumulated over a working life, the status of pensioner/social mentor/knowledge transmitter could be enhanced, making it more attractive to combine an old-age pension with a professional income. Whatever these future developments, craft skills centres will play a key role in continuing education and life-long learning.

Making the most of all available skills requires not only **a positive attitude to ageing**, but also gender parity. By making the most of all human resources, and ensuring equal access to all jobs and to lifelong education and training, it is possible to create a labour market adapted to economic realities. Education for young people must take account of all their diversity, so that both girls and boys can benefit from a future that enables them to make full use of their skills.

Luxembourg has one of the lowest rates of female participation in business start-ups.¹⁶⁷ In general, the ratio of women to men is inversely proportional to the degree of responsibility for the position in question: 75% of managers are men, whereas 57% of administrative assistant jobs are held by women. Industry is a special case, with 83% of its employees being male.¹⁶⁸ Specific incentives need to be put in place for women in order to rectify this and to ensure a balanced representation of women and men in companies in order to take advantage of the complementary nature of the knowledge and interests of men and women. Gender diversity makes it possible to take wiser decisions and be more resilient in times of crisis, since no crisis is gender-neutral. It is therefore essential to take account

¹⁶⁵ Fondation IDEA (2023), *Grands Défis*, p. 90.

¹⁶⁶ Fondation IDEA (2023), *Grands Défis*, p. 99.

¹⁶⁷ Chamber of Commerce (2023), *Maintenir et accroître l'attractivité et la compétitivité du modèle économique*.

¹⁶⁸ MEGA (2018), *Part des femmes et des hommes sur le marché de l'emploi*, Observatoire de l'égalité des chances.

of the know-how, needs and potential of the entire population at all stages of projects, whether at international, national or local level, in education, research or the economy. Women can act as the driving force behind transitions,¹⁶⁹ given the role they play as consumers, influential members of their communities, workers and entrepreneurs.

Luxembourg also has one of the highest ratios of **university graduates** to non-graduates.¹⁷⁰ However, a diverse range of levels of training and qualifications is needed to contribute to the transitions. According to the FEDIL, the training courses most in demand by industrial companies are the *diplôme d'aptitude professionnelle* (DAP) (44%), followed by master's/doctorates (20%), the technician's diploma (13%), and the bachelor's degree (13%).¹⁷¹ Finally, the promotion of craft professions, by guiding people towards these trades and by recognizing their innovative value, appears to be key.

To understand what is necessary for sustaining our lives, people need to be taught at all levels about the challenges of the transitions and circularity. This means **teaching people about biophysical limits**, the laws of thermodynamics, the criticality of energy and materials, complexity, social innovation and the role of the consumer. Alongside these fundamental lessons, basic **repair** and **gardening** courses could be offered from primary school onwards. The SOC2050 study on the need for behavioural change, which Luxembourg Strategy is currently conducting in collaboration with LISER, is attempting to spell out why we consume beyond our needs while still remaining dissatisfied, and how to consume differently and increase satisfaction.¹⁷² Similarly, people need knowledge to better understand the complex and interdependent systems, with a view to simplifying and humanising them. Self-manufacturing and repair, for example, allow to save money, control and personalise our work, acquire skills such as teamwork, and gain personal satisfaction. Administrative procedures are often simpler person-to-person than through a screen or a telephone.

Economics education should cover the **economics of disruption**: a non-linear economy exposed to profound shocks (regime change), including climatic and sociological tipping points, ecosystem collapse, pandemics and mass migrations, and disruptive technologies and policies.

If young people should be exposed to other curricula and career paths, it is important to offer them attractive conditions and to change the way professions and the value of work is looked at. The transitions also present an opportunity to enable all young people, whatever their socio-economic background, to devote themselves to training and jobs that are fulfilling, valued and useful.

Results in mathematics and science in Luxembourg are below the OECD average. Yet **STEM skills** (science, technology, engineering and mathematics) are needed to carry out the major infrastructure projects described here. There is considerable work to be done to attract and guide people – particularly girls and women, but also **start-ups**, which are currently male-dominated and very focused on the virtual¹⁷³ – towards these disciplines, towards digital skills, and towards the manufacturing and food industries, by combining them with the social sciences. Continuing education will enable people already in work to stay in an increasingly automated and digitalised labour market.

As well as investing in the skills of residents, Luxembourg will need to remain open to the world and embrace science, in order to more easily attract international talent and third-country nationals. The establishment of a **European remote worker status** could be promoted. It may be desirable to create cross-border mutualised training organisations in the Greater Region.¹⁷⁴ The 100,000 Luxembourgers living abroad offer a source of connections and commercial partners. Using a 'Global Citizenship' approach, a two-way transfer of know-how and innovative approaches with the

169 Cara Daggett (2022), *Feminist Energy*, presentation at the *Luxembourg Strategy conference*, 17 October 2022.

170 Chamber of Commerce (2023), *Maintenir et accroître l'attractivité et la compétitivité du modèle économique*.

171 FEDIL (2023), *L'industrie: Les jobs du futur, Résultats de la 13e édition de l'enquête 'Les qualifications de demain dans l'industrie'*, 23 March 2023.

172 Luxembourg Strategy (2022), *SOC2050 study, Comprendre la désirabilité du changement vers plus de résilience*.

173 Start-up Genome (2022), *Luxembourg Startup Ecosystem Assessment and Benchmarking*, commissioned by the Luxembourg Ministry of the Economy.

174 Fondation IDEA (2023), *Grands Défis*, p. 76.

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partner countries of Luxembourg's Directorate for Development Cooperation and Humanitarian Affairs could be promoted. This would include education for sustainable development.

Multilingualism is an asset for Luxembourg – a country that has campaigned for a plurality of languages within the EU – and a commercial and relational advantage that should continue to be nurtured, and may become an industry in its own right ([building block 7](#)). Linguistic practice is also evolving in Luxembourg. Teleconferences, webinars and social digital exchanges have become widespread since the COVID-19 lockdowns, and English is playing an increasingly important role in the economic, administrative and academic worlds.

Collaboration with **researchers** is essential if transformative economic strategies are to be implemented. New knowledge is needed regarding resilience and technological, societal, infrastructural and ecosystem adaptation to a changing production environment. To achieve this, it is important for researchers to devote the bulk of their time to research, rather than administrative duties. The transformation of the results of their research into products and services (carbon services and climate tech) could also be facilitated to ensure maximum dissemination. Companies could be further encouraged to invest in research, in coordination with public policies. A growing number of exchanges and bootcamps for (young) researchers, engineers, entrepreneurs and finance experts could be organised.¹⁷⁵

C. Promoting new business and management models (organisational innovation)

A company's director is the torchbearer of change, who can change a firm's business model and inspire employees by example. Productivity trends are closely linked to managerial practices, and good business management is good for production.¹⁷⁶ Fulfilling and emancipating work is a factor in a person's wellbeing. Yet the CSL's *Panorama Social 2022* notes that, between 2014 and 2021, there was a decline in feedback from management, autonomy at work, cooperation between colleagues and employee participation in company affairs. This trend is likely to lead to a decline in satisfaction, motivation and wellbeing at work, as well as an increase in cases of burnout, depression and physical health problems among employees.¹⁷⁷

Francesco Sarracino of STATEC Research argues that a **crisis of confidence**, particularly in others and in institutions, is undermining the collective effort towards greater sustainability: 'if people are confident that everyone is doing their bit in the collective effort, and that the institutions in charge of coordination and redistribution can be trusted, then people are more inclined to cooperate to solve common problems. Otherwise, people opt for private solutions to protect themselves from environmental problems. Anxiety about the future and a lack of trust in fair collective action can turn people into strong consumers'.¹⁷⁸

In response to the **crisis at work**¹⁷⁹ (emotional burdens, poor support from managers and colleagues, low levels of participation), a rethink of management and new forms of business management are needed to restore the desire to work and produce.

175 Chamber of Commerce (2023), Rapport éco-innovation, Ministry of the Economy.

176 CES (2023), Avis relatif au rapport 2021-2022 du CNP, 11 July 2023.

177 Chamber of Employees Luxembourg, *Panorama Social 2021*, dialogue number 1.

178 Francesco Sarracino (2023), *How to lead happy lives in post-growth societies*, Improof.lu, 5 June 2023.

179 David Graeber (2018), *Bullshit jobs: A Theory*, Simon & Schuster. Olivier Blachard and Jean Tirole (2021), *Les grands défis économiques*, France Stratégie.

‘Uncertain times, unsettled lives: shaping our future in a transforming world’

This is the title of the UNDP Human Development Report (HDR) 2021/2022. It provides an in-depth analysis of the global human development situation, raising awareness of development inequalities between countries and promoting policies to improve the wellbeing of people worldwide. It examines various aspects of development, including education, health, income, gender equality and environmental sustainability, and ranks countries according to the Human Development Index (HDI), which takes into account indicators such as life expectancy, education levels and per capita income. In 2021, for the first time, the HDI was adjusted to take account of planetary boundaries,¹⁸⁰ placing Luxembourg in the quadrant of countries with a very high HDI and very high pressure on resources.

In its 2021/2022 edition, the HDR analyses three new sources of uncertainty which, both individually and through their mutual interactions, are holding back human development:

- The increasingly pronounced effects of the Anthropocene on the planet
- Destabilising societal changes linked to new technologies and lifestyles
- Political and social polarisation both within and between countries

At a time when the influence of societies on their future has never been greater, and negative perceptions of the world have never been more prevalent, the report observes that these are manifesting themselves in unpredictable ways. For example,

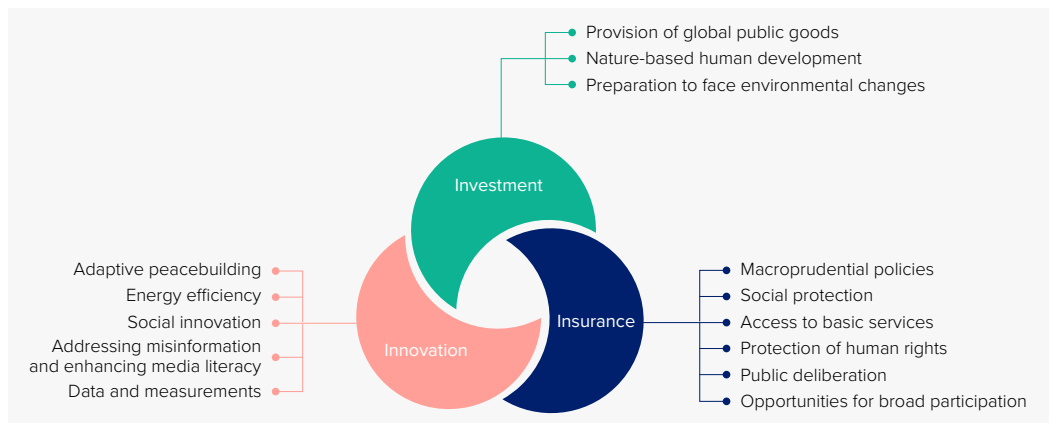
- 6 out of 7 people in the world feel insecure and distressed, despite ‘progress’ and prosperity
- In the wake of the pandemic, the HDI fell for the first time in its history in 2020 and 2021
- The war in Ukraine has slowed human development and efforts to mitigate and adapt to climate change
- People’s mental wellbeing is threatened by the uncertainties of the Anthropocene, which revolve around 4 main axes: general climate-related anxiety, physical illness, traumatic events and food insecurity
- Global change, the collapse of biodiversity and the depletion of natural resources are major sources of anger and anxiety about the future (eco-anxiety, solastalgia)
- The energy transition to solar power, wind power and batteries is increasing pressure on the planet

180 UNDP (2021), *The Next Frontier: Human Development and the Anthropocene*.

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- The benefits of innovation are not equitably distributed and are widening inequalities (e.g. the digital divide)
- Recent technical developments (e.g. social networks, genome modification, AI) are advancing faster than societies' ability to analyse the consequences and risks (particularly ethical risks)
- Disinformation is increasing the mistrust of a growing section of the population towards democracies

In these alarming circumstances, the report emphasises the need to question the very idea of 'progress' in the traditional sense of the term, and to shape policies as illustrated in the image below.



Source: 'Making people more secure through investment, insurance and innovation', HDR, Figure 10, UNDP (2022).

Nevertheless, according to the UNDP, the increasingly uncertain prospects for favourable human development provide an opportunity to re-imagine the future of societies, and to renew and adapt institutions by forging new paradigms for identity and values. Moreover, universal basic services such as health and education are important investments in sustainability and enable human development to be extended in an inclusive way. They also fulfil an essential insurance function, helping to stabilise populations in the face of seemingly inescapable shocks and encouraging experimentation.

Co-determination also appears to be an avenue worth exploring.¹⁸¹ Forms of production based on '**coopetition**' may emerge: alliances between competing companies to develop innovations with societal, economic or environmental value, or to pool production and logistics chains. Developing these models may require changes in European law.

Various forms of organisation are possible: a cross-border business model, a progressive model combining economic wealth, public goods and individual wellbeing, one that takes a long-term view and takes account of planetary boundaries, and one that partially links pay to commitment and customer satisfaction.¹⁸²

¹⁸¹ Dominique Méda and Maëlezig Bigi (2023), *Prendre la mesure de la crise du travail en France*, Le Monde, 19 June 2023.

¹⁸² André Coupet (2020), *Les valeurs de l'entreprise progressiste*, Gestion 2020/3.

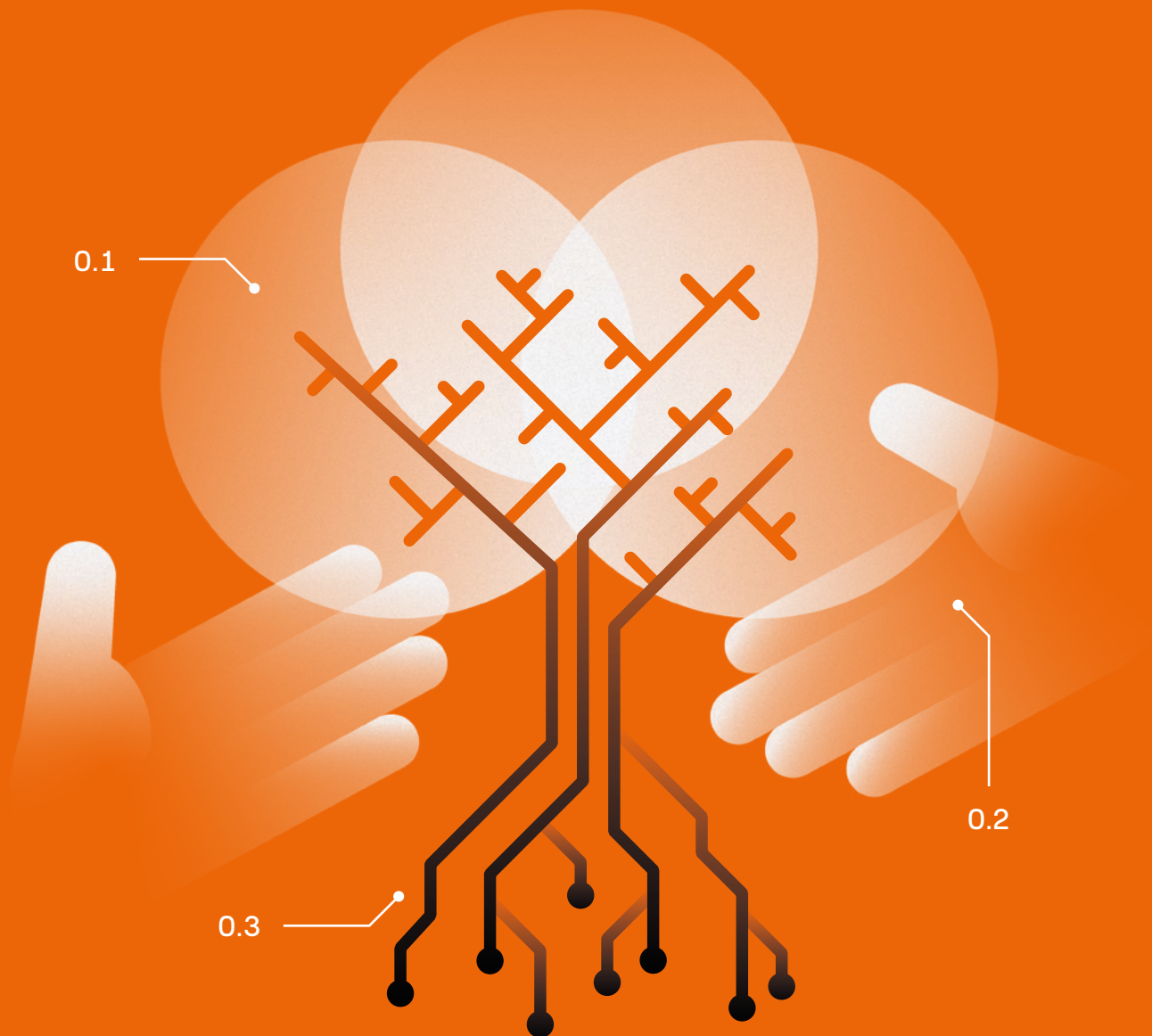
In terms of new economic and digital models, the **craft sector** can be at the vanguard of a whole new production chain that offers design, production, delivery, service and after-sales all from a single craft producer/supplier, enabling circular and regional approaches to be integrated in the creation and development of integral value creation chains.

The **sharing economy** helps to reduce resource use and waste generation by making better use of underused products. The underlying consumption model is not based on ownership but on use.

The **social and solidarity economy** offers other forms of organisation. Depending on national circumstances, these include cooperatives, energy communities, associations, mutual societies, foundations, social enterprises, mutual assistance groups and other entities operating on their own values and principles (groupings of people rather than capital playing an economic role and creating social links). The social and solidarity economy should be supported and employee participation in company management and profits should be encouraged. The possible levers for **expanding the social and solidarity economy**, fuelled by social innovation and supported by the new United Nations resolution adopted in April 2023 and the overhaul of the 2016 law on **societal impact companies (SIS)**,¹⁸³ are as follows:

- Contribute to more inclusive and sustainable economic growth by striking a new balance between economic efficiency and social and environmental resilience
- Develop the *Social Business Incubator* into a skills centre for social innovation, offering support for social entrepreneurs and firms focusing on social impact
- Encourage socially innovative companies by promoting research and development in this field
- Encourage new qualitative and selective forms of growth rather than quantitative growth
- Harmonise methodologies for measuring return on social investment (social return on investment, SDGs, impact assessment, etc.).
- Supporting entrepreneurial spirit in secondary schools, with sustainable entrepreneurial schools become increasingly widespread
- Promote social entrepreneurship as one of the main goals of education
- Support investment in impact funds and micro-finance
- Increase demand for goods and services from the social and solidarity economy sector
- Support social innovation in the private and public sectors
- Support collaborative platforms to encourage the sharing economy

¹⁸³ Loi du 12 décembre 2016 portant création des sociétés d'impact sociétal. UN (2023), Promoting the social and solidarity economy for sustainable development, resolution adopted 18 April 2023.



#4

Reconciling the digital,
ecological and social
transitions

The transformation of economies and societies by the omnipresence of data and hyperconnectivity is a universally recognised megatrend, one that has been called the age of ‘datafication’.¹⁸⁴

‘Digital technologies are formidable tools. Greening them, in an inclusive way is, at the end of the day, the bigger objective behind all of this. We need to do this in a socially inclusive manner without losing people along the way. Losing people means losing the political democratic dialogue.’

Minister of the Economy Franz Fayot,
The twinning of the ‘green’ & digital transitions in Luxembourg (13 June 2022)¹⁸⁵

None of the three plausible future scenarios for Luxembourg’s economy up to 2050 predicts a future without digitalisation. While digital technologies can facilitate a more sustainable future, they also have a significant environmental footprint and shape social relations.¹⁸⁶ How can a virtuous combination of these three issues be achieved in the long term?

‘The opportunities offered by digitalisation will have a central – but still to be determined – place in the national economic strategy. Already, digitalisation for the benefit of society is at the heart of the work of the Ministry of the Economy, which, in the short-term, is following a PNEC roadmap on this subject, “Ons Wirtschaft vu muer”, published in 2021.¹⁸⁷ This digitalisation must be at the service of human beings and not an end in itself.’

Minister of the Economy Franz Fayot, Chamber of Deputies (February 2023)

Expectations for the **triple transition – digital, ecological and social** – are high. The European Commission considers that digital technologies offer enormous growth potential for Europe. Digital solutions at the service of human beings will open up new opportunities for businesses, encourage the development of reliable technologies, foster an open and democratic society, enable a sustainable and vibrant economy, and help combat climate change and achieve the green transition.¹⁸⁸ But while digitisation can lead to reductions in emissions, it also has undesirable side effects unless they are properly managed (IPCC, 2022).

If it is to fulfil these promises, digitalisation must reduce, rather than increase, the need for energy, materials, space and water, and must improve wellbeing, health, social stability and democracy. Digitalisation and AI consume a vast quantity of resources. Digital technologies account for up to 10% of Europe’s energy consumption and up to 4% of its greenhouse gas emissions.¹⁸⁹ Digital technology can also have harmful effects on wellbeing and health (overconnection, surveillance, isolation, loss of productivity).¹⁹⁰ A major effort is needed to better control the growth of this consumption in order to reduce the impact of digital technology on the environment and society.

184 Competence Centre on Foresight (2023), [Accelerating technological change and hyperconnectivity](#), European Commission, Knowledge for Policy. Luxembourg Strategy, [Tableau de suivi des mégatendances](#). Fidelia Ibekwe-Sanjuan (2017), [Vers la datafication de la société?](#), Transition digitale, handicaps et travail social, LEH Editions.

185 EIB Luxembourg Strategy seminar (2022), [Transition digitale et écologique](#).

186 Anne Faure (2021), [Transition numérique: le cas français. Autour du rapport Soutenabilités! Orchestrer et planifier l’action publique](#). France Stratégie presentation at the [Luxembourg Strategy conference](#), 17 October 2022.

187 ‘*Ons Wirtschaft vu muer, 2021*’ is built around 6 pillars: accelerating the digitisation of the economy in all key sectors for the benefit of society; leading the transition to the circular economy through digital; developing resilient strategic value chains; enabling a secure and reliable transformation of the data economy; ensuring a sustainable digital transition; providing a favourable investment environment and instruments to achieve sustainability while remaining competitive.

188 European Commission, [Digital transition](#).

189 IPCC (2022), [Climate Change 2022: Mitigation of Climate Change](#). France Stratégie (2020), [Maîtriser la consommation du numérique: le progrès technologique n’y suffira pas](#), Working paper no. 2020-15. ‘Together with aviation and shipping, ICT are the sectors with the highest emissions growth rates. Digitalisation’s global energy consumption increases by +9%/year, its emissions by +1.2%’ according to European Commission (2022), [Shaping Europe’s digital future](#). ‘The digital services and infrastructure sectors are developing very rapidly in Europe, with annual growth of 27.5% and 41.7% respectively over the period 2014-2019’ according to Eurostat (2022), [ICT sector – value added, employment and R&D](#).

190 OECD (2019), [How’s Life in the Digital Age? Opportunities and Risks of the Digital Transformation for People’s Well-being](#).

#4 Reconciling the digital, ecological and social transitions

In addition, a sovereign infrastructure is essential for greater autonomy, as is the adoption of the principles of circularity and sufficiency through digital technologies. Because their production depends on vulnerable supply chains, digital technologies do not rule out the complementary use of low-tech solutions, craftsmanship and repair.

Three levers are proposed to better reconcile the digital, ecological and societal transitions:

- A. **Responsible digitalisation:** reducing our ecological footprint and promoting virtuous practices
- B. **Responsible digitalisation:** strengthening society, reducing costs and consolidating democracy
- C. **Responsible digitalisation:** ensuring national sovereignty

A. Responsible digitalisation: reducing our ecological footprint and promoting virtuous practices

Reducing the footprint of digitalisation can be done upstream, by limiting the impacts linked to the manufacture and use of digital infrastructure, and downstream, by using digital services to reduce harmful effects and optimise the positive impact of economic activities, or even to stimulate the creation of new economic activities.

Digital responsibility applies the principles of **circularity** and **sufficiency** to the digital world. **Digital sufficiency** is one of the megatrends observed by the European Commission, which argues that a coherent approach to digital sufficiency is essential if ICT is to play a beneficial role in the overall transformation of the environment. According to the Commission, digital sufficiency consists in the 'design of longer lasting services and the control of complexity and resource use, [...] produc[tion of] fewer devices while ensuring their lowest possible energy consumption, [...] software to minimise data traffic and hardware use, [and] [...] a more frugal approach to using digital technology. Finally, economic sufficiency can also be part of digital sufficiency as it views digitalisation as supporting the transition to production and consumption that remain within the planetary boundaries and avoid unbound growth.'¹⁹¹

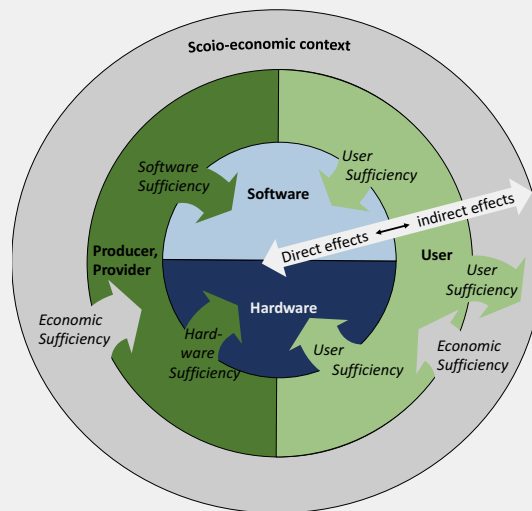
191 Competence Centre on Foresight (2023), *Sufficiency*, European Commission, Knowledge for Policy.

EXAMPLE : DIGITAL SUFFICIENCY

Hardware and software sufficiency measures aim at reducing the total environmental impact throughout the life cycle of ICT hardware and at developing software that is not driving increased data traffic and electricity use of networks.

User sufficiency concern the data traffic that users generate by their activities. Reduced traffic by, e.g., not streaming unnecessary amounts of HD videos would reduce the demand for hardware while also reducing operational energy.

Economic sufficiency concern improved labour productivity, reduced working hours, prevention of rebound effects.



Interplay of the four dimensions of digital sufficiency

Source: Tilman Santarius et al. (2022), [Digital sufficiency: conceptual considerations for ICTs on a finite planet](#), *Annals of Telecommunications*

A responsible digital systems approach involves, among other things, reducing the purchase of equipment and extending its lifespan, giving preference to repairable or reusable equipment and incorporating its decommissioning into specifications, optimising equipment pool management, limiting the flow and volume of data and reducing multimedia content, reviewing the relevance of the system's functionalities, guarding against rebound effects,¹⁹² choosing a responsible hosting provider, grouping servers, using an energy- and water-efficient solution for cooling servers, and aiming to re-use equipment at the end of its life.¹⁹³ Thus, both the 'Ons Wirtschaft vu muer' strategy and the PNEC aim for Luxembourg to distinguish itself by having model **data centres** in terms of their sufficiency.

Examples of **virtuous uses** of digitalisation include the digital facilitation of **carbon monitoring and reporting and corporate social responsibility (CSR)**, with regard to measuring scope 1 to 3 emissions, the resource intensity of decarbonisation and investment options, changes in the carbon, material or water footprint of products and services, and monitoring the carbon incorporated in construction materials.

Digital twins can, among other things, simulate and help to model and optimise efficient energy systems and the buildings of the future, and 3D printing can speed up efficient construction.¹⁹⁴ Remote and on-site data acquisition can help manage decentralised energy systems or optimise food production in greenhouses from a distance. Arduous or repetitive tasks can be carried out by machines: waste sorting, product packaging, automated feeding of fish in aquaculture, etc. Sensors can detect water leaks and help traffic flow.

Digitalisation is also an opportunity to move beyond possession, encourage sharing and reinvigorate shared goods and services: optimising the allocation and collaborative management of resources, and sharing energy, heat, vehicles and parking, canteens, and transport in ZAEs, between municipalities, between cooperatives and across borders.

¹⁹² The increase in consumption linked to the efficiency of a technology.

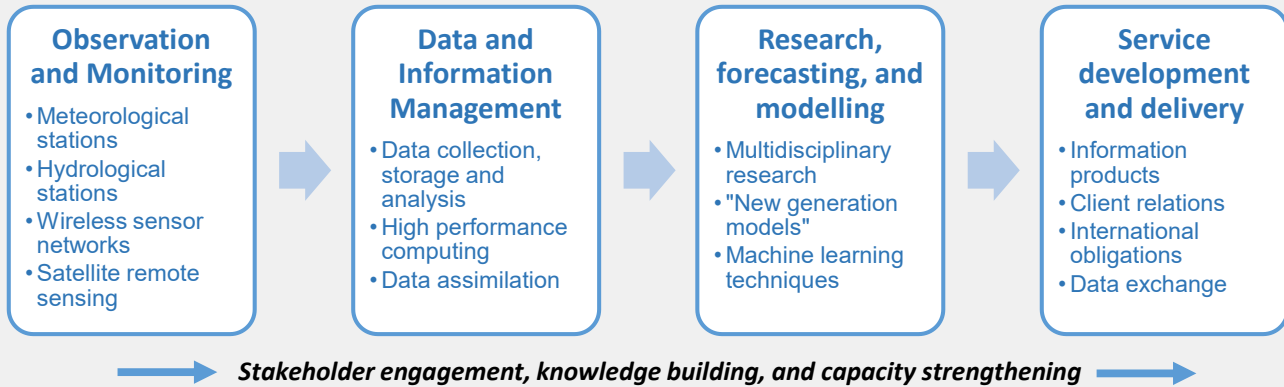
¹⁹³ Institut du numérique responsable (France) (2023), [Bonnes pratiques – numérique responsable pour les organisations](#).

¹⁹⁴ Competence Centre on Foresight (2023), [Trend: Evolving resource management](#), European Commission, Knowledge for Policy.

#4

Reconciling the digital,
ecological and social transitions

EXAMPLE : 'VIRTUOUS' DIGITAL SERVICES



Value chains for weather and climate information services.

Source: OCDE (2022), Climate Tipping Points: Insights for Effective Policy Action



Source: Rhein-Erft-Kreis/dpa



Source: <https://appvales.com>



Source: <https://www.bbc.com>



Source: <https://x.company>

Sustainable construction depends on a database of the volumes, characteristics and locations of materials which facilitates their reuse. The **digital PCDS** set up by the Ministry of the Economy is an example of the use of digital technology to accelerate economic circularity. Through the information it provides, the PCDS makes it possible to dismantle goods and products and to recover their content and value. The Ministry of the Economy has succeeded in making it an ISO standard and a tool integrated into the *EU Digital Product Passport*, which is even more ambitious.

Digitalisation can make us **environmental observers and actors**. Many initiatives focus on crowdsourcing data on the state of nature, such as the presence of invasive alien species or bird sightings, but initiatives can also focus on other areas such as water management, sustainable consumption, etc. Technological advances such as the use of barcodes now make it possible to characterise ecosystems. These can be supplemented by other sources of data from social media platforms and citizen science. **Terrestrial satellite observation** also has great commercial potential in terms of supplying images to trace the origins of raw materials and how they were extracted, and providing cartographic products to help prevent damage to infrastructures and adapt to a changing environment. Virtuous digital services are presented in detail in the section of this chapter on economic diversification by 2050 ([building block 7](#)).

B. Responsible digitalisation: strengthening society, reducing costs and consolidating democracy

Two-thirds of Europeans say that digital technologies are having a positive impact on society, the economy and their own lives, but that they also bring new challenges. The majority of respondents believe that the EU, Member State authorities and businesses must take steps to remedy the consequences of these technologies.¹⁹⁵ The digital divide between rich and poor, young and old, exposure to fake news, addictions to videos, games and endless streams of content, and the lack of a framework for AI are all causes of concern. French philosopher Edgar Morin notes that, as information flows and knowledge advances, ignorance proliferates.

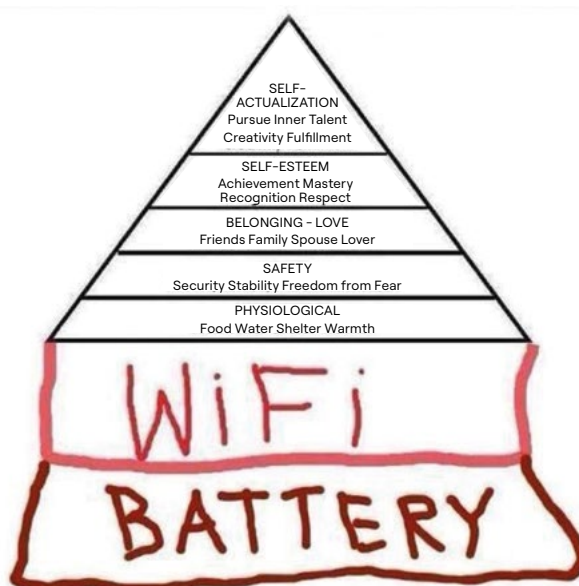


Figure 15. Maslow's pyramid of needs, revisited (see Figure 13) ¹⁹⁶

To help citizens and businesses exploit the full potential of digital technologies, the digital transition must facilitate societal innovation, enhance people's wellbeing and health, empower rather than alienate users, and strengthen democracy.

The **Digital Decade Policy Programme 2030** defines concrete targets and goals for 2030, and provides a guide to Europe's digital transformation.¹⁹⁷ It aims for a secure, safe, sustainable and citizen-centric digital transformation, in line with the EU's fundamental values and rights. Technologies must unite, not divide, citizens. Citizens must be able to participate in the democratic process at all levels and control their personal data. Digital devices must support sustainability and the ecological transition.

¹⁹⁵ Mar Negreiro and Tambiama Madiega (2019), *La transformation numérique*, European Parliament Research Service (EPRS), PE 633.171.

¹⁹⁶ Jeff Palms (2021), *Editorial: Why must the future be 'digital'*, Delano.lu.

¹⁹⁷ European Parliament and Council of the European Union (2022), *Decision (EU) 2022/2481 of the European Parliament and of the Council of 14 December 2022 establishing the Digital Decade Policy Programme 2030*.

#4 Reconciling the digital, ecological and social transitions

A responsible approach to digital issues must therefore ensure, as part of a collective effort in which all actors are made responsible, that the fundamental rights and freedoms of the EU¹⁹⁸ are guaranteed to users without discrimination:

- (Article 6) the right to **liberty and security**: all users must be required to use communication tools responsibly, avoid abuse, discrimination or 'deep fake' defamation campaigns.¹⁹⁹
- (Articles 7 and 8) **respect for private and family life**: Luxembourg must ensure that citizens' privacy is guaranteed. Citizens must be warned, from an early age, of the dangers of surveillance capitalism.²⁰⁰ Business models that rely on generating and marketing user data by constantly drawing users' attention using push notifications must be opt-in only.
- (Article 14) the right to **education**: all users must have access to the necessary training to take full advantage of the benefits of the digital world and be aware of the dangers.
- (Article 11) the right to **freedom of expression and information**: all users must be able to recognise disinformation campaigns, which endanger social cohesion, health and democracy in Europe. Users must be able to protect themselves against methods that influence their free will through deliberately misleading services (dark patterns), encouraging them to over-consume and monopolising their attention. Digitalisation must democratise the knowledge of appropriate practices in a responsible data economy, in line with European values (e.g. open access software and scientific publications, digital standards and data sharing protocols harmonised between Member States, fewer intermediaries and updates, etc.).
- (Article 21) **non-discrimination**: when using algorithms in decision-making or pre-selection processes (such as recruitment), biases or poorly chosen parameters must be avoided in order to guarantee the neutrality of the process and equal opportunities between candidates, and to promote gender parity.
- (Article 35) **health care**: all users must be warned about the dangers of over-consuming online content²⁰¹ and services that promote addiction (notification management).

The **age of datafication** has been accompanied by another major trend, aggravated by COVID-19: the era of solitude, which increasingly affects young people.²⁰² Current and future measures include providing ergonomic equipment, products and formats for the elderly and people with disabilities,²⁰³ regulation aimed at limiting screen time for young people, raising awareness about information-handling issues, regulating incentives to overconsume, introducing a right to disconnect, preventing algorithms and social networks from disempowering people, and restricting the use of mobile phones in schools. The use of social media or digital services must be regulated so as not to alienate people, encourage them to over-consume, monopolise their attention or influence their decisions through services that are deliberately misleading (dark pattern) and addictive (notification management).

198 European Communities (2000), Charter of Fundamental Rights of the European Union, Official Journal 2000/C 364/01. European Commission (2020), Berlin Declaration on Digital Society and Value-based Digital Government.

199 Vejay Lalla et al. (2022), Intelligence artificielle: les deepfakes dans l'industrie du divertissement.

200 Shoshana Zuboff (2018), The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power, New-York: Public Affairs.

201 See Zenter fir excessivt Verhalen a Verhalenssucht.

202 Neil Howe (2019), Millennials and the Loneliness Epidemic, Forbes. Clea Skopeliti (2023), 'Socially stunted': how Covid pandemic aggravated young people's loneliness, The Guardian.

203 See the provisions already in place on the Portail de l'accessibilité numérique.

The negative consequences for the development of children exposed to screens and social media have been proven. A comprehensive system of legislation protects children, privacy and personal data. Strict data protections would help deflect interest from the 'attention economy' – that is, business models that rely on generating and commercialising user data. To reduce attention-grabbing practices, push messages and notifications should only be allowed on an opt-in basis.²⁰⁴

'New technologies and entertainment have taken over our leisure and free time. Screens have taken over our attention. The time gained through ingenuity, scientific discoveries and dizzying innovation is being wasted on the 'forever scroll' through pointless content. We urgently need to do a better job of teaching everyone the difficult art of resisting oneself. At stake here is the question of living better, i.e. spending a little less time on time-consuming tasks, and above all ensuring the conditions for subsistence. The success factor that is least recognised today is effort. Effort may even surpass intelligence as a factor for success. The triumph of entertainment is in fact the triumph of boredom and the need for recognition. An education based on iron discipline is needed. Achieving a new balance in the use of leisure depends on a philosophy of delayed pleasure rather than immediate gratification.'

Olivier Babeau, *La tyrannie du divertissement*, 2023

Digital tools can shape the transition from owning to simply using an asset (leasing, car-sharing, crowdfunding, cooperative platforms, the Internet of things). They can open up access to knowledge and know-how by digitising technical manuals and references.

In the creation and management of Luxembourg's 'smart grid',²⁰⁵ digitalisation will play a key role in **controlling electricity costs** by regulating production, consumption and local storage (peak smoothing), promoting decentralised self-consumption and improving energy performance (smart metering).

It is also important to monitor the impact of digitalisation on business productivity and competitiveness.

C. Responsible digitalisation: ensuring national sovereignty

Developing digital sovereignty will make it easier to ensure the privacy of the users of digital services. To preserve the sovereignty of a responsible digital world, its resilience must be guaranteed in relation to many factors, such as the availability of the necessary low-carbon energy, uninterrupted and trusted communications networks, skilled workers, the ability to detect and mitigate malicious activities and low dependence on abusive commercial decisions and extraterritorial interference.

Luxembourg continues to enjoy reliable, high-capacity, low-latency communication networks that are inclusive in terms of cost and non-discriminatory for citizens and businesses alike.²⁰⁶ Trusted, high value-added services contribute to the security and quality of a digital Luxembourg. The future of these networks will involve a quantum key distribution infrastructure accessible by the public and private sectors in a non-discriminatory manner and guaranteeing highly secure communication channels.²⁰⁷

²⁰⁴ Tilman Santarius et al. (2022), *Digital sufficiency: conceptual considerations for ICTs on a finite planet*, Annals of Telecommunications.

²⁰⁵ Creos Luxembourg, *Smart Grid*.

²⁰⁶ See *MyConnectivity*.

²⁰⁷ ME (2022), *Approbation du 1er jalon du projet Luxembourg Quantum Communication Infrastructure IAb (LUQCIA) démarré en mars 2022 au sein de l'Université du Luxembourg*, Press release.

#4 Reconciling the digital, ecological and social transitions

Luxembourg has training and reorientation programmes to cover at least half of its needs for human resources capable of developing and managing digital networks and applications. At least a third of its skilled workers in this domain are female. Digital technologies are an integral part of basic training from an early age.

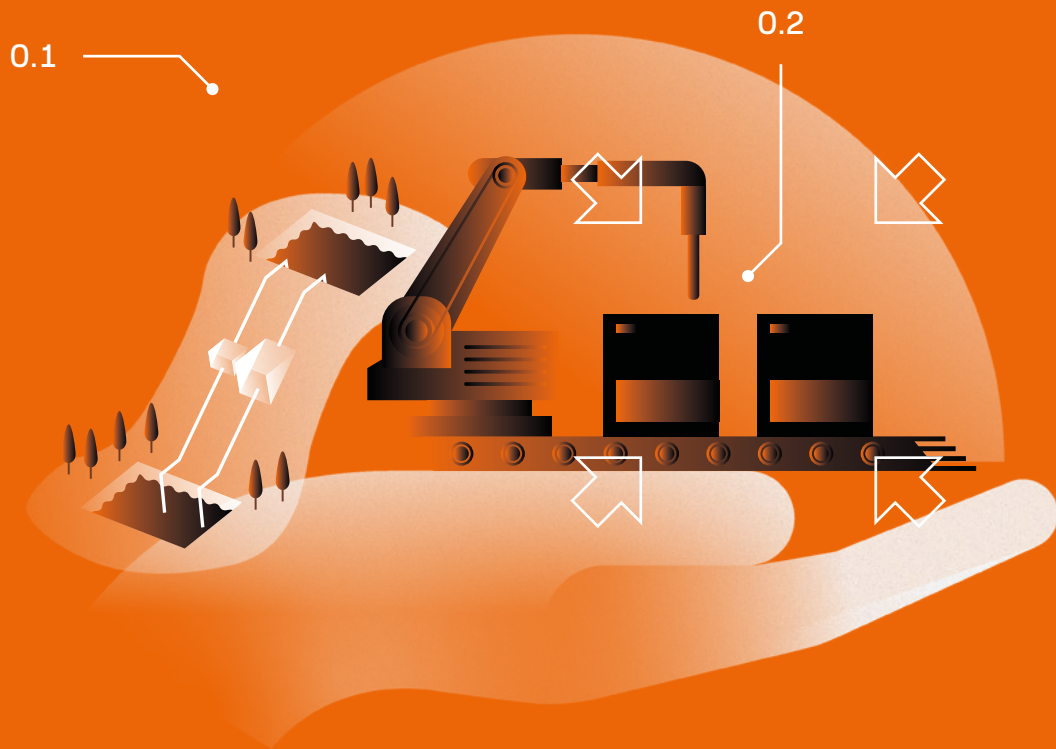
Security services aimed at ensuring the digital resilience of private and public users are non-discriminatory in terms of cost and complexity. The great potential for synergies in the field of information security can be capitalised on by promoting operational collaboration, information exchange, research and innovation, and informed governance. Luxembourg manages an open data space for cybersecurity, in order to promote research and innovation and speed up the identification of malicious activities. Luxembourg has state-of-the-art security tools accessible to SMEs and citizens that do not require expert intervention.

Digital sovereignty can give Luxembourg control over its data (reversibility of data with suppliers, data protection, localisation of data on national territory, open file formats, etc.) but also the freedom to migrate to open source IT systems, which reduce exposure to risks linked to abusive commercial and political decisions while facilitating collaboration and exchange.

The data economy takes off at an accelerated pace and improves its independence. It relies on a high-quality digital infrastructure that inspires confidence. To meet the goal of reconciling the digital and ecological transitions, it is key to invest in 'high value-added' sovereign IT infrastructures. The components of such a national digital system are a national cloud and edge-cloud network, high processing capacity per computer, a national data exchange platform, auditable AI models and a 'data steward' service that ensures high data quality and interoperability (GAIA-X), facilitating the capitalisation of synergies and promoting innovation and research. Blockchain technology presents opportunities (public sector blockchain)²⁰⁸ and risks that need to be circumscribed (cryptocurrencies). By favouring open source software (reuse of existing source code), development times in the IT sector can be reduced and applications made more easily interoperable. Altruism in cybersecurity increases the resilience of the entire Luxembourg ecosystem.

This means that the IT infrastructures made available must be of very high quality, offering secure solutions with high added value and the smallest possible energy, hardware, land and water footprints.

²⁰⁸ Government of the Grand Duchy of Luxembourg, [Le Luxembourg se veut pionnier européen dans le monde du blockchain](#), and [Infrachain](#).



#5

Investing in critical
redundancy,
strategic storage
and duplicated solutions

The COVID-19 pandemic has revealed the importance of ensuring the continuity and proper functioning of vital sectors such as health, IT, energy and drinking water, and of continuing to operate in times of crisis. Resilience – as a system’s ability to bounce back after foreseeable or unforeseeable shocks, and also to transform itself in order to better withstand them in the future – is at the heart of the Vision.

Resilience can come in different forms. Other chapters in this report look at resilience in terms of sovereign physical and digital production, the diversification of supplies and economic sectors, technological and behavioural innovation, fuel switching, efficiency, circularity, sufficiency and crisis management plans. Societal and individual resilience is nurtured by social cohesion, equitable access to economic opportunities and high quality work, a sense of wellbeing and empowerment, and psychological stability. Being healthy is also part of individual resilience.

These different types of resilience are all based on some form of reserves, fall-back resources, buffering or absorption capacity, or stockpiles. This resembles certain natural systems, for example when flora and fauna build up their reserves before winter or periods of drought, or when the oceans absorb the excess heat caused by climate change.

This chapter deals more specifically with infrastructural and functional resilience, the foundations of which are critical redundancy, strategic storage and duplicated solutions.

To ensure that the economy will be more resilient to shocks, can recover more quickly from disruptions and can always access energy, water, communications and healthcare at stable prices, it is recommended, after distinguishing between necessities and conveniences, to invest in **back-up solutions** for these vital goods and services.

Critical redundancy is a response to risks arising from pandemics, environmental disruption and international tensions (cyberattacks, supply problems, or conflicts). A pool of **cybersecurity** experts should be put in place to intervene rapidly in the event of a large-scale cyberattack on critical infrastructures. In all cases, it is a good idea to insure against risks that cannot be anticipated, and which are not yet pressingly urgent or serious. The ECO2050 Vision invites to adopt a **dual operating mode** wherever critical and relevant, rather than relying on just one type of solution.

Redundancy refers to the reserve capacity purposely created within systems so that they can cope with disruptions, extreme pressures or increases in demand.²⁰⁹ This includes diversification, the presence of multiple ways of meeting a given need or fulfilling a particular function, and autonomy, that is, without depending on other countries. Efficiency, circularity and sufficiency are levers for achieving this.²¹⁰

²⁰⁹ In the human body, examples of redundancy include both the duplication of certain organs (e.g. eyes, lungs, kidneys, etc.) and the ability to compensate for certain functions (e.g. the function of a damaged muscle can be compensated for by other muscles, the immune system is based on several lines of defence and includes physical barriers, immune cells and antibodies, blood vessels are branched so that they can provide relays in the event of obstruction, etc.).

²¹⁰ ARUP Project (2021), Luxembourg in Transition, Stage 1 report p. 13.

#5 Investing in critical redundancy, strategic storage and duplicated solutions

Resilience through redundancy is a particular concern for certain **critical infrastructures and activities**.²¹¹ The **High Commission for National Protection (HCNP)** defines critical infrastructures as follows: 'While some threats affect the entire population and country, others affect specific infrastructures whose preservation and proper functioning are of essential importance for national security and the continuity of societal functions. Critical infrastructures such as power plants and grids, oil pipelines, airports and railway stations can be damaged, disrupted or destroyed by deliberate acts of terrorism, natural disasters, negligence, accidents or hacking, and by criminal activity or malicious acts'. The HCNP coordinates issues relating to the protection of national and European critical infrastructures.

Redundancy can be achieved by the geographical duplication of an infrastructure, stocking spare parts and vital components, and distributing critical functions through physical or digital networks. Redundancy contributes to resilience alongside robustness, repairability and adapting infrastructure to extreme climates. **Data centres provide** good examples of redundancy (duplicated cooling systems, stand-by generators and batteries, on- and off-grid operation, water reserves, etc.). Some hospitals have completely duplicated operating theatres, with the second taking over if the first fails (fault tolerance). The design of hospital establishments includes redundancy of supplies (water, electricity, etc.) and solutions for coping with incidents and disasters. The Norwegian government has opened a global seed bank so that food production can be restarted in the event of a disaster.²¹² For aircraft, certain critical parts of the control systems are even tripled. Reinforcing the European electricity grid to provide flexibility and back-up capacity is another example of redundancy.

Infrastructural and functional redundancy aims to increase the security of vital supplies, reduce vulnerability to blackouts or shortages, and ultimately ensure the continuation of the essential functions of the state. While such redundancy does have a cost, it would enable some long-term control over prices, and therefore enable to ensure an affordable and stable cost for basic energy and material needs in the event of excessive price rises. The aim would be to put in place reserves and redundant solutions so that, in unforeseeable or uncertain circumstances, important products and services can still be supplied to the population.

Infrastructure resilience includes the concepts of adaptability and flexibility. Given the number of years required between the design and completion of, for example, a school or a water purification and storage plant, and the difficulties of predicting the capacity required, both in terms of volume and specific equipment, recommendations include:²¹³

- Building **infrastructure that can be adapted and transformed** as needs change
- Including buffer zones that can be developed as new needs emerge

211 The loi modifiée du 23 juillet 2016 portant création d'un Haut-Commissariat à la Protection nationale, Article 2(4), defines a 'critical infrastructure' as 'any point, system or part thereof that is essential for safeguarding the vital interests or essential needs of all or part of the country or population [...]'. Critical infrastructures are identified on the basis of various criteria, including their potential economic impact. This is measured by the extent of economic losses, the degradation of products or services, the market share affected in terms of users, the cost of reconstruction, the cost of using alternatives, the % of total production in the affected sector, or the extent of turnover in the affected market, expressed as % of GDP or % of turnover generated by the sector. The European Commission defines critical infrastructure as follows: 'physical and information technology facilities, networks, services and assets which, if disrupted or destroyed, could have a serious impact on the health, safety or economic well-being of citizens or the work of member state governments'. See Commission of the European Communities (2006), [Communication from the Commission on a European Programme for Critical Infrastructure Protection](#), 12 December 2006.

212 [Svalbard Global Seed Vault](#).

213 WHO Regional Office for Europe (2023), [Hospitals of the future: A technical brief on re-thinking the architecture of hospitals](#), Copenhagen.

The option of using modular elements, which can be designed, purchased, fitted out, assembled and installed on site in a few months at lower cost, and which can be recycled or even sold on the secondary market if needed, should be considered as part of an approach which emphasises sufficiency and flexible adaptation to functional needs, without sacrificing aesthetics, amenity or quality.²¹⁴

To be future proof, major infrastructure projects that are designed to protect from shocks must themselves be protected from shocks: the IEA calls on leaders to design major infrastructures and sites to withstand **extremes of climate** and supply disruptions while reducing emissions as much as possible.²¹⁵ For the past 5 years, weather stations have observed weaker winds in summer in Europe. It is crucial to test and model systems and infrastructures for different climate scenarios and for extreme and non-median weather conditions, and to make provision for periods of low winds. It is therefore necessary to maintain, pass on and adapt the **capacity to design, finance and build large-scale infrastructure**, both grey (man-made, requiring energy) and green (solutions based on nature, with no input of energy or materials).

EXAMPLE : NATURE-BASED SOLUTIONS FOR ASSET PROTECTION, JURONG ISLAND, SINGAPOUR

Jurong Island, a globally prominent oil refinery and chemical manufacturing hub which powers Singapore, is turning to green infrastructures for flood defence.



Source: <https://www.businesswire.com>



Source: <https://www.jtc.gov.sg>



Source: <https://medium.com>

Jurong Island houses critical infrastructures required for Singapore's energy security and economy. In low-lying areas and coastlines, the government is test-bedding a nature-based solution on the island that works to enhance flood resilience against future projections of more intense and frequent storms due to climate change.

Known as the Jurong Island pond, this solution covers an area of about 9 hectares and is designed to make use of existing ground conditions to build up flood resilience.

It is particularly important to develop nature-based solutions. These are among the megatrends observed by the European Commission.²¹⁶ Nature-based solutions are alternative infrastructures that produce the same results as man-made, material-intensive and energy-assisted infrastructures, in addition to providing co-benefits (climate regulation, nutrient supply, water filtration, recreation, health, tourism, food, etc.).²¹⁷ Examples include flood management using the renaturalisation of watercourses, natural retention using vegetation, or the expansion of excess water in flood and wetland areas, instead of building concrete pipes and pumps. Temperature regulation in homes can use bioclimatic or passive construction methods rather than boilers and air conditioning assisted by home automation systems.²¹⁸ Cooling in cities can use trees and fresh air corridors. Wastewater can

²¹⁴ On this subject, see the very fine examples produced in the United Kingdom: [Modular Hospital Building | Healthcare Buildings | Premier Modular](#).

²¹⁵ IEA (2022), Electricity Report.

²¹⁶ 'Ecosystem approaches, Green and Blue Infrastructures (as opposed to grey 'building' infrastructures), and Nature based Solutions (NbS, i.e. the use of nature for tackling challenges) offer an inclusive conceptual basis for environmental policy. These include the contribution of ecosystems to the people and the economy (ecosystem services), ecosystems as safety nets (carbon storage and sequestration, disaster risk reduction), ecosystems as a pool for biodiversity, and ecosystems and their social benefits (jobs, recreation, health). NbS involves locally adapted, resource-efficient and systemic interventions.' See European Commission (2023), [Trend: Evolving resource management](#), Competence Centre on Foresight, Knowledge for policy & European Commission (2022), [Brief me on nature-based solutions](#). Knowledge for policy.

²¹⁷ World Bank (2023), [Assessing the Benefits and Costs of Nature-Based Solutions for Climate Resilience: A Guideline for Project Developers](#).

²¹⁸ LuxDev (2016), [Bioclimatic construction in Niger](#), LuxDev.

#5 Investing in critical redundancy, strategic storage and duplicated solutions

be treated by lagooning rather than through mechanical or chemical methods. Green solutions have multiple environmental co-benefits, and some cost less than their grey counterparts.²¹⁹

Industrial relocation, local production of energy, materials and food, environmental rehabilitation, and integration with European networks for rail (including night trains), electricity and waterways (river freight) are other tools for increasing territorial resilience. In this respect, Luxembourg could propose a review of the EU rules for **Important Projects of Common European Interest (IPCEI)**, managed by the European Investment Bank (EIB), to enable smaller industrial projects to qualify. In addition, rehabilitating ecosystems means they can continue to provide good quality water, air, resources and soil. Such rehabilitation also offers financial advantages, limiting the costs of investing in grey infrastructure.

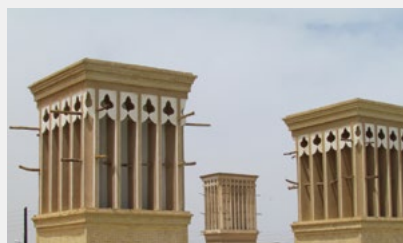
In addition to stockpiling and infrastructural redundancy, **solutions should be duplicated**, maintaining a range of solutions for vital goods and services so that one vulnerability is not replaced with another. For instance, by relying exclusively on electric transportation or battery storage our dependency on the availability of minerals such as cobalt, lithium or nickel, which are exposed to other vulnerabilities remains (the geographical concentration of production, geopolitical risks, carbon-intensive extraction, processing and transport, etc.).

EXAMPLE : DUPLICATED SYSTEMS TO ADOPT

- **Mega- and micro-projects** (e.g. variable energy storage, smaller boats for low-water navigation, etc.)
- **Mitigation and adaptation** (reducing emissions / adapting to the effects of environmental disturbances)
- **Grey and green infrastructure** (e.g. pipes and pumps / floodplains to manage water, electric air conditioning/ natural ventilation, etc.)
- **Centralised and decentralised** systems (e.g. interoperability of the European electricity grid / solar power and batteries, water tanks at the domestic level)
- **Active / assisted and passive** systems (e.g. battery storage / geological or gravity storage)
- **Modern and high-tech** know-how / **traditional and low-tech** know-how (robustness, repairability)
- **Mechanical and digital** solutions (to protect against digital attacks or power cuts, etc.)
- **Technological and behavioural** solutions (e.g. increased efficiency of cars / reduction in forced mobility; increased supply of more efficient technologies / reduction in demand for goods and services)



Energy-assisted cooling
Source: <https://commission.europa.eu>



Bioclimatic cooling, baghirs, Iran
Source: <https://www.flickr.com>



Solar chimneys,
Luxembourg Cooperation in Niger, 2016
Source: LuxDev (2016), bioclimatic construction in Niger

Another example of necessary duplication concerns the availability of high-quality, competitively-priced decarbonised electricity. Such power is highly valued, and supply is lower than demand. There are conflicts of use between the needs of industry, mobility, agriculture (fertilisers) and data centres, plus the additional future needs for air conditioning, 5G, heat pumps, e-fuels and green hydrogen.

Combining different means to increase economic resilience is also the approach adopted by the UK's supply strategy, which is based on the diversification of supply sources, international partnerships, storage and back-up capacity, onshoring and demand management.²²⁰

In terms of **strategic storage**, energy is a priority. The European Commission estimates that the demand for storage technologies in Europe will increase between now and 2050.²²¹ As the penetration of uncertain and variable energies increases, costs will rise, as the system becomes more complex to manage and loses reliability and security. Only with energy storage can renewable energies be used on a permanent basis and increase their penetration in the grid. Storage is a prerequisite for energy security and independence (KBR). It is needed to create stable, reliable, low-carbon electricity systems at affordable and competitive prices for domestic and commercial use. If the prices of electricity and rare earths for batteries rise, investment in onshore storage (pumped-storage stations) could become financially viable.

In terms of redundancy, technologies should be combined according to their efficiency, storage time, costs and resource intensity, including, in Luxembourg, their use of land and water. Various possible energy storage techniques can be studied.²²² In addition to technological solutions (batteries, flywheels, etc.), gravitational, thermal and geological solutions have the advantage of using the natural resources of the national territory, which means that these solutions are less dependent on imports of rare and expensive metals.²²³

Given the budgetary implications of heavy investment in redundancy and the material and energy footprints involved in redundancy and duplication, future needs for critical infrastructure and services should be identified and prioritised on the basis of the best long-term social cost/benefit ratio, and in a participatory and fact-based manner, with a time horizon extending over the next 30 years.²²⁴ To be efficient and effective, it is important to standardise easily reproducible designs, to capitalise on best practices and to share with neighbouring countries. This could begin by drawing up budgeted plans for economic shock resilience. A first step in this direction has been taken by the RISK2050 study initiated by Luxembourg Strategy in 2022.²²⁵

220 Department for International Trade (UK), [Supply Chains Resilience Framework](#).

221 European Commission (2020), [Study on energy storage – Contribution to the security of the electricity supply in Europe](#), Final Report.

222 E.g. Scientific Foresight (STOA) (2023), [What if increased energy storage could help fix climate change?](#) Podcast from the European Parliamentary Research Service.

223 An example of the planning of a medium-sized pumped storage station can be found in the Greater Region, at Trier. See [Pumpspeicherkraftwerk Rio](#).

224 Fondation IDEA (2023), [Grands Défis](#), p. 114.

225 Luxembourg Strategy (2023), [RISK2050 Study](#). Ministry of the Economy.

#5

Investing in critical redundancy,
strategic storage and duplicated solutions**EXAMPLE : THE DUTCH WATER DEFENCES INDUSTRY,
A PUBLIC GOOD AND BUSINESS CASE**

NL Delta plan for achieving flood protection, freshwater availability and spatial adaptation goals by 2050. Delta Fund 2021–2034, EUR 19 billion

“The time for freedom of action is over: we need to speed up to keep our delta safe and liveable.”

“The urgency is increasing, due to the changing climate. Such investments are especially crucial now to sustainably foster our economy and to enhance the resilience of our society. With Covid, we have experienced, more than ever before, how important it is for our vital sectors such as health care, IT, and the power, gas, and drinking water supply, to continue to operate during a crisis. Measures to **climate-proof vital and vulnerable functions** must be intensified.”

Peter Glas, Delta Commissioner

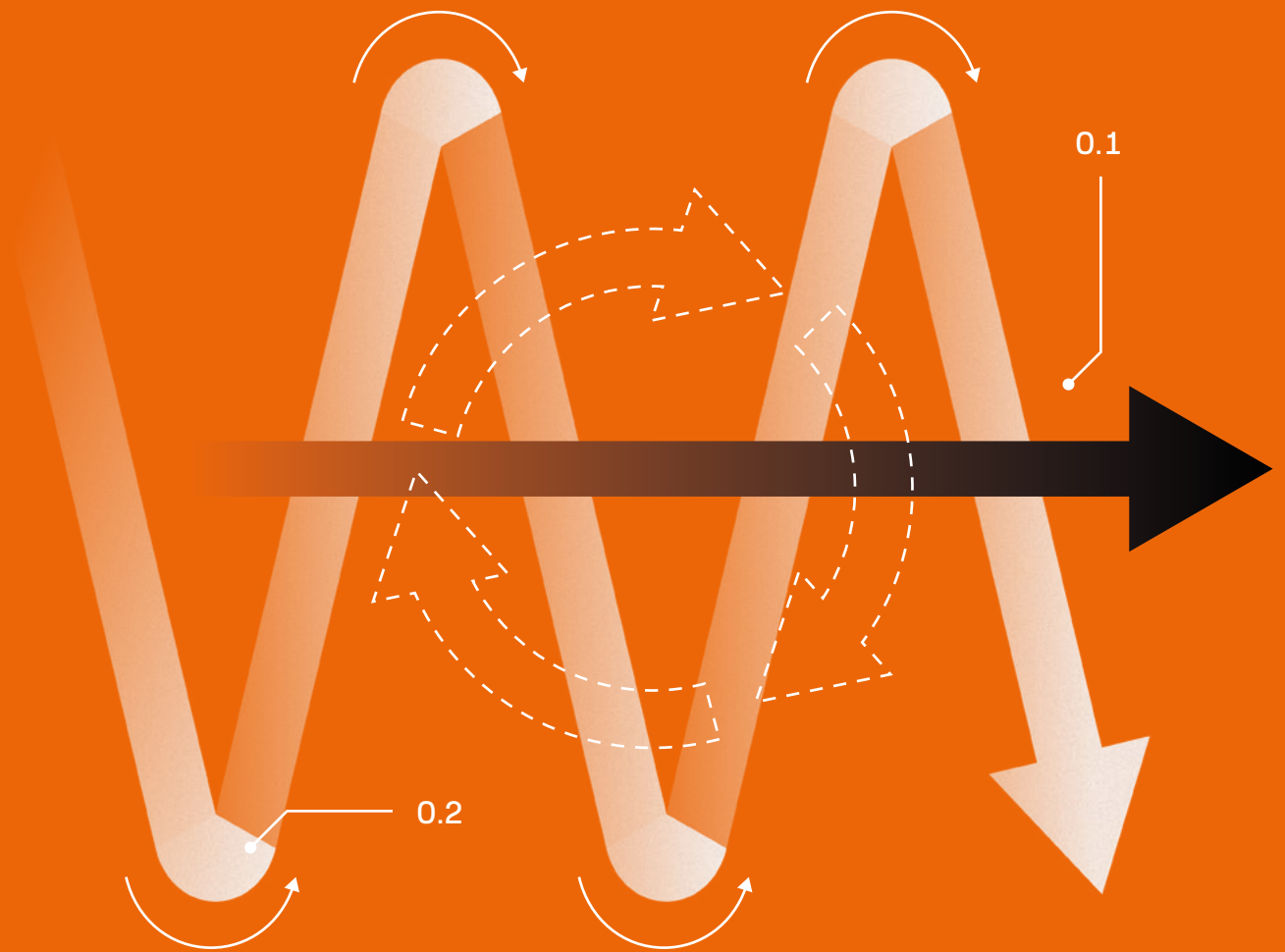


Source:
<https://english.deltaprogramma.nl>



Source: Gundula Winter and Marjolijn Haasnoot (2022), Putting Dynamic Adaptive Policy Pathways into Practice, Deltares

The Delta Plan in the Netherlands is one of the largest programmes for defence against rising sea levels in the world. Its construction has spanned several decades: starting in the wake of the disaster of 1953, the first phase was completed in 1986, and the second in 2010. A threat has therefore been transformed into an opportunity through experimentation and innovation. There are 2,400 Dutch companies operating in the field of hydraulics and adaptation to climate change. Dutch companies and universities are leading the way in coastal development, floating farms, ecosystem-friendly dykes, erosion control and more. They have turned this into an export product, with Bangladesh, for example, using Dutch expertise to draw up its own 100-year Delta Plan.²²⁶



#6

Simplifying **procedures**,
shortening **pathways**
and facilitating **transfers**

Administrative and legal complexities have become a real obstacle to economic competitiveness, entrepreneurial agility and public support. This phenomenon is widespread globally.

How to ensure that bureaucracy genuinely serves the transitions? How to reconcile creativity, freedom, flexibility and initiative with the need to regulate, standardise and monitor, and how to do so while speeding up procedures? How to reconcile social and environmental precautions, economic performance and administrative speed? How can short logistics, nearshoring and green public procurement be implemented without increasing bureaucracy and infringing the free movement of goods and services within the EU? How to maintain existing skills and production tools by facilitating transfers between businesses? What room for manoeuvre does each country have given the regulatory and administrative complexities of the European Commission? Can a small nation like Luxembourg succeed better than large countries in using transitions as an opportunity to simplify procedures?

To meet these challenges, the scenario-building foresight exercise revealed three levers for public action that can be used in each of the three scenarios: simplifying procedures, shortening pathways and facilitating transfers.

- A. Simplifying procedures
- B. Shortening pathways
- C. Facilitating transfers

A. Simplifying procedures

For the state, simplifying procedures involves ensuring better coordination of the different sectoral policies and strategies, checking the coherence of their goals and their combined biophysical feasibility, while taking care to respect material limits and social needs. To respond to uncertainties and risks, the state will ensure that the **regulations** and procedures aimed at accomplishing the transitions are flexible and enabling, in order to improve business agility and responsibility. Coordination and simplification are necessary at all levels and can be achieved in a number of ways:

One possibility is the creation of a **harmonised framework** for monitoring sectoral strategies (of which there are currently 53)²²⁷ and the impact of incentives for implementing them. This could be based on existing national data (monitoring of decarbonisation in the context of the PNEC, land artificialisation in the context of the PDAT, competitiveness through the ODC, and macro-economic indicators and wellbeing through STATEC), while taking care to align with European and international frameworks.

To be future proof, future strategies must better integrate the potential conflicts of use resulting from their simultaneous implementation. For example, adaptation to climate change, the increasing scarcity of raw materials, the decline in biodiversity and territorial impact must all be taken into account. The calculation of the **energy-material-carbon balance** of the strategies provides a tool for facilitating this task. In addition, the PNEC envisages that the state administration will be carbon neutral by 2040. Municipalities are standardising **building regulations** with a view to preserving heritage and prioritising the renovation of existing buildings, ensuring the resilience of occupants (terraces, bicycle storage places, *Spënchen* for food storage, composting, collective management of boilers and waste, rainwater tanks, etc.) and saving space, materials and energy (KBR19-23).

The state has a duty to facilitate the exchange, interconnection and re-use of data between administrations by implementing common semantic and technical standards. The solution commonly chosen to achieve this goal – already in place in a large number of EU member states – is a **central data intermediation platform** which data providers (authentic sources) and data consumers can connect to in a standardised way. Such a platform does not store the data centrally, but simply allows it to pass from the supplier to the data consumer.

²²⁷ Luxembourg Strategy (2022), *Tableau de suivi des stratégies sectorielles nationales*. Ministry of the Economy.

#6

Simplifying procedures, shortening pathways and facilitating transfers

Businesses are asking for a **one-stop-shop** for their administrative procedures, centralised access to data, paperwork automation and a reduction in administrative procedures. The re-use of information held by public sector bodies should be facilitated to promote transparency, data-driven innovation and a level playing field.²²⁸ The government could implement the electronic **once-only** principle, aiming to eliminate all unnecessary administrative procedures and simplify those that remain as much as possible. The combination of these different elements will lead to a significant reduction in those administrative procedures that online users still have to carry out.

Authorisation procedures could be further accelerated, digitised and automated or, where appropriate, replaced by declarations of compliance by companies (PNEC). Public enquiries should be available electronically (**e-Commodo**). Administrative procedures relating to the implementation and manufacture of decarbonisation technologies must be accelerated. Companies of all sizes and needs will be involved in designing the products needed to simplify procedures.

A biometric 'blue card' could be introduced to speed up the recruitment of highly qualified employees from non-EU countries, and administrative procedures could be digitised. A single European framework could be created for worker postings, focusing on internships and temporary loans of cross-border labour.

Digitalisation is a central tool for achieving this goal. It must be implemented in a user-centred way. There are many complaints from disillusioned users faced with outdated paperwork that cannot be filled in, or forms that are too quickly updated and replaced. Citizens and businesses complain of dehumanised public services, a loss of contact and knowledge, and an inability to resolve problems simply. Users lose control and become exhausted when faced with automated call centres, virtual queues, automatically renewed contracts, endlessly updating apps, an excess of tokens and passwords, and the outsourcing of customer services. True to the principles of the Vision, exclusivity is not an option. The virtual world has its advantages, but services should remain simple and practical, and distances should be on a human scale, with the provision of local and decentralised public agencies and offices (in 15-minute cities), enhanced services and intermediation, and accessible products and formats for the elderly and disabled.

Companies are faced with an avalanche of monitoring and reporting systems, as well as criteria for non-financial reporting on their performance in terms of the environment, inclusion and governance, and soon also biodiversity ([building block 7](#) and [building block 9](#)). However, these provisions, integrated in the recently adopted directive on **corporate sustainability reporting (CSR)**, are also likely to speed up the reform of public procurement to make it a useful tool for the transitions ahead ([building block 2](#)).

Companies could receive support in meeting the new standardised requirements across the EU and in drawing up a physical balance sheet of greenhouse gas emissions. By **defending the single market and harmonising laws**, rules and assistance across regions, Luxembourg will be able to take advantage of the reduction in procedural burden for strategic industries and services that is provided for in the NZIA.

B. Shortening pathways

Based on the hypothesis of a probable increase in the price of energy, carbon and materials, the costs of globalisation and imports will increase.²²⁹ Relying on long-distance electrified transport that is as cheap and plentiful as used to be the case for fossil-fuel based transport by truck, ship or plane is not a future-proof strategy. In the long term, international movements are likely to become less frequent and more expensive. The transport of strategic and high-value goods will be prioritised over mass-produced, heavy or disposable goods. It is advisable to shorten physical distances where this makes sense, and to produce closer to home. The opportunities for reducing these quantities or distances lie in achieving greater material autonomy, efficiency, circularity and sufficiency (e.g. reducing essential travel) ([building block 1](#) and [building block 2](#)), as well as shortening supply chains and transfers between modes of transport. Nearshoring will make it possible to reduce emissions related to international transport. The potential territorial impacts of an economic shift towards greater resilience, inclusiveness and competitiveness are described in [Appendix 7](#). A foresight map presenting possible changes in the spatial arrangement of economic activities is provided at the end of this report.

It is essential to consider not only the potential of the market inside and outside the European Community, but also the potential for bringing certain value chains closer to national borders²³⁰ and for increasing production and consumption in the market of the Greater Region. Although demographic projections predict widespread ageing and a slowdown in population growth between now and 2050, the Greater Region still represents a market of 12 million residents, with a growing proportion of pensions paid by Luxembourg to retired cross-border workers in other countries.²³¹

Making better use of productive potential at **local, municipal** level and at the level of the **Greater Region** will contribute to territorial resilience (a goal of the PDAT). In fact, the implementation and expansion of economic activities can be made easier and more profitable by aggregating national volumes and structuring supply and demand according to real catchment areas and catchment basins, regardless of administrative boundaries. Enlarging the production-consumption perimeter contributes to attaining a critical mass. Which activities are best carried out at which territorial level needs to be analysed on a case-by-case basis, and **local economic actors, citizen cooperatives, municipalities and inter-municipal associations, and neighbouring regions and provinces** need to be supported to enable them to handle the consequences and opportunities presented by the transitions.

Examples abound of **subsidiarity, decentralisation and mutualisation at the local level**, which represent important business opportunities:

Faced with public demand for more local shops and services and smaller shopping centres in urban areas accessible by public transport and soft mobility,²³² a **relocation of commercial activities** to town centres can be predicted.

Households installing rainwater harvesting cisterns in their homes, and municipalities installing micro-stations for electricity generation or storage and heat networks can also be foreseen. Challenges such as adapting ecosystems to climate change and assisting the migration of crops and forests northwards transcend administrative boundaries and are instead a function of agro-climatic conditions, water catchment areas and regional forest formations.

229 'We have reached peak globalisation' according to François Heischbourg, Journée de l'économie, Chamber of Commerce Luxembourg, 17 April 2023.

230 Interreg Europe (2023), [Reshoring and nearshoring for stronger European Value Chains](#).

231 Statistiques Grande Région, [Projection de la population totale 2021-2050](#).

232 ILRES survey: residents' responses are in line with the objectives of PDAT2023: 8 out of 10 respondents are in favour of limiting land consumption. See ILRES (2023), [Qualité de vie et développement urbain futur et Imperméabilisation et artificialisation du sol](#), 7 February 2023.

#6

Simplifying procedures, shortening pathways and facilitating transfers

Decentralised energy community initiatives also offer considerable potential. An energy community provides for the sharing of electricity produced locally between members. The use of on-site or multi-site solar or wind power as part of a collective self-generation scheme provides greater autonomy and avoids losing surpluses generated depending on the weather, by equalising between surplus and deficit producers and storing the surplus. Intelligent management can be carried out locally and in real time using an IT platform and machine learning.²³³

Industrial development, geological prospecting of the subsoil, the development of repair-recycling channels, storage of inert waste, renewable energy generation (PNEC), and remediation of contaminated soil on former industrial sites may be more efficient and profitable for a larger market that accumulates volumes and shares costs. The real perimeters of supply and distribution can then be defined in terms of pools of employees or of raw and secondary materials.

The economy will support **agriculture, market gardening, arboriculture and forestry projects** in redirecting and diversifying production towards national²³⁴ and local needs by developing agri-food, forestry and agro-mechanical industries in the Greater Region. There are also opportunities for local tourism resulting from a decline in long-haul flights, for natural carbon sequestration activities and for the geographical expansion of **winegrowing**.

Working together to tackle labour shortages and recruitment difficulties is a shared priority across the **Greater Region**. It is important to coordinate actions to improve the match between job supply and demand in the Greater Region. To limit the risk of competition between territories, Fondation IDEA proposes the creation of cross-border economic development agencies, a cross-border business model, investment in industrial, craft and commercial companies beyond the national borders, joint degrees in critical skills or those that do not exist at a national level, mutual recognition of qualifications, and cross-border mobility for apprentices.²³⁵

To stimulate this, **national public procurement contracts will be greened and localised (KBR)**: harmonised ecological criteria (environmental and carbon footprints), social criteria (human rights, transparency), geographical criteria (scope of supply and delivery) and aesthetic criteria (architectural quality) will be developed. Circularity and innovation ([building block 1](#) and [building block 2](#)) will be integrated into public procurement contracts, starting with state acquisitions. To take account of matters of resilience, price should no longer be the sole criterion for choosing a tender and qualitative award criteria should be used.²³⁶

²³³ See, for example, Energiepark Réiden SA.

²³⁴ MAVDR (2021), *Assurer un développement durable du secteur agricole*, Plan stratégique national du Grand-Duché de Luxembourg pour la politique agricole commune (PAC) 2023-2027.

²³⁵ CES (2022), *Pour un développement cohérent de la métropole transfrontalière du Luxembourg dans la Grande Région*. Fondation IDEA (2023), *Une vision territoriale pour le Luxembourg à long terme*. Chamber of Commerce Luxembourg (2023), *Vers un modèle de développement trans-frontalier*.

²³⁶ This is the case in France, for example, in the application of the Loi Climat et Résilience, cited in the OAI Programme for the 2023 Legislative Elections, p. 6/16.

Support for tenderers and contracting authorities would involve, for example, preparing a **guide to green public procurement**, making it possible to identify how to green a contract at each stage of a public procurement process using the tools currently permitted by the *Loi sur les marchés publics*, and, if necessary, new tools. There is also considerable potential for supporting the development of green procurement by providing for pre-procedure dialogue and analysis, defining green specifications (green criteria in the definition of needs, selection clauses and criteria, award criteria, etc.), the choice of green companies or the inclusion of green criteria (variants, bonuses, etc.), monitoring the application of these criteria, choosing green companies, encouraging green labelling, etc. Green innovations could also be encouraged through training, exchanges of best practice and feedback. All of this will lead to the **standardisation of clauses that can serve as a basis** for contracting authorities, and which they can confidently disseminate and use.

The lessons of the pandemic lead to review not only public procurement procedures but also the management of stockpiles of essential products. The aim is to achieve greater security of supply at controlled quality, purchase and storage prices. This will make it possible to anticipate and combine certain purchases, and to monitor distance, delivery and resupply times, with a general concern for low ecological impact. A **public strategic purchasing centre** for the hospital, energy, IT and other sectors will be an asset in the face of new crises, making it possible to guarantee lower costs and delivery times. As the national market is limited in size, it could operate at the level of the Greater Region and include criteria for carbon impact and local origin in order to favour companies present in the region.

Measures for reducing essential mobility include long-term **remote working schemes** for residents and crossborder workers and jobs that lend themselves to remote working, hybrid remote working with shared satellite spaces, **grouped deliveries** in combination with **e-commerce**, and the development of **15-minute cities**, which combine shops, workshops, services, recreation and housing. Grouping deliveries (including by drone) or providing basic services within walking distance are also preventive measures against the resurgence of pandemics or the rising cost of transport. According to the think tank The Shift Project, 'various experiments have shown that good management of e-commerce distribution leads to significant savings in terms of travel when the distribution of a large number of purchases is grouped within a geographically close perimeter. For basic shopping, individual journeys to supermarkets can be replaced by grouped rounds based on prior electronic orders'.

In line with the *Plan national de mobilité 2035* (National Mobility Plan 2035), the transition from resource-intensive modes of passenger transport to low-carbon, collective, light and soft modes of transport (KBR, Climate Policy Observatory (OPC), PDAT) could be extended to **road, rail and river freight transport** and inter-urban **logistics**. A second, short-distance logistics-warehousing-delivery system can be envisaged, with reduced distances and intermediaries, which delivers regional and basic products (food, spare parts, firewood, tool hire, etc.) for direct sale or barter to customers in the Greater Region functional area. The Greater Region and its logistics hubs can serve as a test case for 'reverse logistics'.

Reverse logistics requires more time and space than linear logistics, but is a promising sector given material scarcity and the need for circularity, and can enable companies to differentiate themselves from competitors. A strategic approach to reverse logistics requires the coordination of physical and digital infrastructures, the organisation of trading zones with a network of resellers close to manufacturers and customer service centres, big data and predictive analytics support, technical skills, and regulations favouring guarantees and re-use ([building block 2](#)).

#6

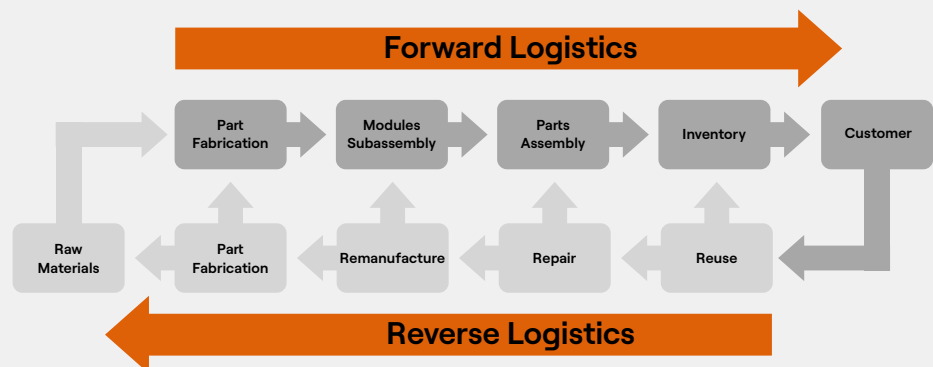
Simplifying procedures, shortening pathways and facilitating transfers

EXAMPLE : REVERSE LOGISTICS

Reverse logistics refers to the supply chain process of **returning** products from end-users via the supply chain to the retailer or manufacturer for re-use, repair, dismantling and re-use as raw materials or parts.



Source: Tavant



Source: Ihar Baranau and Andrej Lisec (2020), Reverse Logistics in Agriculture

Making the most of regional resources also involves the craft sector and the creation of future 'resilient strategic value chains' capable of integrating processes of design, manufacturing, use, maintenance and repair in the Greater Region. This offers new opportunities for craft industries through new forms of cooperation, particularly in terms of local circular value chains, via concepts for returning sought-after components or materials to the economy.²³⁷

Infrastructure to connect Luxembourg to neighbouring countries are also needed. In the Greater Region, shared activity zones and a **repairable bicycle industry** could be created. Between 2012 and 2021, Luxembourg imported an average of 25,000 to 30,000 bicycles a year. The value of this market was €21 million for the period 2017-2021.²³⁸ Luxembourg could extend express public transport and cycle path networks, and strengthen collaboration on the development of low-carbon public transport infrastructure and services across borders to employment areas. By ensuring that the Greater Region is well connected to the major low-carbon European transport corridors (rail, river, night trains), Luxembourg's economy would be provided with a second pillar for its logistics supply network.

²³⁷ Chamber of Skilled Trades & Crafts (2023), Position paper (following the discussion between Luxembourg Strategy and the members of the Commission du Centre de Promotion et de Recherche (artisanat) of the Chamber of Skilled Trades & Crafts on 27 April 2023). 10 July 2023.

²³⁸ STATEC (2022), Un portrait chiffré des entreprises au Luxembourg.

C. Facilitating transfers

In order to avoid losing the capital of knowledge and know-how between generations, it is necessary to facilitate transfers and maintain the fabric of national entrepreneurship, particularly for SMEs and family-run craft businesses, which are drivers of innovation, decarbonisation, circularity and job creation. An inter-generational sponsorship system should be introduced to facilitate the transfer of businesses and knowledge between generations.

This would involve making capital available to support this transfer, either internally, through employees, or externally, through profit-sharing instruments, equity participation or guarantees to SMEs.

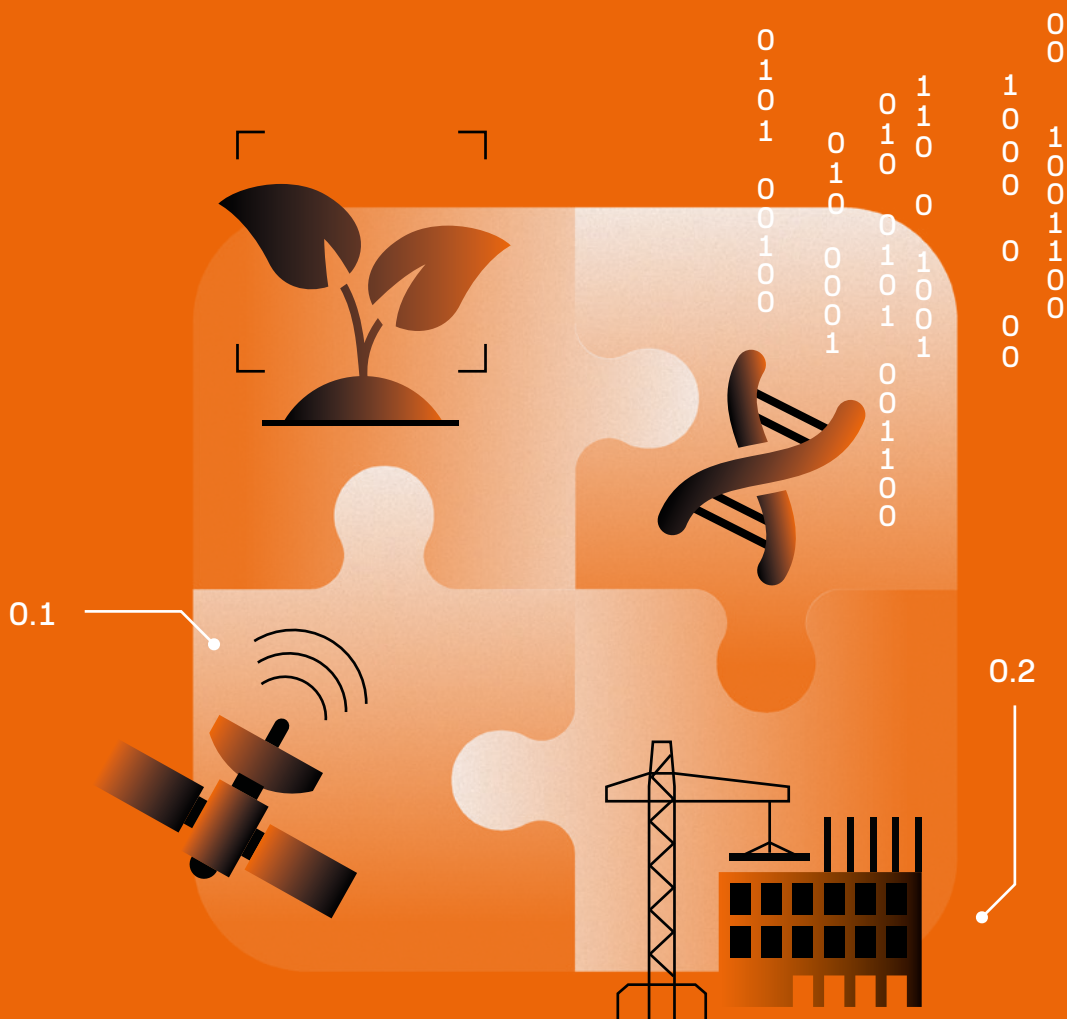
In light of demographic changes among business owners,²³⁹ the transfer of businesses to the next generation is one of the sector's central challenges, not only for entrepreneurial activity but also for employees. The procedures for transferring and taking over businesses must, in general, be **flexible and rapid** to ensure a large number of business takeovers and transfers in the years to come. The CDM is also calling for the creation of a craft library (physical and virtual) containing the best of craft industry to ensure that knowledge and know-how are seamlessly passed on for future generations and society as a whole.

It should be easier for citizens, forest owners, trade unions and municipalities to invest in projects such as *Holzhaft*, wind farms, repair workshops, greenhouses and peri-urban farms.

Family ownership is the most widespread form of business ownership globally. 'The corporate finance literature reveals that the desire to leave a lasting business to one's children has led to a growing concern for the long term within family businesses. Family groups also tend to attach greater importance to non-financial issues. Multigenerational family businesses have lower emissions than large multinational companies with recruited CEOs'.²⁴⁰

²³⁹ In 2022, almost 1,300 business owners will pass the age of 60 and are likely begin looking for a successor to prepare the business and employees for a transfer/takeover. In the longer term, 46% of business owners aged 50 or over are likely to face the question of transferring their business. In 2022, these businesses will account for 48% of all employees. Chamber of Skilled Trades & Crafts (2023), Position paper (following discussion between Luxembourg Strategy and the members of the Commission du Centre de Promotion et de Recherche (artisanat) of the Chamber of Skilled Trades & Crafts on 27 April 2023). 10 July 2023.

²⁴⁰ 'When differences between businesses are taken into account, family businesses still emit 12.8t CO2 per million dollars of revenue less than non-family businesses'. See The Conversation (2023), [Les entreprises familiales, discrètement plus vertes](#).



#7

Diversifying the economy by
adapting to the challenges
of the future

‘It will also be important to make choices. First of all, choices about the sectors we will focus on in the future to decarbonise our economy: I recently announced the “Green Valley” initiative, an infrastructure project to bring together and develop our businesses in the field of “eco-technologies” in the broadest sense, i.e. everything to do with renewable energies, climate adaptation, circular construction and decarbonisation. Obviously, all companies have a role to play here, whether manufacturers, craft industries or start-ups. Other diversification sectors chosen by Luxembourg are developing dynamically, including health, space and digital technologies.’

Minister of the Economy Franz Fayot, Carte blanche, Paperjam (22 May 2023)

Luxembourg has already experienced several industrial revolutions. In the last century, despite having no coal and few iron deposits, the country’s agrarian economy was transformed into one of the world’s leading steelproducing nations. From the 1970s onwards, the economy began to be tertiarised and became an international financial centre.

Today, the **plan for the future** is to transform the economy once again, in order to respond to the new challenges of resilience: diversification, compatibility with biophysical limits and contributing to basic public services.

Luxembourg has moved from one monolithic economic structure (steel) to another (finance). Specialisation in the steel industry was followed by industrial diversification and then by the sustained expansion of financial activities. Financial activities took off in the 1970s and have now come to dominate the economy. Over the last few decades, successive governments have tried to develop a limited number of other economic sectors in order to reduce the country’s major dependence on the financial sector. An economy is diversified if its productive structure is dispersed across a large number of activities that differ from one another in the nature of the goods and services produced.²⁴¹

Given that a labour- and resource-intensive economy (extensive growth) is not sustainable in Luxembourg, the priorities of the economic diversification strategy pursued since the start of the new millennium are aimed at a more resource-efficient and innovation-intensive development (intensive growth):²⁴²

1. Environmental technologies (eco-tech or clean tech)
2. Information & communication technologies (ICT or digital tech)
3. Space technology and applications (space tech)
4. Logistics and supply chain management (including the maritime sector)
5. Health sciences and technologies (health tech)

For environmental technologies, the Ministry of the Economy launched an initial action plan in 2009.²⁴³ In the 2014–2018 government plan, three eco-tech industries were identified for development: eco-construction (sustainable construction), sustainable mobility and the circular economy.

The transformation of the **manufacturing industry** (Industry 4.0) and increased use of **digitisation** and knowledge (**Knowledge-Intensive Services (KIS)**) are cross-cutting and driving forces for this diversification policy, which actively supports the general ‘greening’ of Luxembourg’s economic structure. To achieve this, digitalisation must also decouple the pace of its expansion from resource consumption (building block 4).

241 Jean-Claude Berthélemy (2005), *Commerce international et diversification économique*, Revue d’économie politique 2005/5 (Vol. 115), pp. 591–611, Éditions Dalloz.

242 The Observatory of Competitiveness analysed the performance of these 5 sectors of diversification sectors in 2018. See also Max Jentgen (2017, updated 2023), *Le degré de diversification est faible en comparaison internationale, varie peu et connaît une quasi-stagnation sur 1995–2021*, memorandum, Ministry of the Economy.

243 *Programme National de Réforme (PNR) 2022*, see p. 37.

#7

Diversifying the economy by adapting to the challenges of the future

Clusters and support programmes for generating new processes, products and services have been set up by Luxinnovation for each of these five sectors. Luxinnovation and professional organisations are supporting businesses and start-ups seeking expertise, training, financial aid, investment, networks and markets. Luxinnovation provides mapping and constantly updated indicators for the main areas of diversification.²⁴⁴

By 2050, the aim is to strengthen this orientation, capitalise on these priorities and **focus** firmly on decarbonisation and resilience. Small, medium and large businesses could develop cutting-edge expertise in grey and green climate solutions, enabling restored economic competitiveness through **carbon industries and services**.

Changes in the structure of the economy over the last 30 years, in terms of share of gross value added (in %), have been marked by a recent decline in financial and insurance activities since 2015, an increase in scientific and technical activities, activities related to human health and social work, and transport and warehousing, a virtual stagnation in activities related to ICTs, and a continued decline in the share of manufacturing industry (iron and steel, energy and water, and others) in proportion to the other branches. Agriculture, forestry and fishing have collapsed. Services remain the dominant sector, accounting for 85% of the gross value added generated (2022).²⁴⁵

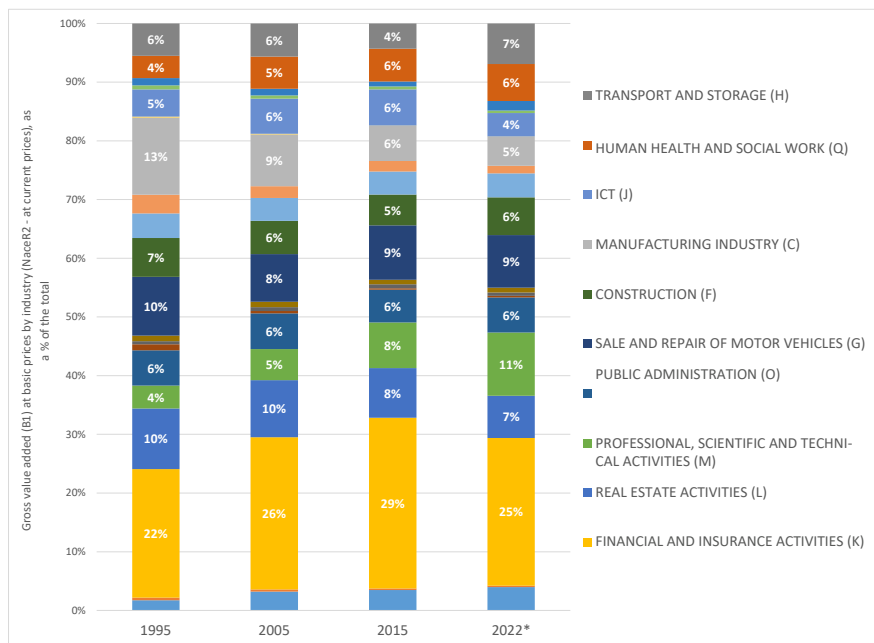


Figure 16. Changes in the structure of the economy 1995-2022 (*estimate)²⁴⁶

The challenge for the diversification policy lies in finding the right balance between diluting risk and exploiting the benefits of scale.²⁴⁷ Faced with the transitions to be made, in a context of biophysical constraints, socio-economic tensions and uncertainties, the concept of risk takes on another dimension and, as Mariana Mazzucato argues, the question arises as to whether the role of the state will become more significant in the long term in reducing risks and creating economic and

²⁴⁴ Luxinnovation, [Mapping Cybersecurity Ecosystem](#), [Mapping of Sustainability Enablers](#), [Mapping: Luxembourg Manufacturing Ecosystem](#), [Mapping: Luxembourg AutoMobility Ecosystem](#), [Key figures about the HealthTech private sector in Luxembourg \(2020\)](#), [Mapping: Luxembourg Wood Sector](#), and [Key figures about the Creative Industries sector in Luxembourg \(2020\)](#).

²⁴⁵ See also Chamber of Commerce (2019), [Économie du Luxembourg. Ouverte, Dynamique, Fiable](#).

²⁴⁶ STATEC (données téléchargées en juillet 2023)

²⁴⁷ Luisito Bertinelli (Uni.lu) and Eric Strobl (École polytechnique) (2007), [An analysis of the sectoral diversification of a small open economy: the case of Luxembourg](#). Ministère de l'Économie et du Commerce extérieur (2007), [Perspectives de politique économique](#).

social value.²⁴⁸ By applying the principles of precaution, autonomy, redundancy and adaptation to environmental crises, economic diversification and the strengthening of manufacturing sectors (building block 1) serve as future-proof approaches that should be emphasised within the framework of the Vision.

The economy has a **role to play in providing essential common goods** that are expected by the population, and in contributing to improving inclusiveness and wellbeing for all.²⁴⁹ As part of the ECO2050 foresight process of collaborative scenario building and constructing the ECO2050 Vision, several universal public services²⁵⁰ and non-market activities²⁵¹ were considered as being particularly important for ensuring a secure, prosperous, fair and inclusive future for the population. The economy supports the country's essential infrastructure and the means to satisfy people's basic needs, and contributes to the social protection of populations in the face of new uncertainties. This includes affordable public health for all, education and training in the skills needed for the transitions, access to information, the empowerment of economic actors and citizens, gender equity, public transport, leisure, culture and security.

On this last point, the physical protection of populations and assets in the face of climate crises and ecosystem disturbances is becoming increasingly important. Demands for climate goods and services are also reflected in the work of the KBR and the ODC relating to the PNEC: adapting cities to higher temperatures, creating excess water capacity, bringing producers and consumers closer together, developing 15-minute cities, regenerating forests and wetlands, generating and storing energy, etc. One principle of the PDAT is to develop the resilience of the territory by equipping it with the capacity to anticipate, react and adapt to disturbances, whether they arise from climatic, health or geopolitical issues. The potential territorial impact of this diversification is described in Appendix 7. A foresight map representing possible changes in the location of economic activities across the national territory is included at the end of this report.

For the economy, it is crucial to **seize the business opportunities** presented by these new public needs and expectations by supplying climate-proof goods and services. In order to grow, the production and export of goods and services must reduce their environmental impact. To this end, companies will have to invest in the transitions through material (products) and immaterial (services) means. By 2050, **niches of excellence** could be developed in KIS as part of the drive for economic diversification, in the following future domains:

- A. Specialising in carbon industries and services:** a business opportunity and the creation of a common good
- B. Adapting food production:** a business opportunity and the creation of a common good
- C. Adapting healthcare:** a business opportunity and the creation of a common good

²⁴⁸ 'Governments should be able to explore, experiment and take risks for the public good'. See Mariana Mazzucato (2018), *The Value of Everything: Making and Taking in the Global Economy*.

²⁴⁹ Christopher Oik et al. (2023), *How universal public services can end the cost-of-living crisis. Government provision of basic human needs, like healthcare and housing, can fight price shocks and save the planet*, New Statesman.

²⁵⁰ 'A set of general interest requirements ensuring that certain services are made available at a specified quality to all consumers and users throughout the territory of a Member State, independently of geographical location, and, in the light of specific national conditions, at an affordable price'. See European Commission (2003), *Green Paper on Services of General Interest*.

²⁵¹ 'Non-market activities (health, education, security, etc.) [...] should continue to grow in importance'. See Fondation IDEA (2023), *Grands Défis*, p.33.

#7

Diversifying the economy by adapting to the challenges of the future

A. Specialising in carbon industries and services: a business opportunity and the creation of a common good

Investments in climate mitigation and adaptation will increase dramatically in the future, providing historic opportunities to diversify the economy. Already, 'the EU has committed to devoting at least 30% of its 2021-2027 budget to climate action, i.e. 87 billion euros per year. This amount represents less than 10% of the total investment needed to meet the 2030 targets, which have been estimated at around €1,000 billion per year. The rest of the investments must come from national and private funds'.²⁵² In addition, administrative procedures relating to the implementation and manufacture of decarbonisation technologies are being streamlined.²⁵³

The industry and crafts of the future will be decarbonised in terms of processes, technologies and products. Lowcarbon and resource-efficient **industrial, manufacturing and craft production** will be a key pillar of any future economy and will become increasingly important (building block 1 and building block 2). In 2021, Roland Berger estimated that the global market for the greening of industry will reach nearly €10,000 billion by 2030:

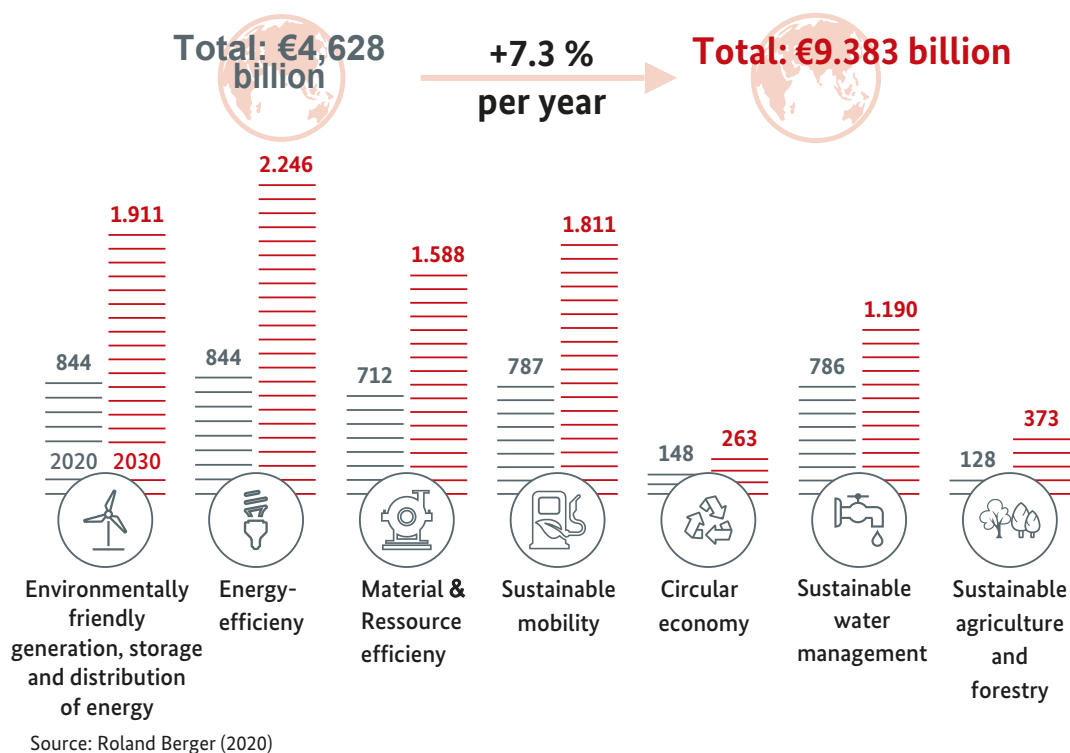


Figure 17. Global market volume for environmental technologies and resource-efficiency in 2020, and estimated development up to 2030 (in billions of euros)²⁵⁴

Luxembourg's economy could use decarbonisation and the European NZIA regulations as opportunities for **reindustrialisation**. It could thereby become a supplier of climate mitigation and adaptation components, equipment and services. With regard to mitigation, there will be an emphasis on products and services that reduce emissions. With regard to adaptation, it will be key

²⁵² European Court of Auditors (2023), EU auditors see 2030 climate and energy targets at risk, special report.

²⁵³ Dossier ENVIR 074b/2023 (2023), Avant-projet de loi relative à l'accélération de procédures administratives relatives à la mise en œuvre et la fabrication de technologies de décarbonation, à des projets de construction ou de rénovation de logements et à des projets de tramways et de voies ferroviaires.

²⁵⁴ BMUV (2021), Umwelttechnologie-Atlas für Deutschland. Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit & Verbraucherschutz. Deutschlands Neue Agenda (2021), Zum Stand der Transformation in eine klimaneutrale und digitale Zukunft. & Roland Berger (2021), GreenTech-Branche bleibt auf Wachstumskurs

to provide materials, products and services that will enable to build societies and economies capable of coping with more extreme weather conditions.

In fact, the situation is encouraging: the EU's Digital Decade Policy Programme 2030 is promoting 'the use of digital technologies to combat climate change and environmental problems',²⁵⁵ and the PNEC is calling on researchers and entrepreneurs to test and deliver 'climate solutions'. From 2024, businesses can receive a **tax rebate** for investments and costs related to the digital, ecological or energy transitions. This applies to projects involving energy efficiency and the decarbonisation of a company's production process, or the production and storage of energy from renewable non-fossil sources.

'Modernising the investment tax rebate constitutes an additional measure for supporting businesses on the path to the dual ecological and digital transition in order to preserve our industrial, craft and commercial resources and the jobs associated with them, while helping to develop a resilient and competitive economy in the years ahead.'

Minister of the Economy Franz Fayot (July 2023)²⁵⁶

Business opportunities and the potential for new products, services, construction and work in the field of climate mitigation and adaptation are present in almost all of the 10 building blocks that make up the ECO2050 Vision. Bringing them together here gives an idea of the cumulative and mutually beneficial potential knock-on effects of focusing on carbon goods and services. In line with Singapore's strategy of promoting carbon services,²⁵⁷ Luxembourg could encourage investment in the following economic areas related to climate, nature and carbon:

- Carbon and nature research, experimentation and training (all building blocks)
- ICT, civil, electronic, agronomic, forestry, ecosystem and hydrological engineering ([building block 1](#), [building block 2](#), [building block 3](#) and [building block 5](#))
- Design and implementation of major engineering projects, ecological rehabilitation and climate projects ([building block 1](#), [building block 2](#), [building block 3](#) and [building block 5](#))
- The manufacture of parts, tools and equipment required for the energy and climate transitions ([building block 1](#) and [building block 2](#))
- Optimising supply chains ([building block 6](#))
- Digital applications, developing software and apps to reduce emissions and resource consumption ([building block 2](#)), and creating virtual marketplaces (*e-Holzhaft*) ([building block 2](#), [building block 4](#) and [building block 6](#))
- Accounting, recording and reporting emissions data and statistical transfers ([building block 6](#) and [building block 9](#))
- International law, peaceful global governance of resources, and climate diplomacy ([building block 8](#))
- Legal advice, intermediation and climate or carbon litigation ([building block 9](#))
- Market analysis, certification, validation, benchmarking and carbon rating ([building block 9](#))
- Carbon pricing and taxation ([building block 9](#))
- Technologies for monitoring emissions and disaster risks, including satellite-based technologies ([building block 4](#), [building block 8](#) and [building block 10](#))
- Risk prevention and management ([building block 10](#))
- Insurance for physical damage or under-emission in relation to carbon credits ([building block 9](#) and [building block 10](#))

²⁵⁵ European Parliament and Council of the European Union (2022), [Decision \(EU\) 2022/2481 of the European Parliament and of the Council of 14 December 2022 establishing the Digital Decade Policy Programme 2030](#).

²⁵⁶ Ministry of the Economy (2023), [Yuriko Backes et Franz Fayot ont présenté une réforme majeure de la bonification d'impôt pour investissement applicable au niveau des entreprises](#), press release.

²⁵⁷ South Pole (2021), [Study of Singapore as a Carbon Services Hub](#).

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In response to the megatrend of greening economies, Luxembourg could focus these research centres on adapting the economy and society to a new biophysical context characterised by environmental crises. They would provide the new economy with environmental innovation²⁵⁸ and knowledge that leads to the development of carbon and nature products and services.

Investors and companies are looking for projects that are credibly **'sustainable' or 'climate-friendly'**, either to make profitable investments or as a way of acquiring carbon credits. Luxembourg would become a leader in the development of physical climate projects, within its own territory and also in collaborations in the Greater Region, across Europe, and with countries of the Global South with which Luxembourg maintains partnerships. In fact, it is the countries of the Global South that have the greatest experience adapting to extreme climatic conditions, low-carbon development and the low-tech and circular economy, and the countries of the North should draw inspiration from this expertise.

In terms of mitigation infrastructures and services, an emphasis could be placed on energy storage. Due to the accumulated experience from the pumped storage facility at Vianden, energy storage represents a possible market to be developed through international partnerships, using the possibilities offered domestically,²⁵⁹ so as not to rely solely on batteries, which require scarce and imported components. National research could invest in inertial services for electrical systems. It could help to maintain and improve (e.g. via fungi in the soil) the **natural sequestration of carbon** in soils and forests, to adapt the Greater Region's forestry and water resources, to invest in biomimicry, to encourage ecological rehabilitation (green infrastructures, [building block 5](#)), to design redundancy systems ([building block 5](#)), and to operationalise the sufficiency with regard to resources and behaviour (societal innovation and development of new business models – [building block 3](#)).

The PNEC identifies economic opportunities in the energy and climate transitions. The work involved in strengthening and interconnecting the **European electricity grid** represents a huge market for manufacturing.²⁶⁰ Closer to home, national industries could also provide products and services for renewable energy generation plants, heat pumps and heat networks, geothermal systems and biogas plants. The biogas industry in Luxembourg, once the European leader in terms of volume produced per inhabitant, would be given a new lease of life. The carbon products to be manufactured are both high-tech (precision parts, ultra-light products, electronic or fine mechanical technologies) and low-tech (repairs, spare parts, tools, cyclo-logistics).

258 MECDD (2023), [Avis de la plateforme pour l'action-climat et la transition énergétique relatif à l'avant-projet de la mise à jour du PNEC du Luxembourg pour la période 2021 – 2030](#). Final version of 11 July 23.

259 Vasileios Kitsikoudis et al. (2020), [Underground pumped-storage hydropower \(UPSH\) at the Martelange Mine \(Belgium\): Underground reservoir hydraulics](#), *Energies*, 13(14), 3512 & SWT (2013), [Pumpspeicherwerk RIO, Trier](#).

260 Eyes on Europe (2021), [The European Super Grid: A solution to the EU's energy problems](#). "One potential policy remedy relates to electrical grid upgrades and cross border energy flow within Europe. IEA reports that capital investments in Europe's electrical grid were stagnant between 2015 and 2020 at about \$50 billion per year, and barely rose in the years 2021 and 2022. By contrast, in China, capital investments in the grid grew by 16% to almost \$83 billion in 2022. Our findings about the energy security benefits of renewables, which requires a capable electrical grid, provide support to calls by IRENA and others to increase investment in power grids and energy storage", Jeff D. Colgan et al. (2023), [Quantifying the value of energy security: How Russia's invasion of Ukraine exploded Europe's fossil fuel costs](#), *Energy Research & Social Science*, Volume 103.

Flagship projects for **climate-proofing** systems involve collaboration at the European and that of the Greater Region in order to make critical infrastructures and activities **robust** in the **face of extreme weather conditions** (wind- and tornado-resistant pylons, heat and water protection for buildings, redundancy and duplicated solutions ([building block 5](#))). As part of the European Green Deal and the EU Adaptation Strategy, the European Commission has created **technical guidelines** for the period 2021-2027 and has set out the funding available for this purpose.²⁶¹

Other adaptation projects involve, for example, the assisted northward migration of forests, the prevention and management of water surpluses (flooding) and shortages (sufficiency, storage), and the anticipation of new disease vectors. Just as the Netherlands has been undertaking major works for decades to deal with rising sea levels, and Singapore has a 100-year plan to protect its coastline, so Luxembourg is embarking on major, long-term projects which are stimulating the economy.

In terms of 'soft' development, carbon services do not need a lot of new land for buildings, equipment or staff. For the most part, they can be grafted onto the existing urban fabric, which already houses service sector actors, suppliers and customers. Nomadic employees working remotely on their computers, employees working from home or employees in co-working spaces close to hubs, are all possible options. In this way, protecting ourselves from climate threats can also become an economic instrument for using less land.

²⁶¹ European Commission (2021), [Commission adopts new guidance on how to climate-proof future infrastructure projects](#), press release. [Technical guidance on the climate proofing of infrastructure in the period 2021-2027](#) (2021/C 373/01).

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The IPCC has also provided a list of climate mitigation and adaptation projects and investments (Figure 18), including technologies, green and grey infrastructure, services and new demand management models:

There are multiple opportunities for scaling up climate action

a) Feasibility of climate responses and adaptation, and potential of mitigation options in the near-term

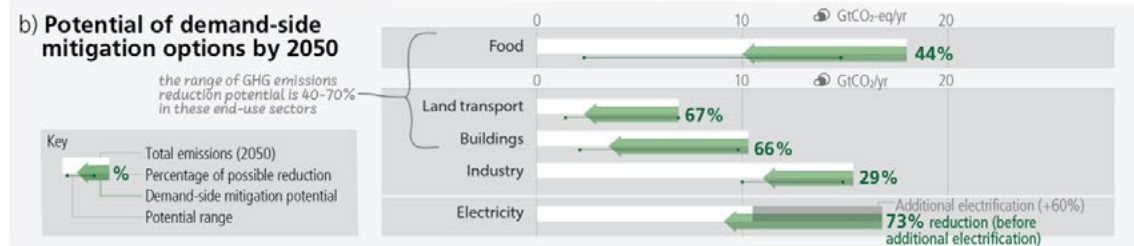
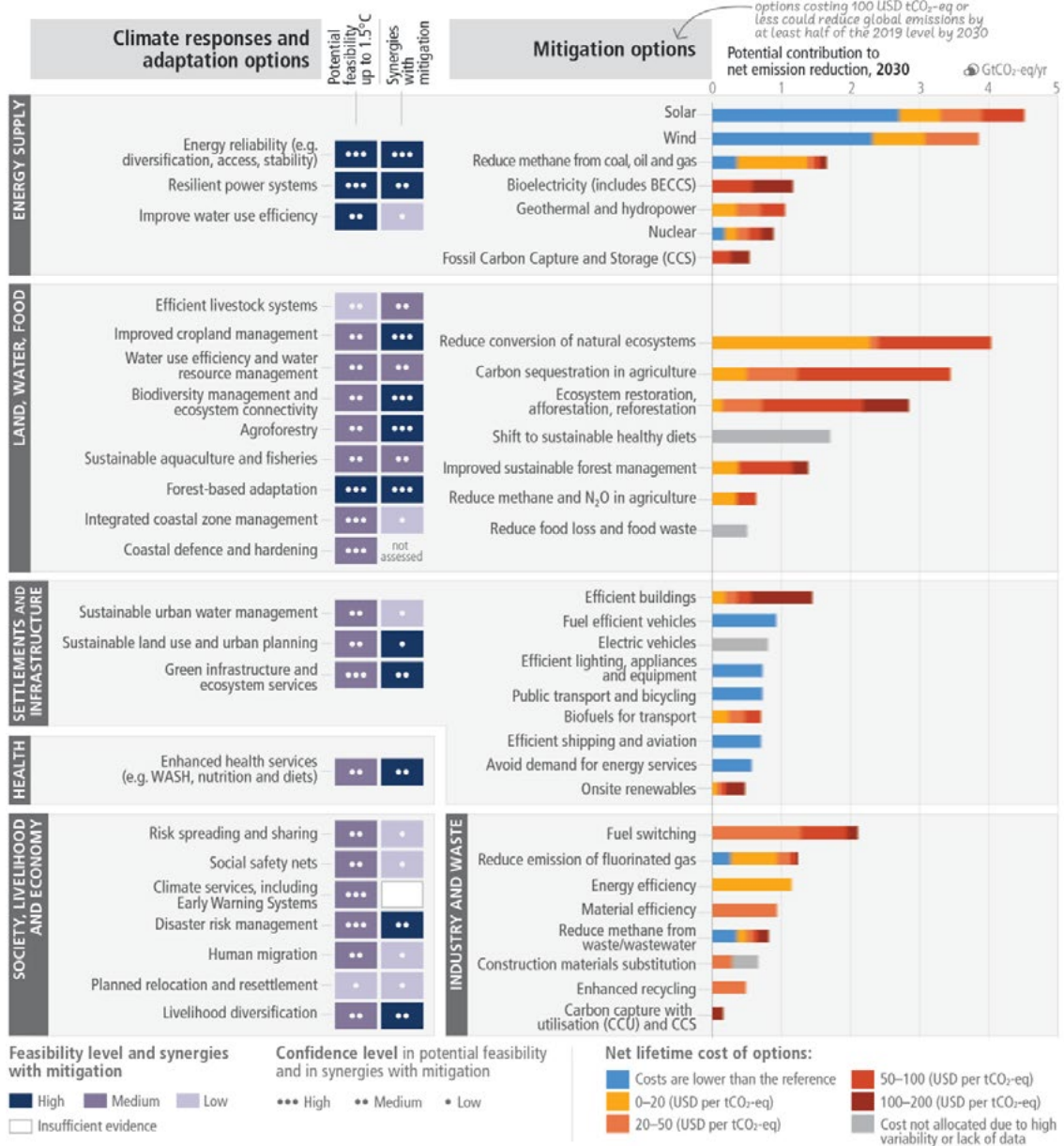


Figure 18. Synoptic view of adaptation and mitigation measures and the contribution of production and consumption to the fight against climate change²⁶²

262 IPCC (2023), *Summary for Policymakers, Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the IPCC, Figure SPM.7*

The potential of **digital infrastructure** and the national computing capacity of high performance computers (HPC) should be fully exploited. Luxembourg's interests and expertise in the steel industry (regulated decarbonisation via ETS), maritime affairs²⁶³ and aviation (the International Maritime Organisation (IMO) and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)), the banking sector (compliance and carbon projects, risks) and space (satellite observation) can converge to form the foundation for a carbon industry that is unique on the global stage.

All carbon products and services need to be digitised. Luxembourg's advantage lies in offering digital carbon applications that are both multilingual (LU, FR, DE, EN, PT) and exportable. Luxembourg's strong digital infrastructure and intellectual property framework²⁶⁴ can be combined to turn Luxembourg's **multilingualism** into a commercial advantage.

Beyond the carbon industry, language applications constitute a sector in their own right that must be encouraged. By developing multilingual technologies, services and digital tools, language barriers can be broken down, language learning can be facilitated, and support can be provided for working with texts and voice recordings in several languages. Linguistic technologies go far beyond machine translation. They offer applications for text analysis, such as named entity recognition and anonymisation, dialogue systems, search engines, automatic text synthesis, speech-to-text and more. Linguistic technologies can be developed and customised for any specific scenario where human language is processed.

Another example where Luxembourg is well equipped is in the field of **insurance**. Climate change and the decline of biodiversity will generate new risks and needs that are not necessarily covered by private insurance. These types of insurance risk becoming unaffordable for vulnerable and exposed companies and households.²⁶⁵ New insurance models need to be developed. This is also an argument in favour of prevention: each euro invested in early warning systems generates on average €131 through the avoidance of physical losses and response costs and the production of societal benefits.

There is also a strong complementarity between the needs and strengths of the financial sector and those of carbon services.

The **Luxembourg financial centre** is playing a pioneering role in the field of green, inclusive and innovative finance. The aim is to support and strengthen the excellence of this economic sector and its rise to prominence in order to increase the financial attractiveness of green capital and enable investment horizons to be extended. The relatively lower returns in this domain can be offset by the greater integrity of the financial centre. The tendency towards greater financial losses due to future climate damages must also be anticipated. In fact, 'sustainable' investments will become more attractive and will increase. The economy could take advantage of the international openness of the financial centre to finance the heavy investments required by the transitions.

263 It should be noted that decarbonisation in the maritime sector is governed by the revised strategy of the International Maritime Organisation (IMO) ([Marine Environment Protection Committee](#), 3-7 July 2023), which considerably strengthens the climate objectives for international maritime transport. The aim is to achieve zero greenhouse gas emissions from ships by 2050, with a reduction of at least 20% in 2030 (30% compared with the 2008 baseline) and a reduction of at least 70% by 2040 (80% compared with the 2008 baseline).

264 The Institut de la Propriété Intellectuelle Luxembourg (IPIIL) was created in 2015. This economic interest grouping (EIG) is designed to bring together national and international expertise in intellectual property.

265 Shane Whright (2023), [Looming insurance crisis could make the GFC 'look like a picnic'](#), The Sydney Morning Herald.

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Additional skills are needed for the new domains related to extra-financial reporting, identifying and managing physical and transitional risks, integrating climate scenarios,²⁶⁶ monitoring double materiality as required in the new Corporate Sustainability Reporting Directive (CSDR), detecting greenwashing, and designing and monitoring genuinely sustainable investment products based on physical emission reduction and ecological restoration projects. Given the impact of the degradation of nature on the economy and finance, biodiversity reporting²⁶⁷ will in future be added to the climate reporting²⁶⁸ required of banking institutions and businesses. All these new needs call for specialised and multilingual expertise.

Physical risks for businesses in Luxembourg resulting from loss of biodiversity



IMS Luxembourg collaborated on Luxembourg Strategy's RISK2050 study.

General comments:

On-site solutions focus primarily on regenerating, protecting or restoring biodiversity and ecosystems rather than raising awareness of the physical risks arising from business and human inaction. Furthermore, on-site solutions do not illustrate the major impacts and dependencies of the business sector itself. To distinguish this, it is imperative to remember that a value chain is divided in two:

- The value chain for building maintenance (grounds management, maintenance products, etc.)
- The value chain of the main activity (extraction, production, distribution, etc.)

Given the complexity of biodiversity and ecosystems, it is crucial for companies to distinguish between these two aspects to understand where their physical risks lie in the short, medium and long term.

Specific findings:

- IMS has confirmed the lack of awareness identified in the RISK2050 report.
- IMS Luxembourg confirms the fact, reported in the RISK2050 report, that a profound transformation will be difficult to achieve without binding regulations. The role of the IMS is to show that, by positioning themselves proactively, companies can benefit from anticipating European or national directives.

²⁶⁶ For example, the climate scenarios for central banks and regulators drawn up in 2021 by the Network of central banks and supervisors for Greening the Financial System (NGFS) are (i) Orderly transition, (ii) Disorderly transition and (iii) Hothouse world.

²⁶⁷ See Taskforce for Nature-related Financial Disclosures and The Economics of Ecosystems and Biodiversity. 'US\$10tn cost to the world economy from the loss of nature in a "business-as-usual" scenario by 2050' according to WWF (2020), Assessing the global economic impacts of environmental change to support policymaking. 85% of the largest international firms have a moderate or high risk of nature dependence through their direct operations (see S&P, Nature positive, May 2023). Trucost (2013), Natural capital at risk: the top 100 externalities of business.

²⁶⁸ See Taskforce on Climate-related Financial Disclosures.

Synergies also exist between the space and carbon sectors. The objective of the **Luxembourg space strategy for the period 2023-2027** is to continue efforts to develop the Luxembourg space sector as a vector for the diversification and long-term success of Luxembourg's economy, but also as a major contributor to the sustainability of activities on Earth and to favouring a responsible approach to activities in space.

'The renewed strategy for the next 5 years will focus on developing industrial skills in areas that will contribute in part to sustainable development objectives, support Luxembourg's development cooperation and humanitarian action, and contribute to the development of other economic sectors of interest to the Grand Duchy.'

Minister of the Economy Franz Fayot, presentation of the 2023-2027 space strategy (December 2022)

The 2023-2027 space strategy has 4 main focuses:

- Sustainability of economic activities
- Sustainability of terrestrial activities
- Sustainability of activities in space
- Sustainable use of space resources

Space strategy could directly supply the carbon and natural economy with knowledge, know-how, data, products, equipment, and materials. Luxembourg can become a pioneer in the recovery of space debris that endangers satellites and contains rare metals.

B. Adapting food production: a business opportunity and the creation of a common good

Luxembourg's national strategic plan for the implementation of the Common Agricultural Policy 2023-2027 aims to ensure that **agriculture is sustainable and adapted to the new challenges**. The first priority is to ensure a fair income for producers, to support their competitiveness, to distribute aid to family farms more fairly, to provide more support for sectors in difficulty and to diversify and modernise agricultural production. The second major priority is to make agriculture more respectful of the environment and natural resources. Finally, the National Strategic Plan (PSN) supports generational renewal, new farmers and business start-ups. This involves support for young farmers and new entrants (in Luxembourg, 75% of young farmers rent land), innovative and ecological equipment, direct payments for actions to protect biodiversity and the climate, promoting short distribution channels, and strengthening the sustainability of farms with targeted investment aid.

In June 2023, a new agricultural law was adopted to promote **sustainable, competitive agriculture** and rural development that will enhance quality of life for all. More than a third of the overall budget (€812 million) is devoted to **climate-friendly agri-environmental aid**, which active farmers receive on condition that they orientate their production towards sustainable practices that respect the environment, the climate, biodiversity and animal welfare. As the primary purpose of agriculture is the production of food products, the law places the **competitiveness** of all Luxembourg's agricultural sectors at the centre of its concerns. The use of new technologies, the electrification and digitalisation of agriculture, strategic partnerships with the research and innovation sectors and the development of holistic farm advisory programmes are among the other priorities of this new law.

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With this in mind, the Ministry of Agriculture, Viticulture and Rural Development (MAVDR) and Luxinnovation have signed an initial partnership agreement to support **innovation in the agricultural sector**. The aim is to support the agri-food sector and make it more competitive, diverse, and resilient through innovation, digitalisation and collaboration with research actors. The potential beneficiaries of this cooperation are suppliers of agri-food products and services as well as companies involved in agri-food processing, aquaponics and vertical farming, digital services, equipment, agri-food consultancy, agri-food distribution and the bio-economy.²⁶⁹

Ensuring the continuity of food production and increasing food self-sufficiency also requires agronomic adaptation to changing biophysical conditions, and the development of crop varieties that are more resistant to drought or new diseases. According to France Stratégie, **agro-ecology** appears to perform better than conventional agriculture from both an economic (farmer remuneration) and an environmental point of view. This trend is set to increase with climate change and the rising price of synthetic inputs. Agro-ecology is based on a fundamental principle: making optimum use of the resources provided by nature to develop a form of agriculture that uses a minimum of synthetic inputs (fertilisers, pesticides or antibiotics) and increases the resilience and autonomy of farms.²⁷⁰

C. Adapting healthcare: a business opportunity and the creation of a common good

Healthcare is an essential public service, whose effective operation was put to the test by the COVID-19 pandemic, which saw an unprecedented mobilisation of private and public actors in the healthcare system.

In light of the lessons learned from this health crisis, the principles of the ECO2050 Vision can support the transition to a more resilient healthcare system and create business opportunities, in particular by pursuing the following structuring measures:

- Anticipating new health challenges
- Effecting a digital transition to strengthen the healthcare system and optimise the safety and quality of care
- Effecting an ecological transition in care facilities
- Strengthening prevention initiatives²⁷¹

Anticipation and long-term planning will help prepare the healthcare system for new health challenges. In February 2020, the Ministers for Health and Social Security convened stakeholders in the health and care sector at the *Gesondheetsdësch*, in order to define 'a shared vision of tomorrow's healthcare'.²⁷² The result is the **National Health Plan (PNS)** adopted by the government in July 2023.²⁷³ Among the challenges to be met in adapting the health and care sectors, it highlights, for example, the demography of the medical and nursing professions, Luxembourg's exceptional demographic growth over the last 10 years, and the career aspirations of young healthcare professionals. The PNS uses the World Health Organization's (WHO) Wellbeing Index as its benchmark. In parallel, Luxinnovation undertook a project on megatrends in 2020.²⁷⁴

²⁶⁹ Ministry of the Economy (2023), *Signature d'une première convention de partenariat pour soutenir le secteur agro-alimentaire et renforcer la compétitivité et la durabilité à travers l'innovation*, press release.

²⁷⁰ Alice Grémillet and Julien Fosse (2020), *Les performances économiques et environnementales de l'agroécologie*, France Stratégie.

²⁷¹ Deloitte (2016), *Health Care Foresight, Identifying megatrends*.

²⁷² *Gesondheetsdësch*.

²⁷³ MS and MSS (2023), *Présentation du Plan national santé*.

²⁷⁴ Luxinnovation (2020), *Post COVID-19 Market Trends*, Market analysis

New megatrends²⁷⁵ were observed regarding the ageing of the population, increasing healthcare needs of senior citizens and their budgetary impact, the digitalisation of healthcare services and the personalisation of care, the removal of taboos around mental health,²⁷⁶ and an increase in substance abuse. Other trends with a potential impact on the healthcare system include climate change,²⁷⁷ urbanisation and environmental degradation, and the challenges of securing long-term funding for the system. While deaths from communicable diseases are declining worldwide, non-communicable diseases such as cancer, diabetes and cardiovascular disease are increasing rapidly. These factors are also reflected in the PNS.

It is important to guard against new pandemics and disease vectors, and to curb pollution and biodiversity loss. The EU's Health Emergency Preparedness and Response Authority (HERA) has been set up to better anticipate potential health threats and crises. This enables intelligence to be gathered and the necessary response capacities to be strengthened at the European level. The EU also supports the One Health initiative, set up in the wake of the COVID-19 pandemic, through which international organisations can coordinate their mandates and approaches, while recognising that human, animal and environmental health are intimately linked.²⁷⁸ Finally, the WHO Pandemic Treaty similarly aims to improve pandemic preparedness, but at global level.

The digital transition aims to increase the quality, safety and effectiveness of patient care, the efficiency of the health system and the attractiveness of the working environment for health professionals. It reinforces the development of an integrated healthcare system, ensuring better continuity of care. It also enables the development of scientific research and the monitoring of the healthcare system through the provision of new evidence based on real life.

Digital healthcare technologies, developed with the help of companies in the field, are creating new possibilities in care, prevention, diagnosis and medical treatment, such as telemedicine, remote monitoring, integrated patient pathways and the use of AI. In this way, they are becoming an aid to clinical decision-making, optimising patient follow-up and the orientation and coordination of care pathways. They allow diagnoses to be made earlier, with a reduced margin of error.²⁷⁹ Thanks to specific monitoring functions, these technologies can be an important tool during teleconsultation or remote monitoring, particularly after hospitalisation or during home care. They can also enable patients to be better informed about their illness and fully involved in decisions about treatment.

Digitalisation in the health sector can also have a major impact on the organisation of healthcare establishments and the quality of the work environment for medical and nursing staff. Digitalising hospital management systems enhances the efficiency, effectiveness and resilience of healthcare establishments, as well as the safety of the care provided. The automation of certain administrative tasks frees up care staff, who can give more time to the patient and the human aspects of the medical and care professions. Thanks to a sovereign and reliable personal data management system, digital technologies will accelerate the advent of personalised medicine, increasing the effectiveness and efficiency of treatment and care.

Digital literacy should also be part of education, in order to prepare users to understand the use of data and the relevance of the new tools available to them. Without an inclusive approach to the development of digital literacy, new technologies will not be accessible to all who could benefit from them. The result will be a two-tier system based on differences in digital literacy.

275 WEF (2022), [6 Trends that define the future of health and wellness](#). Deloitte (2016), [Health Care Foresight, Identifying megatrends](#).

276 'The World Health Organisation (WHO) estimates that if current trends for demographic and epidemiological transition continue, the burden of depression will become the second leading cause of disability-adjusted life year (DALYs) lost. There are grave concerns regarding the exponential increase in mental health issues' according to Deloitte (2016), [Health Care Foresight, Identifying megatrends](#), p.10. The WHO estimates that, before the COVID-19 crisis, 1 in 8 people in the world had a mental disorder. Most sufferers do not have access to effective care. See WHO (2022), [Troubles mentaux](#). The OECD evaluates the global economic cost of mental health issues.

277 WHO (2013), [Protecting Health from Climate Change: Vulnerability and Adaptation Assessment](#). World Bank (2018), [Climate Change and Health Diagnostic. A Country-Based Approach for Assessing Risks and Investing in Climate-Smart Health Systems](#). WHO (2020), [WHO Guidance for climate-resilient and environmentally sustainable health care facilities](#). CDC (2019), [Assessing Health Vulnerability to Climate Change: A Guide for Health Departments](#). Centers for Disease Control and Prevention.

278 European Commission (2022), [Brief me on Biodiversity and health](#), Knowledge for policy, Knowledge Centre for Biodiversity.

279 Luxinnovation (2020), [Post COVID-19 Market Trends](#), Market analysis.

#7

Diversifying the economy by adapting to the challenges of the future

Digital literacy is also vital if healthcare professionals are to be trained in the use of new tools, including teleconsultation, telemonitoring, integrated clinical decision support and new technologies in general. Professionals also need to develop their skills in the secondary use of data to evaluate and improve care on an ongoing basis. This process of continuous improvement and comparison of clinical practices depends on the use (primary or secondary) of structured data generated during clinical practice, supported by appropriate information systems.

The application of ecological transition measures to healthcare establishments will mean equipping them with resilient and decarbonised infrastructures.²⁸⁰ Infrastructures and operating methods will have to become more resource-sufficient and more resistant to climatic extremes, supply chain disruptions and cyberattacks, in order to provide sustainable care.²⁸¹ AI could help to choose the product or care with the lowest emissions. The COVID-19 crisis highlighted the importance of diversifying supply sources ([building block 1](#)). Strategic national stockpiling of medicines and medical equipment is a good practice that should be maintained and systematised. It has also made possible the emergence of a regional strategic medical diagnostics value chain in Luxembourg. This success led the Ministry of the Economy to make it a pilot project in the '*Ons Wirtschaft vu muer*' roadmap prepared during the pandemic. The challenge is now to make this value chain sustainable and usable in emergencies.

The transition towards more preventive medicine will help improve the general health of the population and reduce healthcare costs. This requires investing in health literacy, i.e. the skills that enable people to make the right choices for their health. This means learning, from an early age, how to access and understand information, and how to use it to make judgements that will help maintain or improve health. This is not a 'prescriptive' form of education, where a person learns to do this or that, since such rules can become obsolete as knowledge evolves, but rather the development of a skill that enables a person to manage large amounts of information, and identify reliable sources and relevant information, so that they can navigate an increasingly complex and changing healthcare system.

280 Nathalie Baudinière (2022), [Quelle sobriété pour le numérique en santé à l'heure de l'accélération du déploiement?](#), Agence du numérique en santé, Transition écologique des établissements de soin.

281 In France, it is estimated that healthcare emissions account for between 6.6% and 10% of the national carbon footprint. See The Shift Project (2022), [Décarboner la santé pour soigner durablement](#), and [additional notes](#). '4.4% of the world's and 5.2% of Germany's national GHG emissions are produced by the health system', Josh Karliner et al. (2019), [How the Health Sector Contributes to the Global Climate Crisis and Opportunities for Action](#), in Climate-smart health care series.

In line with the ECO2050 Vision, personal health is another reserve that needs to be maintained and cared for. Good health is essential for individual wellbeing, psychological balance, self-esteem, and enjoyment of work – in short, for societal resilience. Improving people’s health has a positive impact on their quality of life, their social relationships and the environment around them (building block 3). Changes in living conditions and the environment are accelerating and can have a direct effect on people’s health:²⁸² a few examples include ozone depletion (skin cancer), bioaccumulation of chemical pollutants (genetic and fertility degradation), heat waves, and air pollution by aerosols and fine particles (potentially lethal).²⁸³ While improving the environment and making cities greener is a long-term collective undertaking, each individual can be encouraged to lead a healthier life in terms of diet, exercise, working life, digital hygiene and leisure activities (building block 3).

In the future, it will be key to help the system to transition by applying the maxim ‘raise the price of vice and lower the cost of virtue’.²⁸⁴ Strengthening the synergy between the economy and health will help to preserve affordable, inclusive access to the public health service over the long term.²⁸⁵

282 Sabine François (2022), Comment accompagner les territoires en Grand-Est pour renforcer leur résilience?, presentation at the Luxembourg Strategy conference, 17 October 2022.

283 Will Steffen et al. (2015), The nine planetary boundaries, and Dorothea Baltruks et al. (2022), Health within planetary boundaries.

284 Deloitte (2016), Health Care Foresight, Identifying megatrends.

285 ‘Universal health coverage (UHC) means that all people have access to the full range of quality health services they need, when and where they need them, without financial hardship’. WHO (2023), Universal health coverage.



#8

Integrating
new challenges into
economic diplomacy

Doing it on your own is a recipe for failure. Following the example of global public goods,²⁸⁶ which are governed by international treaties, conventions and agreements (human rights, climate change and biodiversity), Luxembourg can advocate in multilateral forums for these international legal frameworks to be extended to essential public goods that currently lack one and which strongly affect the national economy. In light of the new challenges posed by multiple transitions in a global context of biophysical limits and social imbalances, the opportunities need to be seized and the threats posed to humanity by certain global public goods need to be guarded against. This means promoting fairness in sharing and managing the world's resources, and preserving the ability of the poorest countries to achieve a level of development that will ensure their citizens a decent standard of living.

Among the global common goods in which Luxembourg has either a direct economic interest or a degree of experience, and therefore a potential role as mediator or defender, are:

- Critical raw materials
- Geoengineering
- AI and the metaverse
- Space resources
- Green shipping (KBR) and deep sea mining
- Measuring economic resilience and wellbeing

Luxembourg stands out internationally because it invests 1% of gross national income in development aid, making it one of the five most ambitious developed economies in this area. The government is currently working on a legal framework for responsible business conduct and due diligence in supply chain management.²⁸⁷ Luxembourg's global diplomatic and consular network supports the national economy, trade and investment.²⁸⁸ Added to this are the nine Luxembourg Trade and Investment Offices (LTIO) of the Ministry of the Economy, which develop knowledge of local markets, identify potential investors and support companies working in foreign markets.

Procuring strategic metals is essential for successful decarbonisation.²⁸⁹ Luxembourg could become an advocate for access to and fair, negotiated sharing of critical raw materials and scarce resources, for example by working to set up a 'COP of raw materials'.²⁹⁰

286 As 'public goods', global public goods are (as defined by economic science) (i) non-rival (i.e. their use by a first actor does not prevent their use by a second) and (ii) on-excludable (i.e. no one can be stopped from using them). They are also characterised by the global scale on which they are used. The Earth's ecosystem, its biodiversity, air quality, and even health (cf. Boidin (2016), *La santé, bien public mondial ou bien marchand? Réflexions à partir des expériences africaines*, Presses Universitaires du Septentrion) are examples of global public goods.

287 Ministry of Foreign and European Affairs (2021), *Conduite responsable des entreprises*.

288 Luxembourg Trade & Invest, *Luxembourg's global diplomatic and consular network is supporting the national economy, and Trade and Invest*.

289 Guillaume Pitron (2022), *La guerre des métaux rares, Les Liens qui Libèrent*.

290 Yves Jégourel (2023), *Pour une véritable diplomatie européenne des matières premières*, FEDIL (24 January 2023).

#8 Integrating new challenges into economic diplomacy

The OECD argues that **geoengineering and AI** present existential risks (X-risks), depending on the direction they take and the regulation that is set up around them.²⁹¹ **X-risks** are risks that threaten the entire future of humanity.²⁹² Reducing existential risks is a global public good that justifies the creation of an institutional framework for international action. Ideally, this framework should be such that the cost and responsibility of providing these goods can be shared equitably by all.²⁹³

Geoengineering (e.g. direct air capture, aerosol injection, cloud thinning, ocean fertilisation) can be defined as the process by which humans deliberately manipulate the supply of energy to the Earth system by deploying natural processes that have an impact on the climate using available technologies.²⁹⁴ There is currently no international framework governing public or private initiatives to technically interfere with the climate, even though solar radiation is a common good. There is an urgent need for global governance in order to prevent interference, crises or maladaptation with irreversible harmful effects. Such anticipatory policy-making is also advocated by the European Parliament think tank: 'The EU could help advance preparedness in this area; for example, by throwing its diplomatic weight behind multilateral initiatives moving in this direction. The EU and its partners could promote an international governance framework for geoengineering'.²⁹⁵

Given the importance of **digitalisation** and **AI**, an international framework setting standards for the protection of people and digital infrastructures against malicious digital attacks, criminal activities and autonomous weapons systems will be an asset in preventing global risks. Relevant texts are being drafted by the EU, the Council of Europe, the Trade and Technology Council and at other levels. AI should help humanity resolve polycrises, not accelerate them. This would be an extension of national efforts to build resilience in cyberspace, as illustrated by the **cyber defence strategy**.

Asimov's Three Laws of Robotics, dating back to 1942, provide an interesting, if fictitious, starting point for creating a global framework to be respected so that AI and robotics remain beneficial to humanity.²⁹⁶ The UNESCO recommendation adopted in 2021 on the ethics of AI is another such starting point. 'This text, which gained the support of all 193 Member States, is the sign of a real awareness of the potential dangers of a technology that extends to all areas of society, with the risk of bias and discrimination first and foremost, but also the risks of standardisation, mass surveillance and environmental damage, particularly through excessive energy consumption'.²⁹⁷ As part of international solidarity efforts, 'AI could be used to maintain and strengthen common public goods such as education (particularly in citizenship and democracy, sustainability, planetary boundaries and systems thinking), access to healthcare and the fight against inequalities and socio-territorial divisions'.

Luxembourg's commitment to developing a **space sector** dates back to the 1980s with the creation of SES. The political goal, then as now, is to make space one of the pillars of the national economy. In 2005, Luxembourg became a member of the European Space Agency (ESA), and in 2020 the Grand

291 OECD Strategic Foresight Unit (2022), Project existential threats, 'Better understood existential risks include nuclear war and climate change, but new risks are emerging, such as those from engineered pandemics and advanced AI systems', see Duncan Cass Beggs (2022), Longtermism and Emerging Global Existential Risks, OECD presentation, Luxembourg Strategy conference, 17 October 2022.

292 Win Naudé and Otto Barten (2023), Artificial General Intelligence: can we avoid the ultimate existential threat? OECD Artificial Intelligence Policy Observatory.

293 Other X-risks are linked to the misuse of nanotechnologies, nuclear war, genetic and pandemic engineering, volcanic super-eruption, disasters, climate disruption, ecological destruction, resource depletion, asteroids, totalitarian regimes and hostile super intelligence. See Nick Bostrom (2002), Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards, Journal of Evolution and Technology, Vol. 9, No. 1 (2002).

294 European Commission (2022), Geo-engineering: A roadmap towards international guidelines, JRC Publications.

295 Scientific Foresight (STOA) (2021), What if we could engineer the planet to help fight climate change, European Parliamentary Research Service podcast.

296 The first law is that a robot must not harm a human or, by its inaction, allow a human to harm itself. The second law is that a robot must obey any instruction given to it by a human, and the third law is that a robot must avoid actions or situations that could lead to injury to itself.

297 Christian Byk (2022), L'ère du numérique conduit-elle à l'émergence de nouveaux acteurs et formes de souveraineté?, Cahiers Droit, Sciences & Technologies.

Duchy became a founding member of the Artemis Accords led by the National Aeronautics and Space Administration (NASA), which aims for the peaceful, transparent and sustainable exploration of space.

The objective of the **Luxembourg space strategy for 2023–2027** is to continue efforts to develop the Luxembourg space sector as a vector for the diversification and long-term success of Luxembourg's economy, but also as a major contributor to the sustainability of activities on Earth and to developing a responsible approach to activities in space.

The country can become active on the international stage in order to ensure the universality of space resources and applications, defend the EU's independence in terms of access to space and space infrastructure and the resulting commercial opportunities for member states. Luxembourg could stand out by specifically promoting the elimination of space debris. The Grand Duchy could also join forces with like-minded countries to profit from the socio-economic results of space exploration and benefit sharing.

EXAMPLE : SPACE PROJECTS WHICH BENEFIT HUMANITY

- Developing life and materials sciences based on space experiments
- Solving the problem of space debris
- Terrestrial observation and satellite communications for:
 - Monitoring sea, ice and permafrost levels
 - Planning adaptation measures (e.g. building polders in front of seaside megacities)
 - Preventing disasters and extreme weather events
 - Improving knowledge of the global situation, particularly during conflicts (e.g. as part of NATO)
 - Managing crisis/emergency situations (e.g. emergency.lu)
 - Monitoring biodiversity, ecological restoration and migration
 - Detect CH4 emissions
 - Improving **maritime and river navigability** forecasts: new trade routes via the North Pole, low water on the Moselle/Rhine, etc.



Source:
<https://www.ses.com/>



Source:
<https://flightradars24.fr/marine-traffic/>



Source:
<https://www.nature.com/>

On a global scale, the maritime sector is responsible for 3% of greenhouse gas emissions – a proportion that is set to rise to 17% as freight transport grows between now and 2050.²⁹⁸ In order to commit the 204 ships flying the Luxembourg flag to green shipping, the Minister of the Economy plans to submit a draft bill to the Council of Government by the end of October 2023 to encourage shipowners to invest in modern, more environmentally friendly technologies. These incentives include adjusting registration fees in line with the 'polluter pays' principle (with a reduction of up to 80% for ships powered by electricity, sail or 'green' hydrogen, Figure 19), and increasing tax bonuses for investment in 'green' ships. Luxembourg is therefore well placed to become active in international green shipping. Efforts are underway to raise funds via the Luxembourg Stock Exchange to finance this transition. Another forerunner in this field is the Global Centre for Maritime Decarbonisation, based in Singapore.

²⁹⁸ MECO (2023), *Franz Fayot introduit le principe du 'green shipping' dans le secteur maritime luxembourgeois*, press release.

#8 Integrating new challenges into economic diplomacy

LES TECHNOLOGIES DU FUTUR: PROPULSIONS ALTERNATIVES

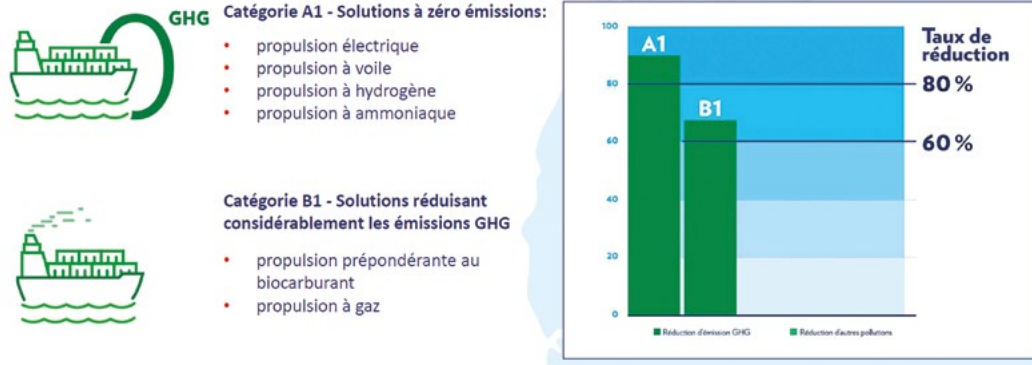


Figure 19. Reduced registration fees for 'green' ships²⁹⁹

On the issue of **deep sea mining**, Luxembourg should work with the other EU member states to develop a level playing field within the International Seabed Authority. This is in the interests of all parties concerned, and would offer the best possible protection for the maritime environment.

On the issue of **measuring national economic performance**, a great deal of research is underway, and the expectations of the public, economic actors and political decision-makers are high for developing master indicators other than GDP. In May 2023, 5,000 people, the majority of them young people, attended the 'Beyond Growth' conference at the European Parliament.³⁰⁰ At the Ministry of the Economy, STATEC is promoting wellbeing measurements and Luxembourg Strategy is focusing on the measurement of economic resilience, including biophysical limits and basic socio-economic needs. Luxembourg could commit to the development and implementation of an international standard at EU and OECD level.

In light of recent developments, including the growing impact of climate change and pandemics, it has become increasingly clear that GDP is an incomplete measure of progress and prosperity. Nor does it fully reflect the major environmental or social challenges of our time.

The European Commission's strategic foresight report³⁰¹ explores concrete ways of going beyond GDP, taking account of social and environmental aspects in order to move towards an **adjusted GDP**. These aspects may include quality of life (health, education or leisure), unpaid care and domestic work, inequalities, the costs of environmental damage (pollution or emissions), and the depletion of natural resources.

In EU forums, Luxembourg will continue to advocate for the establishment of a **strong and integrated internal market** and a harmonised regulatory framework that encourages the dissemination of products, services and production methods that contribute to decarbonisation and sustainable development. Luxembourg is represented in many international bodies and will continue to support strengthened and effective multilateralism. To defend the interests of the country and Luxembourg citizens, the secondment of nationals to international institutions of importance to the country and its causes could be systematically facilitated and extended.

²⁹⁹ Commissariat aux affaires maritimes, press conference, 16 August 2023, p. 13.

³⁰⁰ Beyond Growth conference (2023), Pathways towards Sustainable Prosperity in the EU.

³⁰¹ European Commission (2023), Sustainability and wellbeing at the heart of Europe's Open Strategic Autonomy, Strategic Foresight Report.



#9

Ensuring
sustainable and solid
public finances

To move away from fossil fuels, investment is needed.³⁰² 'The climate transition is a major transformation, similar in scale to the industrial revolutions of the past, and because of the delay in reducing emissions and the new geopolitical context it must be carried out at an accelerated pace. In the coming years, it will affect growth, inflation, public finances, competitiveness, employment and inequalities'.³⁰³

This feeling is all the more pronounced given that the climate transition will have to be carried out in conjunction with the energy, ecological, digital and societal transitions. From a macro-economic point of view, these transitions will require a substantial increase in investment, with a strong equity component. Public policies have the capacity to substantially reduce the costs involved by setting priorities and extending the financial planning horizon, in an environment in which public finances are increasingly under pressure.³⁰⁴ Technological and behavioural innovation, efficiency and sufficiency, circularity and increased use of locally available resources, training and skills, strategic redundancy and storage, and nature-based solutions are all principles put forward by the ECO2050 Vision to help control costs and unexpected factors, and to support the efforts of insufficiently solvent businesses and households.

Various estimates of the investment needed for the energy and climate transitions by 2050 have been made for different geographical areas. STATEC concludes that, in general, in the EU, the energy transition will require investments amounting to **+2% of GDP** per year between now and 2050.³⁰⁵ While these studies are exhaustive in terms of direct energy investments related to climate mitigation (technologies), they pay less attention to the investments required in other sectors (agriculture, mobility, industry, buildings, waste and above all ecosystems (carbon sinks)). The scope of such studies is not always clear or comparable. For example, the European Commission adds up the costs of the climate, energy and industrial transitions and argues that additional investments of more than €620 billion per year will be needed to achieve the objectives of the Green Deal and REPowerEU,³⁰⁶ as well as €92 billion between now and 2030 to implement the NZIA.³⁰⁷

The studies are also based on domestic emissions and ignore those from imports, aviation and international maritime freight. They assume continuity in the supply of energy and materials in favourable quantities, quality and prices, and strong economic growth (estimated by STATEC at 5% on average per year in Luxembourg, from 2023 to 2050, in its projections on the macro-economic impact of the energy transition (2023)). However, the challenge of carbon neutrality is global in nature. It concerns all global emissions, and global fossil fuel consumption is still growing at the moment (Figure 7). Carbon neutrality also depends on natural sequestration in carbon sinks (ocean, forests, soil). In this respect, the Energy Transitions Commission estimates that the global costs of avoiding deforestation will exceed US\$130 billion per year by 2030.³⁰⁸

The costs of **climate adaptation** are often ignored or underestimated. In addition to the costs of preventing and adapting populations, production systems, infrastructures and vital networks to the effects of environmental crises, there are also the costs of repairing and rebuilding damaged or destroyed physical assets in order to reduce the future economic damage of global warming. The sum of these expenses is the cost of climate inaction.

302 'The world is not investing enough to meet its future energy needs; oil and gas investment is geared to a world of stagnant or falling demand, while transition-related spending is not rising nearly fast enough'. See Laura Cozzi (2021), *World Energy Outlook 2021 and the Net Zero by 2050 Scenario*, presentation by the International Energy Agency at the *Luxembourg Strategy conference*, 15 November 2021.

303 Jean Pisani-Ferry and Selma Mahzouf (2022), *L'action climatique: un enjeu macro-économique*, France Stratégie.

304 Contribution of the Chamber of Commerce to the draft update of the PNEC 2021-2030, June 2023.

305 Tom Haas (2023), *Analyse des incidences macroéconomiques de la transition énergétique*, STATEC presentation, 6 July 2023.

306 European Commission (2023), *Sustainability and wellbeing at the heart of Europe's Open Strategic Autonomy*, Strategic Foresight Report. REPower Europe, Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action.

307 Anne Calteux (2023), *Interview* citing the European Commission's latest 'Strategic Foresight' report published in July 2023, FEDIL Echo, 2 August 2023.

308 Energy Transitions Commission (2023), *Financing the transition: Costs of avoiding deforestation*, 19 April 2023.

#9

Ensuring sustainable and solid public finances

While everyone agrees that the cost of inaction on climate exceeds the cost of action,³⁰⁹ estimates of the cost of inaction vary widely and have increased significantly over time since the Stern Review in 2006.³¹⁰ In 2022 Oxford Economics estimated the **cost of climate inaction at 20% of GDP** at 2.2°C of warming. Needless to say, beyond a certain level of warming, the cost is total, since there is no economy to be saved.³¹¹ The growing impact of extreme weather events is already causing serious economic losses. In the EU, for example, these amount to around €9 billion a year for droughts and €7.6 billion a year for river floods.³¹² And this is without taking into account the additional cost of action or inaction in terms of biodiversity, which is another fundamental pillar of the continued habitability of the planet. On a global scale and for the period from 1997 to 2011, the cost of ecosystem services was between €3,500 billion and €18,500 billion per year, and the cost of soil degradation is estimated at between €5,500 billion and €10,500 billion per year.³¹³

The following box gives some references to budgetary projections regarding the **cost of climate action**. In particular, the Rifkin Study estimated the cost of Luxembourg's climate transition up to 2050 at around 2% of its GDP. In terms of new revenue, it should be noted that overall revenue from the carbon tax reached a new record in 2022, with almost US\$100 billion collected.³¹⁴

Although Luxembourg finds itself in a less buoyant economic context than in the past and is facing an upward trajectory in its public debt over the medium term, it nonetheless has financial reserves that would enable it to **invest in transitions** and **redundancy**, where other countries would have more difficulty. These investments could also be extended to cross-border transition projects (energy, water, infrastructure).

To maintain the confidence of investors and the public, a long-term programme for public finances compatible with the multiple objectives of the transitions must be proposed. Complementary measures need to be identified to increase funding for transitions, detailing the specific support arrangements for vulnerable businesses and households in order to ensure equity.

The state has a number of tools at its disposal to support **transition** investments: by investing itself where necessary and by ensuring social equity. Subsidies and public contracts can be made conditional on compliance with non-financial criteria. By building up **strategic financial reserves** and directing productive public investment towards transitions and adaptation to climate change, the state can act as a driving force for the economy. The **EIB** and the **Luxembourg Stock Exchange** are essential partners in financing transitions. Public-private partnerships would also let the state act as **guarantor** by assuming part of the investment risk, which is particularly high in the current context of multiple concurrent transitions.

309 'Short-term costs of green transition always more than compensated by long-term benefits'. See Carmelo Salleo (2021), ECB economy-wide climate stress test, presentation by the European Central Bank at the [Luxembourg Strategy conference](#), on 15 November 2022.

310 The Economics of Climate Change: The Stern Review (2006). This review puts the costs of climate damage at 5% of GDP a year compared to the cost of mitigation of 1%.

311 'We find that 2.2°C of warming by 2050 has the potential to reduce global GDP levels by up to 20%. Warming of up to 5°C by 2100 would lead to economic annihilation, consistent with scientific research on mass extinction thresholds', David Winter and Manuela Kiehl (2022), [The global economic costs of climate change inaction](#), Oxford Economics.

312 European Commission (2023), [Sustainability and wellbeing at the heart of Europe's Open Strategic Autonomy](#), Strategic Foresight Report.

313 European Commission (2020), [The business case for biodiversity](#), EU Green Deal, May 2020.

314 World Bank (2023), [State and trends of carbon pricing 2023](#).

Comparing the costs of climate action

at the global level: between **US\$2,300 and US\$9,000 billion** a year in investment required (depending on estimates)³¹⁵

- **IPCC (2022) 'Climate Change 2022: Impacts, Adaptation, and Vulnerability'**: The investments needed in the electricity sector are on average US\$2,300 billion per year (2015 prices) between 2023 and 2052 (i.e. US\$69,000 billion for 30 years) to comply with trajectories that limit global warming to 1.5°C.
- **IEA/UNCTAD**: US\$2,600 billion per year are needed by 2030 to achieve the SDGs and stay on the net zero trajectory by 2050.³¹⁶
- **IEA, Net Zero Emissions scenario**: Investment in clean energy should exceed US\$4,000 billion by 2030.³¹⁷
- **McKinsey (2022) 'Net zero transition'**: The cumulative investment in physical assets required to achieve net zero emissions amounts to around US\$275,000 billion by 2050, or around US\$9,000 billion per year.
- **BloombergNEF (2023) 'Decarbonization: The long view, trends and transience'**:³¹⁸ US\$194,000 billion should be spent globally between 2022 and 2050 to reach net zero, i.e. around US\$7,000 billion per year.

at the European level: between **€260 billion and €1,000 billion** a year (depending on estimates)

- **European Commission (cited in the 2021-2030 NECP)**: €260 billion per year over the next ten years to meet the Paris Agreement targets.
- **European Court of Auditors**:³¹⁹ Carbon neutrality by 2050 in the EU-27 would require total investment (ongoing and additional investments) of around €1,000 billion per year over the period 2021-2050.

at the national level: between **€1.0 billion and 1.4 billion** a year (depending on estimates)

- **FR – France Stratégie (2022) 'L'action climatique, un enjeu macro-économique'**:³²⁰ investments in the climate transition represent around 2.5 GDP points in 2030, or €70 billion (2021 prices).
- **LU – Rifkin Study (TIR) (2016)**: €14 billion for 33 years (2017-2050), i.e. €425 million per year) are needed to achieve the energy efficiency and renewable energy targets of the TIR study's global innovation scenario. Total cost for TIR: €46 billion, or €1.4 billion per year (approximately 2% of annual GDP, value 2021).
- **LU – MECDD (2023) The Integrated National Energy and Climate Plan 2023-2030 (updated PNEC)**: Additional investment and expenditure in decarbonisation (energy, transport, buildings, industry) is estimated at €8.3 billion for 2023-2030, or €1.0 billion per year (around 2% of annual GDP).³²¹

³¹⁵ By way of comparison, the financial crisis is estimated to have caused the loss of US\$2,000 billion to the global economy between the second quarter of 2008 and the first quarter of 2009. See Renae Merle (2018), *A guide to the financial crisis – 10 years later*, Washington Post.

³¹⁶ 'Estimates obtained by adding data from the United Nations Conference on Trade and Development (UNCTAD) and IEA, show that roughly \$2.6 trillion dollars is required annually through 2030 to meet the Sustainable Development Goals (SDGs) and stay on a path to a net-zero society by 2050', Daniel Zelikow and Fuat Savas (2022), *Mind the gap: Time to rethink infrastructure finance*, World Bank Blogs.

³¹⁷ WEO 2022, IEA, 2022.

³¹⁸ Nat Bullard (2023), *Decarbonization: The long view, trends and transience, net zero*.

³¹⁹ European Court of Auditors (2023), *EU auditors see 2030 climate and energy targets at risk*, special report, 26 June 2023.

³²⁰ Jean Pisani-Ferry and Selma Mahzouf (2022), *L'action climatique: un enjeu macro-économique*, France Stratégie.

³²¹ Tom Haas (2023), *Incidences macro-économiques de la transition énergétique*, STATEC presentation, July 2023.

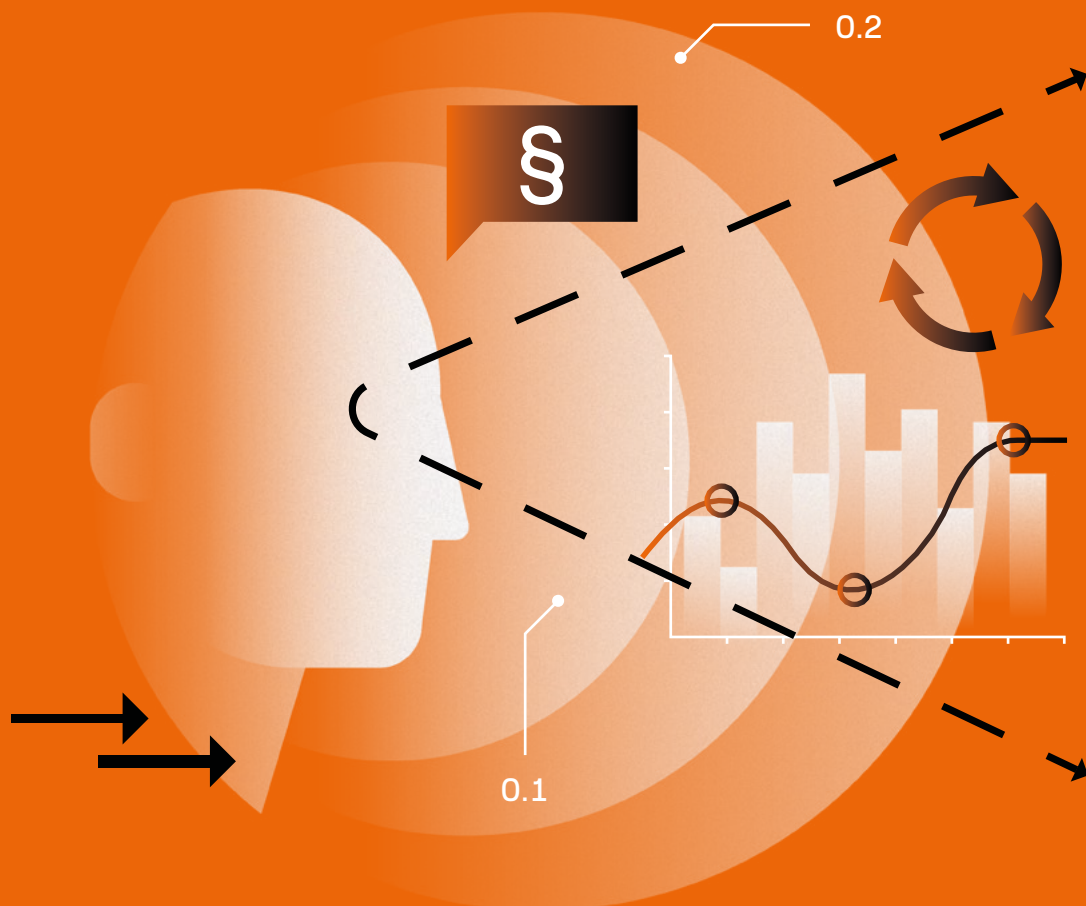
#9

Ensuring sustainable and solid public finances

In order to guide production and consumption behaviour, the state could alter **taxation** in line with economic policy – for example, by imposing higher taxes on fossil fuels (TIR study, 2016) and non-essential goods and services with a high environmental footprint, or on purely speculative property investment, and by offering tax deductions for investment in low-carbon technologies and the decarbonisation of industry. Transition-related revenues and expenditure can be incorporated into long-term budget projections. Sustainable investments can be encouraged for pension funds. Supplementary pension products based on sustainable asset classes may be offered.

By promoting sustainable and climate-friendly finance solutions aimed at decarbonising the economy and by modernising **tax relief** to encourage investment in the energy and ecological transition, the state can effectively steer private investment in a sustainable direction. This would also involve mobilising and channelling national savings and encouraging the establishment or relocation of economic activities that can accelerate the transition.

Given the substantial investment required and the need for stability in a complex and uncertain environment, every tool of economic policy (fiscal, financial, regulatory) must be used and all actors must be mobilised to make progress in a coordinated, determined way.



#10

Turning **anticipation**
into a competitive
advantage

Looking to the future is a fundamentally optimistic act.

‘Foresight is the work of anticipation that gives an organisation the resilience it needs to maintain its activity beyond the horizon of the foreseeable.’

Olivier Desjeux, *Ateliers des futurs* (2022).

Given that traditional approaches to public policy are no longer sufficient in an environment of great complexity, uncertainty and rapid change influenced by a variety of stakeholders – many of which are found outside the public sector – it is desirable to pursue widespread, innovative anticipation and risk management for public services.

Strategic foresight helps to prepare for and respond to futures that require radically different approaches to public services. Anticipatory innovation refers to the ability of organisations to perceive, understand and act coherently on the future as it emerges in the present. The public sector must prepare for what is to come, continuously identifying, testing and implementing innovative solutions to take advantage of future opportunities while reducing risk through increased resilience of public systems.³²²

Anticipatory innovation involves identifying the vulnerabilities and opportunities that will influence public action sufficiently in advance. Risks can be dealt with before they become so serious that a country or region can no longer manage them alone. Nobody likes to be caught unprepared. In the words of Jean Pisani-Ferry, ‘the more precipitous the transitions, the more they will result in the brutal devaluation of equipment, skills and intangible capital. By facilitating this horizon for private actors through the planning of public initiatives, and by supporting business adaptation and retraining, public policies can greatly reduce the costs of reallocation’.³²³ By informing public and private investors early on about the sectors, technologies, materials, trades, partners and sites of the future, and therefore reducing the risk of stranded assets, economic opportunities can be seized at the right time and converted into successful areas of business (conversion, market, substitution of materials, etc.).

Anticipating risks requires effective collaboration between the public and private sectors which hold the relevant information (stock and reserve levels, incidents, threats, vulnerabilities, adaptation and remediation measures, trends, etc.).

To build an early warning system, a foresight-based approach monitors megatrends, **blind spots** and weak signals that have not yet been publicly recognised (see [foresight glossary](#)). This approach is complemented by an analysis of the long-term **costs and benefits** of a policy, which shows the potential gains of early action or the potential costs of inaction. A lack of credibility is damaging to transitions and costly for the economy. By adopting a shared, confident vision of the future, plans will become more stable, projects more concrete and investments more predictable. Financing will follow.

Public expertise in foresight and the culture of risk are being built from within. The national thematic observatories – of which there will be 17 by 2023³²⁴ – will work together to provide decision-makers with tailor-made monitoring of global megatrends and their implications for Luxembourg, and early identification of weak signals. The results will be combined to inform policy-making. An illustration of the role of public foresight can be seen in the national cybersecurity and cyberdefence strategies. These invest in foresight in order to draw up a map of ‘cyberfutures’.³²⁵ Another possible application of foresight studies is the development of technology forecasts (see the [foresight applications](#) detailed in Chapter I.3, as well as the [foresight glossary](#)).

322 The OECD QPSI Anticipatory Innovation Governance project is developing and testing new approaches and conducting action research with governments and partners in this emerging area of anticipatory innovation.

323 Jean Pisani-Ferry and Selma Mahzouf (2022), *L’action climatique: un enjeu macro-économique*, France Stratégie.

324 This includes the observatories for Competitiveness, Spatial Development, Equality, Children, Youth and School Quality, the Natural Environment, Employment (RETEL), the Civil Service, Price Formation, Housing, Mobility, SMEs, Climate Policy, Social Policy, Health, Labour and Social Cohesion.

325 ME et al. (2021), *4ème Stratégie nationale en matière de cybersécurité 2021-2025*.

#10 Turning anticipation into a competitive advantage

How do you generate a new and useful point of view when faced with the sheer quantity of information and available but under-used sources? STATEC notes that the vast majority of companies (81%) do not analyse megadata, whether because of insufficient human resources, knowledge and skills, opportunity costs versus other priorities, doubts about the usefulness of such analyses, the quality of the data or the cost/benefit ratio of its use, or difficulties in complying with privacy protection laws (24%).³²⁶ Foresight can be assisted by digitalisation and algorithms to better identify, synthesise and exploit resources, to conduct new surveys and more detailed analyses based on metadata and big data, to strengthen statistical modelling and to visualise results (**advanced foresight**).

Governments and businesses that think ahead give themselves the means to achieve better results. Without the ability to plan ahead, adapt and transform, any business is in danger of disappearing. For businesses, anticipation can help reduce emissions. In the financial sector, the first adopters who acted early to implement extra-financial reporting, which has been mandatory in the EU for 10 years, now have a comparative advantage in implementing the Corporate Sustainability Reporting Directive (CSRD). The CSRD endorses the principle of **double materiality**.³²⁷ Depending on their size, sector and profile, companies must report not only on the financial and physical risks to which they are exposed as a result of environmental change (the 'outside in' effect of the climate on assets), but also the impact of their activities on people and the environment (the 'inside out' effect of assets on the climate). Transaction costs are higher for companies that did not see this coming than for those that were prepared and had already strengthened their human resources, databases and IT systems in anticipation. This is one reason why the Luxembourg Bankers' Association (ABBL) is calling for the creation of a national register of companies' non-financial data to enable risk assessment of banks, insurers and funds.

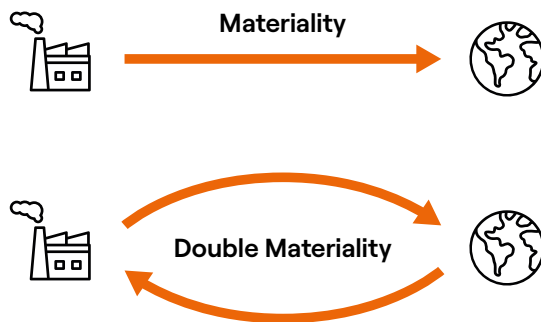


Figure 20. Double materiality³²⁸

³²⁶ STATEC (2022), *Un portrait chiffré des entreprises au Luxembourg*.

³²⁷ European Commission (2022), *Sustainable finance*.

³²⁸ Matthias Täger (2021), *Double materiality: what is it and why does it matter?*

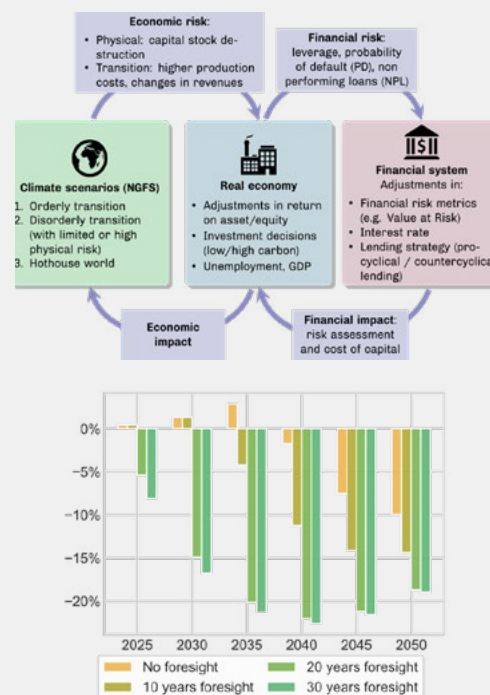
Long-term planning makes things simple. Research has confirmed the importance of companies tackling environmental issues early if they are to make an effective transition to a low-carbon economy and control its impact on future physical risks.³²⁹ An orderly and early transition to decarbonisation will increase economic dynamism while limiting global warming. Conversely, a disorganised and delayed transition increases the risk of stranded assets and the destruction of physical assets. The perception that energy taxation is being developed in a coordinated and clear way influences investment decisions. The crucial point here is to recognise the particular importance of anticipation with regard to environmental risks and the benefits of foresight in steering public policy and private investment.

EXAMPLE : FORESIGHT IN THE ECONOMIC AND FINANCIAL SECTORS

Financial investments are by nature based on the anticipation of future risks. The strength of Luxembourg's financial centre depends on it.

- Delay in carrying out the transitions presents a **risk with two material dimensions**: (i) financial depreciation and physical destruction of assets and (ii) amplification of climate change by eco-financial activities.
- **Foresight guidance** gives a clear indication of how regulation and the technologies of the future will evolve, enables private investment to be directed effectively and **makes the benefits of an orderly and early transition more tangible**.
- Companies providing financial services through innovative solutions (FinTech) make it possible to improve the **collection and interpretation of weak signals**.
- The estimated **global costs of decarbonisation 2050**: US\$200 – US\$300 trillion, or US\$9,000 billion/year*
- TIR cost estimate (2017-2050), Luxembourg: €46 billion, i.e. €1.4 billion/year, i.e. approx. 2% GDP

* McKinsey (2022), BloombergNEF (2023)



The double materiality of climate physical and transition risks in the economy and finance

Impact of firms' climate sentiments on economic decarbonisation

Source: Gourdel et al. (2022) The double materiality of climate physical and transition risks in the euro area, SUERF Policy brief n° 436, Oct. 2022

Today, central banks are recognising climate risk as a systemic risk to financial stability.³³⁰ As a corollary, new products are being proposed (green funds, sustainability or climate bonds) and new business opportunities are emerging in the field of climate consulting, auditing and litigation.

³²⁹ Regis Gourdel et al. (2022), *The double materiality of climate physical and transition risks in the euro area*, SUERF Policy brief no. 436.

³³⁰ Carmelo Salleo (2021), *ECB economy-wide climate stress test*, presentation by the European Central Bank at the *Luxembourg Strategy conference*, 15 November 2022.

#10 Turning anticipation into a competitive advantage

In a world where everything is moving ever faster, the focus of attention needs to be on both the long term and the 'slow term'. Planning gives predictability and security to investments, for example through the PDAT, which protects land resources over the long term. Another example of taking risk into account in long-term public planning is Luxembourg's 2021-2027 national flood risk management plan. The plan aims to reduce the risk of flooding and raise public awareness of the dangers of flooding. Although the ZAEs are located on sites that are not highly vulnerable, the potential physical impact on transport and supply infrastructures and on certain residential areas would have significant economic repercussions. It is estimated that, in terms of the value of assets at risk in Luxembourg, areas used for economic production (industrial estates and commercial establishments) are among the most exposed.³³¹

In times of uncertainty and crisis, it is prudent to have a plan B and not simply expect the future to be identical to the past. Resilience must be learnt and external shocks must be built into plans for the future.³³² By being agile, confident and strategic, Luxembourg will have all the necessary assets to succeed in rapidly transforming its economy. The future has yet to be decided, and what happens next is up to us.

331 See Abbildung 43: Ermittelte spezifische Vermögenswerte für Luxemburg 2020 in €/m² aus der Schadenspotenzialstudie (2021) in MECDD (2023), *Ébauche du Plan de gestion des risques d'inondation 2021-2027*.

332 The concept of 'resilience as new policy compass'. See Dimitri Lorenzani (2021), *Strategic Foresight & the Resilience Dashboard*, European Commission presentation at the *Luxembourg Strategy conference*, 15 November 2021.

I Method

II The Vision

III **Scenarios**

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III. Scenarios

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1. Constructing the scenarios, based on megatrends and bifurcations

As part of an open foresight process coordinated by Luxembourg Strategy between 2022 and 2023, using the scenario planning foresight method, three scenarios and a black swan (entitled the 'Red Queen', see [Appendix 2](#)) were developed for Luxembourg's economy with a time horizon of 2050. As black swans (see [Glossary](#)) are by definition rare, improbable and extreme, the Red Queen was not included in the basis that served for the basis for developing the ECO2050 Vision. However, it is included in the appendix for the sake of methodological completeness.

These three scenarios describe possible futures for Luxembourg's economy up to 2050. They are not predictions, and still less political manifestos, but rather the boundary points of plausible futures that could emerge for the country as a result of the development and interaction of **megatrends** (MTs), and their **bifurcations**. These exploratory scenarios cannot represent the complexity of foresight debates. While defining the limits of plausibility, the future reality is expected to lie somewhere between the three scenarios. This means that if a policy is subsequently revised and it appears to be robust in all the scenarios, it will probably stand the test of time (i.e. it will be considered future-proof).

As far as the content of the scenarios is concerned, it is clear that in all three scenarios, global **climate change** will occur and humanity will have to adapt to a warmer world affected by extreme events, from heatwaves to floods. Furthermore, most countries want to move their economies towards decarbonised production systems, which could exacerbate geopolitical tensions if everyone tries to lay hold of limited resources (e.g. lithium reserves for batteries) at the same time.

The global **economic model** will shape this transition. The first to act, without others making a similar change, risks losing out: competitors may not invest, but instead continue to sell their most polluting products at a lower price. For example, companies may choose to relocate their production, thereby changing the location of emissions, but not their impact at global level. This situation raises the following questions: firstly, does the global **geopolitical** order allow all nations to change their economic model at the same time, or is the transition blocked by geopolitical rivalries? Secondly, will the EU succeed in generating a shift in **geo-economic** power through the successful implementation of the European Green Deal? The EU's ability to do this will be strongly affected by the types of **governance** emerging in other European countries (and beyond). Indeed, populism and extremism could even pose an existential threat to the EU. This populism is, in turn, driven by a perceived increase in **inequalities** and a shift in values towards individualism. And if all else fails, can the twin pillars of **digitalisation** and **green technology** deliver a transformation, in a context of fierce geo-economic competition?

These forces determine the way in which **demography**, **work** and **knowledge** are developing in Luxembourg.

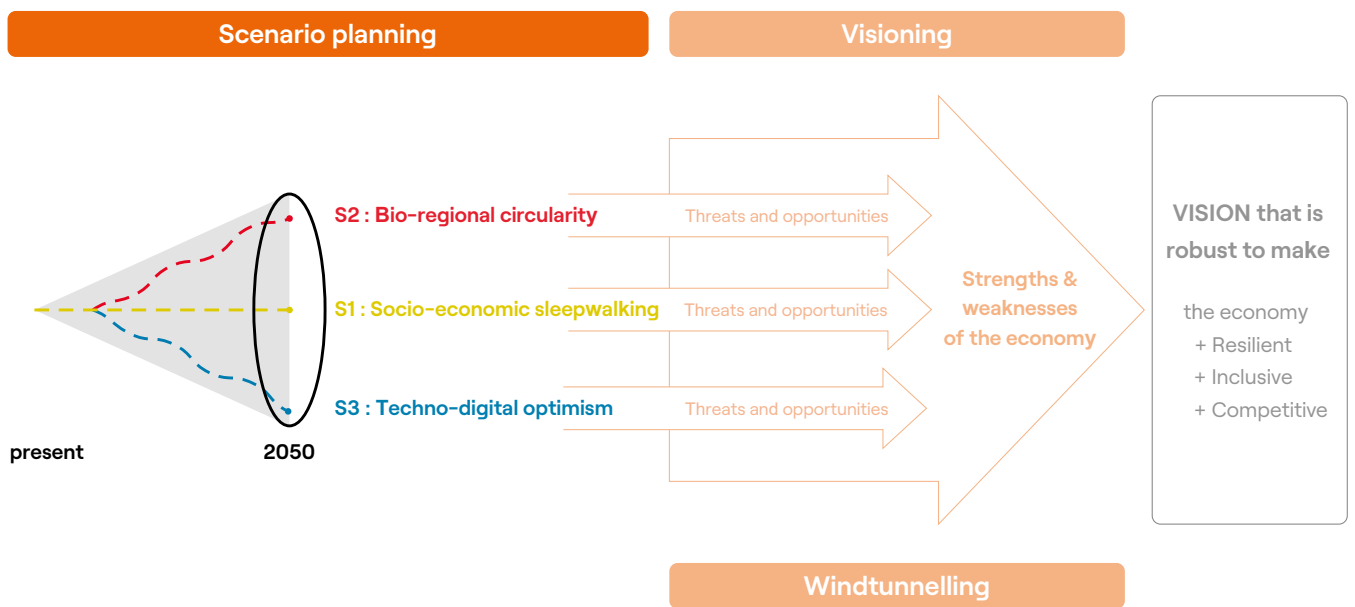


Figure 21. The range of possible futures covered by the ECO2050 scenarios (see Figure 22 for continuation and completion)

2. Short scenario description

The three scenarios (S1, S2, S3) systematically present various directions that national economic development could take in the coming decades. For the sake of information and guidance, they contain figures (on population, economic output and global warming) that develop connections with other important scenarios (such as STATEC's socio-economic projections or the IPCC's shared socio-economic trajectories). These data should be read with caution, as no figure, combination of figures or average in the scenario statements is intended to reflect a precise existing projection, a recalculation or a new estimate made specifically for this exercise.

SCENARIO 1 (S1) : SOCIO-ECONOMIC SLEEPWALKING

The scenario of permanent transitions.

- The year is 2050, and Luxembourg has a population of around 1.1 million.
- Luxembourg is attracting ever more employees without quenching its thirst for skilled labour to accomplish the transitions. Traffic jams continue, and public transport and housing are under pressure. Social security and pension schemes remain in place but are fragile and less protective than in 2022. Income and wealth are unequally distributed.
- Digitalisation and technologies that enable a more careful use of resources are placed at the service of the economy, which is aimed at achieving quantitative growth (GDP growth of +2% to +3%/year), but the efficiency gains are being overtaken by increases in demand. Since CSR criteria and the EU taxonomy carry little weight, the financial centre is failing to go green.
- The increasing complexity of the systems is running up against the end of the era of abundant resources, and limiting the ability to act. Societies and economies are running out of steam, lacking the talent necessary for the digital and green transitions, and suffering from administrative overload, information overload, an imperative for instant gratification, rising living costs and monetary poverty.
- The EU is trying to reconcile the ecological and digital transitions, reindustrialisation and strategic autonomy. The rest of the world is only slowly following suit. China and Russia are closing themselves off from the West. Global warming exceeds +2°C and little has been invested in adaptation. Insurance companies are overwhelmed by claims for climate damage. Carbon, material and ecological footprints are growing.
- Governance is short-term, and algorithms interfere with public opinion. Thanks to its financial resources, Luxembourg retains its model of compromise between collective and individual interests.

SCENARIO 2 (S2) : BIO-REGIONAL CIRCULARITY

The scenario of social and territorial simplification.

- The year is 2050, and Luxembourg has a population of around 770,000.
- Population and economic growth are slowing, which is easing the pressure on traffic, housing, health and education systems, the environment and water. The shortage of manual and low-tech skills is being overcome by an increase in technical training, and multi-activity careers combining services and manual work, in SMEs or at home, are becoming the norm. Everything is getting closer and simpler.
- Levels of wages, pensions and social security cover are stagnating. After a far-reaching transformation of the system, the gap between the richest and the poorest is narrowing and most people are living well on less, and within their means.
- Digitalisation and technologies are there to serve living beings, the financial centre is 'dark green', and the energy mix is diversified and decentralised. Air freight has been reduced in favour of river and rail transport. The last mile of deliveries is covered by urban cyclo-logistics.
- Since all countries are acting together, with the EU among the world leaders, global warming does not exceed +2°C. Circular reindustrialisation, energy diversification and the sharing economy in the Greater Region aim for qualitative growth measured by bio-regional '*PIBien-être*' (a wellbeing index).
- Efforts to adapt to climate extremes, the erosion of biodiversity and the scarcity of resources are carried out through a public programme of environmental rehabilitation, the re-learning of craft and technical skills, and investment in green infrastructure.
- Luxembourg makes extensive use of participatory democracy within the Greater Region, where local and regional authorities carry considerable weight, and within a smaller, more agile EU with less internal resistance, which is becoming a world leader in the ecological transition.

SCENARIO 3 (S3) : TECHNO-DIGITAL OPTIMISM

The scenario of technological innovation without behavioural change.

- The year is 2050, and Luxembourg has a population of around 1.2 million.
- The housing and employment markets are highly precarious. Although construction is being standardised and digitised to build faster and cut costs, housing prices are pushing workers to find accommodation outside Luxembourg's borders, which has a positive impact on the Greater Region. The education system is entirely digitised, privatised, tailored to the individual and focused on digital technology and finance. The shortage of high-tech and digital skills is being resolved by the virtualisation of the labour market, with employees all over the world and, given the time differences, work carried out at all hours.
- Continued quantitative growth at national level (GDP of +3% to +4.5%/year) means that the pension and social security funds and the central and municipal budgets are relatively balanced.
- Globalisation continues to structure international relations, and competition between countries, particularly for access to resources, is fierce and sometimes polarising. This has consequences for governance, with a surge in populism, which is weakening the EU. As a result, there is a search for new digital solutions to such privatised form of governance, such as the use of AI.
- Technological intensification, financed by Luxembourg's financial centre, is placed in the service of efficiency, but comes at the cost of greater surveillance and exposure to cyberattacks. Good progress is being made in health tech and some people's life expectancy is increasing. Digitalisation is targeted at dematerialising and decarbonising the economy, and reducing dependence on non-resident labour, which remains significant.
- Warming exceeds +2°C. Geoengineering and grey infrastructure are the primary means used to deal with climate change, which is putting a strain on budgets. As geoengineering lacks universal and representative governance, some countries, and even very wealthy individuals, are undertaking individual ventures, often with uncertain, irreversible or harmful side-effects for other countries and populations.

3. Breaking down and comparing the scenarios theme by theme

The table below presents the framework of the 12 megatrends ([Glossary](#)) and their thematic components that have shaped and will continue to shape Luxembourg's economy in the coming decades. The three scenarios (S1, S2, S3) are distinguished by the combination of different possible forms or bifurcations ([Glossary](#)) that each of the megatrends (MT1-MT12) could take on. The table characterises and details each scenario by theme or sub-sector, and highlights the similarities and differences between the scenarios. Each reader can therefore find the particular characterisation and details that pertain to the theme or sub-sector that is of greatest interest to them.

BIFURCATIONS		SCENARIO 1 (S1) SOCIO-ECONOMIC SLEEPWALKING	SCENARIO 2 (S2) BIO-REGIONAL CIRCULARITY	SCENARIO 3 (S3) TECHNO-DIGITAL OPTIMISM
MT 1	POPULATION IN LUXEMBOURG AND GREATER REGION	Strong growth in resident population (1.1 million) and border population	Low growth in resident population (770,000) and border population	Strong growth in resident population (1.2 million) and border population
	A) TERRITORIAL ORGANISATION	Urban sprawl with high levels of individual motorised mobility and land consumption. Homogenisation of the landscape and urban development.	Targeted, dense, mixed-use and multifunctional urban and rural development, reducing motorised mobility and land consumption (15-minute cities, reduced distance between work and home). Diversification of the landscape.	Hyper-dense urbanisation, spatial specialisation in order to limit land consumption and saturation of space. Widespread remote working to reduce commuting. The end of the landscape as 'countryside'.
	B) DEMOGRAPHICS	The age of the population is being reduced by immigration. Stagnation in life expectancy.	The population initially ages, then shrinks.	The age of the population is being reduced by immigration.
	C) INTERSECTIONAL DISCRIMINATION (GENDER, ETHNICITY, DISABILITY, RELIGION)	An effort to achieve equality for all, without entirely achieving it.	Cultural expectations change. Unpaid work comes to be valued as well. New distribution of tasks, depending on the physical intensity of the work.	The end of differentiation. It is easy to change gender, transhumanism becomes prevalent, and the intermarriage of ethnic groups makes it increasingly difficult to make ethnic distinctions.
	D) MIGRATION WITHIN EUROPE	From poor countries in the South to rich countries in the North.	In all directions: both to the North and the South, wherever the climate or availability of resources are best.	From the countries of the South to the North, and the beginning of a permanent human presence in space.
MT 2	NATURE OF SOCIAL INEQUALITIES	Imbalance in housing, pensions and social security	Major imbalance in pensions and social security. Balance in housing	Imbalance in housing. Balance in pensions and social security
	A) ACCESS TO HOUSING	Strong pressure on property prices leading to major inequalities in access to housing. Inheritors of property assets benefit.	The problem of access to housing is gradually being resolved.	Pressure on housing demand and prices is leading to major inequalities in access.

	SCENARIO 1 (S1) SOCIO-ECONOMIC SLEEPWALKING	SCENARIO 2 (S2) BIO-REGIONAL CIRCULARITY	SCENARIO 3 (S3) TECHNO-DIGITAL OPTIMISM
BIFURCATIONS			
B) SOCIAL SECURITY AND PENSIONS	The imbalance in social security and pension schemes is mitigated by reforms (with increase in contributions) and the continuation of demographic growth, but the system provides less protection than in 2020.	The imbalance in social security and pension schemes results in a fall in the level of service. There is a temporary shortfall in young contributors, but in time the number of beneficiaries falls as well.	Demographic growth and economic development in Luxembourg, combined with an increase in the retirement age, reduce the imbalance in social security and pension schemes, allowing the level of service to be maintained.
C) SALARIES AND GINI COEFFICIENT	Real wages are rising slowly in an effort to attract employees (given the problem of rapid employee turnover). The Gini coefficient remains relatively stable.	Real wages are stagnating, consumption and tax revenues are falling. Inequalities between the richest and the poorest are reduced, with upgrading of manual and craft workers. The Gini coefficient falls.	Real wages are rising for financial and techno-digital professions, but automation and offshoring are threats for other, less specialised workers. The Gini coefficient rises.
D) OTHER INEQUALITIES	Young people are discontent: they pay pension and social security contributions, but benefit from little security themselves, and find it difficult to find housing and work corresponding to their skills and aspirations.	Poverty falls, but there are difficulties for older generations (at least those who cannot work) due to the pressures on pensions. Transfer of knowledge between older people and younger people.	There is a digital divide, which risks excluding the poor, the elderly and the less educated.
MT 3			
CHANGES IN THE LABOUR MARKET	Competitive and expanding labour market, with individualised jobs	Shrinking labour market, with flexible, collaborative work and widespread multiple employment	Outsourced labour market, for digitalised jobs. Hyperflexible but precarious work
A) TYPES OF WORK	There are labour shortages and a skills mismatch for carrying out the transitions, which is creating vulnerabilities for young people entering the labour market. Workers are always looking for the best offer, and frequently leaving their jobs. Widespread job insecurity and high employee turnover. Recruitment in Luxembourg and the Greater Region.	Change towards a new model of work aimed at providing good quality of life, meaningful work and flexibility in terms of working hours and types of contracts (multi-activity across seasons, professions, places). Temporary shortages of skilled, resident workers for circular, manual and technical jobs. Increased working in physically present and collaborative teams.	Traditional, locally residential, long-term contracts are replaced by shorter-term contracts for individual projects, and internationalised, virtualised or even uberised contracts. Work is done either alone or in virtual teams. Globalised recruitment. The fragmentation of the EU impedes free physical circulation of workers in the Greater Region.
B) REMOTE WORKING	Remote working is limited to certain types of jobs and a fixed number of days. Taxes are paid in Luxembourg.	Within the expanded Greater Region, workers from neighbouring countries are no longer considered as cross-border workers, and increasingly work from home. Hybrid working becomes more widespread.	Remote working increases, and tasks are often outsourced to online service providers, whose labour costs are lower, and who live outside the Greater Region, across the world. Resident, highly specialised workers work for distant companies without changing residence (but some taxes are paid in the country where the company is based). The payment of taxes and social security contributions at the location of the employer's head office becomes widespread.

BIFURCATIONS		SCENARIO 1 (S1) SOCIO-ECONOMIC SLEEPWALKING	SCENARIO 2 (S2) BIO-REGIONAL CIRCULARITY	SCENARIO 3 (S3) TECHNO-DIGITAL OPTIMISM
	C) EMPLOYERS' STRATEGIES	Labour demands outstrip supply. For employers struggling to find and retain qualified staff, the problems are partly solved by the return of retired people to work, digitalisation and/or increasing salaries. A mix of SMEs, large companies, start-ups and scaleups.	Eventually, labour supply is meeting demand, after resolving a shortage of skilled labour, particularly in the craft sector (sustainable and circular construction) and the financial sector (green finance). Mainly SMEs, cooperatives, companies with a social mission, and crossborder start-ups. An increase in employee profit-sharing.	Demand is met by the virtual recruitment of global talent. Employers automate everything they can: customer service, e-commerce and administrative procedures. A mix of major international and national companies, and start-ups and scale-ups.
MT 4	INNOVATION IN THE EDUCATION SYSTEM	Traditional system with more use of technology	Permeable, mixed system (work/education)	A highly digitalised and individualised system
	A) DEGREE OF INNOVATION	An education system based on traditional teaching methods, with a diversified offer of programmes, international schools, learning methods and a high rate of higher education graduates. Use of new digital and technological tools.	An education system with a permeable boundary between education and work, encouraging life-long learning, with alternating periods of study and work, or a combination of both, with on-the-job technical, practical and manual training.	An education system adapted to the needs of the private sector, and highly individualised thanks to digitalisation. Digital and often remote educational methods. University research and training are privatised in order to better adapt them to the needs of the job market.
	B) PRIORITIES FOR TEACHING	Focus on economic, digital, financial and care-related subjects. Crafts are less valued. A division between German-speaking and French-speaking educational streams.	Focus on biophysical, social, artistic and craft subjects. Ecological and food engineering and 'dark green' finance are valued. Increase in multilingualism.	Focus on digital engineering, computer programming, high tech fields and finance. Multilingualism is ensured by the use of algorithms.
MT 5	DIGITALISATION	Focused on the economy	Focused on people	An end in itself
	A) USAGE	Digitalisation extends to all national, regional and global actors. It favours SMEs and start-ups.	Targeted digitalisation, where its use is justified. Rejection of technologies that are resource-intensive and high in CO2 eq. emissions. Commitment to low-tech solutions.	Blind acceptance and application of digitalisation by default. Digitalisation is an industry in its own right. Digitalisation of the world's knowledge. Hopes for an increasingly powerful global AI.
	B) IMPACT	Focused on job creation. Allows gains in production efficiency, but fails to significantly reduce bureaucracy. Gains are limited by rebound effects.	Impacts are disruptive but beneficial. Digitalisation is focusing on reducing pollution, waste and hardship, with the result that craft workshops are relocated to towns and cities, reducing work-home distances and therefore traffic.	Digitalisation favours the creation of economic and monetary added value and of major international virtual platforms. Climate change increases the energy costs of digitalisation.
	C) DATA	Data is regulated at national and European level, but this does not prevent it from exercising strong control over the lives of citizens and businesses. GDPR stifles entrepreneurial spirit.	Ban on the commercialisation of personal data.	Data lies in the hands of the digital platforms. High exposure to cyberattacks. A single, worldwide GDPR system provides a level playing field.

BIFURCATIONS		SCENARIO 1 (S1) SOCIO-ECONOMIC SLEEPWALKING	SCENARIO 2 (S2) BIO-REGIONAL CIRCULARITY	SCENARIO 3 (S3) TECHNO-DIGITAL OPTIMISM
MT 6	ENERGY & TECHNOLOGY: APPLICATION AND CONSEQUENCES	Pursuit of cleaner energy, but with many rebound effects	A mix of low-carbon technologies and sources and low-tech	Technology is seen as the solution
	A) TECHNOLOGIES FOR MITIGATING CLIMATE CHANGE	Technologies are focused on efficiency.	Technological developments are focused on the protection of the living world and sufficiency.	Technology is presented as providing a 'silver bullet': geoengineering is adopted, and a new strategic market is stimulated by the rise in the price per tonne of CO2 eq.
	B) TECHNOLOGIES FOR ADAPTING TO THE EFFECTS OF CLIMATE CHANGE	Adaptation is not a priority. Floods and droughts take their toll on GDP.	Climate mitigation and adaptation go hand in hand. The focus is on damage prevention and green infrastructure, which creates jobs.	Adaptation is not a priority. The focus is on grey infrastructure. Populations and infrastructures at risk are relocated.
	C) ATTITUDE OF CITIZENS TOWARDS TECHNOLOGY	Efficiency gains are swallowed up by rising demand and rebound effects.	Use of technologies is matched by recourse to behavioural change and optimising ecosystems (green infrastructure). Preference for low-tech, labour-intensive solutions.	Widespread belief that behavioural change is not necessary. Absolute confidence in technology. Preference for capital-intensive, high-tech solutions.
	D) ENERGY AND ELECTRIFICATION	Increasingly 'green' electricity for certain applications. The grid is centralised and connected between countries. Production is liberalised. The proportion of energy from fossil fuels declines, but not as quickly, or to the extent as expected, partly because of shortages of certain raw materials (lithium, etc.). Green H2 remains limited in scale and expensive.	A decarbonised and diversified energy mix, combining centralisation (with supranational interconnections) and decentralisation with local self-production. The energy transition is accomplished sooner than expected, through energy efficiency, reducing energy demand, grid stabilisation, and major public investment in all decarbonised energies and in inter-seasonal and intra-day storage.	Progress towards new sources of lowcarbon energy: innovations in the nuclear sector make it possible to increase electricity consumption, while maintaining and strengthening a centralised network. Further liberalisation of the energy market. Capture and chemical reuse of CO2 extends the life of fossil fuels.
MT 7	GLOBALISATION SHIFTING PRODUCTIONS	De-globalisation and friendshoring	Reinventing the global model: nearshoring and onshoring	Globalisation and the free market: offshoring
	A) STRATEGY	An industrial strategy aimed at autonomy and the strategic reindustrialisation of the EU.	A strong regulatory framework at the European level. Strategic industries are relocated, with materials sourced from the nearby bio-region.	The European regulatory framework has been reduced to the bare minimum. Strategy is focused on innovation and globalisation.
	B) PRIORITY SECTORS IN EUROPE	Promotion of digitalisation, decarbonisation, electrification and the development of renewable energies and green H2.	Promotion of local agriculture, regional and craft production, services, energy and waste recovery at local level, as well as the circular economy.	No priorities. The guiding principle is to 'let the market do its thing'.

		SCENARIO 1 (S1) SOCIO-ECONOMIC SLEEPWALKING	SCENARIO 2 (S2) BIO-REGIONAL CIRCULARITY	SCENARIO 3 (S3) TECHNO-DIGITAL OPTIMISM
BIFURCATIONS				
C) SUPPLY CHAINS	A preference for friendshoring within the EU and with 'friendly countries'. China is closing itself off.	A preference for nearshoring within an enlarged Greater Region.	A preference for offshoring in order to reduce economic costs.	
D) DEVELOPMENT AID	Remains equal to 1% of GNI.	Reduction in development aid. GNI is no longer measured, and there is less money available. ODA consists less in financial aid and more in the exchange of good technical and strategic practice.	Replaced by 'aid through trade'.	
MT 8 CLIMATE CHANGE AND LOSS OF BIODIVERSITY				
	Continuation	Slowdown	Intensification	
A) IMPACT ON CLIMATE	The carbon footprint and climatic vulnerability continue to grow. +2.7°C by 2100 (IPCC SSP2 – Middle of the road scenario, see Appendix 3).	The overall trend is slowing down, but not reversing. Localised efforts are having a limited positive impact. +/- 1.8°C by 2100 (IPCC SSP1 – Sustainability scenario, see Appendix 3).	The carbon footprint and climate vulnerability continue to grow. High exposure to the combined effects of environmental crises. There are attempts to counter via the decarbonisation industry, geoeengineering and relocation. +3°C by 2100 (IPCC SSP4 – Inequality scenario, see Appendix 3).	
B) BIODIVERSITY	There are major losses of biodiversity worldwide. In Europe, there are efforts to put a price on the value of natural services (clean water, etc.) so as to limit the damage.	The loss of biodiversity is slowing down, but not reversing at the global level. In Europe, plans for rehabilitation and rewilding are organised with reference to natural boundaries (bio-regions) rather than national ones.	At the global level, biodiversity is preserved only in places or reserves where it serves economic and tourism interests. In Europe, competition between countries is undermining transnational measures.	
MT 9 ECONOMIC SYSTEM				
	Traditional / Quantitative growth / Competition	Sustainable / Qualitative growth / Cooperation	Darwinian / Quantitative growth / Competition	
A) ECONOMIC MODEL	Traditional capitalist model at the global level, although the EU is seeking to modify it within its own borders. 'We're trying to do just as much, with less, for more people.'	An 'economic' model that respects the SDGs and aims for resilience. 'We're trying to do less but better, with less, for fewer people.'	A Darwinian economic model marked by strong economic polarisation between countries at the global level. 'We're trying to do more, with less, for a smaller number of privileged people.'	
B) GROWTH	Quantitative growth, with average GDP growth of between +2% and +3%/year. Exposure to the combined effects of environmental crises (see MT 8 above).	Qualitative growth. GDP is replaced by ' <i>PIBien-être</i> ' (an index of wellbeing). Less exposure to the combined effects of environmental crises.	Quantitative growth, with average GDP growth of between +3% and +4.5%/year. High exposure to the combined effects of environmental crises (see MT 8).	

BIFURCATIONS	SCENARIO 1 (S1) SOCIO-ECONOMIC SLEEPWALKING	SCENARIO 2 (S2) BIO-REGIONAL CIRCULARITY	SCENARIO 3 (S3) TECHNO-DIGITAL OPTIMISM
C) INTERNATIONAL TRADE	Focus on the internal market, protected by a European Border Carbon Adjustment Mechanism.	Protectionist measures for strategic and vital goods and services. Focus on the regional market.	Free trade wherever geopolitics and environmental crises allow. Focus on exports.
D) TAXATION	A continuation of policy based on national debt. Taxation is not very progressive, with high taxes on labour and low taxes on capital and resources. The financial centre remains attractive in terms of taxation (funds, securitisation, holding companies, private equity, etc.). Luxembourg continues to face the challenge of fiscal and regulatory harmonisation at EU and international level in order to maintain its budget revenues.	An increasingly European tax system for Member States. There is heavy taxation on behaviour that is harmful to the environment, on the over-consumption of non-essential goods, energy and resources (progressive pricing) and on high incomes. The financial centre remains attractive from a fiscal point of view (green and social funds). A tax incentive framework to attract new green and public activities and investments has been created.	A reduction in national debt by limiting the role and spending of the state. Taxes are reviewed with the aim of capturing the maximum revenue from digital services, electronic data and robots, which runs the risk of discouraging multinational technology companies. Increased tax revenue from consumption and the property sector. Attractive tax regime for highly qualified and specialised employees.
E) FINANCIAL SECTOR	The sector is failing to go green. CSR, the EU green taxonomy and rules around green H2 are insufficient. Insurance companies are overburdened with claims for climate damage.	Banks and the stock market are strongly favouring green investments. Insurance companies are seizing new opportunities, such as guarantees and liabilities for repaired/recycled products.	Financial markets are deregulated. AI is being used to better calculate and anticipate damages and reputational risks. Investments in geoengineering.
F) LOGISTICS AND SUPPLY CHAIN MANAGEMENT	The EU has introduced a carbon offsetting scheme (built into the price) applicable to all freight journeys. Payment and data flows are digitised.	A reduction in long-distance freight due to a reduced dependence on products from abroad. Strong development of piggyback and river transport and of urban cyclo-logistics in 15-minute cities.	Flows and stocks are digitised and optimised to limit losses and empty trips, improve efficiency and minimise resource requirements. The gains are offset by the growth in volumes transported and the increase in demand. Competition between logistics hubs in the Greater Region.
G) MOBILITY	Improved coordination of the construction of new infrastructures in the Greater Region but congestion remains, due to the increase in the number of users. Cross-border public transport is also being promoted. The EU has banned the construction of new cars with internal combustion engines.	The construction of new roads is prohibited. Road traffic in the Greater Region is easing with the development of 15-minute cities and the demographic slowdown. The trans-regional public transport network covers the whole of the Greater Region and is more efficient than carbon-based individual mobility, which is strictly regulated.	Individual transport has become electrified, but this does not solve the problem of traffic jams and material needs. Public transport is optimised thanks to digitalisation, and autonomous vehicles are becoming commonplace. But coordination in the Greater Region remains difficult. A minority enjoys individual mobility for leisure.
H) SPACE	Expansion of access to space attracts many more national and private actors to participate. There is also more and more waste in orbit. A minority is taking trips into space.	European countries are coordinating their space activities to avoid duplication of effort and to limit the number of space missions. The priority is terrestrial observation and recycling waste in orbit.	International agreements specify what is permitted and private companies dominate the industry. Space mining is an integral part of the economy. Space is a playground for the rich.

BIFURCATIONS	SCENARIO 1 (S1) SOCIO-ECONOMIC SLEEPWALKING	SCENARIO 2 (S2) BIO-REGIONAL CIRCULARITY	SCENARIO 3 (S3) TECHNO-DIGITAL OPTIMISM
I) CONCEPTION AND DESIGN OF PRODUCTS	The concept of producer/importer responsibility has been strengthened, with the aim of reducing or even banning single-use products and packaging throughout the EU. Data on the circular properties of products are digitised, standardised and centralised, using the Luxembourg PCDS format, which is becoming the EU standard.	A European ban on planned obsolescence, advertising and greenwashing. A reduction in the number of labels. There are fewer products, and these have been redesigned to be more robust, repairable, sharable and sustainable. At the end of their life, products are composted or recycled.	With the help of digitalisation, design has become highly flexible and modular, and requires fewer resources, which are expensive and sometimes unavailable. Where possible, materials are substituted. Waste is recycled as much as possible, in order to obtain more resources, but this is very energyintensive and comes up against physical limits (nano & composite materials, etc.).
J) CONSUMER BEHAVIOUR	Under the influence of digital technology, a 'no-effort, high-dopamine' mindset and the search for 'instant gratification' prevail. Organic produce and CSR are seen as a fad of the affluent classes, and a luxury that the less well-off say they cannot afford. Retail sales are increasingly in the hands of international chains and concentrated on the outskirts of urban centres.	Behaviour has changed and time is slowing down, driven by environmental awareness and social pressure. The sharing economy has become a way of life, and sufficiency is a social value. Local markets are becoming not only hubs for trade, but also important places for meeting and political exchange (an 'agora').	We are consuming more and faster – as long as there are enough resources available – and technology is allowing to do more with less. Behavioural change is not on the agenda. The greatest difference is found in distribution: the rise of e-commerce platforms and home deliveries has a negative impact on local businesses, but a positive impact on tax revenues.
K) CONSTRUCTION	It is proving difficult to reduce land artificialisation and the destruction of built heritage. Wood is used locally as timber and for industrial purposes (e.g. house building, parquet flooring, valuable furniture). However, the poor health of the forests is holding back growth. The construction industry is also heavily dependent on foreign labour and cement products.	Construction has slowed with the shift to a circular model, the avoidance of new land artificialisation and the preservation of built heritage. The shortage of skilled workers is being addressed through upskilling older workers and providing training for young people. Cement products are being replaced by earth, stone and wood from healthy forests.	Extreme densification and verticalisation are helping to curb land artificialisation. Buildings are homogenised (standardised prefabricated modules) and 'digitised' to reduce costs and resources, which makes it possible to build more, with fewer resources, but also to monitor the occupants. Most of the materials are imported.

BIFURCATIONS	SCENARIO 1 (S1) SOCIO-ECONOMIC SLEEPWALKING	SCENARIO 2 (S2) BIO-REGIONAL CIRCULARITY	SCENARIO 3 (S3) TECHNO-DIGITAL OPTIMISM
L) INDUSTRY	<p>The digital and ecological transition is slow and expensive, requiring a fundamental rethink of the business model. The ecological transition is accompanied by additional costs and over-regulation, which is seen as an obstacle by many industries. The energy, material and ecological footprint has barely been reduced. There is a shortage of the necessary workforce and skills to achieve the transitions. The areas of industry showing promising adaptation include manufacturing, logistics and supply chain management, clean tech, health tech, space and maritime, ICT and cybersecurity, start-ups and scale-ups.</p>	<p>The combined digital and ecological transition is reducing the need for energy, land and materials, and relieving employees of tedious and repetitive tasks. There is a focus on the manufacture of tools and spare parts, combining high- and low-tech processes, urban logistics and local supply, health and clean tech. Digitalisation is at the service of meteorology, territorial observation, disaster early-warning systems, the management of intermittent or decentralised energies and the stabilisation of supranational electricity grids. Production is circular and certain products are made – or repaired, reallocated or recycled – locally and within the Greater Region.</p>	<p>The accelerated digital transition is not reducing the carbon, energy or material footprint, due to the massive increase in their uses (the data economy, entertainment) and the physical limits of recycling. Land and resident labour are too expensive to keep production local. Digitalisation is at the service of the assembly of parts imported from all over the world. The Internet of things, health tech and 3D printing are making major advances in cost and speed. There is a focus on the data industry (and building trust in data), cybersecurity, virtual prototyping, predictive maintenance, additive materials, roaming, cloud technology and sensors. There is fierce global competition for materials and electromagnetic frequencies that will make it possible to quickly adopt 6G connectivity, and beyond.</p>
M) RESOURCES	<p>Despite gains in efficiency, material flows and footprints are rising, as are resource prices. The EU is banning the use of non-recyclable, non-reusable or deforestation-based materials and coordinating the circularity of materials within the EU.</p>	<p>As a result of reduced demand and geographic refocusing, material throughput is shifting and shrinking. The trend towards scarcity of natural resources is slowing, but prices remain high, with high taxes on nonrenewable sources.</p>	<p>Decarbonisation and digitalisation have failed to deliver their promises of dematerialisation. A global ‘war’ around competition for resources means that they are often expensive and sometimes unavailable. There is investment in materials research to promote innovation, substitution and the application of new technologies and processes. There are plans to exploit extra-terrestrial resources.</p>
N) WATER	<p>Water is in short supply. Meanders, pools and ponds have been created in valleys to store water and recharge aquifers. Watercourses are being given more space to prevent flooding.</p>	<p>Water is in short supply. Rainwater is held back in cities by planting ‘sponge’ vegetation along streets and pavements and linking these structures to tree roots. Development of agroforestry and inter-seasonal storage of drinking water.</p>	<p>Water is in short supply. Industries are competing for access to water. The shortage of water is also addressed by technological means with grey infrastructure (pumping, purification, imports, greenhouses, reservoirs).</p>

BIFURCATIONS		SCENARIO 1 (S1) SOCIO-ECONOMIC SLEEPWALKING	SCENARIO 2 (S2) BIO-REGIONAL CIRCULARITY	SCENARIO 3 (S3) TECHNO-DIGITAL OPTIMISM
O) AGRICULTURE		There are efforts to reduce livestock populations in order to reduce emissions. Meanwhile, the negative effects of climate change are being felt in this sector. Agricultural land is under pressure from land requirements for housing and infrastructure. Dependence on imports for fertiliser, animal feed and human food remains, which reduces production costs and food retail prices. There is significant progress in reducing food waste, but little progress in expanding organic farming.	There are far-reaching changes in farming methods that favour trade within the Greater Region over exports, while reducing or substituting the use of imported proteins and synthetic inputs. Reduced choice and rising food prices are encouraging people to favour high-quality local produce (game and seasonal foods) over high-quantity imported foods. Urban farms are becoming more common and diets are becoming less meat-based and less varied. There is no shortage of farm labour and incomes in the sector are high and stable.	Agriculture is adopting industrial processes, robotised precision and soil-free methods, making it possible to reduce chemical inputs and working time, with a view to maximising yields at affordable prices. Contracts are signed to buy land and farms elsewhere, and food products are traded on world markets. Failing ecosystem functions are being replaced by technological solutions (e.g. artificial substrates in place of soil, air conditioning in place of natural shade and ventilation).
P) HEALTH & CARE		The healthcare system is under pressure from the resurgence of pandemics, the spread of mental illness and lifestyle diseases, and the exhaustion of healthcare workers due to the shortage of personnel – from nurses to paediatricians, surgeons and psychiatrists – as well as overmedication and antibiotic resistance. The reduction of lowvalue care and wasteful spending presents an opportunity to make savings.	An increase in wellbeing and health, helped by the reduction in pollution, the preservation of recreational ecosystems and landscapes, and the increase in physical and outdoor work. Psychological wellbeing leads to a significant reduction in illness and the associated social costs. Centres of medical expertise and shared health infrastructures are emerging in rural areas and across the Greater Region. AI is helping to select the product or treatment with the lowest associated emissions.	High levels of investment and progress in health tech. On the one hand, science is making it possible to overcome more and more illnesses and to prolong life. Medical check-ups are conducted online. Machine learning predicts risks, wearables detect problems earlier and automation reduces the need for staff. Thanks to health literacy, diets are more balanced. On the other hand, life is moving faster and constant change and social pressures are having a detrimental impact on health.
MT 10	NEW TYPES OF GOVERNANCE IN EUROPE	Democracy taken for granted, continuing trust in institutions and the media	Democratic fragmentation and renewal, a mix of trust and mistrust	'Privatised' and divided governance, mistrust of institutions and the media
A) DEMOCRACY AND REPRESENTATION		Representative democracies are influenced by pressure groups, and are struggling with civil society's lack of interest in politics and the common good. With more and more parties, it is necessary to find a broad consensus, which makes it impossible to take decisions on difficult or long-term issues. Red tape is getting worse. The transitions are managed by central governments.	The legacy of democratic systems established in the nineteenth century has been overhauled. New forms of expression of the will of the people have been added, such as citizens' conventions or public consultations, in which people put forward their point of view and argue their case. The voices of non-national residents are also included. Local and regional authorities are given greater weight. Strong rule of law, but in a smaller EU.	Populism and extremism are rampant and paralysing the EU. The expression of popular will takes place online and in solitude. Some countries are seeking a solution in digital participation mechanisms and the use of AI to make 'optimised' decisions. Megafirms and megacities carry a lot of weight. Subsidies/taxes are preferred to laws.

	SCENARIO 1 (S1) SOCIO-ECONOMIC SLEEPWALKING	SCENARIO 2 (S2) BIO-REGIONAL CIRCULARITY	SCENARIO 3 (S3) TECHNO-DIGITAL OPTIMISM
BIFURCATIONS			
B) MEDIA	A number of global and national media outlets remain points of reference. Social networks are regulated, but are sometimes subverted by Big Tech, which pushes users towards consumerism and conformity. There is a limited supply of critical information based on facts and investigation.	There are reputable media outlets in every region. They are regulated by a limited number of actors (state and private) and are supposed to provide objective, realitychecked information. There is still a risk of bias and 'splinternet'.	Access to information has become more widespread and digitalised, but in the absence of a role for media editors and regulators, there is no way of guaranteeing the quality of a source. The amount of information available is overwhelming, but the quality leaves much to be desired. It is therefore difficult to detect 'fake news' or to escape a single dominant narrative.
MIT			
THE ROLE OF THE EU AND THE EUROPEAN GREEN DEAL	The Green Deal is making progress, but the rest of the world is lagging behind	The Green Deal is the model followed worldwide	The Green Deal has been blocked and the EU is diminished
A) GLOBAL ECOLOGICAL TRANSITION	A new global geopolitical order in which the EU is conducting its own ecological transition in isolation.	A new global geopolitical order which, with regard to the ecological transition, is led by a reduced EU.	A new global geopolitical order in which no one is really succeeding in the ecological transition.
B) STATE OF THE EU	The EU's transition comes at the cost of economic competitiveness and global political influence (see the Inflation Reduction Act in the US, comparable measures in China, etc.).	Some EU countries are much more integrated, forming a 'core Europe', and are progressing by themselves towards the goals of the common market. Others are less integrated and, to varying extents, have less stringent regulations.	The legitimacy of the EU is called into question by some domestic populist parties and some foreign forces. As a result, it is fragmented and decisionmaking is blocked.
C) GEOPOLITICAL TENSIONS	A strong polarisation between democratic and authoritarian countries.	The decline in international trade in natural resources is causing tense and protectionist relations.	Intense economic competition between states has positive political spin-offs (cooperation) and negative ones (confrontation), with the formation of opportunistic alliances. There is little progress towards international tax harmonisation (OECD, etc.).
MIT			
BALANCE BETWEEN COLLECTIVE AND INDIVIDUAL INTERESTS	Compromise, with slow behavioural change	Collective awareness, rapid change in behaviour	Individualism and polarisation, little change in behaviour
1. SOCIO-POLITICAL MODEL	A model based on the tradition of compromise between individual and collective interests, in a context of cultural and linguistic openness. Non-Luxembourgers do not have a right to vote, even though they are almost in the majority.	A model based on strong social and environmental awareness, which brings individuals together. Resilience is found in citizen participation, deconcentration and decentralisation, with small disconnectable links. Participation in elections is made easier.	A model based on individualism, prioritising individual comfort and protection. Polarisation between interest groups. Resilience is found in a large connected network and centralised critical infrastructures. The voting system favours the rich (and men). Oligarchy.

BIFURCATIONS	SCENARIO 1 (S1) SOCIO-ECONOMIC SLEEPWALKING	SCENARIO 2 (S2) BIO-REGIONAL CIRCULARITY	SCENARIO 3 (S3) TECHNO-DIGITAL OPTIMISM
2. CHANGE IN CONSUMER BEHAVIOUR	There is a willingness to change, but it is very difficult to do so. There is a lack of alternatives, and advertising still encourages consumption.	A substantial change in approach – consumption is often a service, and the focus is on reparability and reuse.	A lack of change, which is linked to the idea that technology will provide all the solutions.
3. CRISIS MANAGEMENT	A distant relationship between the government and its citizens. It is a struggle to manage disagreements and multi-crises through public consultation. There is a failure to recognise the depth of crises, and they are managed on a case by case basis, in silos and with short-term thinking.	Solidarity in the face of crises, sometimes with polarisation between different regions and decision-making centres (green populism). Crisis management is anticipatory, bottom-up, cross-border, and slow but long-term, in a post-abundance context.	Anonymisation and dehumanisation, with the use of algorithms and surveillance to solve crises. Crisis management is top-down, reactive, localised, and rapid but short-term, involving privatisation and the securitisation of resources.

More information on the scenarios is available on the [Luxembourg Strategy website](#).

4. The scenarios and associated dilemmas

All the scenarios highlight the dilemmas facing Luxembourg's economy. These dilemmas are problems for which there is no simple solution: either one option conflicts with another, or neither option is satisfactory.

The three scenarios have already given rise to public debate on these dilemmas. But it should be stressed that Luxembourg does not need to choose immediately and definitively between any extremes. As time goes by, new options may emerge and the dilemma may fade. This does mean, however, that constant vigilance and anticipation on what comes next is needed.

The three main dilemmas raised in the public debates seem to be the following:

- **Decarbonisation vs. Competitiveness:** it is clear that carbon neutrality is essential, in a global perspective, in order to combat global warming. The scenarios differ in terms of the willingness and ability of the rest of Europe and the world to move towards a new, more sustainable economic model. So how can Luxembourg and its businesses respond to the climate imperative while maintaining their levels of competitiveness?

- **Population growth vs. Welfare state:** Population growth, which in Luxembourg is mainly due to immigration, brings certain disadvantages, such as increased traffic congestion, the feeling of being excessively crowded together, and, in the minds of some, the fear that Luxembourg's culture and language will be submerged (*Überfremdung*). But workers employed in Luxembourg also provide the funds needed to keep the pension and social security systems afloat, not to mention making Luxembourg an attractive market in terms of classic economic growth. So how to limit the perceived destabilising effects of demographic growth without causing the collapse of the welfare state and the economy?

- **Technology vs. Dependency:** Technology (more recently digital technology) has been a great catalyst for innovation, setting new social norms and changing business practices and operations. It can potentially allow to decouple growth from the use of resources, that is, to dematerialise the economy. But one must not overlook the fact that technology also has an ecological footprint and suffers from well-known rebound effects (when greater efficiency reduces unit costs, leading to a sharp increase in demand that cancels out the efficiency gains). In addition, Luxembourg is increasingly dependent on digital technologies, making the economy vulnerable to cyberattacks and other threats, such as destabilisation of the supply of components. And as businesses turn to the use of 'digital platforms', economic dependence on the suppliers of these platforms – most of whom are not located in Europe – increases. So how to harness the value of technology without becoming totally dependent on it?

Some other dilemmas that were discussed in the context of the scenarios include:

- **Political inclusion vs. Urgency of change:** Luxembourg's economy needs to make a number of major changes linked to the elimination of the use of fossil fuel, the introduction of a circular economy and the intensification of digitalisation. However, change can be perceived as a threat in an economically affluent society, where freedom of economic choice is rightly valued. It will not be possible to bring about this change successfully without democratic support. However, building a new consensus is slow, and the challenge is urgent. Furthermore, all those who contribute to Luxembourg's economy (residents and cross-border workers) will need to be involved if the change is to be fully implemented. The 'dräi mol nee!' referendum³³³ results also clearly express the will, in Luxembourg, that citizenship must be a pillar of political participation – thus excluding other residents and cross-border workers from mainstream democratic processes. So how to mobilise the whole of the relevant population (not just citizens), while moving fast enough to meet the challenge?

- **Green electrification vs. Security of supply:** the path towards decarbonisation of the energy supply is currently mainly focused on electrification, and all scenarios are likely to see an increase in the share of electricity as a proportion of total energy consumption, regardless of how it is generated or stored (batteries, hydrogen, etc.). The danger is that this increased dependence will make Luxembourg even more vulnerable, with future blackouts potentially also affecting transport, domestic heating and everything else. So how to decarbonise without compromising the security of our energy supply?

- **Global development vs. Local ecological footprints:** the world cannot be saved by saving only Luxembourg. Clearly, if other nations – beyond Europe's borders – are unable to generate the wealth they need for a decent standard of living, this could have widespread repercussions, including accelerated climate change (as they seek to generate wealth by whatever means necessary) and mass migration. On the other hand, both ecological and economic interests are converging to suggest that production needs to be more local, in conditions that will meet our standards and do not leave us at the mercy of the whims of distant authoritarian regimes. So how to ensure that global development continues, while establishing circularity at the local level?

³³³ The Referendum on 7 June 2015, known as the 'dräi mol nee!' Referendum, allowed Luxembourgers to vote on three key issues: extending the right to vote to young people from the age of 16, extending the right to vote to residents (including those without Luxembourgish citizenship), and limiting the duration of ministerial mandates. In every municipality, a majority of voters answered 'no' to all three questions.


In addition, a few false dilemmas were discussed, where, although there are clearly tensions between the selection options, it is already apparent that there is a way to avoid the worst of both worlds:

- **Behavioural change vs. Economic slowdown:** another critical factor that emerges in the scenarios is the willingness (or not) of businesses and citizens to change their consumption habits so as to reduce their ecological footprint. This is often interpreted by industry as meaning that citizens should stop buying anything, and is therefore seen as leading to a reduction in turnover and a path to mass unemployment. But this dilemma, while it might be real if the solution were simply to stop buying, is probably wrong. The reality is more complex. For example, changing consumption may mean transforming a product into a service, such as providing the use of a shared vehicle, accessible via an app, rather than selling a car to each individual (which, on average, is inactive for 96% of its life). This can lead to savings in resources. Although such changes may be made possible by technology, the key point is the development of new economic perceptions and new business models.

- **Mitigation of climate change vs. Adaptation to climate change:** it seems that political and economic attention can more easily be focused on one issue at a time, and at the moment, the current focus on the mitigation of climate disruption is leading to a neglect of thinking about how to adapt to this disruption. Indeed, in some circles, talking about the need to address adaptation measures may even be perceived as a tacit abandonment of mitigation efforts. But this is not necessarily the case. In fact, by undertaking adaptation efforts, including the construction of green and grey infrastructure, it is likely that future emissions will be avoided, especially if radical climate change occurs. For example, if Luxembourg develops additional water purification and storage capacity now, this will avoid the need to use huge amounts of energy (with the associated emissions) to bring water from elsewhere in the event of a future drought.

- **Entrepreneurial flexibility vs. Legal regulation:** a vital necessity in all scenarios will be agility. Luxembourg's economy has traditionally demonstrated its agility thanks to the entrepreneurial spirit of its businesses and the flexibility of its population. On the other hand, in order to successfully achieve the necessary transitions, a clear framework needs to be in place to provide direction. Such rules and regulations can hinder agility. However, this dilemma depends on how the framework is established. Rather than detailing every step that needs to be taken, the framework should provide guarantees about the destination, so that, for example, companies investing in expensive new technologies know that they will be able to make a return on that investment in the future – and that others who are not investing will not be able to compete with them in the market.

 Method
 The Vision
 Scenarios

 **IV Appendices**

IV. Appendices

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Appendix 1. Methodological note

Scenarios concern the evolution of factors beyond our control. When it comes to strategic foresight, there are many possible approaches and methods. The approach adopted for this process consists in creating exploratory scenarios of how the world around Luxembourg could change up to 2050. These developments may either help or hinder to be resilient and achieve carbon neutrality. Once the scenarios had been worked out, strategic choices that are robust in all these scenarios were developed for the Luxembourg government. The scenarios are therefore hypotheses about how issues beyond our control might evolve. On the other hand, the strategic choices and the resulting Vision are elements that the Luxembourg government can use in decision-making.

The scenarios describe the limits of a plausible evolution. These scenarios for 2050 are not predictions. The future is expected to lie somewhere between these distinct scenarios, or even to be a mixture of elements from them. The aim of developing these scenarios is to open our minds to multiple possible futures that are plausible in light of the megatrends already observable today. Policies can then be tested against possible future developments, by asking whether a given strategic choice is appropriate in the event of a particular scenario occurring. For choices to fare well in all the different scenarios, they need to be robust, whatever the actual future will bring. On this basis a list of ‘no regrets’ actions to undertake can be identified.

Criteria for choosing scenarios. Plausibility is an important criterion for choosing a scenario. It is important to note that plausibility is not synonymous with probability, especially judging probability over a period of several decades is very difficult. All it takes is for an unexpected event to occur (e.g. the September 11 terrorist attacks, the financial crash of 2008, the Fukushima nuclear disaster, Brexit, President Trump, COVID-19, the Russian invasion of Ukraine, to name but a few in the last twenty years) for any calculation of probability to be rendered useless. Plausibility, on the other hand, relates to the ability to map out a credible path from now until a certain point in the future, while adhering to biophysical constraints. Taken together, the three scenarios sketch out distinct future worlds that span the limits of plausibility.

The scenarios are quantified, but the key indicators are different in each scenario. In other words, the developed scenarios are qualitatively different from one another in their mode of quantification. Even if it is possible to quantify the scenarios, some of the usual indicators used (e.g. GDP) cannot be applied to all the scenarios, precisely because the scenario assumes a rejection of current ways of seeing (and measuring) the world. That said, it is perfectly possible to explore the implications of a scenario for a particular issue in more depth as part of a connected study, as long as the possible necessary to change the perspective on a given issue or sector is remembered (e.g. recognising that the current concept of ‘transport’ may need to be replaced by a concept of ‘mobility’).

The scenarios give rise to a common vision. Each scenario has implications for the resilience of Luxembourg’s economy, and shows the opportunities and threats that could arise. It is therefore possible to use the scenarios to identify the elements of a common vision, and the associated strategic components that will enable Luxembourg’s economy to be resilient, competitive and inclusive in all scenarios.

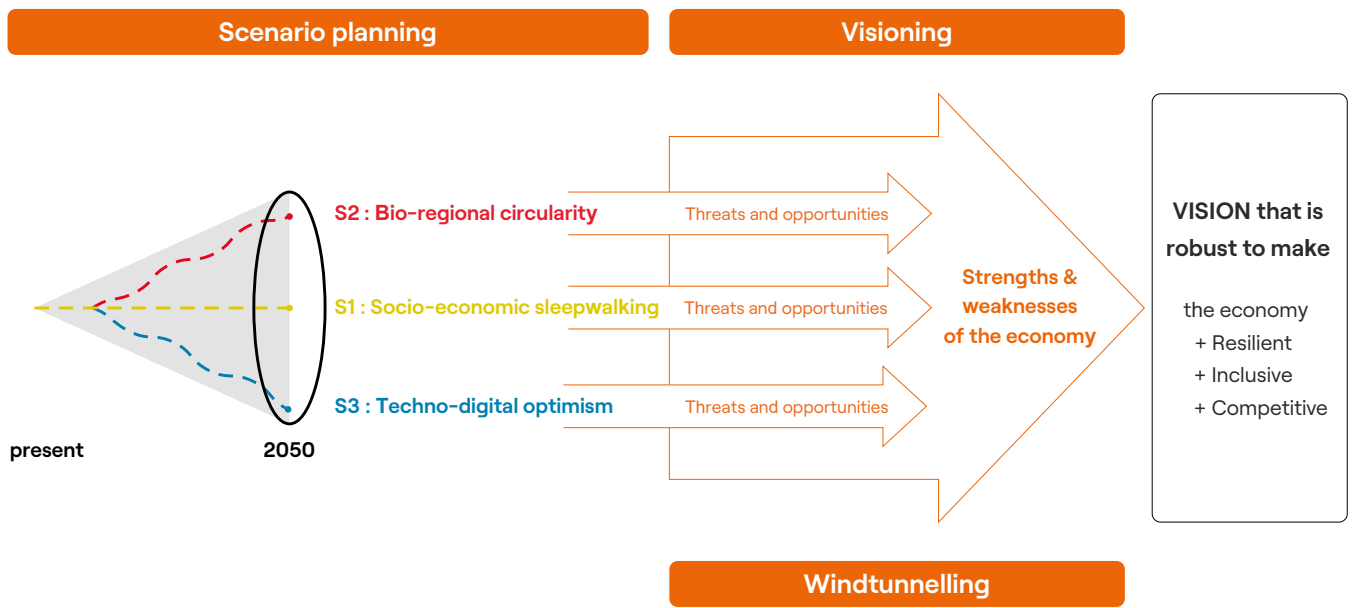
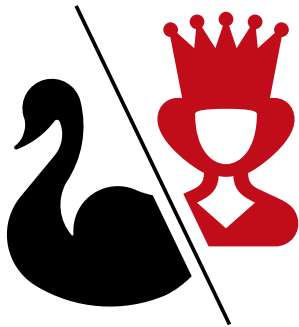


Figure 22. Using the scenarios in an exploratory way to develop the ECO2050 Vision

Appendix 2. Black swan: 'Red Queen'



A 'black swan' is an unpredictable event that has a low probability of occurring but which, if it does, has severe and exceptional consequences. The theory of 'black swan events' can explain the disproportionate role played – in history, science, finance and technology – by rare, statistically highly improbable, impossible-to-calculate and extremely hard-to-predict major events that are outside normal expectations. It also explains the cognitive biases that blind people, both individually and collectively, to uncertainty and the massive role of rare events in history. Some examples of black swans are the September 11 terrorist attacks, the Fukushima nuclear disaster, the Arab Spring and the COVID-19 pandemic.

The black swan used in ECO2050 consists of a **rapid acceleration** of developments and events, beyond the control of populations, in a way that takes away their ability to plan, or even to act. This black swan event builds on the concept of the Great Acceleration,³³⁴ and involves a combination of the following **global phenomena**: climate change, the erosion of biodiversity and the rise of AI and geo-engineering. Climatic, genetic, digital, algorithmic or technological tipping points would be reached and feedback loops³³⁵ would be triggered earlier than anticipated by society as a whole. The deterioration of the environment and of social ties would distort the relationship between **ecological time** and **social time**. The rules of the game would be entirely, and continually changed. The unbridled pace and magnitude of the disruptions would mean that living things would no longer be able to adapt in time. Society would go through partial collapses, in different places and at different times, before being reborn and regenerated. This major crisis would ultimately, and cathartically, bring about its own salvation, sparking a leap forwards leading to a solution to the problem it presents.

This black swan has been named the 'Red Queen', in reference to the character of the Red Queen in Lewis Carroll's novel *Through the Looking-Glass*, who tells Alice: 'Now, here, you see, it takes all the running you can do, to keep in the same place'. The analogy relates to the need for constant, proactive adaptation to avoid being swamped by the rapid acceleration of the phenomena mentioned above.

The 'Red Queen' black swan is not specific to Luxembourg, but would be an event on a global scale.³³⁶ Luxembourg's economy, like others, would find itself exposed to the following potentially major disruptions:

SOCIO-CULTURAL:

- Widespread unrest and activism, with a prevalence of 'short-term discounting' attitudes. Adults behave like children and avoid taking action in the face of existential threats.
- Exodus from Europe, which has become inhospitable, followed by major global population migrations in search of habitable and productive land, including journeys into space. Some of Europe's populations follow the movement of vegetation northwards, while others move to Africa, which has become a land of net immigration.
- After a period of pandemics, declining life expectancy and reduced literacy, environmental regeneration occurs, leading to improved health levels, and there is a boom in technical and manual self-training, followed by a renaissance in science and the arts.

³³⁴ Will Steffen et al. (2015), *The trajectory of the Anthropocene: The Great Acceleration*. *The Anthropocene Review*. 2 (1): 81-98.

³³⁵ For example, global warming causes permafrost to melt, releasing CO2 and methane. The more greenhouse gas emissions increase, the more global warming occurs, which in turn reinforces the melting of the permafrost.

³³⁶ Carbone 4 (2021), *OCARA*, p. 61-88. The OCARA framework for analysing the resilience of businesses to climate shifts uses 4 scenarios, including a black swan.

TECHNOLOGICAL:

- Attempts at geoengineering lead to uncontrolled and irreversible changes to natural processes. The limits of adaptation are reached. Warming is well in excess of +2°C. Once emissions decline, ecosystems slowly begin to recover, and net zero occurs around the year 2100.
- AI develops a 'human' consciousness, which may be either benevolent or malevolent. A 'digital pandemic' destroys all data connected to the internet. The internet and the cloud either enrich universal human capabilities and unite communities, or divide and impoverish humans (the 'splinternet' phenomenon).
- The shock leads either to a simplification of systems (small businesses, low-tech, short paths) or to a techno-digital headlong rush, fuelled by the remains of fossil energy production, which lies in the hands of a few hyperagents or global firms that escape democratic control.
- For countries that, through anticipation, have developed the capacity to store energy from various sources, the decline in fossil fuels results in a massive increase in renewable energies.

ECONOMIC:

- Initially, the financial losses associated with climate disasters mean that purchasing power and incomes fall, particularly in rich countries. There are persistent shortages of food, water, raw materials and energy on the world market.
- An economy of rationed vital public goods and services becomes established, and bartering becomes common, followed by the emergence of a decentralised circular economy.
- After a period of stand-still, followed by the regeneration of biodiversity, water reserves and natural resources, the world makes a new start with a lower, but better distributed, level of wealth.
- Knowledge becomes the new currency. Exchanges of information and knowledge continue despite the end of long-distance hypermobility based on fossil fuels. The memory of human knowledge and previous civilisations is retained. The gene banks of domesticated and wild plants and animals are the other major resource that will enable food and manufacturing production to be revived.

POLITICAL AND LEGAL:

- Initially, traditional institutions fail (the EU, states, governments, the media, schools), which brings a risk of open warfare over resources and increasingly violent civil disobedience.
- Next, communes and cities emerge as important political units, some fortified, privatised and isolated, while others are open and connected with one another. After a while, an awareness emerges of humanity's destiny, leading to the birth of a global citizens' movement working towards environmental and cultural adaptation and regeneration, with the help of the rediscovery of previous knowledge from among the safeguarded store of human learning.

Appendix 3. Other sets of comparable scenarios

The ECO2050 scenarios belong to an established typology of scenarios that have emerged from recent governmental, academic and commercial use, at both national and international level. Luxembourg Strategy monitors these sets of scenarios, updates them regularly and publishes them on its website (see the monitoring tables for [national](#) and [international](#) scenarios).

ARCHETYPAL

Scenarios archetypes of the futures of capitalism (Fergnani, 2019)

- Scenario 1, Continued growth
- Scenario 2, Disarray
- Scenario 3, Steady State
- Scenario 4, Transformation



NATIONAL

Third Industrial Revolution (TIR) (Rifkin, 2016)

- Scenario 1, 2d Industrial Revolution Reference scenario
- Scenario 2, TIR Innovation scenario



Long-term macroeconomic and demographic projections: 2017-2060 (STATEC, 2017)

- Scenario 1, '+4.5% GDP', '+2.8% productivity', '1.2 million population'
- Scenario 2, '+3.0% GDP', '+2.0% productivity', '1.1 million population'
- Scenario 3, '+1.5% GDP', '+1.1% productivity', '1.0 million population'
- Scenario 4, '+0.0% GDP', '+0.1% productivity', '1.0 million population'



Electricity Transmission Grid Scenario report 2040 (Creos, 2022)

- Scenario 1, Reference scenario (PNEC)
- Scenario 2, Target scenario (PNEC)
- Scenario 3, TIR/Fraunhofer scenario



Une vision territoriale pour le Luxembourg à long terme (Fondation IDEA, 2023)

- Scenario 'Au fil de l'eau' (+2.8% GDP/year)
- Scenario A, *Recul du niveau relatif de richesse vers celui constaté avant le décollage de la place financière*
- Scenario B, *Accélération des gains de productivité apparente du travail*



INTERNATIONAL

The Shared Socio-economic Pathways (SSP) (IPCC, 2017)

- SSP1, Sustainability (green road)
- SSP2, Middle of the road
- SSP3, Regional rivalry (rocky road)
- SSP4, Inequality (divided road)
- SSP5, Fossil-fuelled development (highway road)



Scenarios for the 2050 vision for biodiversity (CBD, 2017)

- Scenario 1, Global technology
- Scenario 2, Decentralized solutions
- Scenario 3, Consumption change



Global trends 2040: a more contested world (National Intelligence Council, 2017)

- Scénario 1, Renaissance of democracies
- Scénario 2, A world adrift
- Scénario 3, Competitive coexistence
- Scénario 4, Separate silos
- Scénario 5, Tragedy and mobilization

**Nature Futures Framework** (IPBES, 2020)

- Scenario 1, Nature for Nature
- Scenario 2, Nature for Society
- Scenario 3, Nature for Culture

**World Energy Outlook** (IEA, 2021)

- Scenario 1, Net Zero Emissions (NZE) by 2050
- Scenario 2, Announced Pledges (APS)
- Scenario 3, Stated Policies (STEPS)
- Scenario 4, Sustainable Development (SDS)

**Climate Scenarios 2050 for central banks and supervisors** (NGFS, 2021)

- Scenario 1, Net Zero 2050 (orderly transition)
- Scenario 2, Below 2°C (orderly transition)
- Scenario 3, Divergent Net Zero (disorderly transition)

**Shaping and securing the EU's open strategic autonomy by 2040 and beyond** (COM, 2021)

- Scenario 1, Green leadership
- Scenario 2, Complex prosperity
- Scenario 3, Economic growth above all
- Scenario 4, Retreat inwards

**Scénarios du Futur alimentaire en France 2030** (Greniers d'Abondance, 2021)

- Scenario 1, *Troupeau aveugle*
- Scenario 2, *Atterrissage contrôlé*
- Scenario 3, *Le bonheur est dans la cité*
- Scenario 4, *Les überculteurs*

**À quoi ressemblerait une France autonome et réindustrialisée en 2050 ?**

(Fabrique de l'industrie, 2022)

- Scenario 1, *Une industrie française exportatrice, calquée sur le modèle allemand*
- Scenario 2, *Le retour en force de l'État-stratège*
- Scenario 3, *La France championne de l'usine connectée*

**Climate scenarios**

(Network of Central Banks and Supervisors for Greening the Financial System, 2022)

- Scenario 1, Net Zero 2050 (orderly transition)
- Scenario 2, Below 2 °C (orderly transition)
- Scenario 3, Divergent Net Zero (disorderly transition)
- Scenario 4, Delayed transition (disorderly transition)
- Scenario 5, Nationally Determined Contribution (Hot House World)
- Scenario 6, Current Policies (Hot House World)

**Prototyping 2040** (FutureS Thinking, 2022)

- Scénario 1, Kind Capitalism
- Scénario 2, Active Restoration
- Scénario 3, Self-Consumed
- Scénario 4, Less Is Enough



Appendix 4. Results of the ECO2050 public campaign

As part of the **ECO2050 collaborative foresight initiative** to develop plausible future scenarios and a desirable strategic vision for Luxembourg's economy by 2050, Luxembourg Strategy conducted a public consultation campaign. From 2 December 2022 to 16 January 2023, an **online questionnaire survey** (in Luxembourgish, French, German and English) was carried out and **two citizens' meetings** with Mr Franz Fayot, Minister of the Economy, were organised. The **report** presenting the **detailed results** of this campaign is available on the Luxembourg Strategy website. Here is a summary:

OVERVIEW AND FINDINGS FROM THE SURVEY:

- **Participation:** almost 650 people responded to the questionnaire.
- **Typical profile:** on average, respondents are of working age (35–55 years old), employed and resident in Luxembourg.
- **Preparing for the future:** respondents consider that Luxembourg's economy is well prepared to deal with scenario S1 ('Socio-economic sleepwalking') or scenario S3 ('Techno-digital optimism'), but also consider that it is insufficiently prepared whichever scenario arises (each response receiving almost a third of the votes).
- **Realistic scenarios:** the majority of respondents consider that S1 and S3 are also the scenarios most likely to arise for Luxembourg's economy between now and 2050.
- **Desirable scenario:** scenario S2 ('Bio-regional circularity') is widely perceived as the one that most respects territorial and planetary biophysical limits and the population's basic socio-economic needs. For 75% of respondents, S2 is the most desirable scenario for the economy in 2050.
- **Lessons regarding the scenarios:** what seems most likely is not necessarily what is most desirable (and vice versa).
- **Lessons regarding the Vision:** for all the scenarios, the threats identified are at the same time perceived as opportunities.

OUTCOMES FROM MEETINGS WITH CITIZENS:

- **Participation:** nearly 70 respondents were given the opportunity to discuss matters directly with the Minister.
- **Existing strategies:** participants at these meetings stressed the importance of publicly debating existing national economic strategies and adapting them to environmental challenges.
- **Development model:** more broadly, in recognition of the scale of the challenge, respondents called for a transformation of the current model in order to align socio-economic and biophysical interests more closely.
- **Activities of the future:** the starting point for these changes should be a reflection on the professions of the future.
- **Civic involvement:** these transitions could be facilitated by broad civic involvement (particularly among young people).
- **Training:** this civic involvement could be achieved by integrating an understanding of these challenges and of the biophysical implications of the economy into school syllabi and higher training programmes.
- **International coordination:** noting that the problems are global and that the ability to effect change at the national level is limited, participants stressed the importance of seizing opportunities to influence the international community, taking into account Luxembourg's strengths and weaknesses.

Appendix 5. Comments from foresight experts

A Committee of Experts has been set up to contribute to the strategic foresight work entrusted to Luxembourg Strategy. It is made up of representatives of professional associations, research centres, think tanks and consultancies operating both at national level and across the Greater Region, who were brought together for their foresight expertise. As part of the ECO2050 project, the Committee was asked to respond to two surveys via online questionnaires. The following are extracts from their comments, published with the consent of the authors.

Are the emerging groups of economic scenarios realistic and compatible with a world that is subject to biogeo-physical constraints (e.g. loss of biodiversity, shortage of land and water, reduction in supply of resources and materials, the end of the abundance of fossil fuels, and limits on CO2 eq. concentration)?

'Scenarios are not intended to "last"; that would be forecasting. The aim of scenarios is to cover the whole field of possibilities, as perceived at a given moment in time, in order to deduce the actions that need to be taken to take control of the future, to shape it rather than endure it. So, if at the time T+1, say 5 years later, new elements modify the initial hypotheses, the scenarios then need to be updated.'

Pascale Van Doren, Wallonia Policy Lab of the Destrée Institute

Can the emerging groups of economic scenarios stand the test of time? What implications do they seem likely to have for younger generations, and how might those generations view them?

'Maintaining (...) quantitative growth according to the traditional model based on GDP will lead to serious climate crises, increasingly pollution, and major migratory flows and conflicts, all of which will have direct repercussions on the socio-cultural sphere and on the new global geopolitical order.'

Pascale Van Doren, Wallonia Policy Lab of the Destrée Institute

'A reasonable ambition for our foresight exercise should be (...) to examine a sufficiently broad and diverse range of perspectives to be able to claim, in the eyes of future generations, to have at least attempted to understand what lies ahead. Given the inevitability of future crises (even in the event of drastic choices being made towards achieving transitions, which is not yet the case), the current exercise will have to adopt an attitude of effort rather than mere endurance of the future, if it is to avoid being entirely condemned by people being born today, and who will therefore be in their thirties by the target date of 2050.'

Jean Lasar, Founder, Survcoin.lu

'Perhaps we can ask ourselves what will make Luxembourg attractive to younger generations to come and settle here, if the phenomena of digital nomads and teleworking become more and more extensive.'

Jean Claude Zeimet, Spatial Foresight

Do the emerging groups of economic scenarios seem sufficiently distinct to you? Do they seem to cover a sufficiently wide range of plausible futures?

‘The ECO2050 scenarios are more or less in line with the general scenarios currently being developed by other forecasters around the world.’

Sylvain Cottong, Exploringfutures.net

‘[The scenarios could go even] deeper in terms of the use of resources and the management of these resources and waste. What is the footprint our current lifestyles are leaving on the world and how can we become more sustainable?’

Tom Dusseldorf, CONVIS

What implications do the groups of scenarios have for economic sectors and industries? In your opinion, which economic sectors are future-fit, which will grow and which will decline between now and 2050 (e.g. in terms of GDP creation, employment, physical output, coverage of domestic needs, trade or exports)?

‘Even if it is tempting to classify economic sectors according to their compatibility with the anticipated forms of a decarbonising society, for example by predicting a bright future for those linked to renewable energies or soft mobility, it is important to point out that even these will not fare well unless all human activities are brought into line with the imperatives dictated by the climate and biodiversity crises. Indeed, unless we redefine value creation to take account of these imperatives, manufacturers of photovoltaic panels or electric bicycles will be no better off than oil companies or airlines in a world that has missed the boat on decarbonisation and bringing human activities into line with the survival needs of the species. However, the groups of scenarios that have been developed are undoubtedly useful for assessing the viability of different sectors individually, and helping them to embark on their journey towards resilience.’

Jean Lasar, Founder, Survcoin.lu

‘If we made efficient use of permanent grassland and also grew a little fodder (clover) on arable land, we could also feed cattle according to their needs. In addition, livestock numbers would have to be reduced by around a third to be able to feed them without importing soya, using the land available in Luxembourg. On-farm livestock rearing would also have the advantage of freeing up farmland previously used for animal feed production, so that it could instead grow crops for human consumption. It would also reduce greenhouse gas emissions by around 75%. Of course, this would also have an impact on food. Luxembourg would have to reduce its meat consumption by 76%, for example.’

Stéphanie Zimmer, IBLA

‘If we carried out, in broad strokes, the exercise of cross-referencing the proposed scenarios with the main economic sectors, the science and technology sector unsurprisingly emerges as the big winner, followed by the services sector, particularly those services where the automation of tasks is not possible. (...) Overall, it is the techno-centric dimension of the scenarios that stands out as the consensual lever for change. From this perspective, it would be beneficial to support the development of the creative and cultural sector and to consider the notion of subsistence vs. consumption.’

Christelle Mescolini, acidu

If you were running a company, what implications might these groups of emerging economic scenarios have for your business?

'For a company director who is even remotely aware of the risks, as they stand in 2022, these groups of scenarios should come as no surprise. However, it is a safe bet that the vast majority of them have not incorporated them into their strategies, a situation that reflects the very strong inertia of "business as usual"...'

Jean Lasar, Founder, Survcoin.lu

'Entrepreneurship is all about adaptation and disruption, so faith, imagination and worldview are all factors that influence the choices made by decision-makers, who can then adapt their organisations, working methods, investments and supply chains. It is the speed of adaptation that is crucial. [This is why] it is a good idea to separate foresight and strategy.'

Christelle Mescolini, acidu

What opportunities do you see presented by scenario 2 ('Bio-regional circularity') for your own area of specialisation?

'Ideally, agricultural production will be converted to organic farming, which is the most sustainable form of agriculture in terms of protecting the climate, soil, biodiversity and water. Furthermore, ideally, farming will be linked to surface area. In other words, only as many animals will be bred as can be fed from available land in the national territory. However, consumers will also have to change their eating habits, by eating less meat for example, otherwise imports will increase.'

Stéphanie Zimmer, IBLA

What opportunities do you see presented by scenario 3 ('Techno-digital optimism') for your own area of specialisation?

'[Opportunities S3] As this scenario pushes the possibilities of a digitalised world to the extreme, it will in theory improve the simplification of administrative procedures by digitalising them, which is seen as an advantage for our professions. This scenario would lead to genuine administrative simplification, resulting in the intelligent digitalisation of procedures, dematerialising and accelerating their appraisal so as to provide authorisations more quickly, more fluidly and more traceably. For projects requiring multiple authorisations, there should be a 'one-stop shop' with cross-disciplinary skills to deal with both state and local administrations.'

Pierre Hurt, OAI

What are your recommendations for a strategic vision that increases resilience, inclusiveness and competitiveness in your area of specialisation in all cases (whatever scenario arises by 2050)?

‘[Recommendations concerning the ECO2050 Vision for the banking sector]

Talents and skills

- Increase subsidies for companies that invest in training and retraining.
- Develop more specific training modules on sustainable finance/digitalisation that meet the needs of Luxembourg finance professionals.
- Develop a specific master’s degree in Compliance at university to address the shortage of talent in this field.
- Set up a Public-Private Partnership to create affordable housing for young people.
- Avoid over-regulation of EU social legislation (e.g. additional social holidays).
- Improve the flexibility of labour law without affecting the total number of working hours.
- Establish a uniform framework allowing cross-border working from home for up to two days a week within the Greater Region, or even a remote worker status at European level.

Taxation and indexation

- Reduce the nominal corporate tax rate (including municipal business tax) to the EU/OECD average (20%).
- Introduce corporate tax relief to support the digital transition, training and skills upgrading, as proposed by the UEL.
- Make the tax regime for profit-sharing bonuses and for inpatriates more attractive.
- Link the indexation rate to total individual salary and limit indexation to one index bracket per year.

Sustainable finance

- Create a national register of companies’ non-financial data, enabling ESG assessment to be used in risk assessments by banks, insurers and funds.
- Create a digital register of the energy efficiency of each building (available to banks, notaries, etc.).
- Support the development of supplementary pension products by granting attractive tax incentives for sustainable asset classes.
- Allow the reduction in capital requirements for property loans aimed at financing energy efficiency measures.

Regulatory framework

- Avoid over-regulation, by strictly aligning with EU directives and international regulatory requirements.
- Maintain a strong and effective national regulator and advocate for decentralised supervision at European level.
- Review the national regulator’s funding model with a view to increasing public sector participation.
- Develop a national strategy to defend Luxembourg’s interests in European bodies through a secondment programme in EU institutions.’

Camille Seillès, ABBL

Appendix 6. Participants in the process

The ECO2050 collaborative foresight process conducted between April 2022 and July 2023 was based on specific empirical material compiled using different methods:

- **Documentary research:** academic literature and official reports
- **Semi-structured interviews:** plan and snowball effects
- **Discussion groups:** meetings, workshops & debates
- **Questionnaire surveys:** expert consultations & public campaign

The ongoing aim is to follow expertise while fostering public support. In all, nearly a thousand people contributed to developing the future scenarios and the strategic Vision that responds to them.

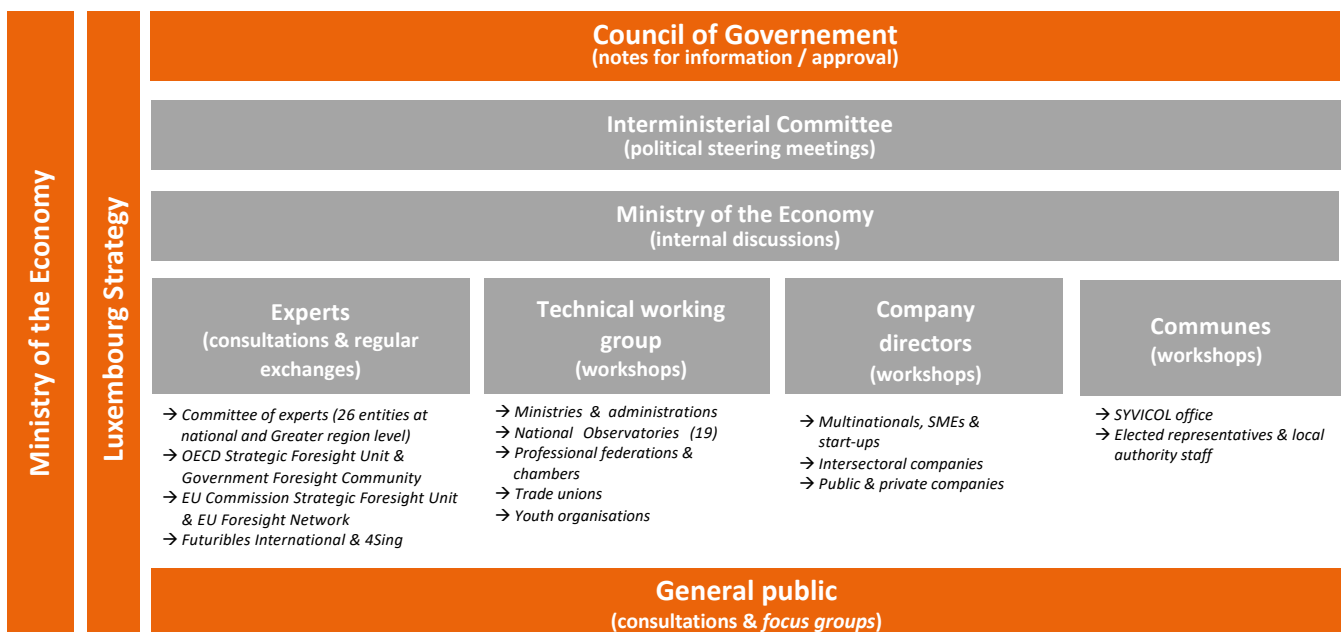


Figure 23. Governance of Luxembourg Strategy

#	DISCUSSION GROUPS	MEETINGS	ATTENDANCES*	PARTICIPANTS
1	POLITICAL INTERMINISTERIAL COMMITTEE	4	71	41
2	TECHNICAL WORKING GROUP	6	224	99
3	WORKING GROUP OF THE MINISTRY OF THE ECONOMY	3	32	27
4	CONSULTATIONS WITH COMPANY DIRECTORS	2	90	76
5	CONSULTATIONS WITH COMMUNES	2	36	35
6	CONSULTATIONS WITH SOCIAL PARTNERS	2	43	43
7	CONSULTATION WITH CHAMBER OF DEPUTIES	1	15	15
8	CITIZENS' DEBATES	2	38	38
	TOTAL	22	549	374

* Some participants attended several meetings

#	QUESTIONNAIRE SURVEYS	NUMBER OF QUESTIONNAIRES	NUMBER OF RESPONDENTS
1	CONSULTATION WITH FORESIGHT EXPERTS	2	21
2	PUBLIC CAMPAIGN	1	641
	TOTAL	3	

#	SEMI-STRUCTURED INTERVIEWS	PARTICIPANTS
1	KEY ECONOMIC DECISION-MAKERS	8
2	EXPERTS IN FINANCE AND TAXATION	2
	TOTAL	10

#	COUNCIL OF GOVERNMENT	SUBMISSIONS
1	NOTE FOR APPROVAL (MISSION STATEMENT)	1
2	NOTE FOR INFORMATION (ECO2050)	1
	TOTAL	2

Figure 24. Participation in the ECO2050 foresight process

Appendix 7. Potential territorial impacts of the ECO2050 Vision



The developments and crises of the last decade, particularly those linked to climate change, armed conflicts, migratory flows and inflation, show the scale of the changes that need to be prepared for. These include ensuring access to essential energy and material resources (autonomy), building the capacity to respond to unforeseen situations and bounce back from crises (resilience), and guaranteeing equal opportunities and social justice (inclusiveness). All these transitions must lay the foundations for a resilient, inclusive and competitive economy.

So where does Luxembourg stand in 2023? What are its territorial and economic assets for building an autonomous, resilient, inclusive and competitive economy by 2050? To answer these questions, it is key to identify the spatial structures that support competitiveness, autonomy, resilience and inclusion today, and to find out which regions are already well prepared for the changes that will occur by 2050.

The performance of Luxembourg's economy is currently closely linked to the networks of exchange and cooperation that link it to the Greater Region, the EU and the globalised economy, for both exports and imports. The current organisation of Luxembourg's territory reflects this great international openness.

The national territory is structured around southern, central and northern **conurbations** and north/south and east/west axes that carry the majority of the transport infrastructure, energy flows and the fibre optic network. Economic and social life is concentrated in these urban centres. Secondary routes serve the **Centres of Development and Attraction (CDA)**. The economic importance of these CDAs is less significant than that of the conurbations. The CDAs, some of which are remote from the main transport routes, rarely play a driving role in economic development. Most of the CDAs are well connected to urban areas. They also help to organise access to public services and social interaction. In border areas, CDAs are important nodes for cross-border flows (e.g. transport and energy, ecological continuity). The four international logistics hubs – the CFL multimodal hub, the Eurohub Center Contern, the airport and the port of Mertert – are located on these axes. The infrastructures linking these hubs enable internal and external flows of goods to be optimised.

Luxembourg's economy is characterised by the diversity of its national and multinational growth sectors, for the production of both goods and services. These include metallurgy, chemicals, finance, crafts and R&D. This diversity is an important factor in the resilience of Luxembourg's economy. Access to major transport routes and logistics hubs facilitates the export of manufactured goods.

However, the continued, sustainable exploitation of these economic assets depends on the carrying capacity of the Luxembourg territory being respected. In a context of economic and demographic growth, it is particularly important to limit soil sealing and to preserve natural, forest and agricultural areas. The PDAT proposes a gradual reduction in the amount of land artificialisation, to an average of 0.25 hectares per day by 2035, with the aim of achieving zero net artificialisation by 2050.³³⁷ This will help to recharge the groundwater table, limit soil erosion and soil impoverishment, and contribute to maintaining quality of life. In addition, natural areas and forests sequester and store CO₂.

Most of the population already has access to a fibre optic internet connection. The plan is for the entire country to be served within a few years. The digital transition is already enabling service companies to leave urban areas. Some are choosing to set up in or around CDAs, at home, in shared public spaces, or working as nomads.

To meet growing energy demand while ensuring the transition to a post-fossil fuel economy, the development of green energies is essential. This is reflected in the current development of wind and hydroelectric power, particularly in the north of the country. Combined with the strengthening of energy storage capacities, this will reduce the effects of Luxembourg's dependence on foreign energy suppliers.

Luxembourg has many assets at its disposal to help preserve and strengthen its security of supply, resilience, inclusion and economic competitiveness. These include, in particular, the quality of its supply networks, its many and varied economic growth sectors and its high level of integration into the globalised economy.

Luxembourg's territory is currently strongly polarised around the southern, central and northern conurbations. In the future, the CDAs could contribute to a more balanced spatial distribution of economic activities, public services and housing, as well as public facilities and infrastructure. The development and densification of urban areas and CDAs would limit land artificialisation outside urban areas and enable rural areas to play a fundamental role in ensuring the production of food, energy and materials (e.g. wood) and providing natural spaces and ecosystem services. However, in recent years, experience has shown that the factors affecting geographical development can change rapidly. It is therefore important to give each locality and commune the means to adapt to these changes and to take advantage of the opportunities available.

Luxembourg Strategy provides two schematic maps showing the current geographical deployment of economic activities (2023, at the very beginning of this report) and their hypothetical geographical deployment over the next 27 years (2050, at the end of this report). The former is based on the existing ZAEs in the ZAE sector plan, in force since 2021. The latter is based on a foresight approach, and aims to illustrate the current ECO2050 Vision, in light of the guiding principles and objectives of the PDAT, adopted in 2023. It is based on the ZAEs projected in the ZAE sector plan of 2021.

337 PDAT: Programme Directeur d'Aménagement du Territoire (2023).

Glossary

The [glossary](#) below is also available on the Luxembourg Strategy website.

Backcasting

A method for determining the steps to be taken to bring about a desired future. It involves first defining a desired future, then identifying what needs to change between the current situation and the desired future, devising a timeline that staggers the different stages of change, and identifying and managing the key internal and external factors that can influence the duration or intensity of these changes. Who or what will be essential in the envisaged future? What problems will users, institutions or society face, and how might they be resolved? What opportunities will arise and how might they be exploited or realised?

Reference: European Foresight Platform, [Backcasting](#)

Bifurcations (and tipping points)

In mathematics, bifurcations are a special case of the general phenomenon of tipping points. These concepts are used to describe complex systems with non-linear evolutionary trajectories (concerning individuals, societies, ecosystems, the climate system or the Earth system). Tipping points (also known as critical points or turning points) occur when a slight disturbance leads to a major change in the developmental trajectory or future state of a system. A classic case of a bifurcation is a 'junction' or 'path intersection' where, under the effect of a slight pressure, the system loses its stability and must make an abrupt transition to an alternative state. There are certain warning signs that a bifurcation is about to occur: for example, when a dynamic system approaches a turning point, it exhibits increased variability and is slow to recover from a disturbance. Anticipating these turning points helps to avoid harmful developments or to encourage desirable changes.

Reference: Timothy M. Lenton (2020), [Tipping positive change](#)

Wild cards and black swans

In the field of foresight studies, the term 'wild card' refers to an event that is not very predictable but which would have extreme consequences if it were to occur in the short (and possibly long) term. To qualify as a wild card, an event must occur quickly and with few warning signs, so that it is difficult to anticipate it, except in a very general sense. Unlikely things regularly occur, so it is essential to anticipate the unexpected, or at least to expect the unexpected to happen. Black swans are a special case of wild cards (alongside white leopards, black elephants and grey rhinoceroses). They refer to unexpected events with extreme consequences that seem improbable until they occur.

References: Nassim N. Taleb (2007), [The Black Swan. The Impact of the Highly Improbable](#)

John L. Petersen (1999), [Out of the Blue: How to Anticipate Big Future Surprises](#)

CIFS (2020), [Using the future](#); Copenhagen Institute for Future Studies, Scenario reports n° 3, pp. 32-34

Hypotheses

Postulates, suppositions or conjectures by which the imagination projects itself beyond what is already known in order to explain or foresee the possible realisation of facts, and to deduce consequences. Anticipatory scenarios are based on a set of more or less plausible hypotheses about the evolution of diverse variables, which need to be made explicit so as to make them more operational. For example, the hypothesis (h1) of an increase or (h2) a reduction of social inequalities might be made. The near future might be expected to be characterised by (h1) urbanisation or (h2) urban exodus, by (h1) the continuation of increasingly high-tech technological development or (h2) a boom in low-tech craft techniques. The scarcity of resources might also be hypothesised a phenomenon that is (h1) structural or (h2) cyclical, or (h3) halfway between the two.

Reference: Jérôme Minonzio (2005), [Une réflexion prospective, hypothèses et scénarios: quatre exemples](#)

Anticipatory innovation (and its governance)

Disciplines such as foresight, which aim to understand the future by analysing existing megatrends, hypotheses, values and worldviews are termed anticipatory. The new solutions, actions or policies that result from the knowledge generated by these disciplines, and which are likely to influence collective values, are known as anticipatory innovations. Structures and systems that encourage the emergence of anticipatory innovations contribute to the governance of anticipatory innovation.

Reference: OECD, [OPSI](#)

Futures literacy

The ability and know-how required to imagine the future and to understand why this is important. The French language has two distinct concepts: ‘avenir’ (often associated with a collective destiny) and ‘futur’ (a temporal category). It is the latter concept that is important here. The future exists only in the form of anticipation. Literacy in this area is a way of mastering the sources of hope and anxiety that influence anticipation. It enables to be more deliberate in the choices constantly made, in order to manage uncertainty and complexity more effectively. In a sense, it allows to colonise ‘tomorrow’ with the ideas of ‘today’. When these exercises go beyond day-to-day calculations, they take the elaborate forms of ‘scenario planning’ or ‘horizon scanning’.

References: UNESCO, [Futures Literacy](#)

Nicklas Larsen et al. (2020), [What Is ‘Futures Literacy’ and Why Is It Important?](#)

Riel Miller (2020), [Transformer le futur: l’anticipation au XXIe siècle](#)

Zentrum für politisch Bildung, [Zukunft elo?!](#)

Megatrend

A driving force whose effects can be felt the world over. It has its roots in the past, is observable today, and will continue to have a profound impact in the years to come. Typically, megatrends have a time horizon of 10 to 20 years. However, analysis of megatrends is usually used to inform medium and long-term strategic planning for the next 5 to 50 years. Their analysis enables to identify continuities and ruptures by distinguishing between different rates of change – either progressive or radical.

Reference: European Commission, [The Megatrend Hub](#)

Delphi method

A questionnaire-based survey method, the primary aim of which is to facilitate the convergence of opinions and reach consensus on certain issues through consultation with experts. The Delphi method was formalised in 1950 at the Rand Corporation, and was subsequently used to support the development of strategies in various fields with a particularly forward-looking character. The approach is iterative and avoids confrontation by preserving the anonymity of the participants. The responses (with justifications) to an initial open questionnaire, provided by various participants, are summarised and sent back to the same participants, indicating the general and specific trends that emerge. Each participant is then invited to respond to a second questionnaire based on the initial opinions gathered. The procedure is repeated until a satisfactory convergence of responses is achieved.

References: European Foresight Platform, [Delphi study](#)

EU Survey, [About the Online Delphi](#)

UK Government Office for Science, [Futures toolkit for policy-makers and analysts](#)

Integrated modelling

A model is a simplified representation of a system that illustrates its parts, the relations between them, and its emergent properties, and accounts for the (often non-linear) dynamics of the system. Integrated modelling of the economy is based on its physical quantification and incorporates various assumptions about its potential evolution. It is also ‘integrated’ because it combines macroeconomic quantification (particularly financial and social quantification, where possible) and physical quantification (particularly energy, ecological and spatial quantification). A model is used to run simulations, produce scenarios and to develop recommendations.

References: OECD, [Environment-economy modelling](#)

UNFCCC, [Integrated Assessment Models & Energy-Environment-Economy models](#)

The Shift Project, [modélisation énergie-climat-économie](#)

IIASA, [Integrate Assessment](#)

Strategic foresight

A discipline that explores, anticipates and shapes the future, in order to help build and use collective intelligence in a structured and systemic way, with a view to better forecasting future developments, developing possible transitions and withstanding shocks. Foresight is said to be strategic when it is integrated into the development of strategies and policies.

References: European Commission, [Strategic foresight](#)
 Futuribles, [La démarche prospective](#)
 OECD, [Strategic Foresight for Better Policies](#)
 OECD-OPSI, [Futures & Foresight](#)

Physical quantification

Naming and measuring the world is a way of understanding it. It is a form of knowledge and argument that influences our normal behaviour. It is also a form of writing that differs from both oral expression and narrative writing. It enables to grasp at a glance, rather than step by step, the complexity of a system and the relations between its parts. Quantification is said to be 'physical' when it measures physical phenomena (e.g. consumption of energy, land or water, polluting emissions, or jobs in the economy, a particular sector or a given company). In the context of foresight studies, it is used in particular to characterise the initial and desired situation of a type of activity in order to identify levers that are effective – in terms of their cost/benefit ratios – for supporting the transformation of that activity.

References: University of Leeds, [A Good Life For All Within Planetary Boundaries](#)
 WU Vienna, [materialflows.net](#)
 WU Vienna, [The Hotspot Analysis Tool for Sustainable Consumption and Production](#)
 The Observatory of Economic Complexity (OEC)
 Circle Economy, [Knowledge Hub](#)
 United Nations Environment Programme (UNEP), [Inclusive Wealth Report 2018](#)
 Eurostat, [Economy-wide material flow accounts](#)

Resilience

The meaning of this concept is a matter of debate. In one sense, resilience refers to the capacity of a system to manage, respond, adapt and recover from an experienced disturbance, whether this is a latent stress or a sudden shock. The concept has been used in the context of scientific analysis since the eighteenth century, but has recently become established as a normative imperative on the international political agenda. It refers to the maintenance of the essential functions, identity and structures of the systems under consideration, and also the maintenance of wellbeing in the case of social systems or biodiversity in the case of ecosystems. 'Resilience is a positive attribute when it maintains such a capacity for adaptation, learning and/or transformation' (IPCC, 2022, p. 7). The concepts of resilience and sustainability, although distinct, are therefore linked. Being resilient does not simply mean returning to an initial state or moving towards a new state, but also remaining stable in a changing environment.

References: IPCC, [Climate Change 2022: Impacts, Adaptation and Vulnerability](#)
 IPCC, [Glossary](#)
 Luxembourg Strategy, [Resilience \(ODC, 2021: Ch. 1\)](#)

Scenarios

In the context of foresight, scenarios are narratives, maps or images that describe possible futures. They outline the world as it might be tomorrow. There are different types of scenarios (possible, plausible, projected, probable or desirable) and they are often presented in small numbers (3 to 6) to suit our capacity to process information. They are developed using a variety of methods, including consultation with expert opinion and the involvement of wider stakeholder groups. Scenarios have no intrinsic value; what matters is their construction and their use in strategic dialogue. They are used for exploration (to gain a better understanding of future challenges), intervention (to identify the conditions required to achieve certain goals, to estimate the impact of policies before they are implemented) and evaluation (to measure the gap between future objectives and the results of current policies).

Reference: Futuribles, [La méthode des scénarios](#)

Weak signals

A set of warning signs that help to detect major developments early on. The term was introduced to the field of management by Igor Ansoff in the 1970s, when the oil crisis came as a strategic surprise to many. For Ansoff, a weak signal is essentially ‘early warning information, of low intensity, which may herald a trend, a threat or an opportunity’. This signal becomes stronger as new information becomes known. The ‘weakness’ of the signal relates to the distance of the information it contains from the knowledge system of those who perceive it. By perceiving these signals in good time and interpreting them correctly, the next strategic surprise can be avoided.

Reference: Barbara L. van Veen and Roland Ortt (2021), [Unifying weak signals definitions to improve construct understanding](#)

Strategy

A way through a difficulty, an approach to overcoming an obstacle, or a response to a challenge. In the case of public service, strategy consists in the determination of the fundamental long-term objectives of a public organisation, the adoption of courses of action, and the allocation of the resources necessary to achieve these objectives. Strategy is also the action plan that management uses to direct its activities, which shapes the way in which the organisation employs its resources, skills and assets. A ‘good’ strategy provides a diagnosis of a complex reality, and defines a direction of travel, coherent activities and coordinated responsibilities for achieving these objectives, in line with the resources previously identified as being available.

Reference: David E. McNabb and Chung-Shing Lee (2020), [Public Sector Strategy Design](#)

Strategic vision

Strategic vision is a particular stage in strategic planning, whereby a community develops an overall picture of what it wants to become (its vocation or purpose) by the end of a pre-determined planning horizon. The vision guides the community in managing the change it is aiming for. It informs a planning and decision-making strategy. By setting a target, communicating it so that it can be shared and explaining the steps that will lead to it, it enables future issues to be addressed, choices to be made, problems to be solved and a common language for community development to be defined.

Reference: Zukunftsinstitut, [Vision](#)

Visioning

The process of developing, in a collective and inclusive way, a long-term, realistic, clear and inspiring representation of the future desired by a majority of stakeholders, in order to guide current actions and decisions and thus influence the future. The visioning approach can be analytical, based on interviews, or creative, or it can emerge from working groups.

Reference: UNDP (2022), [UNDP RBAP: Foresight Playbook](#), New York

Windtunnelling (policy stress-testing)

A method for assessing the robustness of certain strategic orientations or policy options in the face of future scenarios, in order to understand how and to what extent they can withstand a variety of external conditions. Just as when an object is placed in a wind tunnel, the assessment shows how certain strategies or policies would behave under a given set of conditions. Stress tests are applied to certain choices in order to understand to what extent they will remain appropriate or may become untenable. In situations different from today, will these choices lead to the desired success? If so, then they are robust. If not, they need to be adapted.

References: UK Government Office for Science (2017), [The Futures Toolkit](#), pp. 64-67
Copenhagen Institute for Future Studies (2020), [Using the future](#); Scenario reports n° 3, pp. 38-39

About Luxembourg Strategy

Luxembourg Strategy is the department of the Ministry of the Economy responsible for **strategic foresight**. It produces **foresight studies** (*études prospectives* or *Zukunftsstudien*) for economic strategies. This involves the collaborative development of transition scenarios for Luxembourg's economy with a time horizon of 2050. The aim is to ensure that the sectoral **strategies** of the Ministry of the Economy are consistent with each other and with those of the other ministries that influence the economy, with a view to contributing to the country's economic transformation towards greater **resilience, inclusiveness** and **competitiveness** over the coming decades.

Set up in May 2021 and reporting to the Minister's Office, Luxembourg Strategy represents a continuation and extension of the foresight approach initiated in 2015 by the long-term strategic study on the Third Industrial Revolution (TIR).

Luxembourg Strategy is responsible for carrying out collaborative strategic foresight work that is geared towards action and the long-term future of the national economy as a whole. It also calls on specific foresight expertise. In concrete terms, its missions, as set out in the [statement](#) approved by the Council of Government (25 February 2022), are as follows:



Informing. To shed light on public action and thus help political decision-making, by bringing together the strategies that interact with the economy.



Providing objectivity. To Provide methodological support for strategic foresight and anticipatory innovation in the service of economically-orientated public policies.



Scenario-building. To Design, in an iterative and participative way, scenarios for economic development with a time horizon of 2050, based on shared, explicit and probability-based hypotheses.



Materialising. To quantify the physical flows that accompany the creation of economic value by businesses: what is the starting situation (2023) and the desired destination situation (2050) in terms of the consumption of energy, materials, soil or water, polluting emissions, or jobs? On this basis, what resource-efficient levers can be used to revitalise production that is low-carbon, creates highquality jobs and respects available resources and budgets?



Modelling. To Contribute to STATEC's integrated modelling of economic development, i.e. modelling that combines macroeconomic, physical, energy, ecological and spatial variables.



Deliberation. To lead the Luxembourg Strategy Forum and enrich public debate with multidisciplinary studies and new knowledge, by contributing to futures literacy, by promoting a common language and by facilitating mutual learning.

For more information, please visit the [Luxembourg Strategy website](#).

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Main specialised and localised economic sites and activities

-  Existing and projected zones of economic activity (PSZAE 2021)
-  Cluster of sustainable construction/wood/crafts (Wertstoffhaff, Gadderscheier, Esch Handwierkhaff, shared space, etc.)
-  Multifunctional pilot zone in Foetz
-  Geological or topographical pilot zone (former quarriers, mines, basins for construction material, energy/ water/material storage, etc.)
-  Research & Development (R&D)
-  Audiovisual and telecommunications park
-  High-tech/Clean-Tech Park
-  Space Park
-  Automotive zone
-  Major multinational company/companies zone
-  Finance and FinTech
-  Data and Cloud infrastructure
-  HE:AL HealthTech Campus (physical and virtual)
-  Logistics hubs (rail, air, river, road) and reverse logistics

Main networks of economic importance

-  Railway
-  Motorway
-  Cycle network (commuting/transport)
-  High-speed tram
-  Natural gas / green H₂ network
-  Main fibre optic network
-  Electricity network
-  Cross-border cooperation (PDAT)

Land occupation and use

-  River
-  Dam protection zone
-  Lake
-  Urban areas / urban cyclo-logistics (PDAT)
-  Centres of development and attraction (CDA)
-  Density of employment / km²

Foresight mapping of the ECO2050 Vision

This map of the territory of Luxembourg assumes that the digital, energy, climate and ecological transitions will be successfully completed across the continent and the country by 2050. In Luxembourg, the principles of the ECO2050 Vision - autonomy, innovation, efficiency, circularity, sufficiency, decarbonisation, critical redundancy, adaptation - will apply to all economic activity. This idea is represented by symbols surrounded by 3 green arrows in the shape of a circle, which are present on the 2050 map and absent from the 2023 map.

By 2050, the production and consumption of goods and services will, by default, be circular and compatible with objectives for the climate and nature. In line with the PDAT, economic activity will have reduced its land use and will increasingly be attached to land that has already been built upon. The ZAEs will become more multifunctional, circular and dense. Industrial waste will be recycled. Logistics will become more granular. Cross-border cooperation will be stimulated (there are more grey arrows on the 2050 map than on the 2023 map), with borders becoming more fluid and organic. Production of services will become nomadic and economic activity will become more decentralised (self-consumption of energy, remote working, communes as economies, etc.).

There will be more territorial experimentation (e.g. pilot zones for materials and storage, cross-border zones, sustainable construction, living with climate extremes, simplification of urban rules, etc.). Sustainable, innovative agriculture, in urban or peri-urban locations, will become widespread.

To keep better pace with demographic growth, towns and cities, which offer a better jobs/residents ratio, should be densified and expanded vertically.

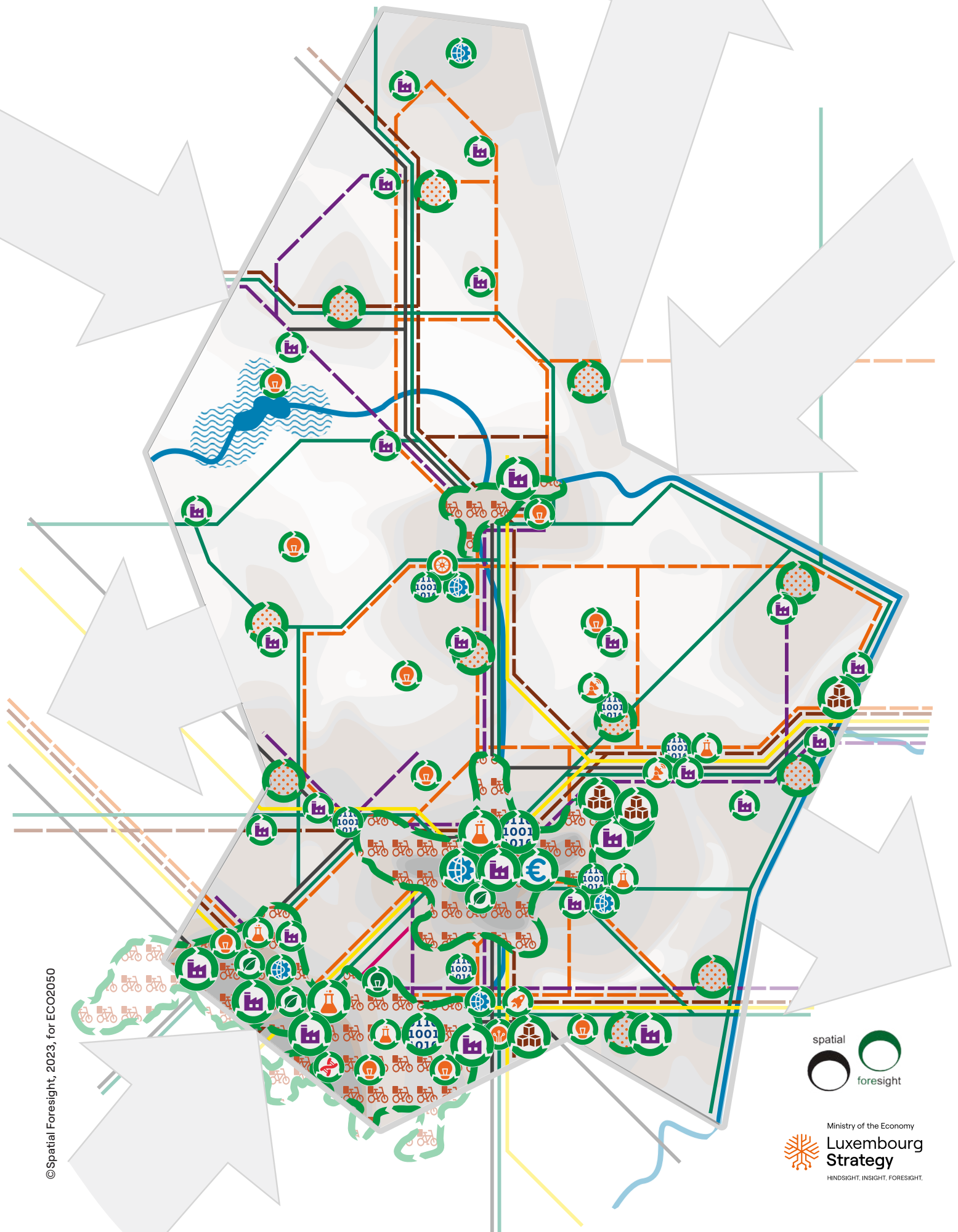
From an economic point of view, two co-existing spatial trends can be observed:

- **territorial specialisation** based on the comparative advantages of the location, with certain ZAEs being dedicated to new industries, all of which are linked to R&D (ICT, clean tech, health tech, adaptation tech, sustainable construction, space tech, etc.). This specialisation is represented by the symbols referring to localised economic activities, which are all surrounded by 3 green arrows in the shape of a circle.
- a **territorial generalisation** based on the principles to all economic activity in the area, regardless of location, and sometimes transcending borders. This generalisation includes:
 - o Carbon services - which may be attached to the built environment, or alternatively may be nomadic, wherever there is fibre optic internet access
 - o The carbon industry - potentially in all areas dedicated to industry
 - o The carbon craft industry - potentially in all areas dedicated to craft industry
 - o The circular economy - potentially in all economic activities and sites

This generalisation is indicated on the map by symbols referring to urban areas and CDAs, and which are surrounded by 3 green arrows in the shape of a circle.

ECO2050

Vision of economic activity 2050





2050



THE GOVERNMENT
OF THE GRAND DUCHY OF LUXEMBOURG
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