



مؤسسة دبي للمستقبل
DUBAI FUTURE FOUNDATION



FUTURE OPPORTUNITIES REPORT

THE GLOBAL 50

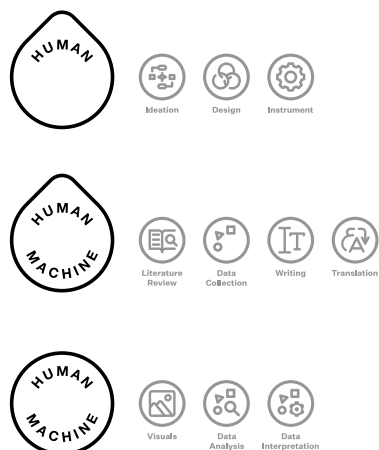
2026



Human–Machine Collaboration (HMC) Icons for ‘Our View of the Future’



Human–Machine Collaboration (HMC) Icons for the ‘Opportunities’



Icons for Human-Machine Collaboration (HMC)
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Foreword



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Vice Chairman of the Board of Trustees
and Managing Director, Dubai Future Foundation
Chairman, Museum of the Future

In a world where change is accelerating and challenges are increasingly intertwined with opportunity, the question that matters most is: how can we design a better future for humanity?

The fifth edition of the *Future Opportunities Report: The Global 50* is both an invitation to think differently and a practical tool for identifying the opportunities that can reshape growth, unlock new engines of prosperity, and improve quality of life around the world.

We are living through an extraordinary moment in history. Economic models are being redefined, technological progress is being fast-tracked, and the boundaries of what is possible continue to expand. What we are witnessing today is the beginning of an entirely new chapter in human history. In this new era, governments and institutions have a greater responsibility than ever to shape change – investing in opportunities before they become reality.

This report highlights 50 global opportunities that represent new pathways for growth; ideas with the potential to become transformative projects, and possibilities that can improve lives at scale. Opportunities do not simply emerge; they are created. They begin with a clear vision, bold decisions, and the ability to turn ideas into tangible impact.

The report is designed as a practical resource for decision-makers, a platform for innovators, and a roadmap for everyone committed to building a better future.

The future is not shaped by ideal circumstances. It is shaped by people who recognise opportunity within uncertainty, who see challenges as the starting point for new paths to progress and growth. Every future opportunity is an invitation to think differently, act boldly, and believe that tomorrow can be better than we imagine.





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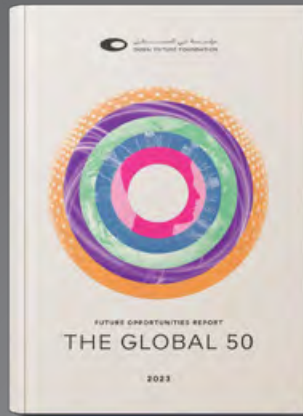
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1st Edition
2022



2nd Edition
2023



3rd Edition
2024



4th Edition
2025

Preface

The Global 50 is our flagship foresight report on future growth, prosperity and well-being. This year, 2026, marks the publication of its fifth edition.

Exploring near-term futures helps us navigate immediate challenges and opportunities. Exploring long-term futures, however, is critical to excellence. Futures-focused thinking helps expand the imagination and generate both near- and long-term ideas about what is plausible and desirable. Foresight does not eliminate uncertainty; it helps us navigate it.

We use The Global 50 to share our view of the global future. While the perceived benefits of ‘predicting’ the future, such as informing policy, mobilising support, provoking engagement and storytelling, help decision-makers feel a sense of certainty, the past four editions have emphasised the need to imagine and navigate the uncertain future through opportunities – some within reach, some transitional and some visionary.

We have often been asked about what comes next once future opportunities are identified, and to help determine approximate implementation timelines. In response, we shifted the conversation this year from ideas to action. We explored opportunities through the lens of value creation for future growth, prosperity and well-being, and the mechanisms needed to capture that value and realise associated benefits. However, we still do not give an estimate of the speed at which each opportunity might materialise, because it depends on underlying mechanisms and the right conditions for change, including maturity of necessary technologies.

At the same time, we recognise that unpacking the ‘how’ of future opportunities must include funding, otherwise an idea remains aspirational. To this end, we went back to the innovation literature to explore ways to approach funding – underpinned by a new megatrend that we have introduced this year, *Redefining Finance and Monetary Systems*.



In all but one case – the idea of national cognitive potential, which we introduced at the Dubai Future Forum in 2025 – we revisit opportunities from previous editions as preferable (desirable) futures. While we use these terms – preferable and desirable futures – interchangeably throughout the report, we recognise that they are distinct in meaning.

After conducting a desk-based review of the status of each opportunity today, we unpacked the ‘how’ – that is, the pathway to impact – using high-level backcasting as a foresight method. As such, we also considered what the necessary enablers and challenges may be, as these open up possibilities for many across the public, private and civil society sectors, and even individuals, to explore their role in a particular future.

During this process, we increasingly recognised that as foresight practitioners and experts, we have to acknowledge and manage the biases we bring into our exploration of the future, particularly when our perspectives may influence others. At the most fundamental level, we often want, or feel we need, to simplify the future, defaulting to what worked before, and we may opt for linearity, projecting familiar patterns forward. For this reason, we used mixed research methods, diverse sources and engagement to expand our research. As you read through the opportunities this year, consider them through the lens of curiosity and reflect on your own context, resources and capacity. You may even consider the approach useful as a blueprint for developing your own ideas.

Across many of the opportunities’ pathways to impact, we found that working together across borders is critical. Whether through consortia, global working groups or coalitions, collaboration is key for future growth, prosperity and well-being. While there are many possible paths to taking action on an opportunity, it is important to remember that no pathway is linear. Before each stage, always ask whether the next step makes sense while keeping an eye on the future. And consider, especially for ideas you had in the past, whether technological advancement and other transformations are pushing or pulling the scope and speed at which an opportunity might be realised. For example, as we worked through our research, we recognised that the scope of six opportunities have shifted from visionary to transitional (highlighted in the respective opportunities).

Looking ahead, the development of new or adjusted forms of blended finance will be necessary to support innovation, and scaling the idea of global sandboxes – beyond their most common application in financial regulation – is long overdue. At the same time, cybersecurity vulnerabilities will become increasingly prominent, making their management even more urgent. And, finally, perhaps the next frontier is to truly enable seamless multimodal connectivity and real-time data exchange, balancing practicality and privacy – not a trivial challenge for any society.

To help you move from ideas to action, we invite you to visit our webpage, where you can explore a simple selector tool (also within the report) designed to help you reflect on your potential role when exploring one of the Global 50 opportunities or an innovative idea of your own. As a starting point, it can support you in your own participatory backcasting efforts and help identify key next steps.

We hope you enjoy this edition.

The Dubai Future Foundation

**We shift the
conversation
this year from
ideas to action.**



Introduction

This is the fifth edition of The Global 50. In addition to sharing an update on our view of the future, including a change to one of the 10 megatrends that we believe will shape future growth, prosperity and well-being (Box 1), we revisit opportunities presented in the past four editions, with a twist. Previously we asked, ‘What is the opportunity and why does it matter?’ – questions that seek to identify and create potential value. **Now we ask, ‘What action could be taken to further each opportunity and who could act?’ – questions that seek to capture future growth, prosperity and well-being. We treat each opportunity as a preferable (desirable) future and map a pathway to action, building on the status of the opportunity today.**

Previously we asked

What is the opportunity and why does it matter?



Now we ask

What action could be taken to further each opportunity and who could act?



BOX

1

Defining Growth, Prosperity and Well-being

TODAY

Growth

Increases in the total output of goods and services in an economy over time.

Prosperity

The ability to live with dignity and stability, free from the threats of poverty or harm, including those caused by the environment. This includes access to suitable employment opportunities, sufficient food, and basic services such as water, energy, education and healthcare.

Well-being

A multifaceted concept centred on a generally good state of mental and physical health and feelings of life satisfaction, based on growth and prosperity along with positive social interactions, a sense of belonging and positive interactions with the environment.

TOMORROW

The definition could go beyond economic factors, accounting for the negative impacts of economic growth (such as deforestation) to create a measure of net-positive growth.

The definition may evolve to include access to personalised and self-managed services. Beyond employment, it may include varying streams or opportunities for income generation by which people can earn a living. It may encompass broader life choices and a more supportive environment in which to make them.

The definition may evolve to include heightened feelings of self-realisation, self-esteem and self-confidence, as advances in medicine and technology could lead to the complete removal of (or greater ability to overcome) mental and physical health issues.



The Opportunities in the Fifth Edition

Innovation drives future progress,¹ and both value creation and value capture are key to making progress happen.² **Value creation** means developing and offering new ideas, products or services that are intended to generate perceived value for users, customers or beneficiaries. **Value capture** happens when the created value is converted into outcomes – profit in the case of the private sector, public benefit or impact in the case of the public sector, and a combination of both in the case of civil society.

In this and the previous editions of The Global 50, value creation means identifying opportunities for future growth, prosperity and well-being. **Value capture** means building pathways to realise future opportunities through deliberate mechanisms and stakeholder action.

We capture value for growth, prosperity and well-being through five distinct yet related mechanisms. Each mechanism represents a different pathway for translating opportunities into outcomes.

Value capture for growth, prosperity and well-being is achieved through



1

New Definitions of Value, where opportunities explore and redefine models of success and value beyond the economy

2

New Markets, where opportunities identify and expand into new markets to meet changing needs

3

Technologies, where opportunities use disruptive and breakthrough innovation to deliver benefits

4

Partnerships, where opportunities focus on establishing effective cross-sectoral alliances, ecosystems and/or international collaboration

5

Agility, where opportunities build strategic capabilities and resilience to enable adaptation to complexity, uncertainty, and rapid and disruptive change



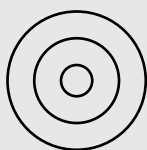
Each opportunity in this fifth edition addresses two critical questions for decision-makers: 'How can your organisation capture value from the opportunity?' and 'What role should you play?' It also addresses two critical questions for individuals: 'Where do you want to invest your time and money?' and 'Which skills do you want to build?'.

As a result, each opportunity requires **decision-makers and individuals to determine the role they will play** based on their capacity and/or ambition to shape outcomes. The four major roles are:



Leader

shaping the preferable (desirable) future set out in the opportunity



Anticipator

preparing for the probable future set out in the opportunity



Enabler

contributing to the possible future set out in the opportunity



Observer

monitoring the plausible future set out in the opportunity

All organisations and individuals should, at a minimum, maintain an observer role to aid future readiness.

The question is no longer just limited to which preferable (desirable) futures are possible, but **who will take the lead in making them a reality.**



Our View of the Future

Our view of the future is based on assumptions and uncertainties (which apply over multiple decades), megatrends (which apply over a decade or so), and action through future opportunities.

Assumptions

An assumption is a trend that we think is here to stay for a long time. Even if events cause shifts, assumptions are expected to remain stable over time.



‘What assumptions would impact your long-term vision should some aspect of them change?’

Megatrends

A megatrend is a pattern evolving from global trends and research that is expected to have a significant impact on economies and societies globally. It is likely to affect growth, prosperity and well-being either positively or negatively. It could affect a large majority of countries and several industry sectors over a decade or more.



‘Which megatrends matter most to your strategic vision?’ and ‘How are you actively monitoring and responding to those megatrends (bearing in mind any links between them)?’

Uncertainties

An uncertainty arises when differences in important contexts – such as socio-economic, political or environmental conditions – could result in radically different trajectories and futures. Uncertainties should be understood as falling on a continuum between two extremes, and they can influence trends at the global and/or regional level. Over the course of the next five decades, uncertainties will lead to new challenges in a rapidly evolving world.



Which uncertainties are you already well equipped to face?’ and ‘Which uncertainties will require new capacities or fresh solutions?’

Opportunities

These are ideas, products and/or services that, if realised, would have a positive impact on future growth, prosperity or well-being.



‘Can your organisation shape how each opportunity is defined or pursued globally or regionally?’ and ‘Can your organisation state which ones are core to your organisation’s mission, value proposition, or long-term strategic direction?’

In an era of quantum shifts,³ people remain central to how we navigate change. Irrespective of the economic paradigms that might evolve; the societal meanings and generational shifts we might witness; and the technological advances, demographic shifts and global commitments to environmental goals that arise, people will continue to strive for their basic and higher-order needs (Box 2).⁴



BOX

2

Maslow's Needs: Basic Needs, Higher-Order Needs and AI

Our research on navigating the era of quantum shifts refers to Abraham Maslow's hierarchy (or pyramid) of needs as a framework for understanding people's needs in this era.⁵ The hierarchy has faced criticism, particularly concerning the notion that needs are sequential.⁶ Additionally, artificial intelligence (AI) may reshape, transform or adjust the Maslow's pyramid.⁷ Nevertheless, while the framework remains beneficial for understanding people's needs, we are constantly monitoring evidence on how it could be understood and applied today and in the future.

For example, one way to look at basic needs is through the basic needs poverty line and the idea of decent living standards.⁸

The **basic needs poverty line** considers the minimum amounts of food, water, clothing, heating and housing that every person needs.

In 2011, 17.3% of the world's population was unable to meet these needs.⁹ No reliable figure exists since then, but a close proxy is food insecurity, which affected **28%** of people in 2024.¹⁰

28%

of the world's population faced food insecurity in 2024



Decent living standards include nutrition, healthcare, education, energy, cooking, sanitation, hygiene, appliances, climate control, computers, the internet, transportation and lighting.

In 2024, **80%** of the world's population was deprived of at least one aspect of decent living standards.¹¹

80%

lacked at least one aspect of basic living standards in 2024



With respect to **higher-order needs**, Maslow's hierarchy progresses from safety and security to belonging, competence and self-esteem.

At the top is fulfilling one's potential (**self-actualisation**), which Maslow stated was rare and achieved mainly by those who are older.¹²

2%

achieved self-actualisation¹⁵ (theorised)

On AI, it will significantly transform workflows, and deliver gains in accuracy, productivity, risk mitigation and learning.¹³ As mentioned above, these changes are not trivial, and they may alter the shape of Maslow's pyramid. As such, more people may achieve self-actualisation with AI and as new needs may emerge, social needs might also prove to be more fundamental than Maslow originally theorised. At the bottom of the pyramid, AI is likely to help us meet our basic needs more efficiently and more effectively,¹⁴ whether by enabling precision agriculture, improving water purification systems or optimising energy grids.

The very definition of needs may evolve.



As the world continues to grow in complexity¹⁶ and as our conceptualisation of meaningful progress continues to evolve,¹⁷ a focus on growth, prosperity and well-being will ultimately continue to be a focus on people: understanding how their expectations are changing, anticipating new risks and opportunities they could face in their daily lives, and navigating uncertainties to create the conditions for individuals to prosper.¹⁸

Growth, prosperity and well-being continue to be the lens through which the long view informs the megatrends and opportunities in this report.



OUR VIEW OF THE FUTURE

Assumptions

Global assumptions serve as guideposts that help us think about the future. They are predictable, and they are still subject to change. Applicable over multiple decades, they may shift significantly in the short-term, which could substantially change the scenarios built upon them and our ability to realise future opportunities.

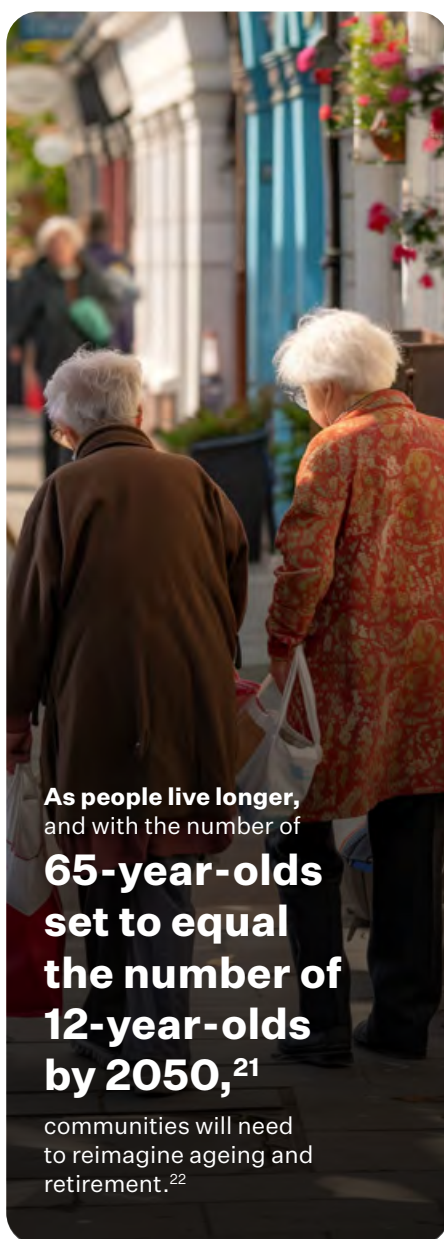
- 1 **Lives Will Be Longer and Healthier**
- 2 **Climate Change Will Persist**
- 3 **Inequalities Will Continue**
- 4 **Technology Will Continue to Advance**
- 5 **Global Interdependencies Will Remain**



ASSUMPTION

1

Lives Will Be Longer and Healthier

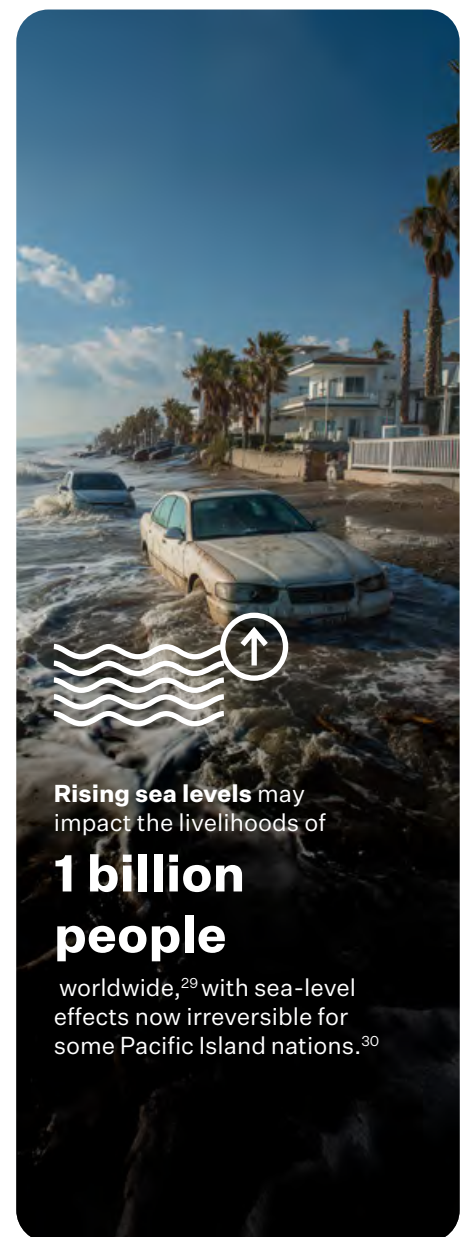
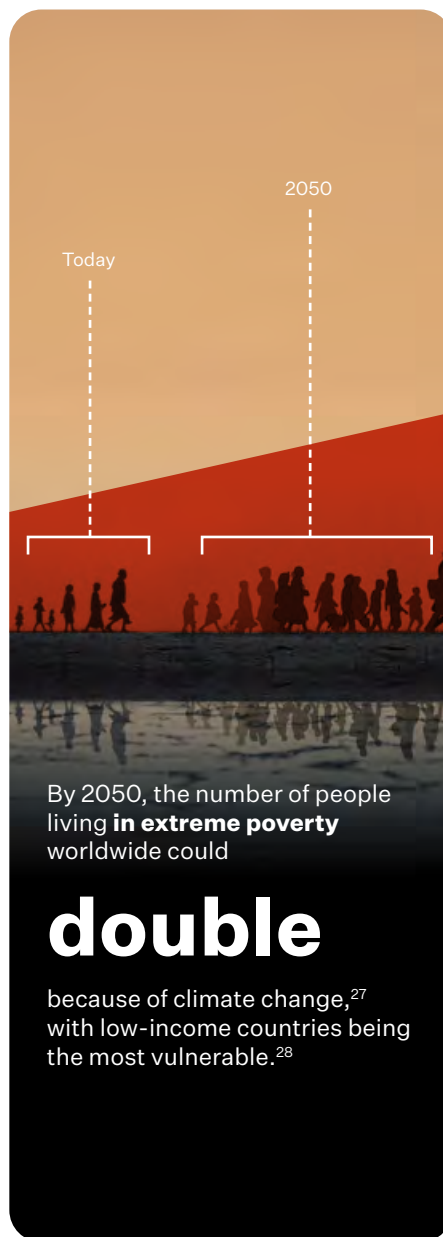
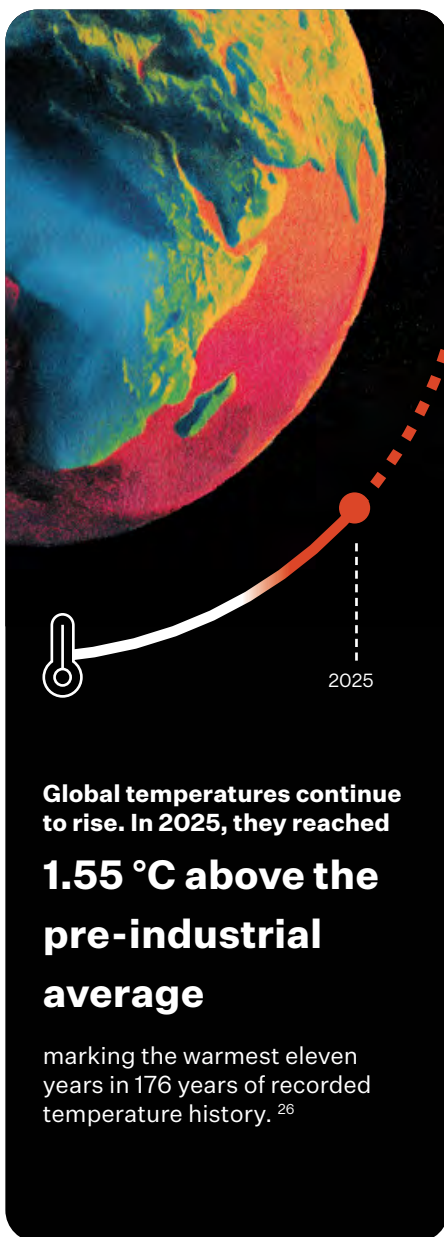




ASSUMPTION

2

Climate Change Will Persist

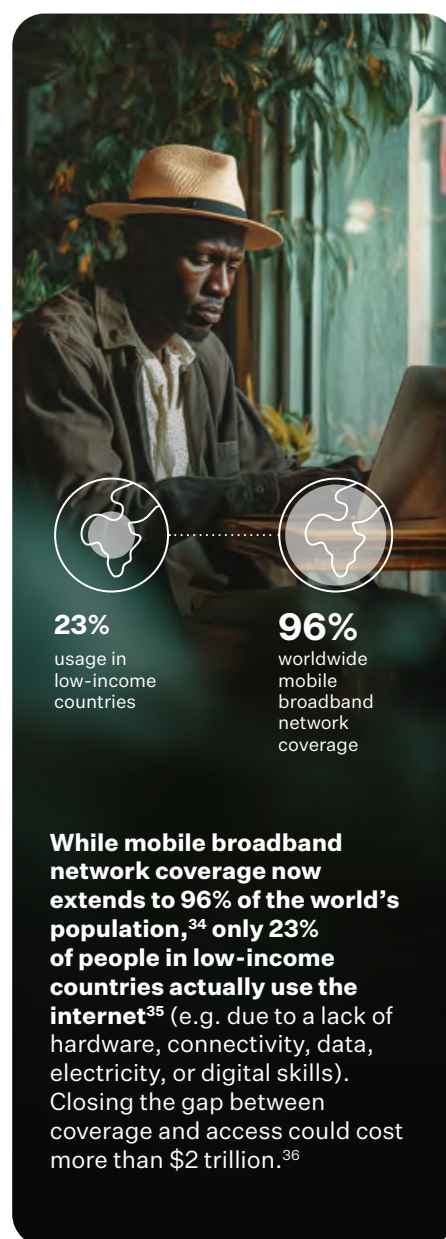
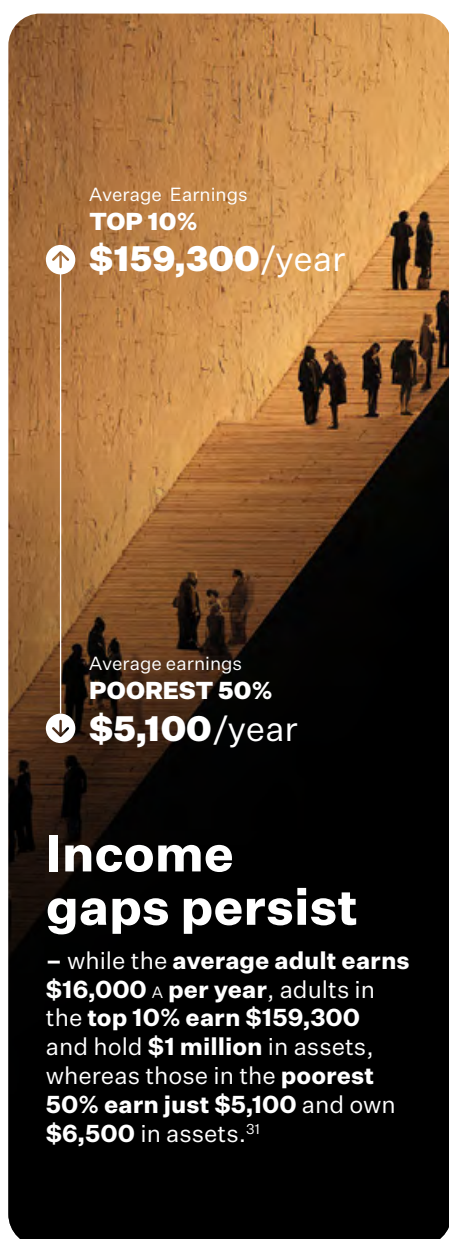




ASSUMPTION

3

Inequalities Will Continue



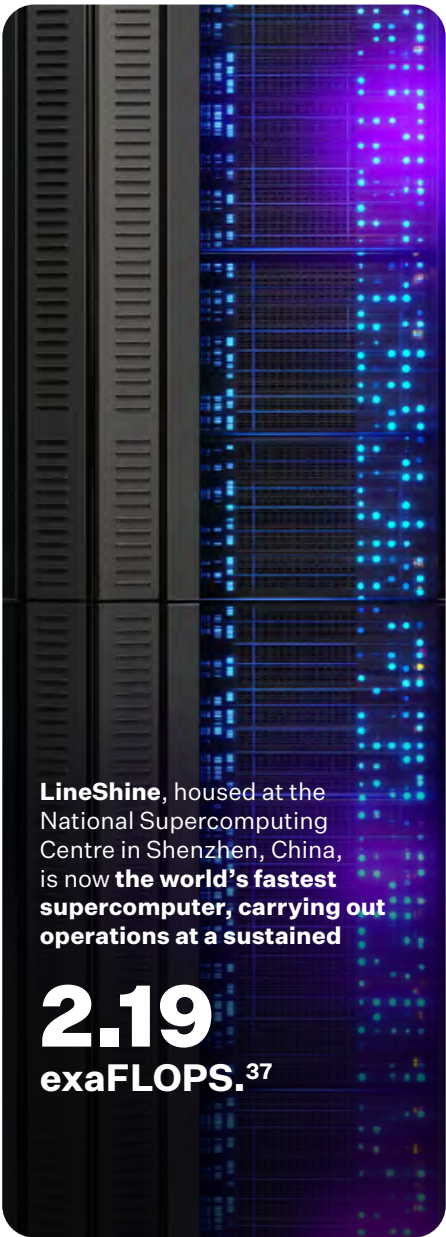
A Based on the EUR:USD exchange rate of 10 July 2026.



ASSUMPTION

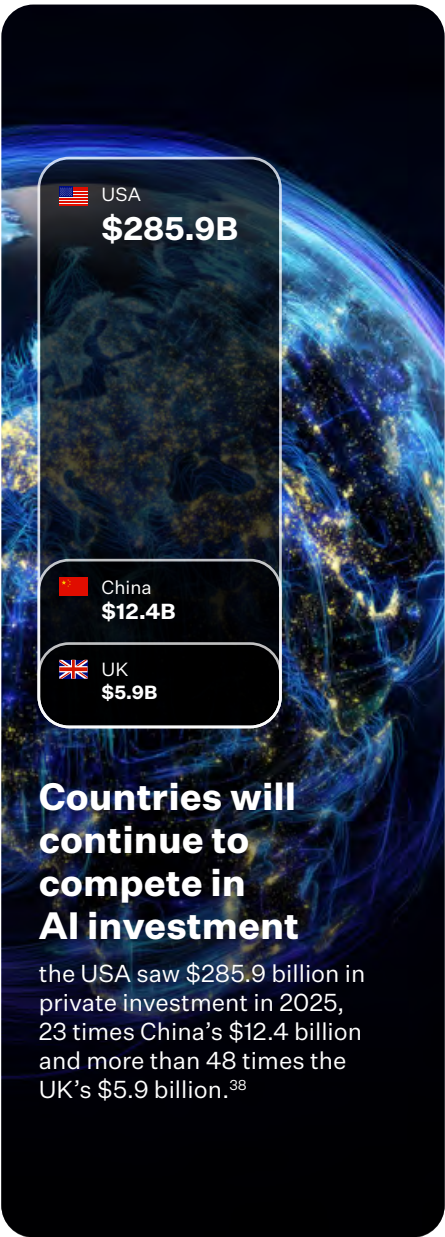
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Technology Will Continue to Advance



LineShine, housed at the National Supercomputing Centre in Shenzhen, China, is now **the world's fastest supercomputer, carrying out operations at a sustained**

2.19
exaFLOPS.³⁷



Country	Investment (\$B)
USA	\$285.9B
China	\$12.4B
UK	\$5.9B

Countries will continue to compete in AI investment

the USA saw \$285.9 billion in private investment in 2025, 23 times China's \$12.4 billion and more than 48 times the UK's \$5.9 billion.³⁸



The share of renewables in total electricity generation will **continue to increase, reaching**

55%

by 2035³⁹ following a drop in cost from approximately \$4.50 per watt for photovoltaic modules in 2000 to **less than \$0.20 per watt in 2024.**⁴⁰



ASSUMPTION

5

Global Interdependencies Will Remain



7.5%
Global Trade Growth in 2025

Global trade in both goods and services continued to grow in 2025, despite geopolitical and trade headwinds persisting from 2024, **expanding by 7.5% to a high of \$35 trillion.**⁴¹

With global economies deeply interconnected, **current conflicts will reshape** trading relationships but not whether they persist.





Even today's oil price volatility **reinforces this interdependence** as IEA member countries released **400 million barrels** of oil from emergency reserves in March 2026.⁴²



The world entered into significant negotiations and agreements on rare earth elements in 2025,⁴³ continuing into 2026.⁴⁴ Demand is expected to increase from around 91 kilotonnes in 2024 to around **150 kilotonnes by 2040.**⁴⁵



OUR VIEW OF THE FUTURE

Uncertainties

The uncertainties reflect the vastly divergent socio-economic, political and environmental conditions that global societies may experience.

Although the uncertainties are not novel, they continually manifest as new challenges within evolving realities. Like the assumptions, the uncertainties apply over multiple decades, and each year we use our research to validate and (where needed) refine them. Even though we take the long view, our reflections remain relevant alongside immediate developments.

For this fifth edition of The Global 50, we engaged with various DFF communities to explore the future. The individuals and communities came from different geographies, cultures, and sectors and had different levels of expertise. During the roundtables we used to explore the future, we avoided groupthink by ensuring that, as facilitators, we deliberately asked deep questions that challenged statements where appropriate. We focused on keeping an open mind and allowing the participants to disrupt our thinking.

We then put our findings together with the results of our metareview and a follow-up survey sent to the participants (and Global 50 experts) to ensure our insights on uncertainties were robust. No new uncertainties emerged, but many important questions arose.

The roundtable and survey data allowed us to gauge participants' current perceptions of the uncertainties, identify where views remained divided and capture participants' sentiment about the future.

Finally, it is important to note that on a broad spectrum, where global communities (cities, countries or regions) sit will vary depending on their context, and these keep shifting over time.

1 **Collaboration**

2 **Values**

3 **Technology**

4 **Nature**

5 **Systems**



UNCERTAINTY

1

Collaboration

To what extent will governance and international **collaboration** advance at the global level?

Multipolarity**Multilateralism**

TODAY

TOMORROW

Multipolarity dominated the roundtable discussions. While this reflects today's reality, **the participants expected renewed multilateralism** but in new institutional forms reflecting changed power structures and global needs. They asked, 'What if global cooperation becomes impossible?' They tended to believe that multilateralism will eventually prevail, because there will be a vacuum where neutral players can, and will need to, bring global players together to bridge gaps – for example – in AI governance and science. During this time, it will be crucial to address the inability of polarised nations to talk to one another.



UNCERTAINTY

2

Values

To what extent will global communities converge on shared **values** or become divided by differences?

Unique**Universal**

TODAY

TOMORROW

The roundtables were **dominated by discussions about disinformation, misinformation, technology's influence on values, along with the current fragmentation driven by social media – aspects that intensify during periods of conflict and geopolitical tension.** In the long run, the participants **expected there to be an AI-mediated convergence of values, and concerns about human agency and authenticity were prominent.** Discussions uncovered deep anxieties about social breakdown, covering questions such as 'What if social cohesion breaks down because of abundant, yet unnecessary, information?' and 'What if social media and constant connectivity create such social fragmentation that physical communities become obsolete?' These concerns revealed tensions between optimism related to AI-enabled sharing of values and lived experiences of accelerating fragmentation. Underlying these tensions are deeper shifts in how social ties form within and between global communities and how the role of physical spaces and institutions, that once anchored them, will evolve.



UNCERTAINTY

3

Technology^B

To what extent will **technology** dictate our lives or serve as a multiplier for productivity and a better quality of life?

Technology
as Master

Technology
as Multiplier

TODAY

TOMORROW

The roundtable participants **discussed algorithmic control and attention capture**, emphasising the **importance of rebalancing technology towards 'multiplier'** applications that enhance, rather than replace, human capacity. Participants raised questions about the future, such as 'What if advancements in AI remove human agency?' and 'What if AI advances so rapidly that it comes to control all decision-making, from the most serious to the most trivial matters?'. They noted that if people become 'AI literate' only to lose their jobs, then we may need to think about a way to ensure they share in the economic gains created by AI. These economic anxieties are particularly important in times of great uncertainty and instability. The AI experts among the participants argued that focusing solely on AI is short-sighted. The true shift will come from the synthesis of three general-purpose technologies: AI, sensors and biotechnology, and that multiplier effects will increase over the long-term.

B Technology is both an uncertainty and an assumption. See the assumptions to understand the difference.



UNCERTAINTY

4

Nature^c

To what extent will our innovative technologies and efforts help **nature** to restore itself?

Degradation**Restoration**

TODAY

TOMORROW

The perception among the roundtable participants was that at present, **we remain on a trajectory of degradation**. Many cities and countries have already faced extreme heat or floods and have had to hastily pursue breakthrough inventions to manage the present and prepare for the future. The participants **expressed hope about restoration and regenerative efforts**. However, whether these will have a significant impact on nature's current negative trajectory remains unclear – it was evident that the participants saw nature's response as unpredictable. Questions included 'What if we do not have water?' and 'What if mass climate migration gets out of control?' Food and water scarcity were also prominent concerns including the concern that technological advances in AgriTech and BioTech may not be able to keep up with demand. The question of how water shortages could affect global power dynamics was also raised.

^c Nature is both an uncertainty and an assumption. See the assumptions to understand the difference.



UNCERTAINTY

5

Systems^D

To what extent will **systems** evolve greater resilience to meet changing needs?

Fragility**Resilience**

TODAY

TOMORROW

Within some of the roundtable discussions, **fragility started to prevail in the long-term interconnected global systems**, with movement towards (or maintenance of) **resilience contingent on adaptive governance, redundancy by design and the ability to learn from past experience**. Roundtable participants had concerns about data quality and how it may deteriorate faster than modelling capabilities improve, threatening decision-making systems. Questions included ‘What if we hit systemic constraints across energy, materials and governance all at the same time?’ These concerns reveal anxiety about whether systems can adapt or fracture irreversibly particularly when cybersecurity threats are in the mix, weakening systems even when they appear resilient. For example, while our financial systems are resilient, our physical systems are hitting constraints, from traffic gridlock to the decline of liveability in some cities and communities.

^D As an uncertainty, systems relate to the processes and mechanisms that are used to operationalise global policies, laws, regulations and cross-border transactions.



OUR VIEW OF THE FUTURE

Megatrends

The Global 50 megatrends focus on the next 10 or so years. As researched thematic paths that are expected to impact our global growth, prosperity and well-being, they form a key part of the Dubai Future Foundation's view of the future. The ability to sense, adapt and respond to them is central to ensuring future readiness and laying the foundations for long-term success.

The 10 megatrends are not just about specific trends or technologies – they include underlying trends and technologies that are linked in complex ways. While they are presented separately, there are considerable overlaps between them.

From an action perspective, the megatrends give decision-makers – and individuals – insight into what could make a difference over the next decade or so. As well as interacting with each other, they interact with the uncertainties and assumptions – each of which mediates, moderates or amplifies each megatrend. They evolve, which is why the Dubai Future Foundation carries out an annual review. In this way, we aim to ensure that we have a comprehensive set of megatrends that can help humanity prepare for and manage the future, and that also inspire ideation and opportunities relating to that future.

Significantly this year, last year's Megatrend 4: Energy Boundaries has been merged into Assumption 4: Technology Will Continue to Advance (Box 3). It has been replaced by Redefining Finance and Monetary Systems, covering tokenisation, central bank digital currencies, the impacts of monetary and fiscal policies, cryptocurrencies, AI, payment systems, trends in regulation, new forms of exchange (e.g. stablecoins), data structures, securitisation, various assets and asset classes, regulatory requirements, and more.⁴⁶ All of these developments are shifting how we view, value and use money and wealth and everything that surrounds them. These changes will have wide-ranging impacts across sectors, organisations, homes, and daily work and life.

1 **Materials Revolution**

2 **Boundless Multidimensional Data**

3 **Technological Vulnerabilities**

4 **Redefining Finance and Monetary Systems**

5 **Evolving Ecosystems**

6 **Borderless World – Fluid Economies**

7 **Digital Realities**

8 **Life with Autonomous Robots and Automation**

9 **Future Humanity**

10 **Advanced Health and Nutrition**



BOX

3

From Energy Boundaries as a **Megatrend** to Energy Boundaries as an **Assumption**

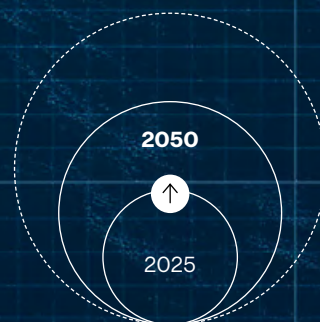
Energy Boundaries as a megatrend has matured and is now part of technologies encompassed by *Assumption 4*. Energy generation, distribution and management have become inseparable from the broader assumption that technology will advance across all sectors over the next couple of decades.⁴⁷ How quickly and in what manner energy evolves, as it pertains to future growth, prosperity and well-being, will depend on where it sits on the spectrum of technology as an uncertainty – between master and multiplier (see Uncertainty 3) – and the speed, scale, and purpose of innovation and development of future energy technologies.⁴⁸

Our research and metareview revealed that the transition to renewable energy continues to advance. Based on the prevailing trends, renewables are projected to generate more than two-thirds of all electricity by 2050, up from one-third in 2025.⁴⁹

This transition, led by solar and wind energy,⁵⁰ is being enabled by batteries that manage intermittency challenges while delivering improved safety and performance through advanced materials science.⁵¹ In terms of costs, 91% of new renewable projects are cheaper today than fossil-fuel alternatives.⁵² Additionally, AI development is increasing the need for sustainable energy, as a typical AI-focused data centre can consume the power used by 100,000 homes; global data centre electricity needs will more than double by 2030 to 945 TWh, just more than Japan's total electricity consumption today.⁵³ Meeting this growth will require up to \$3 trillion in investment⁵⁴ including investment in renewable integration and grid modernisation.⁵⁵

However, as energy advances, challenges will remain. None of the 45 climate indicators aligned with the Paris Agreement are on track to meet the 2030 targets, and an annual \$1 trillion increase in spending is needed by 2030 to close the climate finance gap.⁵⁶ We are seeing a global rollback of environmental policies and regulations,⁵⁷ and only 7% of more than 10,000 global organisations that have pledged net zero goals have credible strategies.⁵⁸ Nevertheless, the pursuit of cheaper, cleaner and more consistent energy will persist and disruption will likely accelerate this, as supply shocks and price volatility strengthen the case for energy diversification and renewable capacity; though scale and speed will depend on various other factors.⁵⁹

Taking the long view, energy will continue to be at the heart of progress,⁶⁰ and the move towards new, clean energy sources will remain a priority driven by economic realities and technological needs.



Based on the prevailing trends, renewables are projected to generate **more than two-thirds** of all electricity **by 2050**, up from **one-third** in 2025.



The information provided on the megatrends in the following pages is indicative only, and the drivers, trends and signals are non-exhaustive. For each megatrend, we offer a mix of current facts and future forecasts. Additionally, we identify three potential areas of opportunity within each megatrend that may be of interest to decision-makers and individuals alike.

As The Global 50 is a futures report, many of the areas of opportunity covered in previous editions,^E and listed in this edition, have not (yet) materialised.

^E The 2022 Edition of The Global 50 did not present areas of future opportunity.



MEGATREND

1

Materials Revolution

Materials are fundamental to all products, foods, medicines and drinks that we consume on a daily basis. Driven by extensive progress in advanced machine intelligence, nanotechnology and materials science, as well as interdisciplinary research and innovation, new opportunities are arising in the use of materials in almost all industrial, technological and consumer sectors.

Areas of Future Opportunity (Past Editions)

Synthetic Biology (2023)
Materials for Climate Change (2023)
Semiconductors (2023)
Tissue Engineering (2024)
Materials for Engineering Parts (2024)

Nanobiomaterials for Dental Applications (2024)
Permanent Magnets (2025)
Biomimetic Materials (2025)
Quantum Materials (2025)

Keywords

Aerospace Materials
Algae-Based Dyes
Biodegradable Food Packaging
Biopolymers
Carbon Capture
Circular Economy
Covalent Organic Frameworks (COFs)
Material Passports
Nanocoatings
Smart Materials

Things to Look Out for in the Short-Term



COF-999 for more efficient carbon capture

A covalent organic framework (COF) material, COF-999 captures carbon dioxide (CO₂) faster and at lower temperatures than other materials and does not degrade as quickly with use over time.⁶¹ COF-999 could significantly reduce the operating costs of carbon capture, utilisation and storage (CCUS) through improved CO₂ adsorption.⁶²



Algae-Based Textile Coatings

Algae-based textile coatings offer fully bio-based, naturally coloured fabrics that stay bright and durable, replacing harmful synthetic dyes.⁶³ Every year, the textile industry releases 180,000 tonnes of dye-contaminated wastewater, polluting drinking water, endangering aquatic life and destroying ecosystems.⁶⁴



Waste to Packaging

Biopolymers (chitosan, pectin and starch) extracted from fruit peels and food waste can be used to create biodegradable packaging with antimicrobial properties.⁶⁵ In pilots, such packaging tripled the shelf life of guava, doubled that for pears and kept mangoes fresh for up to 25 days.⁶⁶ This could address the 1.2 billion tonnes of food wasted globally each year, 35% of which is fruit, while offering sustainable alternatives to conventional packaging.⁶⁷



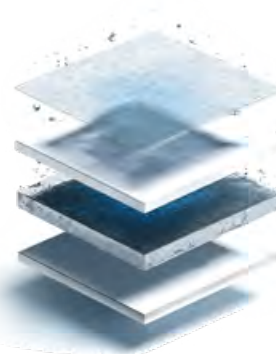
Areas of Future Opportunity

AI-Ready Material Passports

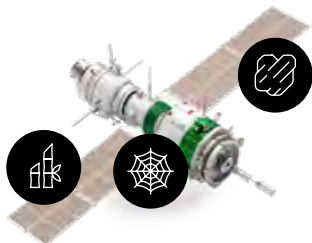
Material passports are not a universal requirement, although they are often used in sustainability and circular economy contexts. Currently, they are only mandatory in the European Union, where digital product passports will be rolled out across various product categories between 2026 and 2030 under the Ecodesign for Sustainable Products Regulation.⁶⁸ Material passports are currently most often used in the building and construction sector, although they require manual data inputs and are not updated in real time.⁶⁹ Cross-border traceability and interoperable lifecycle-tracking systems are rare, especially in the absence of a standard classification framework.⁷⁰ Even with International Organization for Standardization (ISO), European Committee for Standardization (CEN) and Industry Foundation Classes (IFC) frameworks, the lack of standardisation is a major barrier.⁷¹

The US GBI Test is trialling accepting various identifiers because future material passport frameworks may accommodate multiple platforms rather than one.⁷² In the future, as AI generates formulas for new materials, composites and bioengineered materials, the classification gap will widen. Areas of future opportunity include changes in what constitutes a material when AI design is used and how to disclose such information, particularly in food, pharmaceuticals and advanced manufacturing.

Material passports are currently most often used in the building and construction sector.



Biomaterials offer a potentially more **sustainable, yet durable, solution** to the problem of space debris.



Biomaterial Composites for Space

Materials used in space are chosen to withstand extreme temperatures, radiation and physical damage from meteoroids and other causes; however, they lack adaptability in dynamic conditions.⁷³ Around 83% of orbital debris is concentrated in low Earth orbit – 73% from satellites and rocket bodies – and, in terms of destructive energy, a 10 cm object moving at orbital velocity (in space) is equivalent to a 250 kg object moving at highway speed on Earth.⁷⁴ Such debris can cause considerable physical damage. Biomaterials offer a potentially more sustainable, yet durable, solution to the problem of space debris. Bamboo fibre (with six times steel's strength-to-weight ratio), basalt fibre (with a thermal stability of up to 1,600°C) and spider silk (with exceptional elasticity) can be incorporated into space-grade composites using genetic engineering and additive manufacturing.⁷⁵ With AI-driven sensors for real-time damage detection and autonomous repair,⁷⁶ these materials could enable self-healing satellites and rocket bodies that biodegrade naturally post-mission.⁷⁷

Aerospace Circular Economy

The total number of commercial planes (active and in storage) worldwide is approximately 35,550, with 15% in storage and likely candidates for recycling.⁷⁸ An ongoing commercial plane shortage, expected to persist until 2034, keeps older models flying longer, although many are expected to reach the end of their operational life within the next decade.⁷⁹ More broadly, over the next 20 years, more than 13,000 aircraft across the commercial, military and private sectors (44% of the global fleet), traditionally parked in desert 'boneyards', will present a major opportunity for sustainable recycling and recovery.⁸⁰ Catalytic conversion offers a breakthrough solution. This low-temperature chemical process uses various catalysts to break down plastics and composite materials into reusable hydrocarbons without harmful emissions.⁸¹ With a strong return on investment within one to two years,⁸² catalytic conversion neutralises heavy metals and could reduce the hazardous waste produced by the traditional aerospace recycling process by up to five times.⁸³

35,550
commercial planes worldwide

15%
likely candidates for recycling





MEGATREND

2

Boundless Multidimensional Data

As technology advances – quantum computing, blockchain, the Internet of Things (IoT), edge computing, automation, digital realities and more – data will become both more constant and more multidimensional. It will be more available within, and for, governments, businesses and society, in larger volumes and at greater speeds. With options enhanced by 5G, 6G and uninterrupted connectivity through multiple networks, including satellites, access to real-time analytics and insights will improve. Solutions will be developed to minimise the environmental impacts of data capture, transmission and storage.

Areas of Future Opportunity (Past Editions)

Unlocking Value with Cross-Border Open Data (2023)

Big Data Analytics (2023)

Synthetic Datasets (2023)

Bioinformatics (2024)

Data for Climate Accountability (2024)

Data Cooperatives for Insights (2024)

Preparing for 6G (2025)

Multimodal Explainable Artificial Intelligence (2025)

Sports Artificial Intelligence (2025)

Keywords

AI Governance

Cross-Border Data Flows

Data Sovereignty

Digital Economy

Edge Computing

General Data Protection Regulation (GDPR)

Neural Data

Neurotech

Smart City Data Governance

Space-Based Data Centres

Things to Look Out for in the Short-Term



Global Data Regulatory Fragmentation

Some 79% of countries around the world now have data protection laws.⁸⁴ However, regulatory frameworks are fragmenting as nations individually try to balance AI governance with privacy and data security needs.⁸⁵ These developments will reshape data sovereignty and competition,⁸⁶ creating complex compliance landscapes.



Data Centre Financing

By 2027, 25% of new global computing capacity will come from local data centres, risking the stranding of existing global data centre assets currently providing that capacity.⁸⁷ Commercial mortgage-backed securities and asset-backed securities have jointly financed over \$50 billion in data centres in the past five years.⁸⁸ However, this is still less than the more than \$900 billion in investment needed through to 2029, and asset-backed securities alone are expected to reach \$40 billion in financing in 2026.⁸⁹



Neural Data Governance

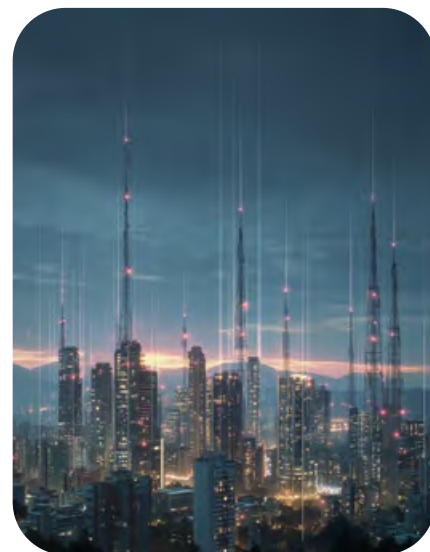
UNESCO's member states adopted a recommendation on neurotechnology (neurotech) in November 2025.⁹⁰ While it is not legally binding, it is a global first for ethical standards in neurotech and designates neural data as highly protected, with mandatory transparency and explicit consent for wearables (such as headbands and headphones) that read brain signals.⁹¹ This area is expected to expand, with possible overlaps as neurotech ethics is integrated into national AI governance frameworks.⁹²



Areas of Future Opportunity

Frictionless Cross-Border Data Flows

Jurisdictions around the world, from California to Japan and from Canada to Brazil, are adopting regulatory frameworks similar to the European Union's General Data Protection Regulation (GDPR). The Middle East and North Africa region is starting to impose strong cross-border data rules, and AI laws will make compliance increasingly important.⁹³ Such measures are adding friction to cross-border flows, yet the digital economy makes up 17.3% of global gross domestic product (GDP), worth approximately \$20 trillion in 2025.⁹⁴ Cross-border data flows are vital in supporting the global economy. Indeed, if every country were to restrict its data flows, global GDP could drop by 4.5%.⁹⁵ Nevertheless, empirical analysis shows that eliminating data flow regulations would not be the optimal solution.⁹⁶ Combined with trust, data flows across borders could lead to a 1.8% growth in global GDP and a 3.6% growth in exports.⁹⁷ In the future, it will be vital to have automated systems that optimise data routing and processing across jurisdictions while maintaining compliance with diverse sovereignty, privacy and security rules.



Space-Based Data Centres

Even after accounting for carbon emissions from rocket launches, space-based data centres could reduce the carbon footprint of data processing by up to 10 times.⁹⁸ The Y combinator-backed space technology start-up Starcloud (previously Lumen Orbit)⁹⁹ launched its first satellite in partnership with Nvidia's Inception programme with large solar arrays and advanced cooling systems.¹⁰⁰ In 2026 it raised \$170 million at a \$1.1 billion valuation, bringing its total funding to \$200 million.¹⁰¹ In 2025, China launched the first of 12 out of a planned 2,800 satellites intended for in-orbit data processing.¹⁰² In the UAE, also a space technology start-up, Madari Space plans to launch its first mission in 2026,¹⁰³ with stated ambitions for a large-scale orbital data centre constellation by 2028.¹⁰⁴ The EU's ASCEND feasibility study aims to achieve proof of concept in 2031.¹⁰⁵ In 2026, Google announced discussions with SpaceX exploring launches supporting Project Suncatcher, Google's orbital data centre project, which has a prototype planned for 2027.¹⁰⁶ However, despite the momentum, challenges remain, including high launch costs, space debris, radiation exposure, difficulties of repair and solar flares.¹⁰⁷

Semiconductor Cluster Hubs

The global semiconductor market is expected to reach \$1 trillion by 2030, with the computing industry accounting for 41%.¹⁰⁸ While publicly stated numbers vary, GlobalFoundries, Intel, Samsung, the Smart Manufacturing Innovation Centre and the Taiwan Semiconductor Manufacturing Company are the key manufacturers of 7 nm (and below) chips, which are critical for AI.¹⁰⁹ Building semiconductor foundries typically costs around \$20 billion and potentially up to \$40 billion.¹¹⁰ While the UK has opted for a design-and-outsource production model,¹¹¹ the EU is pushing for regional manufacturing through its Chips Act (2023).¹¹² Innovation hubs can develop ecosystems that serve as regional distribution hubs to capture value from the semiconductor supply chain through logistics, testing and integration services.



The global semiconductor market is expected to reach

\$1 trillion
by 2030.



MEGATREND

3

Technological Vulnerabilities

New technological vulnerabilities and threats are inevitably arising from advances in biotechnology, gene editing, precision agriculture, widespread digitalisation and automation, multimodal AI, and the spread of wearables and the Internet of Things (IoT). Some of these vulnerabilities and threats are becoming more severe, frequent and complex, crossing technological, industrial and geographical boundaries. Some, as with biotechnology, are also crossing biological boundaries. Cybercriminals are more organised, using AI to coordinate and commit crimes. More innovative approaches to identifying, assessing and addressing vulnerabilities will be key.

Areas of Future Opportunity (Past Editions)

Artificial Intelligence and Quantum Encryption (2023)

Cyberbiosecurity (2023)

Cybersecurity for Small Businesses and Charities (2023)

Cyber-Risk Insurance (2024)

Cybersecurity for the IoT (2024)

Protecting Against Cyber-Physical Attacks (2024)

Incorporating Psychology into Cybersecurity (2025)

Cyberbiosecurity Awareness and Education (2025)

Balancing Interoperability with Cybersecurity (2025)

Keywords

AI-Enabled Cyberattacks

Data Breaches

Deepfakes

Digital Heritage Collections

Digital Identity

Internet of Medical Things (IoMT) Cybersecurity

Legacy Systems

Post-Quantum Cryptography

Quantum-Resistant Security

Shadow AI

Things to Look Out for in the Short-Term



Deepfake Threats

In May 2024, deepfake attacks targeted the CEOs of Accenture¹¹³ and WPP, the latter being the largest advertising group in the world.¹¹⁴ While both of these attempts were unsuccessful, the global engineering firm Arup lost \$25.5 million in a similar attack.¹¹⁵ With losses from deepfake fraud in the first quarter of 2025 reaching \$200 million, AI-enabled fraud losses are expected to increase to \$40 billion by 2027.¹¹⁶ Interestingly, while humans detect real-world deepfakes at 55–60% accuracy, automated systems drop 45–50%.¹¹⁷



Roadmaps for Quantum-Related Cybersecurity

Only 9% of technology leaders have a roadmap in place for post-quantum cryptography (PQC).¹¹⁸ Quantum computing is expected to pose encryption risks within three to five years, yet companies take an average of three to four years just to move from awareness to a strategic PQC roadmap.¹¹⁹



AI Threats

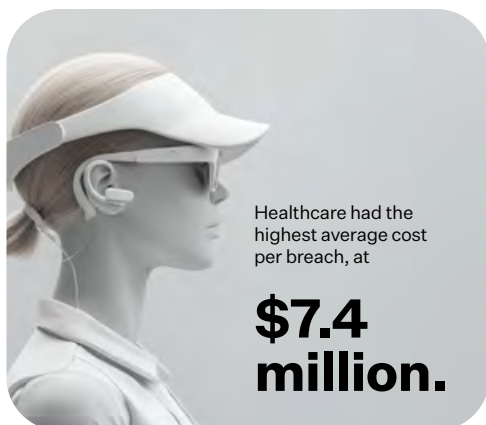
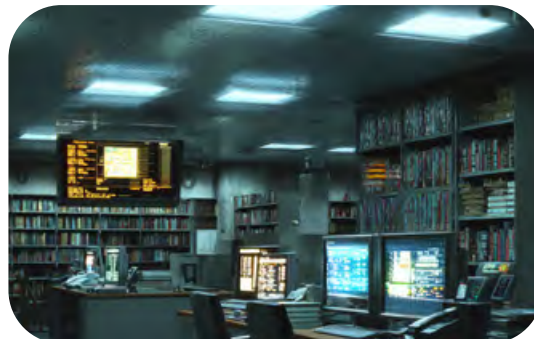
Between March 2024 and February 2025, one in six data breaches involved attackers using AI.¹²⁰ Organisations using AI and automation shortened breaches to 204 days compared with 284 days for those that did not, saving \$1.9 million.¹²¹ Some 97% of organisations that experienced an AI-related breach lacked proper AI access controls.¹²² Additionally, 20% suffered a breach due to shadow AI – AI used without organisational approval or oversight – adding \$670,000 to the average breach cost of \$4.4 million.¹²³



Areas of Future Opportunity

Cyber-Safe Cultural Assets

It took 11 weeks for the British Library to restore its main online catalogue (containing 36 million records of printed and rare books, maps and journals) after a cyberattack in 2023.¹²⁴ As of December 2025, more than two years later, it still had not fully recovered,¹²⁵ losing \$9.4 million^F, approximately 40% of its reserves.¹²⁶ While the British Library's case may have been unusual at a time before the rise of automated cybersecurity, it is essential for libraries, museums and archives to have access to specialised cybersecurity to protect irreplaceable digital collections and legacy systems.¹²⁷

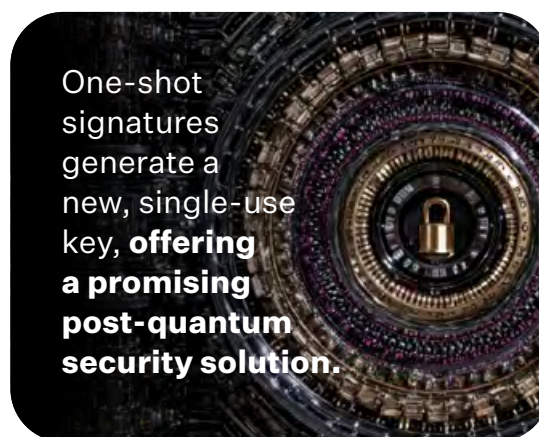


Securing the Internet of Medical Things

There are 500,000 medical technologies that currently impact people's health and quality of life.¹²⁸ The Internet of Medical Things (IoMT) comprises specialised medical devices that range from simple wearables, such as smartwatches and fitness trackers, to implantable devices, such as pacemakers, insulin pumps and life-critical infusion pumps.¹²⁹ In 2025, healthcare had the highest average breach cost at \$7.4 million per breach.¹³⁰ The closer devices get to the end of their life, when they may lack security patches, the more exposed they become to attacks.¹³¹ As IoMT cyberthreats erode patient safety, patient privacy, regulatory compliance¹³² and more importantly trust,¹³³ cybersecurity strategy is key. The healthcare cybersecurity market may grow to \$32.9 billion by 2028.¹³⁴

Quantum Secure Identity

As quantum computing continues to advance, classic digital signatures, including elliptic curve cryptography and the Rivest–Shamir–Adleman algorithm, will become vulnerable to quantum attacks.¹³⁵ One-shot signatures offer a promising post-quantum solution, enabling single-use quantum keys in both traditional and quantum machines.¹³⁶ However, challenges remain: secure coding systems that convert inputs into a unique digital fingerprint will need to be rebuilt from scratch; methods to hide how quantum encryption works are not yet established; and enabling practical applications across blockchain, decentralised finance and digital identity management will present both challenges and opportunities.¹³⁷



^F Based on the GBP:USD exchange rate of 11 July 2026



MEGATREND

4

NEW

Redefining Finance and Monetary Systems

Driven by shifting investor priorities, generational values and technology, the definitions of value, money and investment are evolving. Financial infrastructure is transforming how we allocate capital, manage finance, and process payments in daily work and life. Competing forms of digital money across centralised, decentralised and hybrid models are enabling this megatrend, while asset types are diversifying into physical, digital and tokenised forms. Existing and new non-bank institutions will continue to reshape access to credit and investment. Meanwhile, the interplay of cross-border flows, varying regulatory frameworks and real-time analytics will redefine net worth, income, how we pay for goods and financial innovation. See Box 4 for more.

Keywords

Algorithmic Asset Value
Anti-Money Laundering and Combating the Financing of Terrorism
Central Bank Digital Currency
Financial Literacy
Intangible Assets
Intelligent Banks
Know Your Customer (KYC)
Real-World Assets
Stablecoins
Tokenisation

Things to Look Out for in the Short-Term



Tokenisation X

Tokenisation is the creation of a digital representation of a financial or physical asset.¹³⁸ Examples include stablecoins, central bank digital currencies (CBDCs), bank-issued tokenised deposits,¹³⁹ tokenised real estate,¹⁴⁰ art¹⁴¹ and other real-world assets.¹⁴² While projections vary, the market for real-world tokenised assets could reach \$30 trillion by 2034.¹⁴³



Intangible Assets Beyond Intellectual Property

Value creation is shifting from traditional intellectual property (such as patents, trademarks and copyrights) to other intangible assets (such as data, algorithms and know-how).¹⁴⁴ Most large companies' intangible assets have a higher value than their tangible assets, yet 94% of these companies do not have formal processes to commercialise them.¹⁴⁵ Annual intangible investments have grown two and a half times faster than physical investments, reaching \$10 trillion in the last ten years (2015-2025), with Sweden leading the way at 17.5% of gross domestic product (GDP).¹⁴⁶



Growing Interest in Stablecoins

Between July 2023 and July 2025, the total stablecoin market capitalisation climbed from \$125 billion to \$255 billion, with 90% concentrated among two issuers.¹⁴⁷ Dollar-backed stablecoins now make up 98% of the global market and have grown to over \$300 billion in value, and more than 300 active coins.¹⁴⁸ This topic has become particularly important with the signing into law of the Guiding and Establishing National Innovation for US Stablecoins (GENIUS) Act in the USA in July 2025.¹⁴⁹



BOX

4

The Future of Finance and Monetary Systems as a Megatrend

When we launched The Global 50 in 2022, we noted that while 10 megatrends had been identified, our annual review would reflect how megatrends shift over time. Megatrends are research-led thematic paths relevant for a decade or so, interrelated and shaped by day-to-day signals across all aspects of work and life. Megatrends are dynamic and may evolve. This year's change reflects this approach.

Several global trends have caught our attention in the past few years, particularly in 2025, highlighting that future finance and monetary systems have already entered a decade of significant transformation. This shift is not trivial and it is appropriate to consider it a megatrend as it shapes daily work and life. Megatrends represent patterns evolving from global trends that are likely to impact economies and societies globally. They are plausible, relevant over the next decade and evidence based.

Finance and monetary systems encompass payment settlement and transfers, monetary policy implementation, credit and lending, reconciliation and clearing, compliance and monitoring, and asset and collateral management.¹⁵⁰ Without efficient and effective finance and monetary systems, the implications for growth, prosperity and well-being will be significant, including devaluation of assets, increasing inequality, and financial fragmentation and fragility.

Key stakeholders include central banks, commercial banks, non-bank financial institutions, financial markets and technology providers. These rely on effective asset management, data and information, regulatory frameworks, and technology infrastructure.¹⁵¹ At the heart of it all is trust; over the next decade, a big area of focus will be the foundational requirement for finance and monetary systems to seamlessly enable everyday work and life.¹⁵²



Key Global Trends and signals that Will Shape the Future of Finance and Monetary Systems as a Megatrend

(non-exhaustive)



Tokenisation and Digital Assets

Over 20 government-related bonds tokenised worth more than \$4 billion across nine currencies¹⁵³

While estimates vary, tokenised assets could reach up to \$30 trillion by 2034¹⁵⁴



Unified Ledgers, CBDCs and Digitalisation of Central Banks

91% of 93 central banks recently surveyed by the Bank of International Settlements (BIS) were exploring CBDCs,¹⁵⁵ representing 94% of global GDP¹⁵⁶



Technology-Driven Innovation (AI/Blockchain/FinTech)

80% of global financial technology firms (FinTechs) are implementing AI¹⁵⁷ and 75% reporting cost reductions¹⁵⁸



Global Financial Infrastructure Fragmentation

80% of Organisation for Economic Co-operation and Development (OECD) economies are screening investments¹⁵⁹

Cross-border portfolios are down 15% because of geopolitical tensions¹⁶⁰



World Reserve Currency

The US dollar has declined from 71% (1999)¹⁶¹ to 57.1% (Q1 2026) of global reserves,¹⁶² signifying a possible shift towards a more multipolar monetary system.



The Shift in Payment Systems and Investment Assets

While nearly 90% of cross-border payment instructions go through SWIFT,¹⁶³ stablecoin transaction volumes have reached \$14.7 trillion in the last 12 months¹⁶⁴ — a possible emerging alternative.



Increasing need for Sustainable Finance and Infrastructure Investments

\$120 trillion is needed for energy infrastructure over 25 years (2% of global GDP annually)¹⁶⁵

Green bond tokenisation enables environmental, social and governance tracking and real-time reporting (e.g. the National University of Singapore's \$340 million blockchain pilot within the Monetary Authority of Singapore regulatory sandbox)¹⁶⁶



The Focus on Cyber Resilience and Systemic Risks

46% of global fintechs are using AI for fraud detection¹⁶⁷

The average breach cost in the financial industry between 2024 and 2025 was \$5.56 million (ranked second globally as an impacted sector) compared with a global average of \$4.44 million¹⁶⁸



The Future of Income and evolving Patterns of Wealth Distribution and Financial Inclusion

Top 1% of individuals globally hold 38.5% of global wealth today, projected to rise to 46% in 2050¹⁶⁹

Globally, 1.3 billion adults do not have their own bank account¹⁷⁰ and even when access is provided, 30% of bank accounts in non-OECD countries are dormant and 68% of mobile money accounts are inactive¹⁷¹



Areas of Future Opportunity

Cross-Border Stablecoin Regulation

Stablecoins vary in market capitalisation, adoption levels and degree of interconnectedness within a financial system.¹⁷² For example, two of the largest stablecoins represent around 90%¹⁷³ of the \$312 billion stablecoin market,¹⁷⁴ stablecoins more generally integrated across crypto trading, tokenised asset markets, payment systems and other areas. This presents opportunities for regulatory framework development, particularly in cross-border transactions, given stablecoins' market capitalisation and link to the US dollar.¹⁷⁵ International coordination is needed¹⁷⁶ to establish standards for reserves, redemption, anti-money laundering and countering the financing of terrorism (AML/CFT) compliance, monitoring systems, stress-testing and interoperability protocols.¹⁷⁷ These developments should address stablecoins' borderless nature and the increasing role of non-bank institutions – institutions that often operate without the strict oversight applied to traditional banks.¹⁷⁸ This regulatory gap is particularly important as an estimated \$129 billion (84% of \$154 billion in illicit transactions) in stablecoins was involved in illicit activity in 2025, representing about 41% of these currencies' total year-end market capitalisation.¹⁷⁹



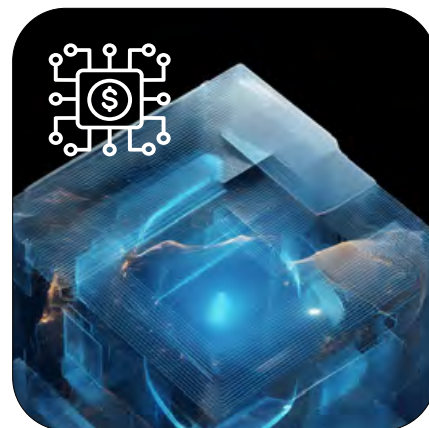
Next-Generation Financial Literacy

According to a 2023 survey conducted by the OECD, the average financial literacy score is only 60%, with an average of 53% for digital financial literacy,¹⁸⁴ and overall, 41% of people are aware of cryptoassets.¹⁸⁵ However, countries vary considerably in this regard: Spain scores highest at 84%, whereas Malaysia scores 16%, France 15% and Indonesia 3%.¹⁸⁶ Globally, only 3.2% of adults hold cryptoassets, and only 41% say that they know that cryptoassets do not have the same legal status as bank notes and coins.¹⁸⁷ Generation Z (born 1997–2012)¹⁸⁸ has even lower overall financial literacy than older generations.¹⁸⁹ As the financial landscape evolves, new instruments and investment mechanisms will emerge that will require the definition of financial literacy to evolve. This will echo the evolution of financial literacy from managing budgets, protecting against scams, and saving and planning for the future¹⁹⁰ to understanding new asset classes, digital money and programmable money.¹⁹¹

Managing the Rise of Intelligent Banking

Many banking institutions rely on legacy systems that are incompatible with AI, requiring infrastructure investment and cultural change. By adopting incremental, agile approaches with security-first designs, banks can enable transformation through pilot projects.¹⁸⁰ Once integrated, AI enables real-time transaction monitoring, immediate fraud detection, and automated know-your-customer checks and onboarding, while generative AI provides financial case summaries to aid decision-making.¹⁸¹

In contrast, legacy systems are slow, inflexible and time-consuming; lack application programming interfaces and real-time information; often contain data silos; and are subject to quality concerns.¹⁸² There are opportunities to enable this transition, and opportunities will also be present in the need to protect this new, complex network, which will come with its own systemic risks. For example, many organisations cannot fully explain or validate model outputs, and there may be issues with interoperability across jurisdictions with different sets of legal and regulatory boundaries and local trends and behaviours.¹⁸³





MEGATREND

5

Evolving Ecosystems

Driven by resource scarcity, climate change and shifts in social values, environmental impact management will increasingly focus on ecosystems as opposed to the environmental impact of specific processes, products or services. Approaches will be more interdisciplinary, with a focus on future impact. They will also consider both societal and environmental factors, with the primary goal of regenerating or conserving biological and ecological services and resources while providing for basic human needs.

Areas of Future Opportunity (Past Editions)

Green Finance (2023)
Smart Sustainable Cities (2023)
Environmental, Social and Governance (ESG) Marketplaces (2023)
Carbon Neutrality Everywhere (2024)
Climate in Education (2024)

Supply Chains as an Ecosystem (2024)
All Things Regenerative (2025)
Acoustic Artificial Intelligence for Ecosystems (2025)
Internet of Underwater Things (IoT) (2025)

Keywords

Biodiversity
Bioeconomy
Carbon Mapper
eDNA and eRNA
Green Building Codes
Greenhouse Gases
Net Positive
Net Zero
Overfishing
Satellites

Things to Look Out for in the Short-Term



Carbon Mapper Satellites

The California-based non-profit Carbon Mapper continues to launch satellites for space-based monitoring of greenhouse gas emissions and, more specifically, methane and carbon dioxide.¹⁹² It enabled the Tanager-1 satellite of NASA's Jet Propulsion Laboratory,¹⁹³ which was fitted with a fifth-generation imaging spectrometer and launched in 2024.¹⁹⁴ With three more 'Tanager' satellites planned,¹⁹⁵ there will be a constellation capable of detecting 80% of global methane and carbon dioxide emissions.¹⁹⁶



Biodiversity Economy

Over 50% of Europe's protected habitats and species have a poor conservation status.¹⁹⁷ Over 75% of emerging infectious diseases, such as Ebola disease and Nipah virus infection, arise in areas where ecosystems and biodiversity have been disrupted.¹⁹⁸ A biodiversity economy places conservation, restoration and sustainable use of nature at the centre of economic growth. Only 16 countries have implemented such a policy in practice, though nearly 60 have developed one.¹⁹⁹ Momentum will grow in 2026 as the G20 and the Food and Agriculture Organization make progress on 10 bioeconomic standards.²⁰⁰



Management of Marine Fish Stocks

The most comprehensive global evaluation of fish stocks by the Food and Agriculture Organization of the United Nations (FAO) shows that 64.5% of 2,570 marine stocks are being fished sustainably, while 35.5% are overfished.²⁰¹ However, this evaluation also shows that strong management techniques work; for example, 92.7% of stocks in the north-east Pacific, and 85% in the south-west Pacific, are sustainably fished.²⁰² With improved monitoring, more regions can replicate these gains.



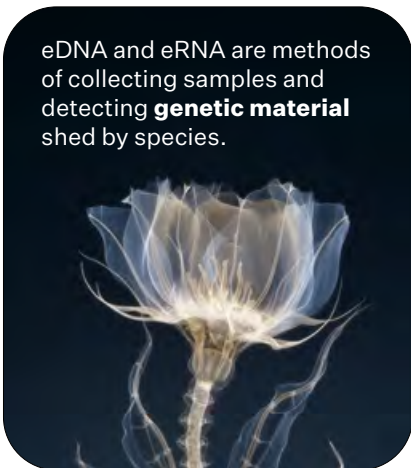
Areas of Future Opportunity

From Green Building Codes to Climate Building Codes

Building codes need to start looking beyond net zero commitments. Future climate scenarios suggest that homes and other structures built today need to be designed for substantially different climates. As things stand, these buildings are likely to last only 10 to 80 years – much less in the hot Gulf Cooperation Council countries, even those with new building codes.²⁰³ Many cities have adopted green building codes and other construction-related codes, but these need to evolve from using green building standards to focusing on climate-resilient standards. For example, Japan's Net Zero Energy Building Roadmap mandates that all buildings meet net zero standards by 2030; however, without major upgrades, it is unlikely this will be achieved.²⁰⁴



eDNA and eRNA are methods of collecting samples and detecting **genetic material** shed by species.

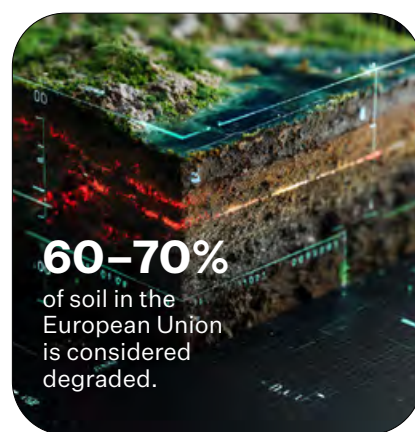


Global eDNA and eRNA Networks for Biodiversity Tracking

Traditional biodiversity assessments are labour intensive, expensive, seasonally restricted, and potentially harmful to both species and the environment. Environmental DNA (eDNA) and environmental RNA (eRNA) methods are a more cost-effective alternative for continuous monitoring.²⁰⁵ Based on collecting samples and detecting genetic material shed by species into water, soil or sediment,²⁰⁶ they allow detection without direct capture or ecosystem disturbance.²⁰⁷ Such monitoring could help to identify pathogens that impact biodiversity and, by extension, even human pandemics, as 60% of emerging human diseases are zoonotic (i.e. transferred from animals to humans), 70% of which originate from wildlife.²⁰⁸ Global eDNA and eRNA networks could improve biodiversity conservation by creating large datasets across ecosystems worldwide, helping to provide a baseline against which other similar environments could be compared.²⁰⁹ This widespread tracking of pathogens over space and time could lead to the formation of an advanced warning system for outbreaks.²¹⁰

AI-enabled Mapping of Soil Ecosystems

Soil is non-renewable²¹¹ and contains up to half of Earth's biodiversity through its microbiota²¹² – bacteria, fungi and other microorganisms critical for agricultural systems. Despite 95% of the global food supply depending on sustainable soil function, research indicates that (for example) 60–70% of soil in the European Union is considered degraded.²¹³ Traditional methods could identify about 1% of soil microbiota, but emerging technologies – including advanced microscopy, AI and robotics – could enable deeper insights.²¹⁴ Soil quality assessments have evolved from observing crop growth to physico-chemical analysis and, recently, identifying living microorganisms within the soil.²¹⁵ Beyond moisture measurement, advanced robotic sensors can scan soil samples and provide thousands of high-resolution images that AI can analyse to identify and map healthy fungal networks within soil.²¹⁶ Eventually, AI-enhanced microscopy could enable comprehensive analysis of full soil ecosystems within hours of sampling,²¹⁷ for faster identification and deeper understanding of soil degradation.





MEGATREND

6

Borderless World – Fluid Economies

Increasingly, unmediated transactions in finance, health, education, trade, services and even space are blurring jurisdictional boundaries, shifting liabilities, and creating larger numbers of cross-border communities and networks. Advances in communications, computing and advanced machine intelligence will accelerate a borderless world that will change the way we work, live and communicate.

Areas of Future Opportunity (Past Editions)

Legal Transformation (2023)
Expanding the Digital Economy (2023)
Supranational Social Policies (2023)
Collaborative Patents (2024)
Software Development for Interoperability (2024)

'Global Social Responsibility' (2024)
Global Cooperation for Cross-Border Digital Asset Regulation (2025)
Exploring Artificial Intelligence Personhood for Legal Boundaries (2025)
Transdisciplinary Education for Global Innovation (2025)

Keywords

Air Freight
Algorithmic Risks
Blockchain
Decentralised Autonomous Organisations
Digital Public–Private Partnerships
Global Commons
Global Trade
Intellectual Property Non-Fungible Tokens
Open Innovation
Prize Competitions

Things to Look Out for in the Short-Term



Global Trade Uncertainty

Trade policy uncertainty was a constant in 2025.²¹⁸ Primarily driven by US-led policy shifts that expanded the use of tariffs (ranging from 10% and 145%) to more countries and sectors,²¹⁹ these fluctuations triggered market reactions and global responses that have driven the World Policy Uncertainty Index and the World Trade Uncertainty Index to their highest levels since 2020.²²⁰ As a result, global trade restructuring will likely continue as India, Gulf Cooperation Council countries and the Association of Southeast Asian Nations pursue partner diversification.²²¹



Air Cargo Shifts

Global air cargo continues to grow in demand from approximately 20 billion cargo tonne-kilometres (CTK) in 2017 to just over 24 billion cargo tonne-kilometers (CTK) in 2026 (May data).²²² Demand is expected to continue expanding due to increased e-commerce flows from Asia to North America, from Europe to Asia, and within Asia.²²³ At the same time, the 2026 maritime shipping route disruptions have further intensified these shifts, with air freight rates rising by as much as 70% on some routes.²²⁴



Rise of Cross-Border Open Innovation

AI may unlock up to \$560 billion in value from R&D annually and could double the speed of R&D in science and software.²²⁵ Open innovation – recognised by the National Aeronautics and Space Administration (NASA)²²⁶ and others²²⁷ as a key mechanism for sourcing ideas outside an organisation – may grow as companies look for insights with, and beyond, AI.²²⁸ Open innovation can boost progress, enable crowdsourcing, build communities,²²⁹ and help organisations further their corporate social responsibility objectives.²³⁰



Areas of Future Opportunity

Cyberspace as a Global Commons

The digital economy's growth calls for a reconceptualisation of territorial, jurisdictional and temporal boundaries. This shift positions cyberspace – the interconnected system of networks, computer systems, the internet and infrastructure that enables digital connectivity²³¹ – as a global commons. A global commons is an area of shared resources beyond national jurisdictions²³² – for example, the Antarctic, oceans and outer space.²³³ However, there is a risk of cyberspace-related resources being overused by some at the expense of others.²³⁴ Research on outer space, for example, demonstrates that the idea of shared resources does not play out in the legal agreements, treaties and contracts governing space activities.²³⁵ Establishing cyberspace as a global commons requires four key steps: identifying common principles, operationalising those principles, navigating buy-in for effective governance frameworks and empirically documenting current practice. This includes examining whether cyberspace is already treated as a global commons in treaties, bilateral agreements, memoranda of understanding, industry standards, and multi-stakeholder frameworks such as the Internet Corporation for Assigned Names and Numbers and the Internet Governance Forum.²³⁶



Decentralised science

allows scientists around the world to collaborate without central control.



DeSci for Cross-Border Scientific Collaboration

Decentralised science (DeSci) is an opportunity to reimagine cross-border scientific collaboration by addressing barriers such as lack of transparency, gatekeeping of funding and knowledge, and restrictive intellectual property frameworks.²³⁷ By leveraging blockchain, smart contracts, and decentralised autonomous organisations, DeSci can be used to govern the distribution of research funding and create transparent, equitable ecosystems for international research cooperation. DeSci enables scientists around the world to collaborate through decentralised protocols that distribute research tasks and share expertise without geographical constraints, offer transparent governance mechanisms, and offer flexible participation through tokenised models such as intellectual property non-fungible tokens (NFTs). This ecosystem ensures secure data storage and peer-to-peer verified funding.²³⁸ More importantly, it allows scientists to follow a set of shared values,²³⁹ building trust and focusing on research rather than governance.

Sustainable Digital Public–Private Partnerships

Digital Public-Private Partnerships (DPPPs) are hybrid forms of cooperation that enable the flow and use of digital resources, including data, algorithms and computing capacity. They aim to balance public value creation, private innovation and regulatory legitimacy. Unlike traditional public–private partnerships, which focus on building and financing physical infrastructure, DPPPs treat shared digital resources and services as strategic factors of production. Examples include digital diagnostics, mobility as a service and digital ID systems. Such agreements already exist at the project level, such as Microsoft's support of the World Health Organization during the COVID-19 pandemic, through its provision of digital solutions to provide platforms for clinical trials and through its support in gathering and organising national-level health data.²⁴⁰ With continued growing digitalisation around the world, a key area of opportunity is to find mechanisms that can help stabilise DPPPs in the long term without limiting innovation.²⁴¹ It will also be necessary to coordinate legal and regulatory systems to ensure both institutional legitimacy and international competitiveness so that these hybrid structures can be established, maintained and transferred effectively.²⁴²



DPPPs are

hybrid forms

of cooperation that enable the flow and use of digital resources, including data, algorithms and computing capacity.



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Digital Realities

Digital natives – those who have grown up with digital forms of entertainment, education and communication – will naturally usher in increasingly virtual 3D and 4D worlds where many ‘real-world’ tasks and behaviours can be replicated and potentially even improved. The emergence and spread of 5G and 6G networks will enhance autonomous applications as these technologies offer more reliable, cost-effective and secure high-speed connectivity, which enables real-time analytics and decision-making. As quantum technologies, such as quantum computing, communications and sensors, become scalable and reliable, immersive experiences will start to feel like reality.

Areas of Future Opportunity (Past Editions)

Immersive Technologies and Wearables (2023)
Virtual Prototyping (2023)
‘Digital Realities’ Social Responsibility (2023)
Enhancing the Digital with the Physical (2024)
‘Green’ Digital Realities (2024)

Generative ‘Realities’ (2024)
Growing the Digital Theatre (2025)
The Virtual–Real Self Divide (2025)
Evolving Acceptance of Augmented/
Virtual Reality Headsets (2025)

Keywords

6G
Augmented Public Spaces
Cognitive Load Theory
Digital Escapism
Digital Twins
Graphics Processing Unit
Inclusion
Latency
Smart Glasses
Tensor Processing Unit

Things to Look Out for in the Short-Term



Advancing Commercialisation of 6G

The International Telecommunication Union’s 6G network standardisation efforts are intended to make commercial 6G systems available by 2030²⁴³ while responding to concerns from the International Air Transport Association about interference.²⁴⁴ It is anticipated that 85% of mobile data will be transmitted through 5G by 2031 compared with 48% at the end of 2025.²⁴⁵ More broadly, 6G will deliver greater speed and enable digital twins and enhanced connectivity for Internet of Things (IoT) sensor networks and devices.²⁴⁶



Augmented Public Spaces

Meta, which dominated the smart glasses space with a 70% global market share in 2026,²⁴⁷ will face growing competition, such as Huawei’s Eyewear 2²⁴⁸ and Warby Parker and Google’s smart glasses powered by AI.²⁴⁹ Despite potential growth from 2.7 million units sold in 2024 to 18.7 million units by 2029 (nearly seven-fold increase in five years), the market remains small compared with the 1.09 billion mobile phones expected to be sold by the end of 2026.²⁵⁰ Privacy concerns will persist.²⁵¹



Prescription Digital Escapism

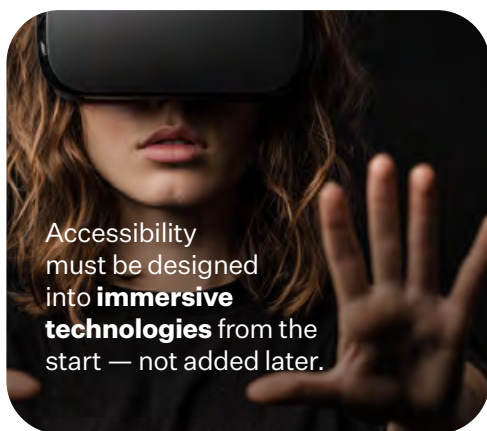
We are increasingly reliant on AI.²⁵² Connectivity is reaching areas that were previously offline, and 94.7% of all internet users have adopted social media.²⁵³ Rather than complete disconnection or unmanaged escapism,²⁵⁴ prescription-based digital therapeutics may increasingly address digital wellness in, and beyond, 2026. These options can monitor stress patterns, adapt interventions, and set personalised boundaries between connectivity and rest.²⁵⁵ The US Food and Drug Administration has authorised 13 prescription digital therapeutics²⁵⁶ and approved 192 digital therapeutics applications.²⁵⁷ Austria, Belgium, France and Germany are integrating them into their national healthcare systems.²⁵⁸



Areas of Future Opportunity

CLT-Guided Immersive Realities

Cognitive load theory (CLT) helps explain how the human brain processes information during learning, informing instructional design approaches.²⁵⁹ Its key concepts are intrinsic load (the difficulty of the content), extraneous load (the quality of the instructional design) and germane load (the amount of effort needed to process information to achieve lasting knowledge).²⁶⁰ CLT aims to find a delicate balance between these concepts and manage the demands on a learner's working memory.²⁶¹ As such, CLT can be used as a basis for (re) designing or assessing immersive experiences to optimise user engagement and effectiveness.

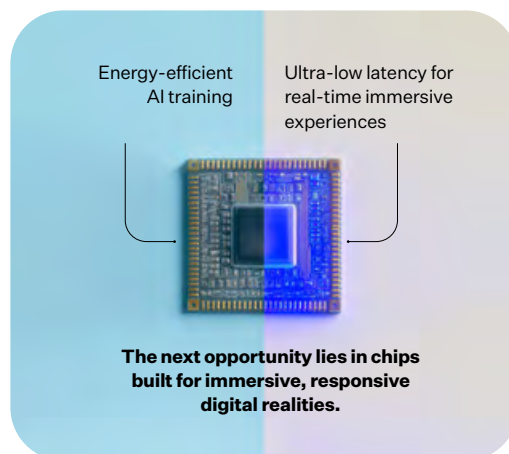


Immersive Realities for All

Disabled people are among the world's largest minority groups, making up one in six individuals.²⁶² Immersive experiences can build public awareness about barriers that disabled people face, increasing the social inclusion of marginalised groups.²⁶³ Furthermore, it is important to ensure that immersive technologies are accessible to disabled people as users. In education, training and social contexts, there is a risk of excluding disabled people if accessibility is not embedded from the start. Inclusive design principles for immersive experiences co-developed with disabled people across a range of experiences can prevent emerging technologies from reintroducing the very exclusions they originally intended to address.²⁶⁴

Advanced Chips for Digital Realities

In next-generation digital realities, immersive experiences are seamless, realistic and responsive, blurring the line between the physical and the digital.²⁶⁵ This requires specialised processors optimised for such use. Tensor processing units (TPUs) have gained attention²⁶⁶ as they are energy efficient and less dependent on critical minerals compared with traditional graphics processing units (GPUs).²⁶⁷ Their production is projected to more than double by 2028, with AI companies (such as Anthropic, which alone is buying around a million units) considering them for the future.²⁶⁸ However, TPUs are more effective for training AI models than for running real-time immersive experiences, which need varied inputs²⁶⁹ and low latency (under 20 milliseconds).²⁷⁰ This creates an area of future opportunity for advanced GPU chips that have low latency and the ability to interpret neural signals together with hardware-based security²⁷¹ to deliver experiences quickly enough to maintain immersion.²⁷²





Life with Autonomous Robots and Automation

Driven by advances in mechanical engineering design, materials science, advanced machine intelligence, and advanced communication networks, robots will increasingly expand into other industries beyond the automotive, manufacturing and supply-chain logistics sectors. The use of robots and automation will provide greater opportunities for efficiency and innovation while presenting ethical and societal challenges around autonomy, decommissioning and the future of work. The growing numbers of robot-to-robot, human-to-robot and human-to-machine interactions will raise questions about intellectual property and robot rights.

Areas of Future Opportunity (Past Editions)

Complex Areas of Discovery, Big and Small (2023)

Increasing Human X Machine Collaboration (2023)

Intelligent, Social and Sentient Robots (2023)

Marine Robots (2024)

Robots for Climate (2024)

Enhancing the Social Impact of Robots (2024)

Biomimicry for Soft Robotics (2025)

Better Understanding of Human–Robot Interaction (2025)

Better Manufacturing Measured Through Robot Collaboration (2025)

Keywords

Agentic AI

AI Scaling

Cybersecurity

Embodied AI

Human Coordination

Humanoids

Risk Management

Robot Interoperability

Robotic Deployment

Swarm Robotics

Things to Look Out for in the Short-Term



Continued Adoption of AI

AI is already dominating technology budgets, consuming 36% of digital initiative budgets and competing with data architecture and cybersecurity, which are typically underfunded.²⁷³ It has proven challenging to link AI to revenue gains or cost reductions,²⁷⁴ and very few organisations report mature AI adoption.²⁷⁵ However, 74% of respondents to a global survey in 2025 said that AI was a top strategic priority, compared to 60% in 2024, with continued future adoption in customer service, marketing, productivity, software development, and worker productivity more generally.²⁷⁶



Rise of the Retail Humanoids

Deployment and adoption of humanoids is growing with the industry receiving \$2.5 billion in venture capital investments in 2024 and could reach \$5 trillion by 2050 and more than 1 billion units in use worldwide.²⁷⁷ As generative AI and sensor technologies advance, robots are gaining capabilities in intelligence, perception and handling²⁷⁸ that make them more adaptive.²⁷⁹ Growth will depend on battery life which currently run for two hours and expected to increase to six hours by 2030.²⁸⁰ Becoming more affordable, Noetix's Bumi costs \$1,400²⁸¹ (single fee) and 1X's NEO \$499 per month or \$20,000 (single fee)²⁸²



Expanding Risk Management for Agentic AI

By 2028, up to 15% of daily work, from cybersecurity to real-time systems monitoring, may be carried out by AI agents that act autonomously.²⁸³ Amazon Web Services maps agentic AI risk by identifying the extent of an AI's agency: none, prescribed, supervised or full.²⁸⁴ One survey found that 80% of organisations have already experienced increased operational risks from AI agents, ranging from unauthorised access to data exposure.²⁸⁵

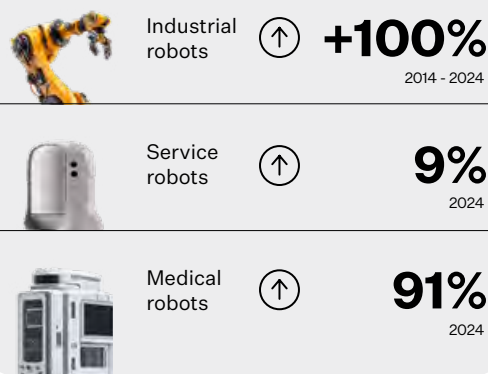


Areas of Future Opportunity

Standards for Robot Deployment

Despite advances in robotics, real-world deployment is still a challenge. Persisting hurdles include stability,²⁸⁶ flexible movement,²⁸⁷ energy efficiency and safe interaction with people and environments.²⁸⁸ Robots need to be adaptable enough to move from controlled laboratory environments to real-world scenarios where they must handle shifting environments and interactions on their own. A new cross-disciplinary field focused on deployment could look at the integration of design, control, learning and interaction with standardised benchmarking based on real-world performance (not just simulation metrics). Statistics from the International Federation of Robotics show that 542,000 industrial robots were installed in 2024 (more than double the number 10 years ago), with the total expected to grow beyond 700,000 in 2028.²⁸⁹ The number of service robots surged by 9% to nearly 200,000 units in 2024 and the number of medical robots increased by 91%.²⁹⁰

Robot Installations



Human-inspired behavioural

rules can make robotic swarms more predictable, interpretable and trustworthy.



Human-Mirrored Robotic Swarms

Swarm robots are decentralised robots that self-organise in a way that is inspired by natural swarms, such as bees, fish and birds.²⁹¹ While there have been technical advances, no commercial deployment yet exists²⁹² because of regulatory challenges and difficulties establishing trust in swarm systems due to uncertainty about how they will behave, especially regarding their collective decision-making.²⁹³ Swarms could become more trustworthy and interpretable when they adopt behavioural models that are based on basic, reproducible principles that emulate the dynamics of human behaviour.²⁹⁴

Interoperability for Embodied AI

As AI, embodied systems (robots and avatars), and the Internet of Things (IoT) converge, interoperability will become more of an issue. Beyond impacts on the user experience, challenges with interoperability will create technological vulnerabilities across connected systems. Establishing coordinated, interoperable frameworks will require collaboration between standards-development organisations, industry stakeholders and policymakers to develop protocols that balance innovation with security and privacy.²⁹⁵





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9

Future Humanity

Advanced machine intelligence, brain–computer interfaces, technological breakthroughs, and advances in science and medicine are enabling an increasingly borderless world, along with the challenges, misinformation and disinformation that come with it. Accordingly, people’s understanding and expectations of self-realisation – including work, education and what it means to thrive – will shift. Reimagined personal development norms, new ways for individuals and communities to innovate and communicate, and emerging definitions of self-esteem, autonomy and stability will reshape ideas about parenting, care, family, belonging, inclusion and community. The traditional boundaries between self, society and institutions will evolve, and fertility rate trends could redefine what constitutes a family unit and community bonds.

Areas of Future Opportunity (Past Editions)

The Creative Economy (2023)
Technology for Mental Health (2023)
New Definitions of Education (2023)
Sustainable Base of the Pyramid Entrepreneurship (2024)

Evolved Understanding of Digital Literacy (2024)

Co-Creation for Youth Employment (2024)
Need for the Arts (2025)
Lab for Online Dispute Resolution Across Legal Systems (2025)
Understanding Talent Retention (2025)

Keywords

Basic Needs
Digital Safety
Fourth Industrial Revolution
Future of Organisations
Loneliness
Maslow’s Hierarchy of Needs
Misinformation and Disinformation
Social Connection
Trust
Youth Mental Health

Things to Look Out for in the Short-Term



Ongoing Digital Safety Dilemma

In December 2025, Australia began blocking children under 16 years of age from accessing social media, with non-compliant companies facing fines of up to \$50 million.²⁹⁶ The USA²⁹⁷ and Denmark are also considering bans,²⁹⁸ while the UK²⁹⁹ and the UAE³⁰⁰ have already announced bans. These changes reflect public sentiment on addressing concerns about youth mental health.³⁰¹ These calls for action are not new,³⁰² and, globally, 65% of people support the idea of such bans.³⁰³ However, bans alone cannot prevent mental health concerns;³⁰⁴ redesigning platforms with consideration for mental health is essential.³⁰⁵



Future of Organisations

The impact of AI on the future of work has been the predominant topic in 2025 – specifically, jobs lost, created or reimagined.³⁰⁶ Among those surveyed for the World Economic Forum’s 2025 *Future of Jobs Report*, 86% believed AI will reshape businesses and 58% indicated that robots and autonomous systems will be among the primary forces.³⁰⁷ Questions may refocus on what comes next for organisations beyond jobs and decision-making, including employee collaboration, human agency, meaning and well-being, and avoiding related risks.³⁰⁸



Bespoke Approaches to Accuracy and Trust

Misinformation (unknowingly spreading false news) and disinformation (knowingly spreading false news to harm)³⁰⁹ will persist in 2026. While AI hallucinations are a growing concern,³¹⁰ risks of disinformation will be amplified and their sources will be increasingly difficult to establish. Communities may start to develop bespoke approaches to evaluating accuracy and trust, recognising that a single, universal framework may no longer be sufficient.

Areas of Future Opportunity

Psychobiography for the Future of Cities

Psychobiography is a form of social science that uses detailed life stories to analyse how an individual's psychology, experiences and decisions shape who they become.³¹¹ While the core concept focuses on individuals, it can be extended to the planning and development of cities undergoing major technological transformations driven by Fourth Industrial Revolution³¹² technologies. Applying psychobiography to urban contexts could help inform more intentional choices today about what cities and communities become in the future.³¹³ Studying global cities and communities that have prototyped and implemented AI systems, robotics and humanoids provides insights and offers an opportunity to unpack key questions about ethics, acceptance, urban identities, and physical and virtual community spaces.³¹⁴



1 in 6

people worldwide are affected by **loneliness**, contributing to roughly 100 deaths per hour.



Social Connection as Public Policy

'Social rewilding' involves rethinking how we spend our free time and focusing on creating genuine human connections and real-world experiences.³¹⁵ Social connections could become harder to establish and maintain at work as the number of robots in the workplace is expected to significantly increase, raising questions about security, control, identity and responsibility.³¹⁶ One in six people are affected by loneliness, and the issue is linked to roughly 100 deaths per hour (i.e. more than 871,000 deaths annually).³¹⁷ Social connection may need to become a new public health policy for communities and individuals, focused on awareness, support, and interaction-focused environments and spaces.³¹⁸

New Definitions of Needs

New poverty measurement frameworks³¹⁹ are emerging beyond the Human Development Index.³²⁰ The basic needs poverty line (BNPL)³²¹ includes the minimum food, water, clothing, heating and housing required by every human being.³²² In 2011, 17.3% of the world's population could not meet these needs — food insecurity data, used to project the trend forward, suggests this figure reached 30% by 2020.³²³ While 847 million people lived in extreme poverty (\$3/day) in 2024,³²⁴ decent living standards³²⁵ include broader needs, such as climate control, computers, education, healthcare, lighting, nutrition, sanitation and transportation.³²⁶ Abraham Maslow's hierarchy of needs, published over 50 years ago, continues to be the foundation of how needs are understood today (Box 2). It progresses from safety to belonging, and from self-esteem to fulfilling one's potential, which is rare.³²⁷ As AI transforms workflows and enables scalable technologies,³²⁸ the shape of Maslow's pyramid and the number of levels may change. Used intentionally, more people may achieve self-actualisation through AI while social needs may prove more fundamental than Maslow theorised.³²⁹





MEGATREND

10

Advanced Health and Nutrition

Progress in advanced machine intelligence, nano- and biotechnology, additive manufacturing, and the Internet of Things (IoT) will change our understanding and experience of health and nutrition. Driven by unprecedented developments and responses to climate change, resource scarcity, and the desire for longevity, this megatrend will improve health across all age groups. It will reduce, if not eradicate, some communicable and non-communicable diseases and enhance the sustainable use of, and access to, water and food. See Box 5 to see how DFF engaged the public on this megatrend.

Areas of Future Opportunity (Past Editions)

Additive Manufacturing for Food (2023)
Diversified Sources of Food (2023)
Personalised Medicine and Genomics (2023)
Deep Learning to Combat Cognitive Ageing (2024)
Nanonutraceuticals for Gut Health (2024)

Diet Choices by Geography (2024)
Air Quality Epigenetics (2025)
Expanding Precision Medicine Through Diverse Genomic Research (2025)
Biochar for Crops (2025)

Keywords

Casgevy
CRISPR
Flavonoids
Geroprotectors
Healthspan
Mental Health
Neurodegenerative Diseases
Nootropics
Phenotyping
Smart Farming

Things to Look Out for in the Short-Term



Expanding CRISPR Portfolio in Health

Despite funding constraints, CRISPR's disease coverage continues to expand.³³⁰ CRISPR-based Casgevy, approved by the US Food and Drug Administration in December 2023³³¹ for sickle cell disease and beta thalassaemia, now has 50 treatment sites across North America, Europe and the Middle East.³³² With AI and advanced sequencing, CRISPR-Cas may expand gene editing into epigenomic expression.³³³ In a Cleveland Clinic study, CRISPR-Cas9 therapy reduced LDL ('bad') cholesterol by 50% on average, with effects visible within two weeks and sustained for 60 days. It also reduced triglycerides by 55%, offering an alternative to daily pills or monthly injections. The study will continue to expand in 2026.³³⁴



Increasing Interest in Research on Geroprotectors

Geroprotectors slow, prevent or reverse age-related decline, helping to improve healthspan.³³⁵ Preclinical studies show promising results for compounds such as metformin and SGLT2 inhibitors.³³⁶ To date, no intervention has proven both effective and safe in slowing human ageing,³³⁷ with the possible exception of collagen amino acids (with limited research).³³⁸ Interest in this area of research may expand alongside the mediating or moderating effects of other interventions, such as exercise.³³⁹



AI Regulation—Practice Gap in Healthcare

AI in healthcare can support efforts to meet public health goals.³⁴⁰ Yet, even when all stakeholders agree on regulations, and even with successful pilots, implementation is challenging.³⁴¹ Despite 85% of healthcare leaders exploring or adopting GenAI,³⁴² mature AI integration in healthcare remains limited (the most recent available data, from 2021, shows just 9%).³⁴³ Additionally, while 48% of clinicians use AI for work, only 16% use it for clinical decision-making.³⁴⁴ While bias, data quality, transparency and explainability are concerns, focus may shift into real-world clinical workflows.³⁴⁵ Initiatives such as AI for Good are likely to have an impact.³⁴⁶



BOX

5

Engaging the Public in Futures – Our Future(s) as a Case Study

Efforts to engage the public in futures have mostly been documented in the Global North,³⁴⁷ but as we have seen through various DFF communities, significant efforts are also underway in the Global South. Engaging the public improves research quality and relevance across futures studies,³⁴⁸ science and innovation,³⁴⁹ and social science.³⁵⁰

Beyond improving research quality, **engaging the public in futures can be viewed as a form of open innovation**³⁵¹ where unique ideas about the future can more effectively emerge from sources external to organisations of all sizes and focuses. However, success requires intentional design and clear objectives. Challenges often arise from poor design and execution, and outcomes differ depending on whether open innovation is used for idea generation, selection or both.³⁵² Today, open innovation is being sought beyond open-source software³⁵³ and technology,³⁵⁴ in schools³⁵⁵ and higher education³⁵⁶ and through community empowerment and engagement.³⁵⁷

In November 2025, the Dubai Future Foundation engaged the public about the Advanced Health and Nutrition megatrend through the second Our Future(s) event.³⁵⁸ While the first event (in 2024) explored public sentiment on global uncertainties, the 2025 event focused on health and wellness.



Starting from the related Global 50 opportunities, the Dubai Future Foundation designed 10 questions to gauge public sentiment:

1. Would you trust an AI doctor to give you health advice?
2. Would you spend time in places with no technology, even if it meant being offline?
3. Would you trust a machine to understand your feelings better than a real person could?
4. Would you let tiny robots go inside your body to fight sickness?
5. Would you sit in a room with algae if it meant cleaner indoor air?
6. Would you take good bacteria as a pill if it could make you feel better?
7. Would you feel excited about a doctor knowing exactly what is wrong with you from your breath only?
8. Would you wear clothes that track your health, even if they shared data about your body?
9. Do you think virtual nature can replace real nature?
10. Do you think the future of health will be all about technology?

More than 500 people who attended the second Our Future(s) event answered these questions through yes-or-no responses, alongside other activities and panel discussions. **Three insights emerged when we integrated the findings with our view of the future:**

People are both open and cautious about AI in health; trust is a key factor.

A balanced approach to health innovation combines technology with nature-based solutions such as beneficial bacteria and natural environments.

Acceptance of nanotechnology for health is in the early stages, and awareness and clear demonstration will be needed to build public trust.

Throughout the planning and running of the event, we learned that to most effectively engage with the public, it is essential to base approaches on research and a point of view on the future as a starting point. Sharing the purpose with participants, reporting on results and following up with actions are key steps for anyone looking to replicate this approach in their own context.



Areas of Future Opportunity

Digital Phenotyping for Scalable Precision Medicine

Digital phenotyping is not new. The continuous, real-time collection of behavioural, environmental, social, medical and psychological data through wearables and sensors could enable and/or inform both the detection and long-term tracking of disease,³⁵⁹ and precision nutrition.³⁶⁰ When integrated with genomics, digital phenotyping represents an area of future opportunity that could enable affordable and scalable precision medicine,³⁶¹ and potentially more responsive public health. In addition to safeguarding patient data, international cooperation will be key.



70%

of global freshwater is used for agriculture.



4 billion

people face severe water shortages yearly.

From Efficient Agriculture to Sustainable Agriculture

Agriculture accounts for nearly 70% of the freshwater we use globally.³⁶² Yet, at the same time, 4 billion people experience severe water shortages for a combined total of at least one month per year, and by 2050, droughts will impact three out of four people.³⁶³ 'Agriculture 4.0' is a term used to describe farming from approximately 2000 to today. Key features are the use of real-time data flows, predictive analytics and automation to optimise agriculture.³⁶⁴ In contrast, the term 'Agriculture 5.0' is used to describe the farming of the future. It will incorporate environmental and social aspects, making smart agriculture human-centred and sustainable while maintaining productivity.³⁶⁵ In other words, Agriculture 5.0 adopts a nexus approach that concentrates on producing food both more sustainably and more efficiently.

Scaling the Link Between Food and Mental and Brain Health

Diet is a promising strategy for improving mental and brain health, particularly in the lowest-income countries, where up to 85% of people receive inadequate treatment for their mental health.³⁶⁶ From a public health perspective, diet may provide an accessible, scalable and cost-effective intervention that could complement or supplement conventional medical care.³⁶⁷ Since the COVID-19 pandemic, an additional 53.2 million cases of major depression and 76.2 million cases of anxiety have arisen.³⁶⁸ Studies on flavonoid-rich foods, including blueberries, cocoa and oranges, have shown significant improvements in mood and reduced anxiety, particularly among those with a previously low fruit intake.³⁶⁹ When it comes to brain health, neurodegenerative diseases cause approximately 11 million deaths globally each year.³⁷⁰ Based on the latest data, nearly 57 million people live with dementia, which highlights the urgency of tackling this disease.³⁷¹ Nootropic foods, fortified with natural anti-inflammatory compounds such as curcumin, support cognitive function through their effect on the gut-brain connection.³⁷² Alongside advances in delivery technologies (such as nanoencapsulation), further trials will be needed to validate these foods' effectiveness as a public health strategy in some areas.³⁷³





Navigating the 2026 Edition

We take a look at the opportunities through the lens of **value creation and capture**, where value is defined as future growth, prosperity and well-being.

In addition to our view of the future, The Global 50 report shares 50 opportunities that, through foresight and innovation, could restore nature, reimagine health, empower societies, optimise systems, and, with the most transformational opportunities, restructure or replace models of daily work and life for future growth, prosperity and well-being.

Some of the 50 opportunities are within reach. Some are transitional, depending on the conditions and underlying enablers that could manifest over the next 10 years. And some are visionary, with a longer time horizon, given their reliance on breakthrough socio-technological developments. In all cases, the speed at which the opportunities materialise will vary depending on context, funding, leadership and other external conditions.

In this year's edition, alongside updating our view of the future, we take a look at the opportunities through the lens of value creation and capture, where value is defined in terms of future growth, prosperity and well-being. While the assumptions, uncertainties and megatrends shape our understanding, the opportunities translate these three elements into action. With 200 opportunities from previous editions, we explored 50 in depth for this edition. The 'Navigating the Opportunities' section contains further information about how we chose these 50 opportunities.

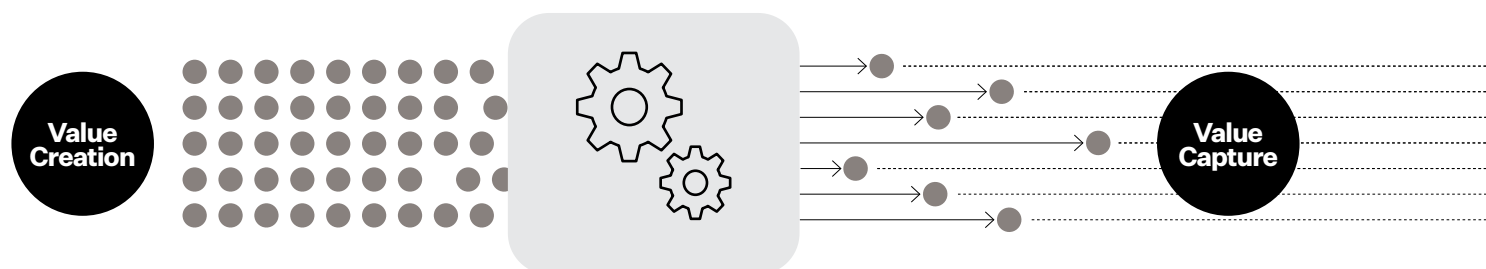




Value Creation, Value Capture and The Global 50

The concept of **value creation** comes from the strategy, innovation and entrepreneurship literature. It commonly refers to the identification and development of new ideas, products or services that are intended to generate perceived value for users, customers or beneficiaries.³⁷⁴ Identifying and sharing the opportunities within all editions of The Global 50 is a form of value creation.

Value capture is the process of delivering on a perceived or intended value (of a new idea, product or service) by converting it into long-term outcomes.³⁷⁵ These outcomes will primarily be profit in the case of the private sector, public benefit or value in the case of the public sector, and a combination of both in the case of civil society. Innovative ideas alone are not enough (especially if they are not implemented or not implemented well); value capture is essential for sustainable long-term outcomes.³⁷⁶ Capturing value, from the perspective of The Global 50, means leveraging key mechanisms within an opportunity and unpacking pathways to deliver future growth, prosperity and well-being.





Key Mechanisms of Value Capture in The Global 50

To identify key mechanisms of value capture relevant to The Global 50, we explored value capture across different domains, including companies, closed and open innovation systems, innovation districts, cities and public value creation.

Value capture **within companies**, including digital ones,³⁷⁷ is generally considered to be the ability to secure financial and non-financial benefits from innovation. It includes fostering unique, hard-to-copy innovation and protecting it from imitation.³⁷⁸ More specifically, value capture can vary depending on whether companies prioritise financial returns, public value both – and whether they use closed innovation, open innovation or a combination of the two.

In **closed innovation**, innovation processes sit within organisational boundaries³⁷⁹ while companies work on increasing their customer and user base. Value is captured through mechanisms such as contracts, intellectual property (patents and trademarks), technology transfers, fees and the careful choice of business model. This involves managing tensions between competition and cooperation, managing trust and reciprocity between partners, and (for global companies) managing cultural and geographical distances and differences.³⁸⁰

In contrast, in **open innovation**, innovation processes are crowdsourced or developed beyond organisational borders.³⁸¹ The same mechanisms are employed as in closed innovation. Additionally, value is captured through non-disclosure clauses, creating and/or enabling complementary assets, and keeping certain aspects proprietary (i.e. blackboxing), despite the open approach.³⁸² Value capture in open innovation tends to come with more challenges because of the possibility of innovative solutions being leaked before they are protected, the need to balance value creation with the protection required for value capture, and the typically higher number of participants in the innovation process.³⁸³

In **innovation districts**, value is captured through collaborative structures, physical and digital infrastructure, sustainable funding, and measuring and acting on socio-economic outcomes.³⁸⁴ For **cities focused on innovation**, value is captured through successful companies and startups, technology parks, and universities and research institutions.³⁸⁵ It may also be captured through securing patents, employing new technologies, attracting new residents, promoting sustainable development, and encouraging civil society to provide social and environmental benefits.³⁸⁶

Where **public value** is sought, mechanisms of value capture also include perceived contribution to society alongside interrelated moral, ethical and social dimensions, such as trust, legitimacy, reputation, quality of life, operational excellence, community cohesion, collaboration and network effects.³⁸⁷

Whether it is in a non-governmental institution, a small business, a large business, a school, or even a family or individual, how value is captured depends on the varied interests and motivations of the innovation actors (Box 6) who directly or indirectly lead, participate in or benefit from value capture.³⁸⁸

BOX

6

Common Innovation Actors³⁸⁹



Governments



International non-governmental organisations



Community-based organisations and non-governmental organisations



Large corporations and businesses



Startups and small and medium enterprises



Think tanks and institutes of research and development



Networks and associations



Educational institutions



Drawing from these perspectives, and grounding The Global 50 opportunities as a form of foresight-driven innovation,³⁹⁰ we identified five key mechanisms of value capture for future growth, prosperity and well-being.



These five mechanisms form the **pillars** within which the opportunities in this fifth edition are presented.

The five pillars are presented in this order to reflect the breadth of their impact and scope of change – from broad to specific. Like the megatrends, however, they are interrelated and multiple mechanisms will be needed to capture value.



Backcasting as a Foresight Approach

The opportunities in The Global 50 include a ‘What if?’ question that suggests a vision of what the future could look like. We see these visions as preferred (or desirable) futures³⁹¹ and we use high-level backcasting to explore what is needed to achieve progress. By tracing an opportunity back to the present, we can visualise both the enablers that will be necessary to move through the stages and the challenges that will need to be overcome.³⁹² In this edition, each opportunity includes a high-level backcast (pathway to impact) that takes into account the status of the opportunity today and how different types of reader can contribute to its development.

Foresight methods and tools can be exploratory or normative. Exploratory foresight methods focus on identifying ‘What if?’ questions to imagine the future. Normative methods focus on ‘what could be’ to understand how a desirable future may be achieved³⁹³ or an undesirable future avoided.³⁹⁴ Backcasting is a normative approach to foresight that translates a desired future into a roadmap with key milestones and actionable steps.³⁹⁵ Solution oriented, backcasting helps foresight researchers to methodically uncover the conditions required for success and the challenges that may arise³⁹⁶ without relying solely on existing trends³⁹⁷ and while allowing for multiple perspectives and stakeholders.³⁹⁸

However, like all foresight and other research methods, backcasting is not without critique. First, a commonly recurring debate is whether backcasting is a foresight method or a strategy; we accept it as both.³⁹⁹ Second, backcasting can be complex and resource intensive, although this point applies to all methodological approaches to foresight.⁴⁰⁰ Finally, backcasts may oversimplify future pathways and reduce the need to assess many alternative futures; we recognise that there are multiple pathways to the future and mention this within each of the opportunities.⁴⁰¹

A final point on the backcasts in this edition is that while backcasts are often time-bound, we have avoided providing either fixed timelines or deterministic predictions. This is because how quickly or slowly we progress through a pathway towards an opportunity will depend on many factors, such as the resources at hand, the alignment of necessary enablers, and the interest of key stakeholders in taking the lead or collaborating on the future.

Backcasting
is a normative
approach to
foresight that
translates a
desired future
into a road
map with key
milestones and
actionable steps.



Funding the Future

Funding is critical for innovation – not only for development but also to sustain value capture and ensure long-term sustainability and viability.⁴⁰² As a result, we have included various funding instruments that are relevant within each opportunity for each of the high-level stages of the backcast. Individual mechanisms could be chosen, or the readers could employ multiple mechanisms as part of a portfolio approach, including blended finance, which combines public funding with private investment to reduce risk.⁴⁰³ Given that innovation requires diverse resources, actors, roles, and funding types and sizes across the stages of the innovation process.⁴⁰⁴ Perhaps the most important aspect of deciding which funding instruments to consider is the stage – and the primary purpose (Box 7) of that stage – within an innovation process.⁴⁰⁵

BOX

7

Stage and Purpose of Innovation

The primary purpose of a given stage of innovation (and by extension foresight-driven innovation) may be one or more of the following across a typical innovation lifecycle of design, testing and scaling (this list is non-exhaustive).



Generating, testing or exploring new ideas and solutions

The key goal here is generating new knowledge, which requires freedom to take risks and is associated with uncertainty. Spending and effort may be succeeded by a long, open-ended time lag before the final pay-off arrives, if it does at all.



Achieving a defined result or outcome

The goal is to pilot or achieve a result or output that is clearly defined in advance, such as better school results or reduced homelessness or emissions.



Creating capacities to achieve future outcomes

This involves the use of funding to create capacities for achieving outcomes in the future, including better capacities to innovate. One aspect of this is providing non-financial help (mentoring and support).



Transforming infrastructure or systems

Ambitious infrastructure or systemic change requires significant investment to build the necessary innovation ecosystems. These projects are likely to be too risky and financially burdensome for any single investor or actor.



Scaling promising innovations

The goal here is to scale up ideas, increase their reach and impact more people. This requires a focus on long-term financial sustainability.



Maximising returns (private sector)

This requires the selection of commercial investments to achieve the highest financial return for a given level of risk. The aim is to achieve significant growth in the value of an asset or organisation.



To determine the funding instruments that might apply to each stage within each opportunity, we looked at various approaches to funding in innovation, policy and futures spaces. In addition to being suitable for the stage or primary purpose of innovation, effective funding strategies must address policy,⁴⁰⁶ incentives and behaviours,⁴⁰⁷ the amount of funding needed, and the risk appetite of the funder(s),⁴⁰⁸ sponsors and leaders of innovation.⁴⁰⁹

The 16 funding instruments in Box 8 represent a broad spectrum of risk, return and obligation of repayment. They are ordered by their strategic risk, from low risk (retaining full ownership) to high risk (diluting equity), and are suitable for different stages or primary purposes of innovation.





BOX

8

Funding Instruments



Grants (Simple)⁴¹⁰

A grant is a non-repayable gift of money with no equity, debt or revenue-sharing obligations. It is typically tied to specific project deliverables or research milestones. The recipient retains 100% ownership.



Stage-Gate Grants⁴¹¹

In this arrangement, grant funding is released in tranches tied to the achievement of specific milestones (technical, commercial or regulatory). An initial small amount typically of up to \$100,000 unlocks larger subsequent phases (typically from \$250,000 to \$1 million or more) upon milestone completion.



Challenge Prizes⁴¹²

In competition-based funding, multiple teams compete to solve a defined problem. Only the winner(s) receive the predetermined prize money. Payment is contingent on delivering a working solution, not effort. This arrangement encourages open innovation.



Matched Crowdfunding⁴¹³

The innovator raises funds from a community or the public (e.g. via sources such as Kickstarter) and an institutional funder (e.g. a government, foundation or company) matches these contributions at a predetermined ratio (typically between 1:2 and 1:4). This arrangement de-risks institutional investments by validating market demand.



Service Contracts⁴¹⁴

Organisations are paid to develop and/or deliver specific innovations or services through procurement processes. The funder, client or buyer commits to a purchase if milestones are met as per contractual agreements. This may include government procurement as demand-side innovation pull, which signals future market opportunity and de-risks private investment in emerging solutions.



Revenue-Dependent Grants⁴¹⁵

These grants consist of non-dilutive financing requiring repayment only as a percentage of future revenue (typically 2–8%) until a cap is reached (usually 1.5 to 3 times the original amount). If there is no revenue, there is no repayment. This encourages commercialisation of innovations.



Social Impact Bonds⁴¹⁶

Investors fund social programmes up front. The government or organisation repays investors only if predefined outcome metrics are achieved, such as a percentage reduction in homelessness. Payment amounts are tied to the degree of success.



Loans (including microloans)⁴¹⁷

Capital is borrowed and requires repayment with interest on a fixed schedule, regardless of the success of the innovation. No equity is offered and the lender has debt priority if the innovation fails.



Combination Grants⁴¹⁸

These are hybrid arrangements combining funding of non-repayable grant money with a small equity stake (typically 2–10%) taken by the funder. This is considered a cheaper form of funding or capital for the innovator than a pure equity investment.



Convertible Loans⁴¹⁹

These loans convert to equity during future funding rounds. Early investors get a 15–25% discount or a valuation or price ceiling as the company increases in value.



Convertible Grants⁴²⁰

Initially structured as a non-repayable grant, this form of funding automatically converts to an equity stake if the recipient raises future venture capital. It allows a funder to benefit if the company scales and provides entrepreneurs and innovators with the capital needed to grow in the early stages of innovation.



Scaling Funds⁴²¹

This arrangement provides growth-stage capital (from \$5 million to \$100 million or more) for proven businesses with product–market fit, allowing them to expand geographically, increase production or enter new markets. The focus is on execution rather than either innovation or R&D.



Accelerator Programmes (funding delivery model)⁴²²

These are fixed-term (three- to six-month) intensive programmes that provide small investments of typically up to \$150,000 and include structured mentorship, a workspace, and access to the network of the investor, buyer or client sometimes in exchange for equity (typically 5–10%). The focus is on capacity-building, not just capital.



Early-Stage Capital with Multiple Funding Partners (Syndicated Investment)⁴²³

Syndicated investments are where three or more investors or funds co-invest in seed (Series A) funding, pooling their capital and expertise. This arrangement spreads the risk between partners while providing a startup with multiple sources of advisory support.



Equity Investment⁴²⁴

Investors purchase an ownership stake (shares) in an organisation in exchange for capital. This can take various forms, including a simple agreement for future equity (SAFE), where an investor provides capital in exchange for the right future equity. No repayment is required and the investors profit through the eventual sale of the shares (i.e. exit via acquisition or an initial public offering). This arrangement dilutes the founder's ownership.



Venture Equity Investment⁴²⁵

In this arrangement, an institutional venture capital fund invests anywhere from \$1 million to \$50 million or more for a significant equity stake (15–40%) in a company with high growth potential. Funders generally expect at least 10-fold returns and are actively involved in governance through board seats.



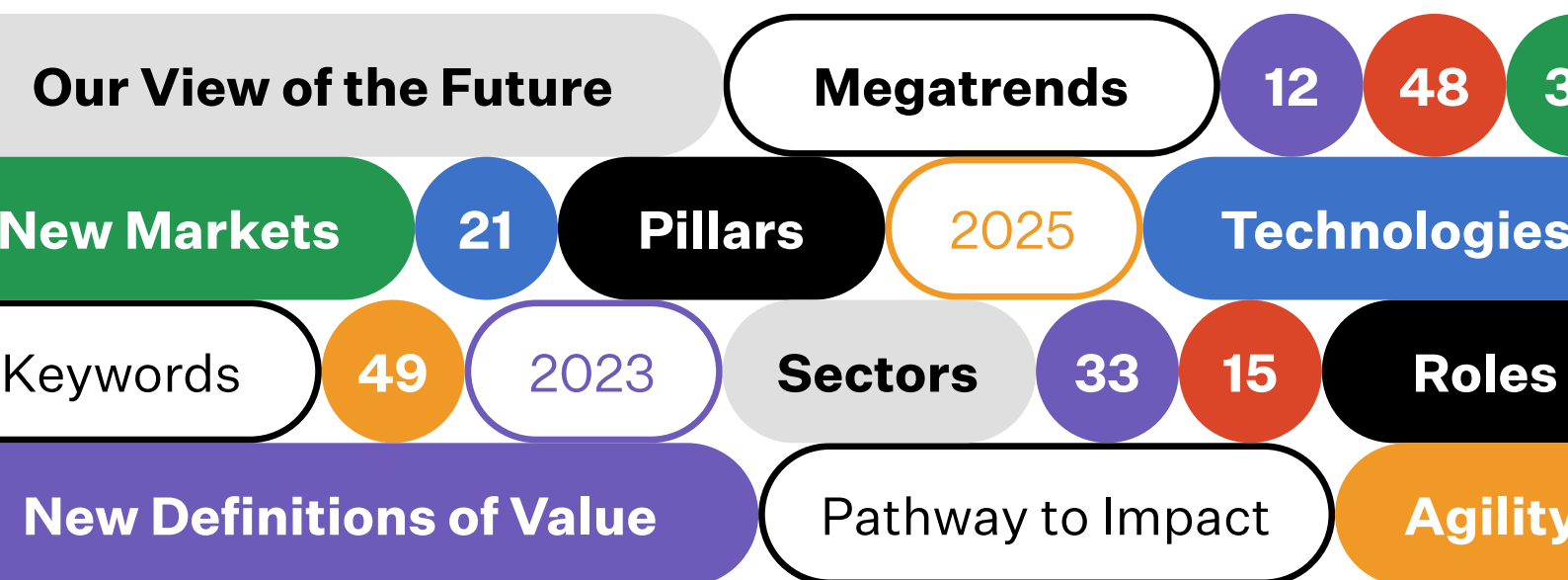
When considering funding from a futures perspective, it is important to recognise the current environment of disruption and uncertainty,⁴²⁶ in which 60% of over 1,000 companies across industries and regions surveyed by McKinsey are either holding steady or reducing their spending on innovation.⁴²⁷ This persisted into 2026, when companies were more than twice as likely to describe spending as cautious rather than growth-focused.⁴²⁸

In addition, the future of finance and monetary systems is now Megatrend 4 in 'Our View of the Future'. This means that today's funding instruments may be transformed as non-bank institutions and AI (besides others) disrupt traditional finance, reshaping how innovation ecosystems access capital, leading to new forms of blended finance.



60%

of over 1,000 companies across industries and regions surveyed by McKinsey are either **holding steady or reducing their spending on innovation.**



Navigating the Opportunities

Each of the opportunities in this edition is structured to enable organisational decision-makers regardless of sector and individuals to assess and engage with the future of the opportunity. They are organised by pillar, with each pillar including a summary of its opportunities and three high-level insights.

In selecting the 50 opportunities, we particularly focused on ones that are classified as ‘transitional’ or ‘visionary’ in scope, and unlike those ‘within reach’, they will depend on key socio-technological development. In addition to having been selected to resonate with a global audience, each opportunity is systemic, impacting at least five sectors.

Each opportunity retains its original framing, including its question for the future, its summary, Why It Matters Today and other information previously appearing on its first page. The rest of the elements are new, intended to inform and demonstrate possible next steps among the many potential pathways to implementation and impact.



Each opportunity is structured to answer **six questions**

What is the preferable (desirable) future and why does it matter?

This is a summary of the opportunity and an update to the original text on Why It Matters Today.

What is the status of the opportunity today?

Understanding the present-day status is necessary for backcasting.

What pathways might lead us to the desirable future?

What tangible benefits (social, technological, economic, legal and environmental) will be provided to communities and stakeholders – in other words, what will progress look like?

What are the enablers without which movement from stage to stage will not be possible and benefits will not be realised?

What social, technological, economic, legal and environmental challenges – which could also be sources of opportunity for key actors – might communities and stakeholders experience?

Box 9 include high-level guidance to help readers assess each opportunity and determine their potential role. All organisations and individuals should, at a minimum, maintain an observer role when an opportunity is within their scope of interest, to ensure future readiness.



BOX

9

Determining Your Role

This is high-level guidance intended to help you assess each opportunity and determine your role. If you find that your situation falls between two roles, consider which one's immediate next steps align best with your strategic priorities and current capacity (time, skills, authority, budget, partnerships, etc.).

For organisational decision-makers

Answer based on your organisation's current capacity and strategic priorities.

For individuals

Answer based on your desired aspirations, desired skill development and preferred vision of the future.

Start

Is this opportunity connected to your strategic vision and goals?
For individuals: is it connected to your aspirations?

Yes**No**

Do you have the capacity to actively shape or influence it within 12 months and, if applicable, at a global/regional level? ^G

Yes**No**

Could you gain tangible benefits (revenue, impact, experience or skills) by getting involved?

Yes**No**

You are **a leader/ aspiring leader** shaping the preferable future



You are **an anticipator** preparing for the probable future



You are **an enabler,** engaging in the possible future



You are **an observer,** scanning for the plausible future

^G Global 50 opportunities either address a global opportunity or challenge, or can be replicated across countries and regions.



On Relative Futures and Next Steps

While The Global 50 focuses on preferable (desirable) futures, each opportunity also represents different futures depending on the role of the **organisational decision-maker** or the **individual**.

A leader or aspiring leader shapes and leads on the preferable future that is set out in the opportunity. Someone who is not leading, but where the opportunity may impact their strategic vision, is an anticipator – in other words, they prepare to capture value from what they view as a probable future. Then there are enablers, who contribute to the possible future that the opportunity would provide. Finally, observers monitor the plausible future through horizon scanning and sense-making as a form of future readiness.⁴²⁹

Depending on your role – leader or aspiring leader, anticipator, enabler, or observer – Box 10 and Box 11 provide high-level guidance on potential next steps.





BOX

10

What Next for **Decision-Makers**

Immediate Next Steps



Leader or Aspiring Leader

Conduct feasibility studies where needed; convene partners through a consortium or advisory body where needed; mobilise immediate action and lead on present-day action.



Anticipator

Review necessary enablers and pathway stages; identify pilot opportunities; connect with leaders to assess co-leadership potential.



Enabler

Map own capabilities and challenges; identify contribution areas; express interest to leaders; explore funding or investment opportunities.



Observer

Conduct horizon-scanning using trends and keywords; track developments through sector reports, expert networks, and conferences; identify early signals; evaluate organisational readiness and strategic fit; reassess role annually or when significant milestones occur.

BOX

11

What Next for **Individuals**

Immediate Next Steps



Leader or Aspiring Leader

Join or build communities and networks; engage publicly on the preferable future; seek collaborators; develop or contribute to research, content and thought leadership.



Anticipator

Build knowledge and capabilities through learning; engage with relevant communities; develop emerging areas of expertise.



Enabler

Contribute through volunteering, community engagement, internships and support-related initiatives.



Observer

Follow relevant publications and thought leaders in related communities; track developments through industry reports, research publications, policy briefs and other research; reassess role annually or when significant milestones occur.



Schematic

Question for the Future

Outlines the preferable future.

Summary

Brief description from previous editions; explains the essential elements of the opportunity.

Scope

Describes the period over which the opportunity is likely to materialise depending on drivers and other aspects of socio-technological development. Where scope has evolved due to technological or socioeconomic shifts, the original publication year and 'new' are labeled accordingly.

Most Significant Megatrend

The most significant megatrend relevant to the opportunity today (because of the interrelated nature of the megatrends, some may be more prominent than others at different times).

Uncertainties

Those most likely to impact the underlying drivers and the conditions for the opportunity to materialise.

Trends

Up to five trends (non-exhaustive, indicating what to monitor).

Technologies

Up to three technologies (non-exhaustive, indicating what to monitor).

Category

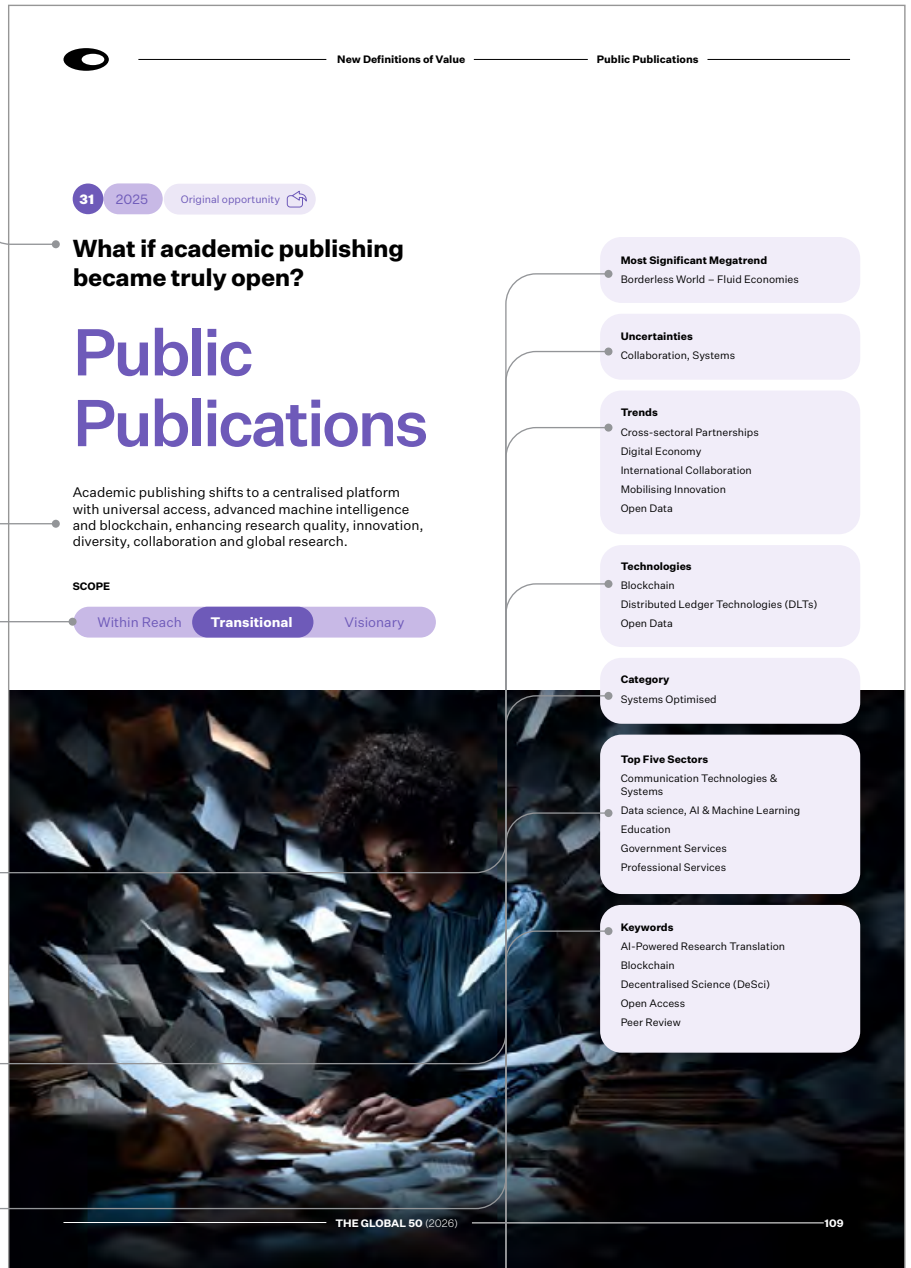
The outcome.

Top Five Sectors

The top sectors that will impact or be impacted by this opportunity (non-exhaustive).

Keywords

Relevant keywords (up to five) that readers can use as prompts to search for information and conduct further research.



**Why It Matters Today**

Highlights some of the drivers that make the opportunity relevant for consideration today.



New Definitions of Value

Public Publications

Why It Matters Today

Open-access publications, in all forms, grew from making up 23% of global articles in 2003 to approximately 51% in 2022,⁵⁵⁸ while closed-access articles comprise the rest of publications.⁵⁵⁹ The ecosystem remains fragmented and adoption of open access varies geographically. China, India and the United States publish predominantly closed-access research.⁵⁶⁰ Around 62% of publications in low-income countries are fully open access, yet these publications make up less than 1% of open-access articles globally.⁵⁶¹ Grant-making organisations increasingly stipulate that funded research must be open access. For example, cOAlition S, supported by the European Commission and the European Research Council, mandates full and immediate open access for publicly funded research⁵⁶² and a new policy in the United States recommends that federal agencies use the open-access model from the end of 2025.^{563, G} Nevertheless, while most nations have implemented national policies for research, many neither mandate nor mention open access, and in general the African and Latin American countries lack national policies despite many research initiatives.⁵⁶⁴

G At the time of publication, it is not clear whether this has been implemented.

**Benefits**

Equal access to knowledge;
accelerated research and innovation;
enhanced global collaboration;
improved research quality and
diversity; broader global reach.

**Risks**

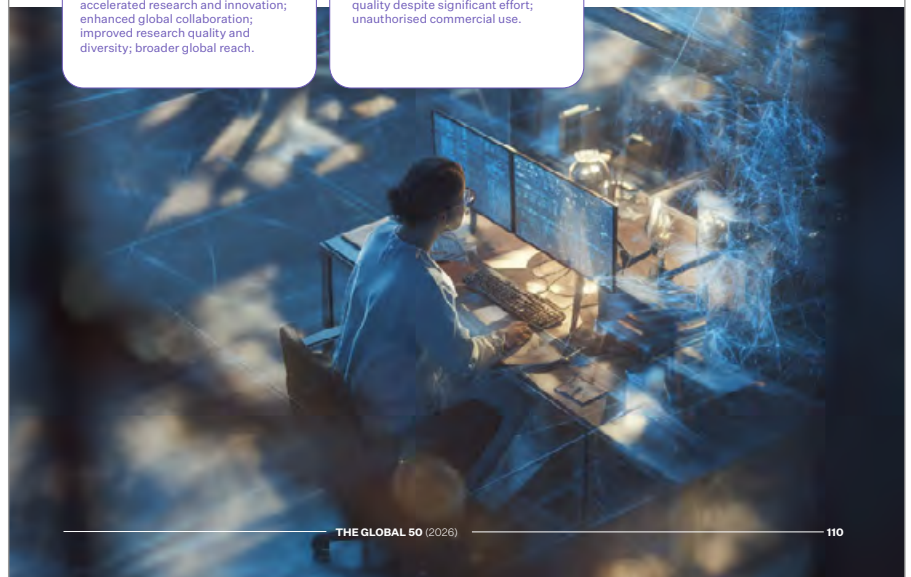
Cultural resistance to change; poor
quality despite significant effort;
unauthorised commercial use.

Benefits

Brief overview of benefits.

Risks

Brief overview of
challenges.



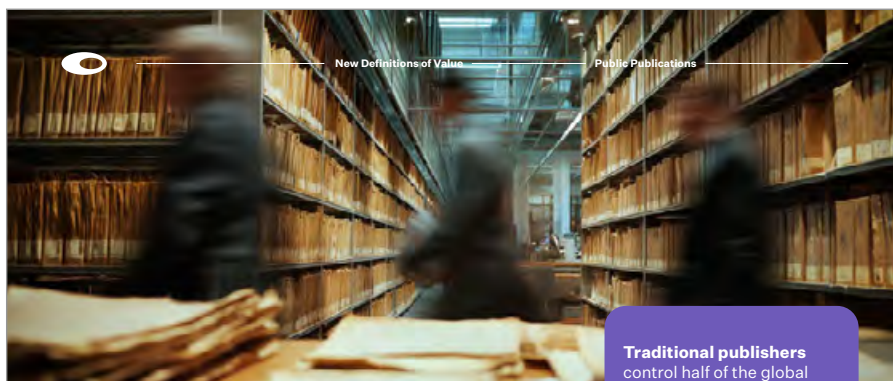
THE GLOBAL 50 (2026)

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Status Today

Explains where the opportunity or related future scenario currently stands.



Status Today

The academic publishing landscape faces significant structural challenges. Traditional publishers – Elsevier, SAGE, Springer, Taylor & Francis and Wiley – control half of the global research output while maintaining over 30% profit margins,⁵⁶⁵ and the drive to maintain these numbers may incentivise volume over quality.⁵⁶⁶ Traditional publishing is particularly susceptible to issues prevalent in the current academic publishing landscape: lengthy publication timelines, sometimes unclear evaluation criteria, variable reviewer expertise and, in some cases, limited diversity among the pool of reviewers.⁵⁶⁷

Open access was intended to address paywalls, but it has inadvertently replicated some of the structural barriers in traditional publishing.⁵⁶⁸ Article processing charges commonly range between \$1,500 and \$2,500⁵⁶⁹ – even up to \$12,690 in *Nature*.⁵⁷⁰ This has shifted financial barriers rather than eliminating them, creating inequities that exclude early-career, unfunded and low-income researchers.⁵⁷¹

Emerging solutions include the publish-review-curate (PRC) model⁵⁷² proposed by Bodo Stern and Erin O'Shea (2019). This model shifts the decision on when to publish to authors, and after publication there is transparent peer review and then curation (e.g. selecting articles for more formal publication) using community feedback.⁵⁷³ However, this model introduces its own uncertainties as peer review, while offering alternative perspectives, does not guarantee the quality of an article, which means that once again editorial acceptance (at the curation stage) becomes the primary quality requirement.⁵⁷⁴

Decentralised academic publishing using blockchain platforms addresses issues relating to speed, attribution and transparency.⁵⁷⁵ The concept of decentralised science (DeSci) takes this idea further, restructuring publishing ecosystems through decentralised autonomous organisations (DAOs) and unique identifiers for collaborative research.⁵⁷⁶ In February 2026, the OpenSci platform was announced at the World Laureates Summit in Dubai, using AI and blockchain to track contributions and distribute rewards through scientific tokens.⁵⁷⁷

Open access and PRC redistribute control and risk but fail to address underlying funding and access challenges. Moving forward requires alignment with publishing's core purpose: advancing innovation, science and society.⁵⁷⁸ As AI reshapes publishing ecosystems,⁵⁷⁹ intellectual property (IP) ownership and compliance monitoring will become critical.⁵⁸⁰ *Frontiers*, one of the largest open-access science publishers, has developed AIRA – an AI model that can perform over 40 article checks every two minutes, flagging issues requiring for human editorial judgement for final decisions and preventing algorithmic drift through continuous feedback loops.⁵⁸¹

Traditional publishers control half of the global research output while maintaining over **30%** profit margins.

Article processing charges commonly range between



\$1,500 and \$2,500 even up to \$12,690 in *Nature*.

AIRA can perform over **40 article checks** every two minutes.





Pathway to Impact

Shows one of many possible pathways to the preferable future. The speed of development will vary based on funding, leadership, the resolution of necessary enablers and external conditions.

Funding Instruments

Stage-specific funding instruments that the related activities could be funded through to ensure a balanced portfolio approach.

What Progress looks Like

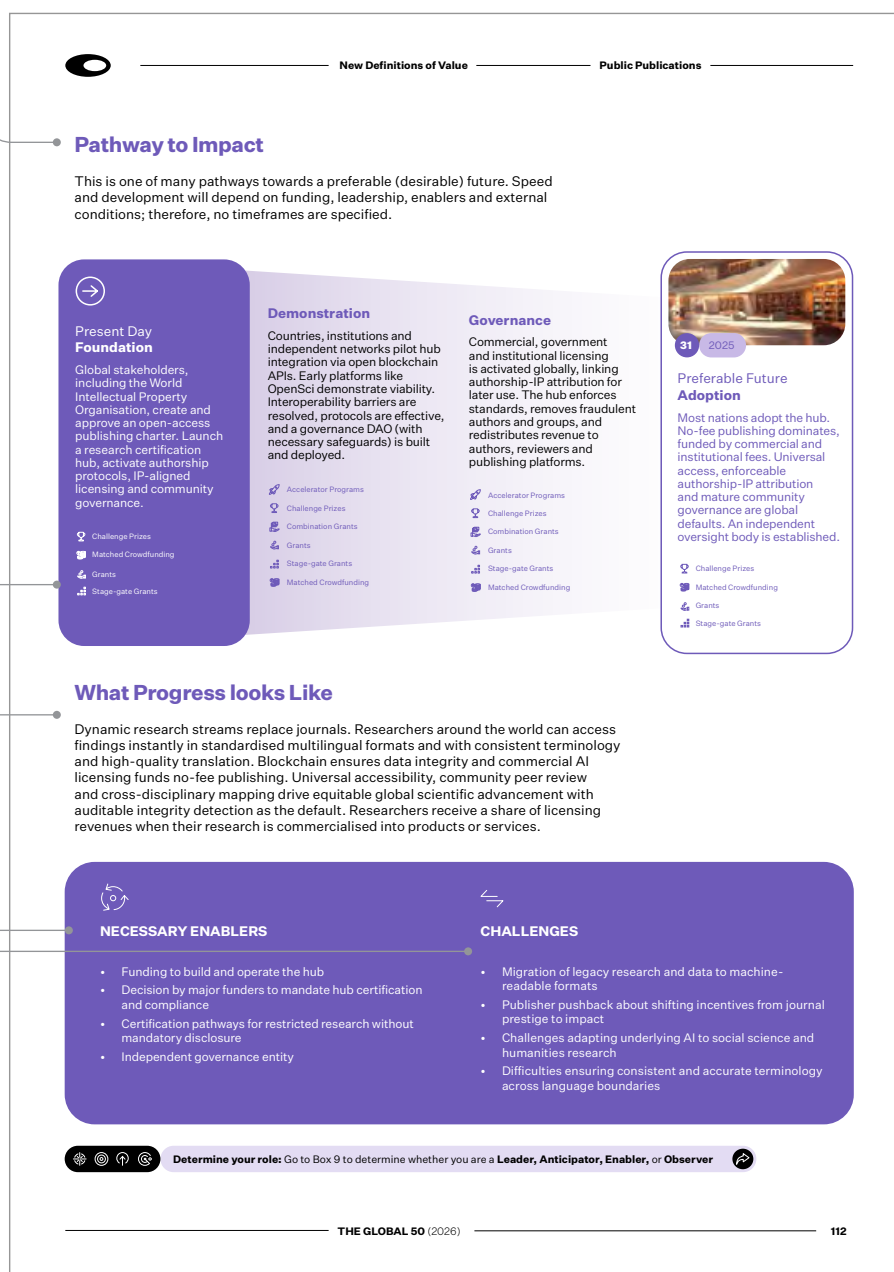
Summarises the positive direct and indirect effects of the opportunity

Necessary Enablers

A list of what must be in place for progress to be realised via the pathway above.

Challenges

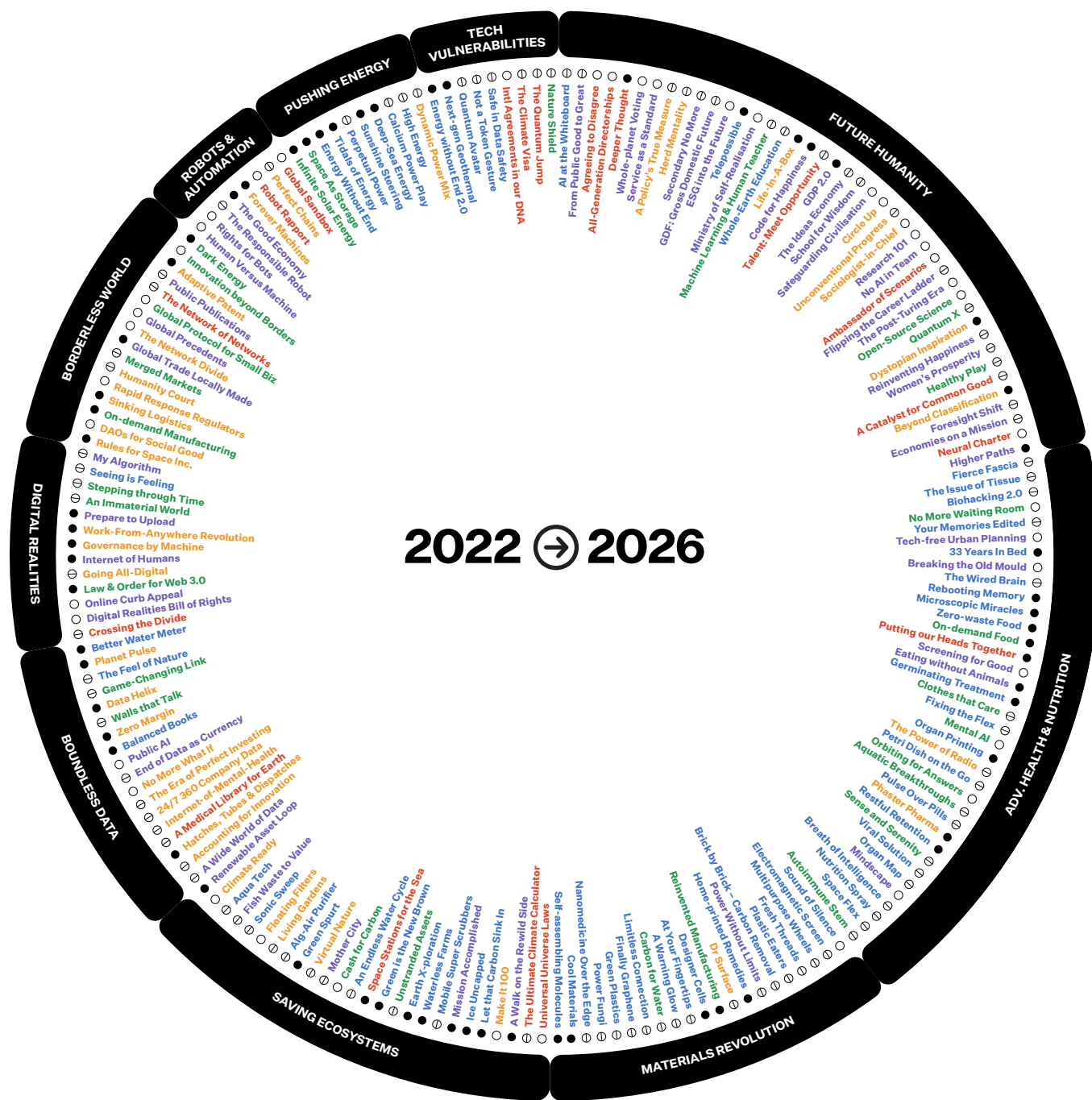
A list of what will be a challenging and needs to be solved. These could be sources of opportunity for key actors.



The opportunities shared in this report are non-exhaustive – they present just some of the potential manifestations of future growth, prosperity and well-being. Some opportunities may seem more relevant than others, some will have the conditions already in place for implementation, while others may not. The risks associated with some opportunities might not be limited to those countries or organisations acting on them.

While this year's edition shares 50 opportunities, its main purpose is to serve as a blueprint for how decision-makers and individuals can evaluate and imagine the implementation of **any future opportunity**. In addition, the information provided can help you determine whether an opportunity is worth pursuing in a given context. Therefore, in contrast to previous editions, in which we encouraged exploration based on category and relevance first, this year we recommend that you go through all five pillars and decide on your role across all 50 opportunities. Even opportunities that initially seem irrelevant to your sector may reveal unexpected connections when viewed through a new lens.

The Opportunities



Pillars

● New Definitions of Value

 **New Markets**

Technologies

 Partnerships

Agility

Scope

☐ Within Reach

☐ Transitional

● Visionary

Megatrends



The Global 50 is a global report focused on innovation. Some aspects may be more relevant in particular contexts or at different times.

The trends, signals, benefits, risks and data mentioned within each opportunity are **non-exhaustive** and are based on the information available at the time of publication. The *status today* within each opportunity may not include developments that are not yet public or already be underway.

This fifth edition of The Global 50 moves beyond identifying future opportunities to exploring how they can be realised. Grounded in innovation theory, the opportunities can be seen as a means of value creation for growth, prosperity and well-being, and this edition unpacks them as a form of value capture. Readers are encouraged to approach them with curiosity, to reflect on their own context and resources, and adapt them as blueprints for their own ideas. While the opportunities can guide readers through future pathways and next steps, decision-makers should engage in deeper analysis and participatory backcasting before taking action potentially identifying a different pathway that is more relevant in their context.

Although backcasting was used to develop the pathways presented in this report, they are simplified here to support accessibility and ease of understanding.





PILLAR

1

New Definitions of Value

Opportunities that capture value by redefining models of success and value beyond the economy and traditional economic metrics.

Insights^H that emerge from the opportunities within this pillar

1

Human agency will continue to be vital in the age of robots and automation

Among the opportunities within this pillar, between one-third and half identify Future Humanity as the most significant megatrend, with Human–Machine Interaction and Automation as core trends. As technology continues to develop, giving us access to advanced possibilities across all sectors, a critical question emerges: ‘How can humans retain meaningful agency where and when it matters most?’

2

Value must be envisioned across ecosystems rather than in siloed domains

Approximately a quarter of the opportunities in this pillar move beyond traditional vertical silos. Instead of focusing on isolated sectors, they target transformative change across entire value chains, ecosystems and economic models. This shift represents a fundamental reconsideration of how value is created and distributed.

3

Collaboration is a critical enabler

For more than 80% of the opportunities in this pillar, collaboration is a critical enabler. This finding underscores that future governance frameworks will be essential. How we govern technologies may be critical for realising new definitions of success.

^H These insights are drawn from the 200 opportunities that were published in the previous editions of The Global 50. They are intended for informational, educational and guidance purposes and are non-exhaustive. Because these insights are based on specific opportunities, they may not be generalisable across all contexts.



Most Significant Megatrend

Uncertainty

Trend

Technology

49 2022 Transitional

The Ideas Economy

What if we could splice and dice intellectual property rights?

Future Humanity

Nature

Collaboration

Cross-sectoral Partnerships

Tokenisation

Future of Purpose & Work

Digital Economy

Ideation, IP & Entrepreneurship

Tokenisation

Artificial Intelligence

Distributed Ledger Technologies (DLTs)

13 2023 Transitional

From Public 'Good' to 'Great'

What if we had a new model for public goods?

Future Humanity

Collaboration

Systems

Cross-sectoral Partnerships

ESG & Beyond GDP

International Collaboration

Mobilising Innovation

Community-Based Solutions

EdTech

HealthTech

Distributed Ledger Technologies (DLTs)

17 2023 Transitional

A Wide World of Data

What if comprehensive data was a public good?

Boundless Multidimensional Data

Technology

Values

Ideation, IP & Entrepreneurship

Open Data

Cross-sectoral Partnerships

Digital Economy

International Collaboration

Artificial Intelligence

Data Protection & Privacy

Distributed Ledger Technologies (DLTs)

18 2024 Transitional

School for Wisdom

What if wisdom was taught?

Future Humanity

Values

Systems

Future of Purpose & Work

Transforming Education

Generational & Cognitive Diversity

Mental Health

Human-Human Interaction

Advanced Connectivity

Artificial Intelligence

Advanced Computing

25 2024 Transitional

The Responsible Robot

What if sustainable development was central to robotics?

Life with Autonomous Robots and Automation

Technology

Systems

Human-Machine Interaction

Mobilising Innovation

Cross-sectoral Partnerships

ESG & Beyond GDP

International Collaboration

Robotics

Artificial Intelligence

Battery Technologies

38 2024 Transitional

Flipping the career ladder

What if the youth were paid to explore careers and retirees never retired?

Future Humanity

Values

Systems

Future of Purpose & Work

Mental Health

Future of Education

Longevity & Vitality

Generational & Cognitive Diversity

FinTech

Artificial Intelligence

Real-Time Analytics

39 2024 Visionary

The Good Economy

What if the future knowledge economy was shaped by the welfare of societies?

Life with Autonomous Robots and Automation

Values

Systems

Future of Purpose & Work

Open Data

ESG & Beyond GDP

Transforming Education

International Collaboration

Real-Time Analytics

Artificial Intelligence

Data Protection & Privacy

25 2025 Transitional

Women's Prosperity

What if women attained their expectations for prosperity and well-being?

Future Humanity

Collaboration

Values

ESG & Beyond GDP

Mobilising Innovation

Future of Purpose & Work

Future of Education

International Collaboration

Open Data

Artificial Intelligence

Real-Time Analytics

31 2025 Transitional

Public Publications

What if all academic publishing became open access?

Borderless World – Fluid Economies

Collaboration

Systems

Cross-sectoral Partnerships

Open Data

Mobilising Innovation

Digital Economy

International Collaboration

Blockchain

Open Data

Distributed Ledger Technologies (DLTs)

50 2025 Transitional

Higher Paths

What if higher education was no longer about the number of years but the quality of years?

Future Humanity

Collaboration

Values

Future of Purpose & Work

Digital Economy

Mobilising Innovation

Transforming Education

Generational & Cognitive Diversity

Blockchain

Artificial Intelligence

Digital Communities

NEW 2026 Transitional

National Cognitive Potential (NCP)

What if a nation's most valuable asset is the focused, interconnected minds of its people?

Future Humanity

Systems

Technology

Cross-sectoral Partnerships

Open Data

Community-Based Solutions

ESG & Beyond GDP

Future of Purpose & Work

Advanced Connectivity

Artificial Intelligence

Internet of Things (IoT)



49 2022

What if we could splice and dice intellectual property rights?

The Ideas Economy

Securitisation as a means of income generation allows widespread creation, ownership and trading of intellectual property (IP) rights.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Future Humanity

Uncertainties

Collaboration, Values

Trends

Cross-Sectoral Partnerships
Digital Economy
Future of Purpose & Work
Ideation, IP & Entrepreneurship
Tokenisation

Technologies

Artificial Intelligence
Distributed Ledger Technologies (DLTs)
Tokenisation

Category

Transformational

Top Five Sectors

Art, Media, Sports & Entertainment
Data science, AI & Machine Learning
Health & Healthcare
Manufacturing
Materials & Biotechnology

Keywords

Digital Assets
IP Bonds
IP-NFTs
Securitisation
Smart Contracts

Why It Matters Today

Even though global unemployment, at 4.9%,⁴³⁰ is at its lowest level since 1991,⁴³¹ it remains a challenge, with youth unemployment increasing slightly to 12.4% in 2025 from 12.3% in 2024.⁴³² The more pressing issue, however, is job quality. Stagnant wages, informal work and a lack of decent working conditions are spreading because economies are not shifting towards higher-value industries and services quickly enough.⁴³³ In addition, the transition to AI and automation is accelerating, threatening traditional jobs.⁴³⁴ While interest in entrepreneurship is high, access to finance remains a challenge.⁴³⁵



Benefits

Ability to smooth income across work and non-work periods, freeing up time for education, caring and community contribution.



Risks

Larger economies refuse the model; criminal misuse of securitisation; innovation hijacking.



Status Today

IP securitisation converts IP rights, such as patents and trademarks, into financial instruments through special-purpose vehicles.⁴³⁶ In one historical use case, in 1997 David Bowie issued \$55 million in 10-year securities at 7.9% interest, backed by 25 of his albums recorded before 1990.⁴³⁷ This was innovative at the time. However, illegal downloads of Bowie's music in the early 2000s significantly damaged the bonds' performance, causing rating agencies to downgrade 'Bowie bonds' as earnings declined.⁴³⁸

What has emerged since then is tokenisation, which achieves similar goals to securitisation of IP but more efficiently, by converting IP rights into digital tokens.⁴³⁹ Tokenisation enables individuals and companies to participate in the IP marketplace while also addressing securitisation's historical limitations (complexity, gatekeepers and slower transactions), using blockchain automation and fractional ownership models.⁴⁴⁰

Another relevant innovation is IP bonds and IP collateralised debt obligations (CDOs) which are nascent concepts that fall under IP-backed finance more generally. Using IP (patents, trademarks, copyright and digital assets) as collateral in debt instruments, represents a yet untapped possibility.⁴⁴¹ With the global value of intangible assets, which includes IP, at just under \$80 trillion in 2024,⁴⁴² and IP representing 90% of S&P 500 company value,⁴⁴³ IP-backed financing, including emerging instruments like IP bonds and IP CDOs, is gaining attention as a key area of future growth.

A recent emergence is IP-NFTs, which combine legal contracts (e.g. research or licensing agreements) with smart contracts.⁴⁴⁴ Unlike generic NFTs (non-fungible tokens), IP-NFTs (a name our research picked up may change in future) seek to define which IP rights transfer with ownership through binding contracts,⁴⁴⁵ though actual IP rights transfer only through separate legal instruments, particularly for copyright, which requires written assignment by law. The Singapore courts recognised NFTs as legal property in 2022, in the context of NFT collateral, and not IP rights transfer, nevertheless establishing an important development for the future institutional credibility of IP-NFTs.⁴⁴⁶ IP-NFTs aim to clarify IP rights transfer, addressing the challenge of ambiguous rights in traditional NFTs.⁴⁴⁷



**\$80
trillion**

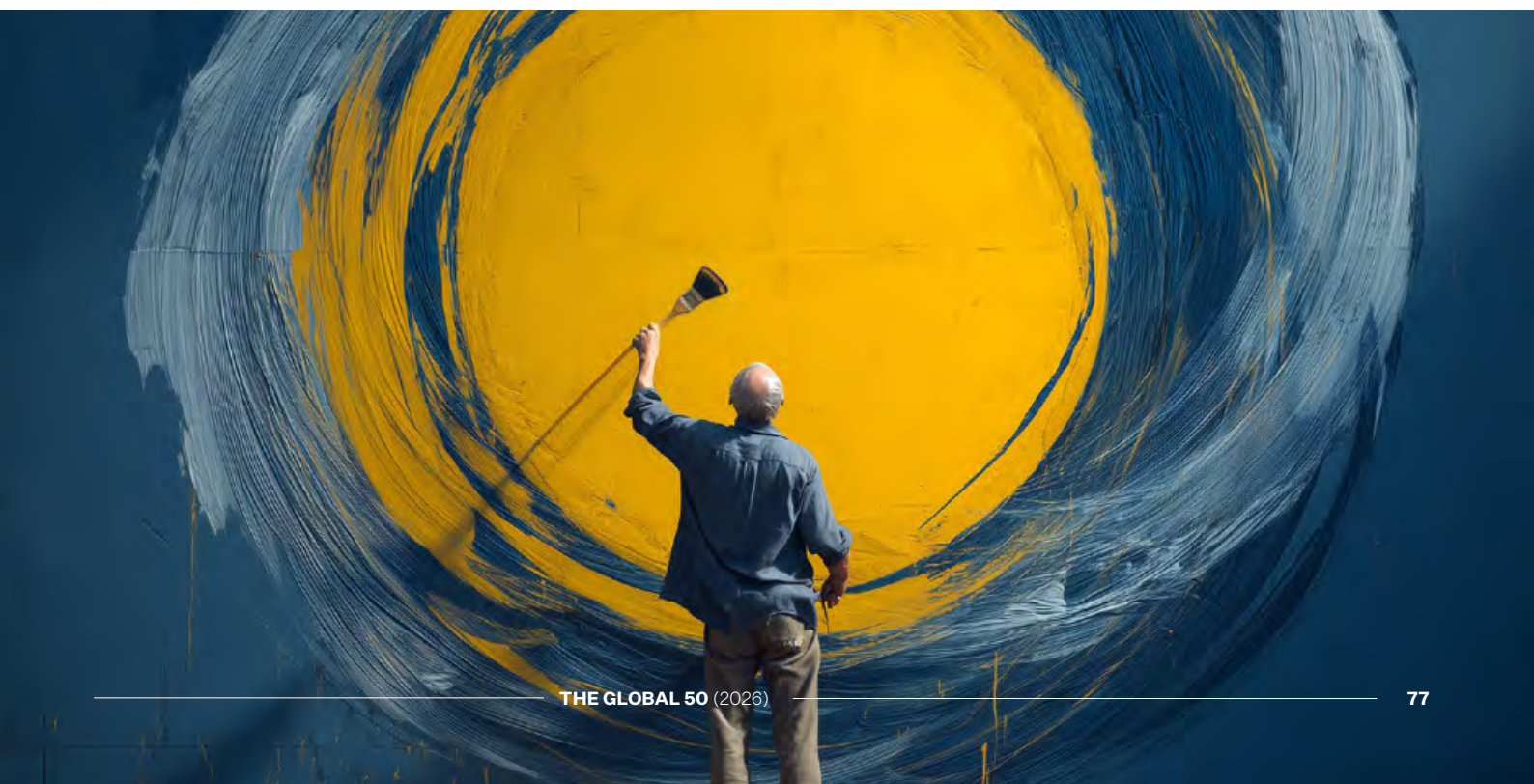
global value of
intangible assets
including IP (2024)



IP represents

90%

of S&P 500
company value





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Global Sandbox for IP Exchange

A global regulatory sandbox is established to validate IP tokenisation and fractional ownership models. Legal frameworks are developed to define IP with distinct requirements for patents, trademarks and copyright. Open standards and blockchain ledgers are created to standardise recording. Stakeholder mapping clarifies ecosystem requirements and participation pathways.

Challenge Prizes

Contracts

Grants

Stage-gate Grants

Foundations for IP Marketplace

Universal legal recognition of IP-NFTs as cross-border property is secured. Standardised smart contracts govern IP transactions, automating licensing and royalty distribution while respecting statutory requirements for IP assignment. AI validation models are built to assess novelty and verify claims against existing patents.

Accelerator Programmes

Early-stage capital and multiple funding partners

Combination Grants

Grants

Stage-gate Grants

Matched Crowdfunding

Piloting IP Marketplace

IP bonds and CDOs become standard liquid assets in financial markets. Cross-border platforms are piloted with AI validation gates and human oversight. Mainstream institutional investment in IP debt starts to accelerate.

Scaling Funds

Loans

Venture Equity Investment

Convertible Loans

Early-stage capital and multiple funding partners



49

2022

Preferable Future IP Marketplace

An IP marketplace is launched as a central platform for IP trading. IP becomes the primary mechanism for wealth creation and economic participation worldwide.

Equity Investment

Service Contract

Loans

Scaling Funds



What Progress looks Like

A person can earn a lifetime income from a single idea that is registered across jurisdictions. First they must develop their idea and submit it for validation. Then, once approved, it is tokenised into fractional shares. Whether the shares are offered openly or to a closed group, investors buy stakes on the IP marketplace. Every time the idea is licensed or used commercially globally, the person receives dividends. Wealth flows from intellectual contribution.



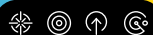
NECESSARY ENABLERS

- Globally aligned IP legislation for fractional ownership
- Transparent, tamper-proof digital ledgers
- Public awareness and creator education campaigns
- Open APIs for IP registration, renewal and trading systems
- Auditable smart contracts and reputation systems



CHALLENGES

- Tools for dynamic pricing and micro-IP analytics
- Platforms to simplify and align global IP compliance
- Auditable smart contracts and reputation systems
- Adaptation of legal and financial frameworks to support new use cases for IP-derived income as they emerge
- Lack of a global IP framework where IP rights are registered and maintained separately in each country



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





13 2023

What if we had a new
model for public goods?

From Public 'Good' to 'Great'

Reframing the provision of public goods under a new model of Society–Public–Private (SPP) cooperation for public goods opens up new solutions in health, the environment and elsewhere.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Future Humanity

Uncertainties

Collaboration, Systems

Trends

Community-Based Solutions
Cross-sectoral Partnerships
ESG & Beyond GDP
International Collaboration
Mobilising Innovation

Technologies

Distributed Ledger Technologies (DLTs)
EdTech
HealthTech

Category

Collaboration Advanced

Why It Matters Today

Public goods – in education, environment, health, infrastructure,⁴⁴⁸ technology,⁴⁴⁹ science⁴⁵⁰ and research⁴⁵¹ – serve all.⁴⁵² Traditional public–private partnerships (PPPs) are often used to deliver these goods with some benefit, including reduction in healthcare⁴⁵³ and construction⁴⁵⁴ schedule and cost overruns relative to original aims and plans. However, PPPs face implementation challenges,⁴⁵⁵ particularly when a given public sector is facing limited capacity (resources and skills) and strategic constraints around managing PPPs.⁴⁵⁶ For example, in Latin America, between 1985 and 2000, 75% of water and 55% of transport concessions required renegotiation within an average of 2.2 years of being awarded.⁴⁵⁷ A subsequent review of Latin America, showed rising renegotiation rates of 87% and 78% for water and transport respectively, with the average time to renegotiation falling to one year.⁴⁵⁸ At the same time, cooperatives (top 300) generated \$2.79 trillion in turnover in 2023, demonstrating scalability and viability for society-owned businesses.⁴⁵⁹ Finding a way to bridge all of these approaches can ensure that public goods serve their inclusive purpose effectively.⁴⁶⁰



Benefits

Improved planning and delivery of public goods at lower cost; improved outcomes for residents.



Risks

Failure to establish autonomy and independence from partners; reduction of public revenues over time; loss of public sector control over strategic assets.

Top Five Sectors

Digital Goods & Services
Financial Services & Investment
Government Services
Health & Healthcare
Infrastructure & Construction

Keywords

Cooperatives
Digital Public Goods (DPGs)
Distributed Ledger Technologies (DLTs)
Regulatory Sandbox
Smart Contracts

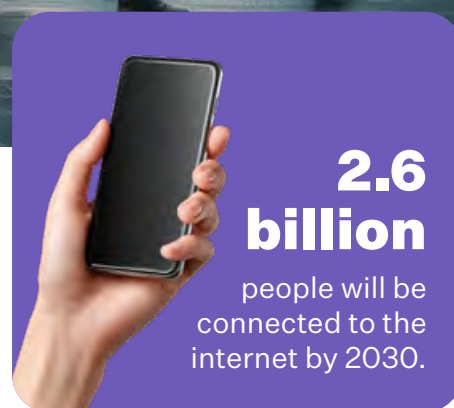


Status Today

The discussion on public goods has emerged in two areas: AI systems as digital public goods (DPGs); and the growing need for a new model for public goods, given the rising global funding gap in development aid.

DPGs, beyond just being non-exclusionary, are meant to promote ethics, privacy, the Sustainable Development Goals (SDGs) and a more equitable digital ecosystem.⁴⁶¹ They include open data, standards and, now, AI systems more generally.⁴⁶² In this context, having open AI systems does not mean that an entire AI system is open⁴⁶³ RAIL (Responsible AI Licences), for example, restricts others' use of AI technology through purpose limitation, documentation and transparency, rather than relying on regulation and governance.⁴⁶⁴ The Digital Public Goods Alliance was established in 2019 to accelerate the SDGs in respect of digitalisation in low- and middle-income countries; it shifts the focus from AI models to AI systems⁴⁶⁵ and supports the UNESCO recommendations on AI ethics adopted by 193 countries in 2021.⁴⁶⁶ This is particularly important as the Global Digital Compact adopted in September 2024 commits to connecting 2.6 billion people to the internet by 2030 and identifies DPGs as key mechanisms to accomplish that.⁴⁶⁷

On the other hand, funding for traditional public goods is shifting towards hybrid public-private models⁴⁶⁸ as official development assistance continues to decrease,⁴⁶⁹ from \$227 billion (2022) to \$174 (2025), a 23% drop.⁴⁷⁰ Careful design is needed to prevent 'free-rider' issues and, at the same time, engage the private sector.⁴⁷¹



Official development assistance continues to **decrease**



from
\$227 billion
(2022) to
\$174 billion
(2025) a 23% drop.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Conceptual SPP Model

A consortium of researchers, policymakers, legal experts, development organisations and cooperatives reviews existing models and designs an SPP model and legal architecture.

Challenge Prizes

Grants

Stage-gate Grants

Capacity-Building

Digital infrastructure and governance frameworks are reviewed and adapted, enabling collaboration and real-time decision-making through smart contracts, data sharing and institutional investor engagement.

Accelerator Programmes

Equity Investment

Combination Grants

Convertible Grants

Service Contracts

Piloting

Pilot projects are launched, for one or more selected public good initiatives, to test, document and refine the SPP model.

Accelerator Programmes

Revenue-dependent Grants

Combination Grants

Early-stage capital and multiple funding partners

Social Impact Bonds (SIB)

Matched Crowdfunding



13 2023

Preferable Future Scaling and Integrating

The SPP model has been adopted across sectors, supported by hybrid funding mechanisms and toolkits that build institutional capacities and policies.

Equity Investment

Revenue-dependent Grants

Loans

Scaling Funds



What Progress looks Like

There is widescale SPP adoption with legal frameworks, governance structures and hybrid funding mechanisms across sectors. Multi-stakeholder collaboration delivers more accessible and higher-quality public goods designed for – and adaptable to – the communities they serve. Digital infrastructure, real-time monitoring and smart contracts ensure transparency and accountability. Institutional toolkits enable replication alongside traditional aid and development assistance and beyond PPP models.



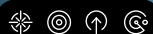
NECESSARY ENABLERS

- Effective and responsible digital identify frameworks to verify community participants and automate smart contracts
- Overcoming data sovereignty issues while also meeting global data privacy requirements
- Risk-sharing funding mechanisms to de-risk private sector entry into public goods infrastructure
- Robust Internet of Things (IoT) infrastructure with interoperability standards and secure data-sharing mechanisms
- Standardised frameworks for public goods delivery, including DPGs



CHALLENGES

- Algorithmic bias
- Cybersecurity
- Mobilisation of transition capital
- Regulatory lags which may delay implementation, possibly creating an opportunity for global regulatory sandboxes



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





17 2023

What if comprehensive data was a public good?

A Wide World of Data

Enabled by incentives for data sharing, a secure platform is set up where entrepreneurs, researchers and policymakers can share and access vast aggregated and anonymised user datasets and related analysis, which aids global innovation, learning and discovery.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Boundless Multidimensional Data

Uncertainties

Technology, Values

Trends

Cross-sectoral Partnerships
Digital Economy
Ideation, IP & Entrepreneurship
International Collaboration
Open Data

Technologies

Artificial Intelligence
Data Protection & Privacy
Distributed Ledger Technologies (DLTs)

Category

Collaboration advanced

Top Five Sectors

Communication Technologies & Systems
Cyber & Information Security
Data science, AI & Machine Learning
Government Services
Health & Healthcare

Keywords

AI training
Cross-border data sharing
Open data platforms
Public goods
Smart contracts

Why It Matters Today

While estimates of the current number vary, data generation could exponentially increase to one yottabyte (1 million exabytes) yearly by 2030.⁴⁷² In the annual worldwide survey of academic researchers, the State of Open Data, approximately 80% (2025) believed data should be openly available as standard practice.⁴⁷³ Only around 6% of businesses globally actively pursue benefits from using, accessing and sharing data, despite open data's potential to drive innovation, reveal opportunities and improve operations.⁴⁷⁴ The digital economy is projected to generate more than two-thirds of all new global economic value over the next ten years.⁴⁷⁵



Benefits

Faster, more accurate modelling in research and innovation. More of a level playing field for actors in the public and private spheres.



Risks

Exploitation of data (even aggregated data) to identify individuals for criminal or malicious purposes, unless extremely advanced security measures are implemented.



Status Today

Europe has pursued open-data platforms both through learning and training at local (city), regional and national (EU member country) levels,⁴⁷⁶ and as well as through the assessment and monitoring of open-data maturity in EU countries.⁴⁷⁷ The most recent assessment based on an evaluation of open-data policy, portal access, quality and impact, along with governance approach, domain of impact and funding levels.⁴⁷⁸ Over 60% of European countries adopt a quality-oriented approach as opposed to a broad expansion of diverse data, while 22 countries use standard open-source platforms compared to 12 that use proprietary, custom-built ones.⁴⁷⁹

The current impact of open data is clear. For example, open-data initiatives across Europe have led to job creation and matching job seekers with employment opportunities; business innovation, with new business models and services and efficiency gains; better government policymaking; and improved health and inclusion, such as helping people make better food choices in France and supporting vulnerable groups through information in Germany.⁴⁸⁰

When it comes to the public sector, the UAE has created open-data portals, be it at the UAE,⁴⁸¹ Abu Dhabi⁴⁸² or Dubai⁴⁸³ levels. In terms of international non-governmental organisations, the World Bank⁴⁸⁴ and the United Nations through various agencies and through UNData,⁴⁸⁵ are also known to support sharing of data.

The Open Data Institute (ODI), working with the UK Department for Culture, Media and Sport (DCMS), has launched an initiative to create open-data infrastructure for volunteering across England where 24.8 million adults volunteer, critical to delivering essential community services, and to bring together volunteer opportunities that are scattered across 47 platforms. The initiative will map the current data ecosystem, develop and test an open standard, pilot with partners and then launch.⁴⁸⁶

Open-data sharing across borders, going beyond private cross-border data flows⁴⁸⁷ and the x-road initiatives between Estonia and Finland,⁴⁸⁸ is important for economic growth. Yet no initiative, beyond pilot programmes, has been designed to make full use of this potential. The question is how we can make the most of the growing volume of data while managing the challenges and tensions between open-data principles and AI training.⁴⁸⁹

Over

60%

of **European countries** adopt a quality-oriented open-data approach



Only

6%

of businesses globally actively pursue benefits from using, accessing and sharing data



24.8 million

adults in England covered by open-data volunteering initiative across 47 platforms





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Clarify Needs

Data governance, cybersecurity, anonymisation and operational requirements are specified, including AI training limitations and conditions for a global regulatory sandbox.

- Challenge Prizes
- Matched Crowdfunding
- Accelerator Program
- Grants
- Stage-gate Grants

Build Systems

A secure platform is selected or built, including multi-layered anonymisation, access controls and routine stress-testing with documented technical and operational configurations.

- Accelerator Programs
- Convertible Grants
- Equity Investment

Pilot

Pilots, within defined use cases for data as a public good, are launched documenting performance, limitations and identified technical or governance gaps.

- Social Impact Bonds
- Service Contracts
- Early-stage capital and multiple funding partners
- Revenue-dependent Grants



17 2023

Preferable Future Adoption

International agreements with clear usage terms are in place, built on evidence-based analysis. Platforms are launched worldwide and in specific areas.

- Scaling Funds
- Loans
- Venture Equity Investments



What Progress looks Like

Cross-border data flows are optimised and lead to global economic growth, particularly in trade and innovation. AI trained on these datasets unlocks economic value from R&D and makes scientific breakthroughs more possible. Early warning systems are built, and a new era of research, innovation and growth is unpacked.



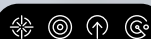
NECESSARY ENABLERS

- Data, ethical, legal and system interoperability across borders
- Advanced and effective data anonymisation and verification techniques
- Clear guidance on data sovereignty and ability for jurisdictions to revoke access
- Jurisdiction-level adoption of data repositories and policies
- Effective multi-player global agreements that support consistent sharing of data



CHALLENGES

- High numbers of users choosing to opt out due to concerns about the visibility and control of their data
- Cybersecurity
- Inconsistent data quality and capabilities, hampering quality insight and analysis
- Regulatory friction and difficulties with cross-border compliance
- AI models may eventually converge, giving rise to the need for secondary synthetic datasets to stress-test models



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





18 2024

What if wisdom
was taught?

School for Wisdom

Schools are transformed with wisdom-based education programmes, fostering culturally informed reasoning and skills to tackle complex challenges posed by emerging technologies for both young and old.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Future Humanity

Uncertainties

Values, Systems

Trends

Future of Purpose & Work
Generational & Cognitive Diversity
Human–Human Interaction
Mental Health
Transforming Education

Technologies

Advanced Computing
Advanced Connectivity
Artificial Intelligence

Category

Societies Empowered

Top Five Sectors

Data science, AI & Machine Learning
Education
Government Services
Health & Healthcare
Professional Services

Keywords

Critical Thinking
Emotional Intelligence
Lifelong Learning
Neuroscience
Pedagogy



Why It Matters Today

AI is expected to displace or redefine up to 40% of global jobs.⁴⁹⁰ There will be a need for robust education reform, with lifelong learning programmes and skills that complement rather than compete with AI.⁴⁹¹ This means that the human ability to merely combine and synthesise information will be less critical, superseded by critical thinking and problem-solving abilities.⁴⁹² Wisdom is an aptitude for making judicious decisions at the appropriate moment, integrating multiple ideas and perspectives. It is multifaceted, involving diverse capacities and competencies, and is evident in decision-making and action in complex social situations.⁴⁹³ It is often sought to tackle challenges associated with societal shifts or emerging technologies.



40%

of Global Jobs

Expected to be impacted, displaced or redefined by AI



Benefits

Wisdom-based decision-making ensures humanity's adept response to increasingly complex societal challenges.



Risks

The underlying conceptual model is too complicated for implementation, loses relevance or does not align with the wider approach to policy development.



Wisdom is an aptitude for making judicious decisions at the appropriate moment, integrating multiple ideas and perspectives.

The human ability to merely combine and synthesise information will be less critical, **superseded by critical thinking and problem-solving abilities**





Status Today

Historically, education has prioritised knowledge transmission, yet rising IQs have not been matched by increases in wisdom.⁴⁹⁴ ‘Smart but foolish’ people exhibit six fallacies – unrealistic optimism, egocentrism, omniscience, omnipotence, invulnerability and ethical disengagement – commonly evident in corporate scandals and global conflicts.⁴⁹⁵

Wisdom entails applying intelligence, creativity and knowledge to decisions and actions, balancing our own and others’ interests over the short and long term.⁴⁹⁶ As AI transforms education and work, wisdom will become essential for navigating change, teaching ethics and developing emotional regulation.

A study of 535 university students identified four dimensions of wisdom: cognitive, ethical-existential, affective and social. Activities that develop scientific and critical thinking predicted students’ levels of wisdom across all dimensions. Sharing and learning from practical experiences was the second strongest predictor of wisdom, particularly for the affective and ethical-existential dimensions. Diverse pedagogical approaches proved more effective than single methods at developing wisdom: combining independent studying, collaboration, and activities that integrated theory with practice yielded the best results.⁴⁹⁷

Education research has seen a dramatic expansion in the focus on wisdom since 2000. In a review of 28 influential publications, four pedagogical dimensions emerge: connecting to others (100 keywords), knowing ourselves (97), knowing the world (84) and connecting to the world (71). The most frequently cited attributes of wisdom across the literature are self-knowledge, openness, altruism, empathy, emotional regulation, judgement, life experience and prosocial behaviour.⁴⁹⁸ Wisdom can be taught through diverse pedagogical approaches. However, education systems currently over-emphasise cognitive skills while neglecting the socio-emotional and ethical–moral development essential for wisdom.⁴⁹⁹ Teaching for wisdom therefore requires integration of multiple methods across all four dimensions simultaneously – no single pedagogy develops wisdom alone.⁵⁰⁰

Reflective methods have proved the most promising: learning journals, group discussions and learning through community service, significantly increase wisdom scores. Systems thinking and integrative thinking develop through assignments combining theoretical knowledge with practical experience, problem-solving and reflection across collaborative formats.⁵⁰¹



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Research

Synthesise neuroscience, psychology and traditional knowledge. Form a global interdisciplinary advisory board. Publish a wisdom competency framework.



Grants



Stage-gate Grants

Pilots

Select diverse pilot sites across at least 20 countries. Train educators at pilot locations on wisdom models. Develop neuroscientifically validated wisdom toolkits. Co-design culturally informed curricula with youth and elders at pilot sites.



Accelerator Programmes



Combination Grants



Early-stage capital and multiple funding partners



Social Impact Bonds (SIB)

Integration

Scale successful pilots to regional networks. Accreditation bodies mandate wisdom modules. Industry partners develop 'wise leadership' certifications. Integrate validated curricula into national testbeds.



Social Impact Bonds (SIBs)



Loans



18 2024

Preferable Future Implementation

Implement wisdom education from primary school and throughout lifelong learning. Link graduation to community impact projects. Deploy AI-assisted wisdom tutoring. Embed ethics and systems thinking into policies. Establish measurable wisdom competencies across all institutions.



Equity investment



Service Contracts



Loans

What Progress looks Like

Beyond accumulating knowledge, schools and communities bring people of all ages, while drawing on their own cultural understanding, learn to reason well, weigh consequences, and act with empathy. Wisdom-based curricula prioritise reasoning over knowledge acquisition, with community impact projects linking graduation to measurable societal benefit. Decision-makers balance decisiveness with acknowledgement of uncertainty. Technology serves, rather than replaces, human judgement.



NECESSARY ENABLERS

- New frameworks for teacher upskilling and training
- Age-appropriate curriculum design
- Parental and community support
- Global alignment on the complexities of defining and measuring wisdom
- Valid and effective approaches to teaching and assessing wisdom



CHALLENGES

- Global alignment on the complexities of defining and measuring wisdom
- Adoption and adaptation to teaching wisdom among teachers
- Integrating wisdom without overburdening or diminishing effective learning goals
- Assessment complexity
- Managing different interpretations / localisation of wisdom frameworks to diverse contexts



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





25 2024

What if sustainable development was central to robotics?

The Responsible Robot

Sustainable development drives robotics strategies and research, advancing sustainable agriculture, construction, disaster relief and healthcare, and aligning with global sustainable development goals.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Life with Autonomous Robots and Automation

Uncertainties

Technology, Systems

Trends

Cross-sectoral Partnerships
ESG & Beyond GDP
Human–Machine Interaction
International Collaboration
Mobilising Innovation

Technologies

Artificial Intelligence
Battery Technologies
Robotics

Category

Systems Optimised

Top Five Sectors

Agriculture & Food
Energy, Oil, Gas & Renewables
Government Services
Health & Healthcare
Infrastructure & Construction

Keywords

Agricultural Robots
Climate Goals
Robot-Assisted Surgery
Robots for Sustainable Development
Sustainable Investing

Why It Matters Today

We are approaching an inflection point where technologies relating to materials science, battery life and machine learning will converge to make robots synonymous with progress on development.⁵⁰² The current growth trajectory in robotics is expected to continue.⁵⁰³ In 2024, 542,000 industrial robots were installed (double the number of a decade earlier) and this figure was expected to reach 575,000 in 2025 and 700,000 by 2028.⁵⁰⁴ The UN Sustainable Development Goals (SDGs) address some of the most complex challenges humanity faces, such as food security and infrastructure resilience.⁵⁰⁵ Robotics may help us reach up to 46% of the SDG targets.⁵⁰⁶



Benefits

Across various geographies, affordable robotics platforms offer scalable solutions that address SDGs previously considered daunting.



Risks

Robots remain unaffordable for countries most needing sustainable development solutions, widening existing gaps and inhibiting rather than enabling development.



Status Today

Robots are already playing a transformative role in healthcare and agriculture, and are expected to continue to do so.

The global agricultural robotics market was valued at \$5.4 billion in 2023 and is expected to see a compound annual growth rate of 19.3% through to 2030.⁵⁰⁷ Large-scale farms achieve a return on investment within two to five years through savings and increased efficiency, with small farms seeing the same return but over a longer period.⁵⁰⁸ In agriculture, robotics automates irrigation, enables the precise application of fertilisers and pesticides, reduces water use and environmental impact, and preserves biodiversity.⁵⁰⁹

In healthcare, the global medical robotics market reached \$16.6 billion in 2023 and is expected to grow to \$63.8 billion by 2032.⁵¹⁰ Applications range from faster diagnostics, reducing emergency room wait times, to robotic-assisted surgery, leading to faster recovery times and reduced post-operative pain.⁵¹¹

Yet, investment in robotics remains limited compared to investment in other technologies. Despite decades of availability, robots remain highly concentrated in automotive manufacturing, with one study finding that 6.11 new robots are installed per 1,000 workers each year in this industry compared to 0.24 across the entire economy.⁵¹²

Today, robotics applications in sustainable development show potential in multiple areas: it is estimated that 53% of the environmental SDG targets will be supported by robotics along with 47% of the societal targets and 42% of the economic targets.⁵¹³ Furthermore, evidence demonstrates that sustainable investment sometimes performs better than traditional benchmarks. Between April 2014 and March 2024, the MSCI ESG Equity Leaders Index delivered higher returns than the broader MSCI World Index.⁵¹⁴

While green technologies offer solutions, they may have unintended consequences, including extraction pollution and environmental harm. Robotics can mitigate these outcomes by automating hazardous processes in extractive and polluting industries.⁵¹⁵ However, achieving this potential will require ongoing research into specialised materials for rigid and soft robotic systems.⁵¹⁶



Agricultural
robotics market

\$5.4 Billion

in 2023, **19.3% CAGR**
through 2030



Medical
robotics market:

\$16.6 Billion

growing to
\$63.8 billion by 2032



Robotics' contribution
across SDG targets

53% Environment

47% Societal

42% Economic





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Realignment

Redirect robotics research towards sustainable development via a consortium of universities, funders and standards bodies. Align R&D pipelines to designs for high-priority development sectors.

- Challenge Prizes
- Combination Grants
- Accelerator Programmes
- Grants
- Stage-gate Grants

Field Testing

Deploy development-focused robots in real-world agriculture, healthcare and disaster-relief settings. Co-design with local research and policy communities to validate safety, affordability and adaptability.

- Accelerator Programs
- Service Contracts
- Combination Grants
- Grants
- Stage-gate Grants
- Early-stage capital and multiple funding partners

Implementation

Replicate successful models across regions. Build skills, supply chains and service contracts that enable sustainable robotics deployment at scale.

- Scaling Funds
- Equity Investment
- Convertible Grants
- Social Impact Bonds (SIBs)
- Service Contracts
- Venture Equity Investment



25 2024

Preferable Future Scaling

Make robotics a core part of development infrastructure globally, sustained through procurement systems, education pipelines, governance frameworks and continuous scanning for opportunities.

- Social Impact Bonds (SIBs)
- Service Contract
- Loans
- Equity Investment
- Stage-gate Grants
- Venture Equity Investment

What Progress looks Like

Robots go from specialised technology to foundational infrastructure that can enable sustainable development globally. They become more affordable, working alongside humans to close development gaps and accelerate progress on critical challenges. Moving beyond peripheral innovation, robotics becomes central to how societies achieve sustainable development.



NECESSARY ENABLERS

- Policy frameworks incentivising alignment of sustainable development with robotics
- Open-access or shared datasets for research and development
- Local manufacturing and capacities around designing for specific contexts
- Multi-stakeholder innovation ecosystems and testbeds
- Innovative financing models for affordable adoption



CHALLENGES

- High cost of robotics, including upfront costs
- Requirement for robots to adapt to diverse unstructured environments
- Lack of skilled, interdisciplinary expertise covering robotics, materials, sustainability, development and design



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





38 2024

What if young people were paid to explore careers and retirees never retired?

Flipping the Career Ladder

Career trajectories are reversed: 'pensions' for young people, a growth period, then 'internships' for retirees encourage dynamic, diverse hiring and societal engagement across generations.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Future Humanity

Uncertainties

Values, Systems

Trends

Future of Education

Future of Purpose & Work

Generational & Cognitive Diversity

Longevity & Vitality

Mental Health

Technologies

Artificial Intelligence

FinTech

Real-Time Analytics

Category

Transformational

Top Five Sectors

Education

Financial Services & Investment

Government Services

Health & Healthcare

Professional Services

Keywords

Intergenerational Workforce

Mentorship

Pension

Productivity

Youth Basic Income (YBI)





Why It Matters Today

By 2050, the global average life expectancy is expected to reach 77.2 years.⁵¹⁷ In the countries of the Organisation for Economic Co-operation and Development, 28% of the population is likely to be over the age of 65 and 10% over the age of 80.⁵¹⁸ Globally, 16.5% of people will be over the age of 65 and 4.7% over the age of 80.⁵¹⁹ Also by this point, 1.4 billion people (14% of the global population) will be aged between 15 and 24, with 35% of these people being youth in Africa.⁵²⁰ As the three typical stages in life (education, work and retirement) shift with longer lives,⁵²¹ 1.2 billion young people will be pursuing an estimated 400 million jobs over the next 10 to 15 years.⁵²²



Benefits

Ability for early career entrants to explore interests without income pressure, focusing on achievements; opportunities for retirees to remain engaged, leading more fulfilling lives.

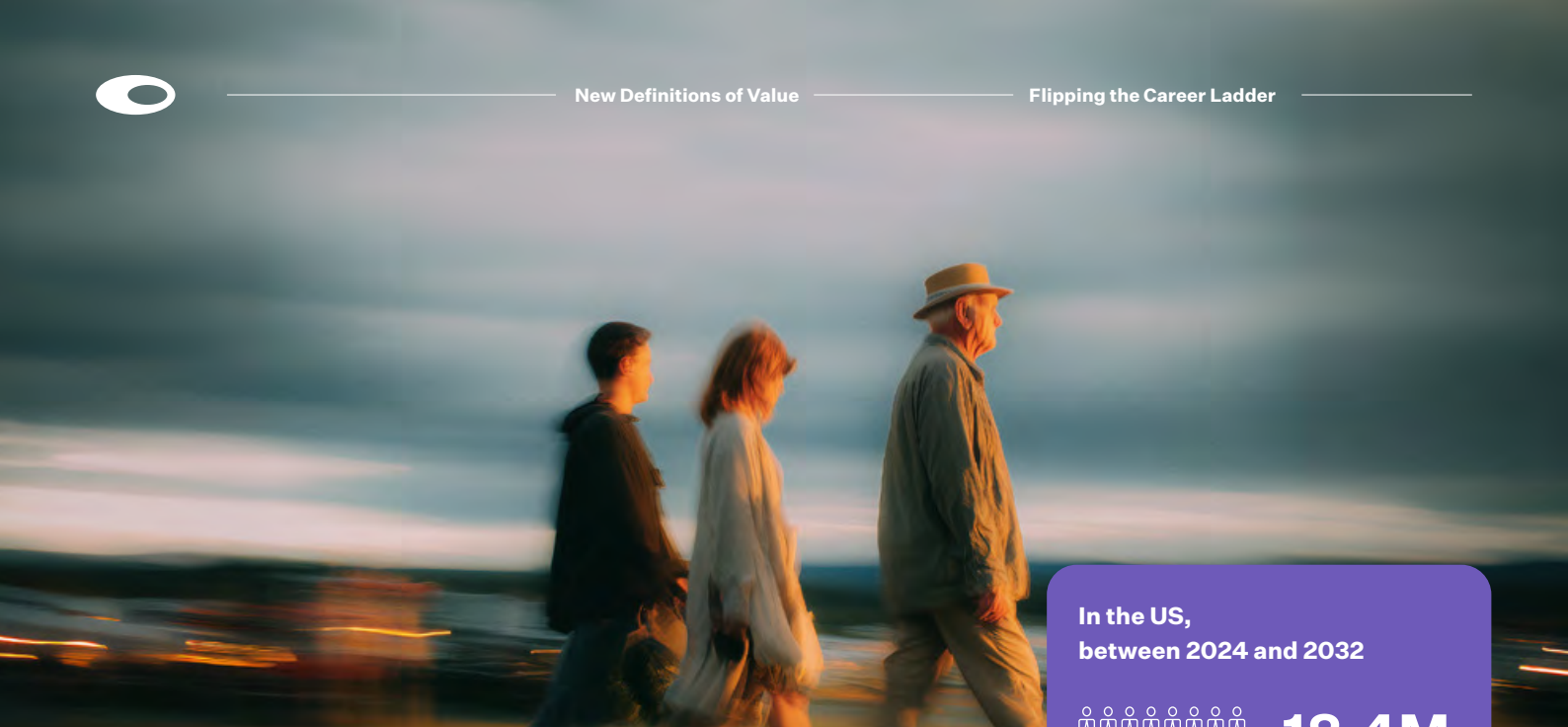


Risks

Experience gaps for early career entrants and challenges in securing full-time roles later on; challenges in securing suitable 'internship' roles for retirees.

By 2050,
the global
average life
expectancy
is expected
to reach
77.2 years





Status Today

The global economy is facing a unique challenge in providing meaningful employment for both young and ageing populations. This situation is evolving amid rapid technological disruption and other key transformations that are impacting other aspects of working life, and it is not limited to any one region.

Between 2024 and 2032 in the United States, 18.4 million workers will retire, while only 13.8 million younger workers will graduate and fill available roles.⁵²³ Combined with 685,000 new jobs created during this time, and adjusting for various skill levels needed, there will be a skills shortage of 5.25 million workers.⁵²⁴ This gap is expected to be particularly felt in teaching, nursing, engineering and construction (ranked from most to least affected).⁵²⁵ This is exacerbated by younger workers struggling to gain entry-level positions because AI is automating many of the tasks they would previously have carried out.⁵²⁶

Some of the actions that are being taken include increasing labour participation, addressing educational attainment gaps, expanding skills-based hiring with adequate training and leveraging technology responsibly.⁵²⁷ Industry representatives have highlighted that additional measures could include embracing human–AI collaboration, addressing AI fluency, and investing in building critical thinking skills and creativity.⁵²⁸ However, these initiatives alone are insufficient.

Productivity is a measure of what is produced in comparison to existing capacity.⁵²⁹ Productivity growth has stagnated despite technological advances, causing more than half of the global economic deceleration that has been seen since 2008 (globally, total-factor productivity fell from 1.6% in the early 2000s to just 0.6% in the 2020–2023 period).⁵³⁰

These sets of challenges are recognised globally. Efforts are being made to promote synergies between technology and human capital, strengthen anticipatory decision-making, future-proof education systems, accelerate technology adoption and diffusion, and invest in the trustworthiness of emerging technologies to narrow gaps in productivity.⁵³¹

In the US,
between 2024 and 2032



18.4M
retiring

vs



13.8M
graduating

Skills shortage
(adjusted for varied skills)

5.25M



Since the early
2000s, **productivity**
fell from

1.6%
to
0.6%

in the 2020–2023
period





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Research

Establish a consortium to model reversed career trajectories. Set up a group of experts to define economic frameworks and operational viability for shifting from linear to circular, multigenerational career lifecycles.

- Service Contracts
- Matched Crowdfunding
- Grants
- Stage-gate Grants

Proof of Concept

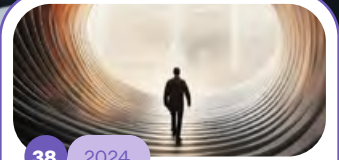
Launch regulatory sandboxes and multi-sector pilots. Document productivity, mentorship efficacy and regulatory gaps to create a replicable playbook applicable across diverse economic contexts.

- Accelerator Programs
- Combination Grants
- Social Impact Bonds (SIB)
- Service Contracts

Transition

Legislate to facilitate investment in career-entry and retiree re-entry. Develop jurisdictional roadmaps to manage labour shifts and reform employment and labour laws accordingly.

- Social Impact Bonds (SIBs)
- Service Contract



38 2024

Preferable Future Integration and Scaling

Scale intergenerational hiring through reformed labour codes and productivity-linked monitoring, normalising dynamic participation across all economic groups.

- Early-stage capital and multiple funding partners
- Equity investment
- Scaling funds
- Loans
- Service Contracts

What Progress looks Like

Young people explore diverse careers through basic income support (YBI), finding better long-term fit and driving innovation. Older individuals engage in structured internships, remaining mentally active while mentoring younger cohorts. Workplaces become resilient intergenerational hubs. Careers are nonlinear. While youth establish foundations with the support of YBI, retirees contribute wisdom through valued roles, maximising knowledge transfer across all ages.



NECESSARY ENABLERS

- Sustainable funding mechanisms
- Reforms of labour and employment law and pension plans
- Effective youth income model linked to productivity
- High-quality jobs for both youth and retirees
- Measures to keep pace with AI-driven job displacement and shifts



CHALLENGES

- Cultural resistance to 'reversed' hierarchies
- Difficulty retaining middle-aged professionals and experienced workers



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





39 2024

What if the future knowledge economy was shaped by the welfare of societies?

The Good Economy

In a future that will pivot on advanced machine intelligence and major technological breakthroughs, the knowledge economy will revolve around the sustained well-being of societies where education and innovation thrives. This era will be shaped by globally aligned societal values about technology, harmonisation of related laws and regulations, and technological progress that enhance quality of life and access to services in support of the common good.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Living with Autonomous Robots and Automation

Uncertainties

Values, Systems

Trends

ESG & Beyond GDP
Future of Purpose & Work
International Collaboration
Open Data
Transforming Education

Technologies

Artificial Intelligence
Data Protection & Privacy
Real-Time Analytics

Category

Transformational

Top Five Sectors

Data science, AI & Machine Learning
Education
Financial Services & Investment
Government Services
Professional Services

Keywords

AI Transition
Beyond GDP
Knowledge Economy
Skills-Based Economy
Wisdom Economy

Why It Matters Today

In the United States, private investment in AI reached \$285.9 billion in 2025, nearly 23 times China's \$12.4 billion, with generative AI attracting \$170.9 billion globally.⁵³² One in six people around the globe have adopted AI,⁵³³ yet adoption in the Global North has grown nearly twice as fast as in the Global South, with 24.7% of the working-age population in the Global North using AI compared to 14.1% in the Global South.⁵³⁴ As advanced machine intelligence automates cognitive work, not just routine tasks, the traditional purpose of the knowledge economy will evolve.



Benefits

Merging human and machine creativity leads to new solutions to global challenges and a creativity revival. This maximises productivity, ensuring sustainability and prosperity for today's and future generations.



Risks

The reliance on advanced machine intelligence may result in people having a diminished set of practical skills and knowledge, particularly when access to advanced machine intelligence is disrupted; those without access to advanced machine intelligence risk falling behind; algorithmic bias risks undermining creativity and original thinking.

Status Today

The knowledge economy, where knowledge informs and drives economic development and growth,⁵³⁵ is going through a major transition in the era of advanced machine intelligence.⁵³⁶ What is unique, compared to other periods of technological progress, is that advanced machine intelligence – including both AI and quantum computing – is automating cognitive, deep know-how (tacit) work rather than just routine tasks.⁵³⁷

However, the knowledge economy's transformation rests on AI autonomy (whether it requires human assistance) and the availability of computing power relative to demand.⁵³⁸ When these conditions stabilise, value creation in the knowledge economy will evolve.^{539, 540}

Multiple futures are possible. In one, AI and robotics will make the knowledge economy obsolete. One is an innovation economy where creativity, curiosity, courage, compassion and communication drive value.⁵⁴¹ Another is a skills-based economy where individual competencies, and not knowledge, will matter.⁵⁴² In our view, the knowledge economy will adapt and the power to create value will extend and shift from those who hold knowledge to those who act on knowledge with skill, purpose and good judgement – what some are calling the wisdom economy.⁵⁴³

Today, the concern is more about the future of work. When AI has knowledge comparable to that of workers, it displaces humans from routine knowledge work towards specialised problem-solving, harming the least knowledgeable individuals.⁵⁴⁴ When AI has knowledge comparable to that of problem-solvers, it benefits both the least and the most knowledgeable individuals as it reduces performance inequality (benefiting low-skilled workers and complementing high-skilled workers).⁵⁴⁵ Yet, today, AI still lacks human-level wisdom, carries data biases, raises copyright and privacy concerns, and requires human judgement and creativity for effective deployment.⁵⁴⁶

AI and Quantum Computing

are automating cognitive, deep know-how (tacit) work rather than just routine tasks.

AI and Robotics

could make the knowledge economy obsolete – or shift it towards an innovation, skills-based or wisdom economy.

The **power to create value** will extend and shift from those who hold knowledge to those who **act on knowledge with skill, purpose and good judgement.**





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Design

A global consortium including cities and/or nations designs progress readiness frameworks, determining which metrics matter in extended knowledge-economy models prioritising quality-of-life infrastructure.

 Service Contracts

Test

Pilot cities test extended economy models and quality-of-life infrastructure priorities in real operating conditions.

-  Accelerator Programmes
-  Challenge Prizes
-  Combination Grants
-  Grants
-  Matched Crowdfunding

Institutionalise

A sandbox approach across selected economies around the world tests policy impacts and AI-driven metrics at scale, integrating real-time indicators into national progress accounting.

-  Social Impact Bonds (SIBs)
-  Service contract



39 2024

Preferable Future Scale

Nations adopt proven frameworks based on the results of the sandbox phase, institutionalising best practices across sectors. These frameworks evolve into a global performance index rewarding societal health and resilience.

-  Loans
-  Early-stage capital and multiple funding partners



What Progress looks Like

Success in the knowledge economy is defined by how effectively knowledge assets improve citizens' lives. Value becomes synonymous with societal health, education and environmental harmony. AI allocates resources in such a way as to encourage communities to thrive. Governments measure well-being through real-time AI-embedded national accounts. Humans do creative work; machines handle routine tasks. Healthcare prioritises prevention, and the economy captures value through purposeful contribution.



NECESSARY ENABLERS

- Mature, autonomous, affordable, secure AI systems
- Unified and interoperable global data standards
- Comprehensive funding for infrastructure and transition costs
- Open-source, decentralised ownership structure for AI
- Effective global consortium governance and coordination



CHALLENGES

- Ensuring equitable technology and AI access globally
- Managing algorithmic bias and model drift risks
- Transforming education systems to support the new model of progress
- Collecting sensitive sovereign health and education data
- Supporting workforce transitions beyond education and upskilling



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





25 2025

What if women attained their expectations for prosperity and well-being?

Women's Prosperity

A future-focused women's prosperity and well-being agenda bridges gaps in subjective well-being, aligning aspirations with realities through multidimensional, data-driven approaches informed by global experiences. This ushers in a new era for women and creates positive spillover effects that benefit everyone.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Future Humanity

Uncertainties

Collaboration, Values

Trends

ESG & Beyond GDP
Future of Education
Future of Purpose & Work
International Collaboration
Mobilising Innovation

Technologies

Artificial Intelligence
Open Data
Real-Time Analytics

Category

Societies Empowered

Top Five Sectors

Education
Financial Services & Investment
Government Services
Health & Healthcare
Professional Services

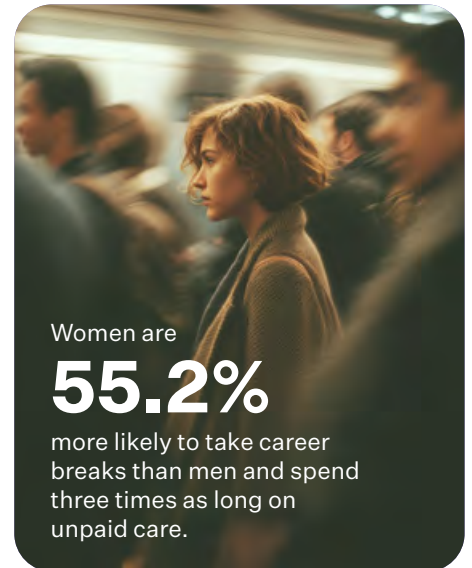
Keywords

Gender Parity
Subjective Well-Being
Sustainable Development Goal 5 (SDG 5)
Unpaid Work
Women's Entrepreneurship



Why It Matters Today

Globally, the share of women in senior management rose from 25.7% to 28.1% between 2015 and 2024,⁵⁴⁷ and 68.8% of the gender gap – progress towards parity across economic opportunity, education, health, and political empowerment – has been closed.⁵⁴⁸ The larger proportion of that gap (80%) arises because women have less work experience and more disrupted career pathways than men over a 30-year career,⁵⁴⁹ with women 55.2% more likely to take career breaks than men.⁵⁵⁰ This is mainly due to caregiving responsibilities: women spend three times as long on unpaid care as men.⁵⁵¹ At the same time, while women report higher life satisfaction than men overall, they experience substantially worse mental health outcomes,⁵⁵² reporting higher rates of depression, anxiety and related physical conditions (such as chronic pain).⁵⁵³



Women are

55.2%

more likely to take career breaks than men and spend three times as long on unpaid care.



Benefits

Greater prosperity for women; increased innovation through diversity; greater gender parity; accelerated progress towards Sustainable Development Goal (SDG) 5; opportunities for women in information and communications technology (ICT) and science, technology, engineering and mathematics (STEM) subjects.



Risks

Gender-based gaps persist; unintended workplace disruptions; global prosperity and well-being disparities; lack of meaningful progress.

Women in senior management rose from **25.7%** to **28.1%** (2015–2024)



68.8% of the gender gap has been closed.





Status Today

Despite decades of effort and significant progress between 2024 and 2025 – reducing the gender gap by 11 years – it will still take 123 years to close the gender parity gap and 135 years to close the economic gender gap.⁵⁵⁴

Women face various structural barriers. For example, globally, women are 47% more likely than men to close a business for family reasons, and in 2024 one in ten women started a business compared to one in eight men.⁵⁵⁵ Women-led startups receive 2% or less of global venture capital funding in Europe and the United States, and only 2.3% in Latin America.⁵⁵⁶ Women's unpaid care work, valued at \$11 trillion (9% of global GDP),⁵⁵⁷ continues to be unaccounted for. However, interestingly, the 2025 update of the System of National Accounts incorporated unpaid household work for the first time, although it is up to countries whether they adopt this new provision and reflect unpaid household work in their GDP reporting.⁵⁵⁸

Several initiatives exist to address these gaps and associated barriers. Global programmes by UN Women focus on five strategic pillars: resources, jobs, time, security and rights.⁵⁵⁹ They also emphasise gender-responsive macroeconomic policies and climate action, transformation of care systems, adoption of gender-responsive laws, and repeal of discriminatory frameworks – all essential to women's economic empowerment.⁵⁶⁰

Other ongoing initiatives sit within the Centre for the New Economy and Society, a body of the World Economic Forum (WEF). Additionally, the WEF's Global Gender Parity Sprint is a five-year coalition focusing on scaling solutions for 1.5 million women.⁵⁶¹ It furthermore aims to ensure AI implementation avoids exacerbating the gender parity gap as AI advances, since women hold only 28.2% of STEM roles and 12.2% of STEM company C-suite positions.⁵⁶² One in four jobs worldwide, particularly in high-income countries, is exposed to generative AI, and women face the greatest risk as 9.6% of jobs held by women are at high risk of automation, compared with 3.5% of jobs held by men.⁵⁶³

Finally, SDG 5 focuses on gender equality and women's empowerment,⁵⁶⁴ and many countries have removed or reformed discriminatory laws. However, out of 131 countries examined, 61 still restrict women's employment.⁵⁶⁵



Women-led startups receive

2%

or less of **global venture capital funding** in Europe and the United States



9.6%

of jobs held by women are exposed to **the risk of automation** compared to **3.5%** of jobs held by men.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Analysis and Capture

Key organisations leading women's initiatives form partnerships, conduct research to identify critical gaps, host global focus groups, map personas, and unpack and identify subjective well-being disparities.

-  Combination grants
-  Accelerator Programmes
-  Grants
-  Service Contracts

Prioritisation

Stakeholders determine urgent priorities for immediate implementation. Evolved into a new global women's agenda, dedicated working groups are established for longer term strategic initiatives.

-  Grants
-  Social Impact Bonds (SIBs)
-  Service contract
-  Accelerator Programs

Funding

Organisations design innovative funding models supporting global women's initiatives, maximising social impact through sustainable, reciprocal investment structures benefiting diverse stakeholders and advance the women's prosperity agenda.

-  Social Impact Bonds (SIBs)
-  Service contract
-  Loans
-  Combination grants
-  Accelerator Programmes



25 2025

Preferable Future Agenda Adoption

Multiple countries and cities implement aspects of the global women's agenda, establishing new progress metrics that close gaps between women's subjective well-being and reality.

-  Early-stage capital and multiple funding partners
-  Convertible Grants
-  Social Impact Bond (SIB)

What Progress looks Like

Products and services are designed for women's real lives and experiences. Cities and countries implement policies addressing previously ignored needs, using new metrics for women's progress relevant to their context. Organisations research gaps between what exists and what's genuinely functional, enabling women to make informed choices based on services designed to support how they actually live and work. While standard data on women's progress remains, the dashboard is now expanded.



NECESSARY ENABLERS

- Sustainable funding to support a long-term agenda
- Unified global data standards
- Robust care-economy infrastructure
- Genuine buy-in from key stakeholders acknowledging real gaps
- Metrics capable of capturing lived realities



CHALLENGES

- Commitment from existing organisations to coordinate initiatives
- Willingness to share data across geographies
- Keeping initiatives grounded in reality
- Ensuring cultural and local contexts inform policy design
- Providing holistic, adaptable policies for women across life stages



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





31 2025

What if academic publishing became truly open?

Public Publications

Academic publishing shifts to a centralised platform with universal access, advanced machine intelligence and blockchain, enhancing research quality, innovation, diversity, collaboration and global research.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Borderless World – Fluid Economies

Uncertainties

Collaboration, Systems

Trends

Cross-sectoral Partnerships

Digital Economy

International Collaboration

Mobilising Innovation

Open Data

Technologies

Blockchain

Distributed Ledger Technologies (DLTs)

Open Data

Category

Systems Optimised

Top Five Sectors

Communication Technologies & Systems

Data science, AI & Machine Learning

Education

Government Services

Professional Services

Keywords

AI-Powered Research Translation

Blockchain

Decentralised Science (DeSci)

Open Access

Peer Review





Why It Matters Today

Open-access publications, in all forms, grew from making up 23% of global articles in 2003 to approximately 51% in 2022 (calculated),⁵⁶⁶ while closed-access articles comprise the rest of publications.⁵⁶⁷ The ecosystem remains fragmented and adoption of open access varies geographically. China, India and the United States publish predominantly closed-access research.⁵⁶⁸ Around 62% of publications in low-income countries are fully open (Gold OA), yet these publications make up less than 1% of open-access articles globally.⁵⁶⁹ Grant-making organisations increasingly stipulate that funded research must be open access. For example, cOAlition S, supported by the European Commission and the European Research Council, mandates full and immediate open access for publicly funded research⁵⁷⁰ and a new policy in the United States recommends that federal agencies provide immediate public access to federally funded research by the end of 2025.^{571,1} Nevertheless, while most nations have implemented national policies for research, many neither mandate nor mention open access, and this is particularly true in some countries in Africa despite many research initiatives.⁵⁷²



Benefits

Equal access to knowledge;
accelerated research and innovation;
enhanced global collaboration;
improved research quality and
diversity; broader global reach.



Risks

Cultural resistance to change; poor
quality despite significant effort;
unauthorised commercial use.

¹ At the time of publication, it is not clear whether this has been implemented.



Status Today

The academic publishing landscape faces significant structural challenges. Traditional publishers – Elsevier, SAGE, Springer, Taylor & Francis and Wiley – control half of the global research output while maintaining over 30% profit margins,⁵⁷³ and the drive to maintain these numbers may incentivise volume over quality.⁵⁷⁴ Traditional publishing is particularly susceptible to issues prevalent in the current academic publishing landscape: lengthy publication timelines, sometimes unclear evaluation criteria, variable reviewer expertise and, in some cases, limited diversity among the pool of reviewers.⁵⁷⁵

Open access was intended to address paywalls, but it has inadvertently replicated some of the structural barriers in traditional publishing.⁵⁷⁶ Article processing charges commonly range between \$1,500 and \$2,500⁵⁷⁷ – even up to \$12,850 in *Nature*.⁵⁷⁸ This has shifted financial barriers rather than eliminating them, creating inequities that exclude early-career, unfunded and low-income researchers.⁵⁷⁹

Emerging solutions include the publish-review-curate (PRC) model⁵⁸⁰ proposed by Bodo Stern and Erin O'Shea (2019). This model shifts the decision on when to publish to authors, and after publication there is transparent peer review and then curation (e.g. selecting articles for more formal publication) using community feedback.⁵⁸¹ However, this model introduces its own uncertainties as peer review, while offering alternative perspectives, does not guarantee the quality of an article, which means that once again editorial acceptance (at the curation stage) becomes the primary quality requirement.⁵⁸²

Decentralised academic publishing using blockchain platforms addresses issues relating to speed, attribution and transparency.⁵⁸³ The concept of decentralised science (DeSci) takes this idea further, restructuring publishing ecosystems through decentralised autonomous organisations (DAOs) and unique identifiers for collaborative research.⁵⁸⁴ In February 2026, the OpenSci platform was announced at the World Laureates Summit in Dubai, using AI and blockchain to track contributions and distribute rewards through scientific tokens.⁵⁸⁵

Open access and PRC redistribute control and risk but fail to address underlying funding and access challenges. Moving forward requires alignment with publishing's core purpose: advancing innovation, science and society.⁵⁸⁶ As AI reshapes publishing ecosystems,⁵⁸⁷ intellectual property (IP) ownership and compliance monitoring will become critical.⁵⁸⁸ *Frontiers*, one of the largest open-access science publishers, has developed AIRA – an AI model that can perform over 40 article checks every two minutes, flagging issues requiring for human editorial judgement for final decisions and preventing algorithmic drift through continuous feedback loops.⁵⁸⁹

Traditional publishers control half of the global research output while maintaining over **30%** profit margins.

Article processing charges commonly range between



\$1,500 and \$2,500

even up to \$12,850 in *Nature*.

AIRA can perform over **40 article checks** every **two minutes**.





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Foundation

Global stakeholders, including the World Intellectual Property Organisation, create and approve an open-access publishing charter. Launch a research certification hub, activate authorship protocols, IP-aligned licensing and community governance.

- Challenge Prizes
- Matched Crowdfunding
- Grants
- Stage-gate Grants

Demonstration

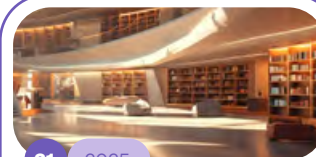
Countries, institutions and independent networks pilot hub integration via open blockchain APIs. Early platforms like OpenSci demonstrate viability. Interoperability barriers are resolved, protocols are effective, and a governance DAO (with necessary safeguards) is built and deployed.

- Accelerator Programs
- Challenge Prizes
- Combination Grants
- Grants
- Stage-gate Grants
- Matched Crowdfunding

Governance

Commercial, government and institutional licensing is activated globally, linking authorship-IP attribution for later use. The hub enforces standards, removes fraudulent authors and groups, and redistributes revenue to authors, reviewers and publishing platforms.

- Accelerator Programs
- Challenge Prizes
- Combination Grants
- Grants
- Stage-gate Grants
- Matched Crowdfunding



31 2025

Preferable Future Adoption

Most nations adopt the hub. No-fee publishing dominates, funded by commercial and institutional fees. Universal access, enforceable authorship-IP attribution and mature community governance are global defaults. An independent oversight body is established.

- Challenge Prizes
- Matched Crowdfunding
- Grants
- Stage-gate Grants

What Progress looks Like

Dynamic research streams replace journals. Researchers around the world can access findings instantly in standardised multilingual formats and with consistent terminology and high-quality translation. Blockchain ensures data integrity and commercial AI licensing funds no-fee publishing. Universal accessibility, community peer review and cross-disciplinary mapping drive equitable global scientific advancement with auditable integrity detection as the default. Researchers receive a share of licensing revenues when their research is commercialised into products or services.



NECESSARY ENABLERS

- Funding to build and operate the hub
- Decision by major funders to mandate hub certification and compliance
- Certification pathways for restricted research without mandatory disclosure
- Independent governance entity



CHALLENGES

- Migration of legacy research and data to machine-readable formats
- Publisher pushback about shifting incentives from journal prestige to impact
- Challenges adapting underlying AI to social science and humanities research
- Difficulties ensuring consistent and accurate terminology across language boundaries



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





50 2025

What if higher education was no longer about the number of years but the quality of years?

Higher Paths

Higher education shifts to personalised and practical learning, prioritising critical thinking and real-world problem-solving. This shapes lifelong learners, with success measured through demonstrated competencies rather than fixed time periods.

SCOPE

Within Reach

Transitional

Visionary

New

2025

Most Significant Megatrend

Future Humanity

Uncertainties

Collaboration, Values

Trends

Digital Economy
Future of Purpose & Work
Generational & Cognitive Diversity
Mobilising Innovation
Transforming education

Technologies

Artificial Intelligence
Blockchain
Digital Communities

Category

Transformational

Top Five Sectors

Communication Technologies & Systems
Data science, AI & Machine Learning
Education
Government Services
Professional Services

Keywords

Competency-based learning
Lifelong learning
Critical thinking
Educational reform
Real-world challenges

Why It Matters Today

In June 2025, 264 million students were enrolled in universities.⁵⁹⁰ The top five core skills required of the future workforce are analytical thinking; resilience, flexibility and agility; leadership and social influence; creative thinking; and motivation.⁵⁹¹ Yet, traditional linear degrees often fail to prepare students for a changing world.⁵⁹² A shift is needed towards lifelong learning, critical thinking and practical application rather than time-served metrics.⁵⁹³



Benefits

Accelerated learning pathways;
enhanced critical thinking skills;
lifelong learning; increased global
innovation; alignment of education
with technological advances.



Risks

Endless educational loops; misaligned
standards across educational levels;
lack of global alignment on credentials;
high operational costs.



Status Today

Higher education has faced challenges before, but this time is different.⁵⁹⁴ There are 264 million students globally studying at universities, the largest population in history.⁵⁹⁵ There are 22,000 universities worldwide and over 6.9 million international students per year.⁵⁹⁶ Geopolitics, immigration restrictions, financial pressures and AI have created considerable uncertainty about the future of higher education,⁵⁹⁷ and the global student population is increasingly shifting east.⁵⁹⁸ In response, Universities UK, for example, launched a Transformation and Efficiency Taskforce in late 2024 to manage a series of challenges within higher education, particularly financial pressures as 45%, or 124 universities in the UK, were expected to face deficits in the 2025/2026 academic year.⁵⁹⁹

Spending on university education is being strained, and the price-to-value ratio of higher education is declining, creating a perception that higher education no longer guarantees a return on investment.⁶⁰⁰ Additionally, the youth population is shrinking in many countries, particularly in high-income economies, and this decline is expected to accelerate in the 2030s and beyond 2050.⁶⁰¹ The global fertility rate stood at 3.3 in 1990, fell to 2.25 in 2024, and expected to fall to 2.1 by 2050,⁶⁰² suggesting that financial pressures in the higher education will continue.

There is some evidence of recent efforts towards transformation in the higher education sector, but not fast enough to keep up with underlying shifts. For example, across the sector, new pathways in higher education delivery are emerging, with online degrees, hybrid courses and micro-credentials complementing traditional models of higher education.⁶⁰³ AI is also starting to disrupt how knowledge is acquired, forcing a rethink of what needs to be taught. AI is expected to improve accessibility, personalised higher education experiences, and adaptive learning environments and to support the development of critical thinking skills.⁶⁰⁴ However, there are concerns about privacy and other technical challenges,⁶⁰⁵ youth are disproportionately affected compared to older workers by GenAI and, in 2025, employment in the technology sector fell below pre-pandemic levels.⁶⁰⁶ Skills and role demands will change across sectors – from tech-enabled agriculture to robots in manufacturing, semi-automated construction and agentic AI assisting on all processes – with great uncertainty about productivity gains or job losses, and an increasing focus on a skills-based economy.⁶⁰⁷

264 Million

students globally

22,000

universities

6.9 Million

international students
per year



45% or 124

universities in the UK were
expected to face deficits
between 2025 and 2026.

Global fertility rate



stood at **3.3** in 1990
fell to **2.25** in 2024,
and expected to
fall to **2.1** by 2050



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Framework Design

A global consortium agrees on core competencies (resilience, agility, etc.), explores integrating micro-credentials into university admissions worldwide, and develops a charter defining the future purpose of higher education and what quality education must entail.

 Service Contracts

 Grants

Universal Foundations

A higher education framework is adopted that sets out the key requirements for 'fulfilment of graduation standards'. A global convention on common curricula is developed by skill and competency training providers.

 Service Contracts

 Grants

 Stage-gate Grants

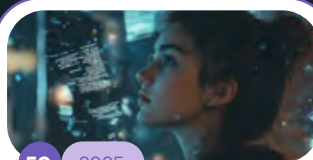
Piloting Phase

A pilot programme is launched at several universities in each participating country, with micro-credentials accepted for applications, where students can opt to use alternative credentials to meet graduation requirements and calculate education equivalency.

 Social Impact Bonds (SIB)

 Grants

 Stage-gate Grants



50 2025

Preferable Future Implementation

A new standard for higher education recognition is implemented worldwide.

 Scaling funds

 Loans

 Service Contracts



What Progress looks Like

Higher education is a worthy investment. Entering a university programme helps young people prepare for the future, not only in terms of career but also for life generally. Micro-credentials, now compulsory components of degree programmes, equip students with the competencies and skills that set them up for success both during university and beyond. Students no longer need to spend 4 to 6 years in university; they need to fulfil key competency requirements. Time-to-degree becomes flexible and individualised based on demonstrated knowledge and skill.



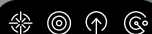
NECESSARY ENABLERS

- Secure digital technology for tracking and authenticating micro-credentials
- Government policies that approve alternative pathways
- Student funding models based on competency completion, not years enrolled
- Global accreditation standards for micro-credentials
- Cross-jurisdictional agreement on quality standards and equivalency



CHALLENGES

- Resistance from traditional academic institutions
- Ensuring quality control across personalised degree pathways
- Maintaining equitable access to micro-credentials for all students
- Ensuring quality control across personalised degree pathways
- Managing students who remain enrolled indefinitely without completing requirements



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





1

2026

NEW

What if a nation's most valuable asset is the focused, interconnected minds of its people?

National Cognitive Potential (NCP)

A leading indicator of what a nation is capable of doing next and measure of a nation's cognitive environment – the depth of its networks, the quality of its relationships, and the collective ability to reason, focus, synthesise, and act at speed to generate future breakthroughs.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Future Humanity

Uncertainties

Systems, Technology

Trends

Community-Based Solutions
Cross-sectoral Partnerships
Open Data; ESG & Beyond GDP
Future of Purpose & Work

Technologies

Artificial Intelligence
Advanced Connectivity
Internet of Things (IoT)

Category

Transformational

Top Five Sectors

Communication Technologies & Systems
Data science, AI & Machine Learning
Education
Financial Services & Investment
Government Services

Keywords

Beyond GDP
Cognitive Capacity
National Progress / Intelligence
Social Capital
System of National Accounts (SNA)



Why It Matters Today

Our ability to focus, identify truth,⁶⁰⁸ and connect authentically seem to be weakening: as attention spans shorten⁶⁰⁹ and AI increasingly reshapes emotional connection,⁶¹⁰ societies risk losing the capacity for deep thinking⁶¹¹ required for innovation and progress despite information overload.⁶¹² Besides early indications of a negative correlation between frequent AI use and critical thinking capability,⁶¹³ cognitive resilience – the ability to focus, assess, and establish and maintain human relationships – may determine which societies are best positioned to lead tomorrow’s solutions to complex challenges. Today, innovation and competitive advantage belong to those who adopt and use AI. Tomorrow, as everyone catches up and reaches a level playing field, people will likely become the center of sustainable competitive advantage.⁶¹⁴

Status Today

Though no National Cognitive Potential measure exists today, building one resonates with efforts in exploring and building approaches to national progress beyond GDP.

In 2009 a high-level expert group (HLEG) of the Organisation for Economic Co-operation and Development issued recommendations on the measurement of economic performance and social progress.⁶¹⁵ Since then, support has continued for alternatives to GDP,⁶¹⁶ not least of which is to manage climate risks.⁶¹⁷ The UN Statistics Division updated the System of National Accounts (SNA) in March 2025, first since the last update in 2008, adding chapters on sustainability and well-being along with digitalisation treating data, databases and AI as distinct assets.⁶¹⁸

However, a critical gap remains. Without taking a long view, we risk planning another transition on measurement of progress that falls short of actual technological potential and societal progress needs. A new HLEG on beyond GDP, formed in May 2025 following the UN Summit of the Future in 2024, includes exploration of seven outcome areas – education, environment, governance, health, material and subjective well-being, and social capital.⁶¹⁹ The HLEG published its Beyond GDP report in 2026, proposing a voluntary multidimensional dashboard, including elements that could feed into national cognitive potential, with an annual UN progress report recommended from 2027.⁶²⁰

Cognitive potential could come from the dimension of social capital, which encompasses trust, shared values and networks and represents a possible measurable structure for cognitive potential that enables collective action towards positive outcomes⁶²¹ such as economic prosperity. Over 40 years, a one standard deviation increase in standard test scores in mathematics, reading and science is associated with a two percentage point increase in annual per capita GDP growth.⁶²² There is evidence to suggest that cognitive skills beyond natural resources – also referred to as national intelligence – are associated with economic prosperity and development, case in point, Japan⁶²³ – a country low on natural resources, was the world’s second largest economy in 2008⁶²⁴ and fourth in 2024.⁶²⁵



Benefits

Gauges potential future competitiveness; Drives focused action and investment in innovation and productivity; Reveals gaps in innovation capacity; Accelerates problem-solving; Strengthens social cohesion; Enhances economic resilience.



Risks

Neglects or undervalues essential non-cognitively-dependent work, especially critical care or labor; Overreliance on AI as a prerequisite rather than an enabler; Groupthink.

As attention spans shorten and AI increasingly reshapes emotional connection, societies risk losing the capacity for deep thinking



There is evidence to suggest that

cognitive skills beyond natural resources are associated with economic prosperity and development





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Framework Design

A coalition of researchers and experts creates a framework that measures how well a community thinks and innovates together. They explore indicators for how people connect, collaborate, focus, and generate breakthroughs.

- Accelerator Programmes
- Challenge Prizes
- Grants
- Stage-gate grants

Prototyping

The working group identifies existing information sources that help map collaboration patterns, partnerships, quality of conversations, and speed of turning ideas into action. They complement productivity and economic indicators.

- Combination grants
- Grants

Piloting

Other communities (at city and/or country-level) pilot the new framework and unpack insights. Participants share findings in real-time and test whether these predict future growth, innovation and prosperity and how nations adapt effectively.

- Service Contracts
- Grants
- Loans

1

2026

NEW

Preferable Future Global Standard

International institutions formally recognise cognitive potential alongside traditional economic or productivity measures in national reporting. Financial markets integrate both metrics into country assessments.

- Loans
- Service Contracts



What Progress looks Like

Jobs prioritise learning and problem-solving alongside output. Growth and future competitiveness rest on developing capacity for collective problem-solving alongside reporting on productivity metrics. Education and collaboration are funded much like infrastructure. Investors and policymakers track collective intelligence. Economic success depends on building societies' capacity to learn, innovate and solve future progress together beyond technological adoption. When communities lose their ability to innovate or collaborate effectively, it triggers national economic concern.



NECESSARY ENABLERS

- Fit-for-purpose framework that links cognitive potential and productivity / output metrics
- Effective measures that capture cognitive potential accurately
- Buy-in from international institutions, policymakers, market players, leading experts, researchers and societies
- Integration into global decision-making on aid, investment and trade decisions
- Interoperable systems and data platforms to capture, analyse and produce cognitive potential measures in real-time



CHALLENGES

- Consistently gaining trust over time, like GDP has done
- Maintaining trusted, accurate data capture, analysis and reporting without drift or algorithmic bias
- Ensuring measures are comparable and possible in contexts where not all data is available, i.e. avoiding the reporting lag experienced by countries that could not capture GDP for a long period of time
- Data privacy and cybersecurity vulnerabilities



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





PILLAR

2

New Markets

Opportunities that capture value by identifying and/or expanding into new markets to meet changing needs.

Insights^J that emerge from the opportunities within this pillar

1

Health and nutrition is a growing area of future opportunity

Over a quarter (27%) of the opportunities in this pillar cover possibilities in health and nutrition. This represents a significant area of future potential as seen in advances in AI, genomics and healthtech. The underlying shift is a move from treating disease to extending quality of life – from one-size-fits-all approaches to personalised interventions focusing on longevity and vitality.

2

Mobilising innovation is a means to expanding into new markets

Among these opportunities, 11 out of 29 identify mobilising innovation as a trend (more than any other trend). Some key opportunities lie in closing inequality gaps by contextualising innovation for diverse settings and needs.

3

Technology is an uncertainty and key driver for new markets

Over 86% of these opportunities identify technology as an uncertainty, with AI a dominant technology. What will prove decisive in the long term is how AI will be designed to enhance quality of life.

^J These insights are deduced from the 200 opportunities that were published in the previous editions of The Global 50. They are for informational, educational and guidance purposes and are non-exhaustive. Because these insights are based on opportunities, they may be generalisable to certain contexts but not others.



Most Significant Megatrend

Uncertainty

Trend

Technology

40 2023 Transitional

Infinite 'Solar' Energy

What if solar farms were moved to space?

Pushing the Boundaries on Energy

Nature

Technology

Future of Space

Net Zero

Future of Raw Materials

Transforming Energy

International Collaboration

Solar Cells

Artificial Intelligence

SpaceTech

48 2023 Visionary

Space As Storage

What if energy was stored in space?

Pushing the Boundaries on Energy

Collaboration

Technology

Future of Space

Net Zero

Transforming Energy

Mobilising Innovation

International Collaboration

SpaceTech

Artificial Intelligence

Battery Technologies

2 2024 Transitional

Clothes that Care

What if clothes kept us healthy?

Advanced Health and Nutrition

Technology

Systems

Mobilising Innovation

Biomaterials

Longevity & Vitality

Nanomedicine

Personalised Medicine

Biomaterials

Nanotechnology

Sensor Technologies

9 2024 Transitional

Aquatic Breakthroughs

What if oceans unlocked innovations in health and food?

Advanced Health and Nutrition

Technology

Nature

Food Innovation

Biomaterials

Blue Economy

Biotechnology

International Collaboration

Robotics

Artificial Intelligence

Biotechnology

15 2024 Transitional

Carbon for Water

What if carbon nanomaterials ensured global access to clean water?

Materials Revolution

Technology

Nature

Mobilising Innovation

Graphene

Nanotechnology

Biomaterials

Food-Water-Energy Nexus

Nanotechnology

Nanomaterials

Advanced Manufacturing



40 2023

What if solar farms
were moved to space?

Infinite 'Solar' Energy

Floating solar panel farms are installed in space and are operated by advanced machine intelligence to ensure optimal positioning, allowing unlimited renewable energy to be generated and transmitted to Earth.

SCOPE

Within Reach

Transitional

Visionary

New

2023

Most Significant Megatrend

Pushing the Boundaries on Energy

Uncertainties

Nature, Technology

Trends

Future of Space
Future of Raw Materials
International Collaboration
Net Zero
Transforming Energy

Technologies

Artificial Intelligence
Solar Cells
SpaceTech

Category

Transformational

Top Five Sectors

Automotive, Aerospace & Aviation
Communication Technologies & Systems
Data science, AI & Machine Learning
Energy, Oil & Gas, & Renewables
Infrastructure & Construction

Keywords

Orbital Solar Farms/Panels
Renewable Energy
Space Debris
Space-Based Solar Power
Wireless Power Transmission

Why It Matters Today

Every hour, more solar energy reaches Earth than the total annual energy used by global populations,⁶²⁶ over 160,000 TWh.⁶²⁷ Yet, about 655 million people live without access to electricity, 85% in Sub-Saharan Africa.⁶²⁸ The world's population is expected to reach 9.7 billion by 2050 and as the global economy is expected to double, energy demand will as well.⁶²⁹ In 1975, solar panels cost around \$4.50 per watt, but by 2024 they had fallen to less than a dollar at approximately \$0.20 per watt.⁶³⁰ China's heavy investment in solar photovoltaics was one of the key drivers of this reduction, and by the end of 2021 China's share across all manufacturing stages for solar panels exceeded 80%,⁶³¹ a dominance that continues to grow even as prices continue to decline.⁶³²



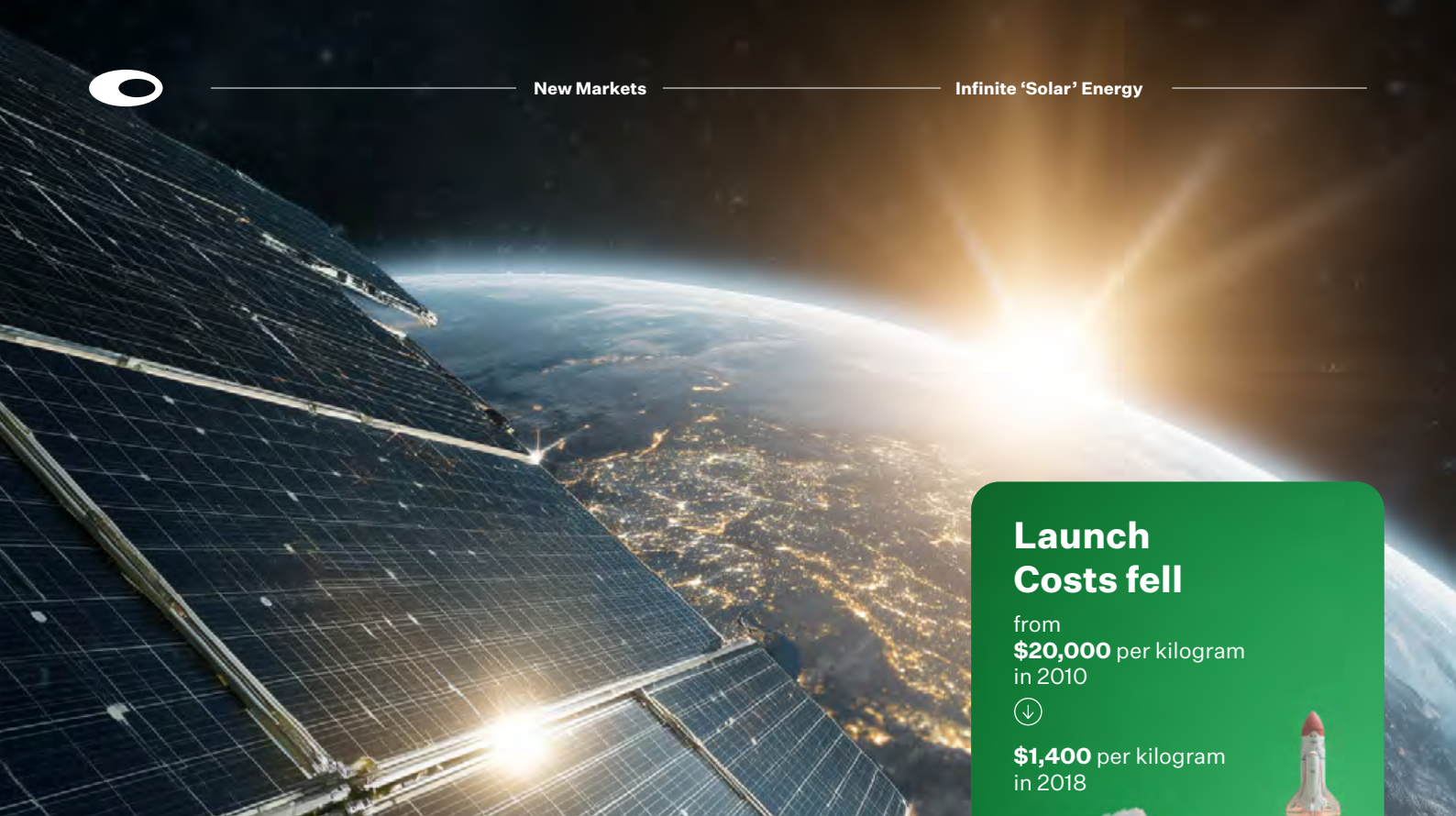
Benefits

Constant flow of clean energy beamed around the world. Ability to meet energy demands and provide off-grid access in remote areas.



Risks

Difficulty of managing extraterrestrial energy facilities and protecting them from accidental (e.g. from asteroids or space debris) or deliberate damage causing power outages on Earth.



Launch Costs fell

from
\$20,000 per kilogram
in 2010



\$1,400 per kilogram
in 2018



Status Today

For decades the leading space agencies, including NASA and the Japan Aerospace Exploration Agency (JAXA), have been exploring the possibility of space solar power plants. The technology is now rapidly gaining momentum because of two key trends. First, a number of technological advances and the overall improving economic viability of the required space technologies are driving increased interest in space solar power plants. Second, an increased, urgent global need to identify scalable energy sources to address energy security, climate concerns and commitments is amplifying interest and bringing space solar technology to the forefront of global innovation.

A milestone was reached in 2023 when the California Institute of Technology's Space Solar Power Demonstrator (SSPD-1) transmitted solar power wirelessly from space to Earth for the first time.⁶³³ The mission was concluded in 2024, demonstrating the viability of more affordable solar cells for space.⁶³⁴ Launch technology is one of the most important technological advances that has improved the economic viability of space-based solar power (SBSP). Launch costs fell in 2010 after the commercialisation of cost-effective reusable rockets, such as SpaceX's Falcon Heavy rocket, dropping from about \$20,000 per kilogram in 1970–2000 to \$1,400 per kilogram in 2018, thus reducing one of the critical constraints inhibiting the economic feasibility of SBSP.⁶³⁵ Increasing private sector competition in the launch industry and further technology advances suggest that launch costs are likely to continue to decline in the near term. Indeed, future launches of SpaceX's Falcon Heavy rocket are expected to further reduce the cost of launch to \$1,000 per kilogram.⁶³⁶

2023,

First successful wireless power

transmission from
space (Caltech
SSPD-1)



The mission was concluded in 2024, demonstrating the viability of more affordable solar cells for space



An increased, urgent global need
to identify scalable energy sources
to address energy security and
climate concerns and commitments
is amplifying interest and

**bringing space solar
technology to the
forefront of global
innovation.**



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Research, Development and Demonstration

National SBSP programmes and private sector companies conduct research, test technologies, map constraints, and document technical, legal and environmental gaps affecting commercial viability.

- Challenge Prizes
- Accelerator Programmes
- Grants
- Stage-gate Grants

Pilot SBSP Plants

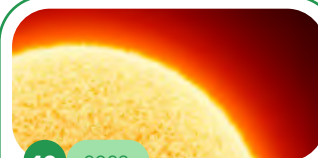
Space solar plant pilots launch, with key players documenting regulatory and technical requirements for the installation and management of solar platforms and transmission bases, orbital management protocols, and advanced machine intelligence.

- Combination Grants
- Accelerator Programmes
- Early-stage capital with multiple funding partners
- Venture Equity

Megawatt-Scale SBSP Plants

Space solar plants continue to be piloted, with some megawatt-scale orbital systems operating under real conditions to test energy transmission reliability, position accuracy, failure models, and regulatory compliance.

- Equity investment
- Convertible Grants
- Loans
- Service Contracts



40 2023

Preferable Future Gigawatt-Scale SBSP Plants

Large gigawatt-scale space solar plants transmit power to terrestrial grids, allowing up to %90 of energy generation to be sourced from SBSP.

- Scaling funds
- Loans
- Service Contracts

What Progress looks Like

Space solar plants enable individual countries to reach their net-zero targets and allow mass-scale decarbonisation. Space solar plants overcome the difficulties of terrestrial renewable energy technologies, allowing large-scale adoption.



NECESSARY ENABLERS

- Global agreement on how to manage increasing space debris
- Large capital investment for technological development, testing and deployment
- Mechanisms for in-space robotic assembly and maintenance operations
- International agreement on power transmission frequencies
- Cost-effective model for operating and maintaining space-based technologies



CHALLENGES

- High launch and technology costs
- Maintaining affordable in-space robotic assembly and maintenance
- Risk of damage from space debris
- Cybersecurity
- Establishing public trust that space-based solar power is dependable



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





48 2023

What if energy was
stored in space?

Space as Storage

Space becomes a site for mass energy storage, with supercapacitors transmitting energy to meet all human needs both on Earth and in space.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Pushing the Boundaries on Energy

Uncertainties

Collaboration, Technology

Trends

Future of Space
International Collaboration
Mobilising Innovation
Net Zero
Transforming Energy

Technologies

Artificial Intelligence
Battery Technologies
SpaceTech

Category

Transformational

Top Five Sectors

Automotive, Aerospace & Aviation
Data science, AI & Machine Learning
Energy, Oil & Gas, & Renewables
Manufacturing
Materials & Biotechnology

Keywords

Energy Storage
In-space Manufacturing
Orbital Supercapacitors
Power Transmission
Space-Based Solar Power



Why It Matters Today

Compared with 2023, global demand for electricity is expected to double by 2050 driven by population growth, building use, and industry use, while, by the same year, data centres will account for more than 40% of electricity demand in North America.⁶³⁷ In parallel, the space economy is projected to reach \$1.8 trillion by 2035 from \$630 billion in 2023,⁶³⁸ relying on 3D-printing capabilities for in-space manufacturing (ISM), covering manufacturing, repair and recycling.⁶³⁹ Future possibilities with space-based solar power (SBSP) rest on the ability to install, repair and dismantle satellite constellations in space.⁶⁴⁰ As an example, the solar panel area of the Representative Design One (RD1) concept design of the National Aeronautics and Space Administration (NASA) spans over 11.5 km² and is 3,000 times larger than that of the International Space Station.⁶⁴¹



Benefits

Expanded access to energy on Earth, supporting further space activity and contributing to growth.



Risks

Human-caused or accidental damage (e.g. from space debris) to space energy generation facilities and supercapacitors. Maintenance costs (due to damage) that make facilities too expensive to maintain.

The space economy is projected to reach **\$1.8 trillion by 2035**



Status Today

Supercapacitors sit between conventional capacitors and batteries. They have a high power density (ability to charge and discharge) and a long lifespan,⁶⁴² which means that they store energy electrically and can charge and discharge much faster than traditional batteries. Their power density is 10 times higher than lead-acid batteries, and they have a shorter charging time of 0.3 to 30 seconds compared with 1 to 5 hours.⁶⁴³

The global supercapacitor market was valued at \$5.5 billion in 2025 and, expanding at a compound annual growth rate of approximately 26%, it is expected to reach a valuation of \$55.5 billion by 2035.⁶⁴⁴ This is being driven by renewable energy, electric vehicles, and Internet of Things (IoT) device demand. Supercapacitors are also used to support transient power demands and stabilise the DC power distribution bus in grids.⁶⁴⁵

Supercapacitors have already been approved for use in space. This energy can be beamed to Earth on demand or used for space stations, space exploration, and lunar bases as a reliable source of power. A project led by the European Space Agency with Airbus Defence and Space developed and tested a supercapacitor design that could provide brief bursts of very high power levels to space missions when required.⁶⁴⁶ Potential uses might include operation of high-power satellite radar systems to stabilise overall onboard power during solar eclipses or other such events. As well as being recyclable, supercapacitors can function in extreme temperatures and do not pose fire or explosion hazards like lithium batteries.⁶⁴⁷

Supercapacitors are improving quickly but are still under development for ultra-large energy storage roles (they excel in power density but energy density is not yet comparable with batteries at massive scales).⁶⁴⁸ Recent developments in NASA's Structural Supercapacitors for Energy Storage in Airframe Components project (2022–2024) have demonstrated progress with supercapacitors using carbon-fibre composites, integrating energy storage into frames or body structures of a spacecraft, for example.⁶⁴⁹

**\$5
billion**

Global supercapacitor
market value (2021)

**\$55.5
billion**

Expected market
value by 2035

\$55.5B

\$5B

Supercapacitor's have
a power density of

**10x
higher**

than lead-acid batteries



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Development of Space Energy Storage Systems

Using sensors enabled by artificial intelligence (AI) and novel materials, research institutions, private sector partners, and material scientists advance supercapacitor technologies capable of withstanding space conditions and effectively storing energy.

- Challenge Prizes
- Accelerator Programmes
- Grants
- Stage-gate Grants

Pilot Deployment of Space Energy Storage Systems

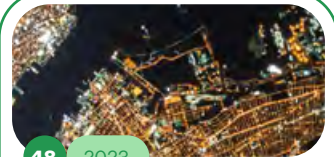
Orbital supercapacitor prototypes are tested in microgravity environments. Space agencies, regulators and international non-governmental organisations establish a governance framework, technical requirements, and safety protocols.

- Grants
- Stage-gate Grants
- Challenge Prizes
- Combination Grants
- Early-stage capital with multiple funding partners
- Service Contracts

Scaling

Orbital supercapacitor pilots operate in real space conditions, demonstrating reliable power transmission to lunar bases and space stations. Performance data drive progress towards replication and scaling across orbital locations.

- Loans
- Equity Investment
- Venture Equity Investment



48 2023

Preferable Future Full Deployment of Space Energy Storage Systems

Supercapacitors are fully deployed across orbital systems. Space-based energy grids transmit power on demand to lunar bases, space stations, and spacecraft, enabling sustained space activities and operations.

- Venture equity Investment
- Service Contract
- Loans
- Scaling Funds

What Progress looks Like

Space exploration and travel have access to energy beyond terrestrial systems and batteries. Affordable and clean energy powers lunar bases and space stations. Energy enables ISM, which in turn enables ideas such as SBSP. Orbital supercapacitor grids are a new area of innovation, enabling growth.



NECESSARY ENABLERS

- Lightweight, radiation-resistant, and space-condition-resilient supercapacitor materials
- AI autonomous assembly and maintenance of orbital energy systems
- International regulatory frameworks
- High capital funding
- Strategies to tackle space debris



CHALLENGES

- Space transmission safety and compatibility with other frequency-based transmission systems
- Launch costs and ISM costs
- Monopolies and early mover advantages limit equitable distribution of space energy
- Reliable energy transmission



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





17 2023

What if clothes kept us healthy?

Clothes that Care

Smart fabrics with nanobiomaterials autonomously deliver health-boosting nutrients that meet minimum daily requirements, promote wellness, and address nutritional deficiencies.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Advanced Health and Nutrition

Uncertainties

Technology, Systems

Trends

Biomaterials
Longevity & Vitality
Mobilising Innovation
Nanomedicine
Personalised Medicine

Technologies

Biomaterials
Nanotechnology
Sensor Technologies

Category (Long-Term Outcome)

Health Reimagined

Top Five Sectors

Chemicals & Petrochemicals
Consumer Goods, Services & Retail
Data science, AI & Machine Learning
Health & Healthcare
Manufacturing

Keywords

Biomaterials
Next-Gen Wearables
Nutrition/Malnutrition
Smart Fabrics
Textiles

Why It Matters Today

Even though vitamins are considered crucial for growth, health and disease prevention,⁶⁵⁰ vitamin deficiency is a significant public health issue in many countries around the world. For example, almost one billion people worldwide have a vitamin D deficiency,⁶⁵¹ even in countries of relative sunshine abundance.⁶⁵² Iron, folate, and vitamins B12 and A deficiencies can lead to serious health issues such as anaemia, which affects an estimated 42% of children under five years of age and 40% of pregnant women globally.⁶⁵³ Vitamin A deficiency, a leading cause of preventable childhood blindness, also heightens the risk of severe infections such as measles or diarrhoeal disease.⁶⁵⁴



Benefits

Scalable, global solution for nutrient delivery that is especially beneficial for those with dietary challenges or specific health conditions. Helps to prevent macronutrient deficiencies and associated diseases.



Risks

Uncertain efficacy as vitamins may degrade over time, particularly with frequent washing of fabrics. Toxicity if sensor technologies malfunction or unneeded vitamins accumulate.



Status Today

Nanotechnology is widely used in the manufacturing of fabrics to add performance features such as water proofing, ultraviolet protection, antimicrobial behaviour, stain resistance, or enhanced strength.⁶⁵⁵ Additionally, smart fabrics are available that can monitor health signals (such as heart rate or sweat) or add protective/functional surface properties.⁶⁵⁶ Nevertheless, smart fabrics that may autonomously release essential nutrients to meet daily requirements have not yet been commercialised and are largely still under development.

Primarily, ongoing research indicates that fabrics will be able to deliver drugs or active compounds via the skin. Such research indicates that textiles can release active molecules (including medicines) through the skin by embedding nanocarriers or carriers into fibres. For example, biofunctional textiles combine pharmaceutical nanocarriers with textile materials to enable controlled release of drugs through skin contact. These are studied largely in laboratories and for medical applications, not daily micronutrient delivery.⁶⁵⁷

Furthermore, although studies do exist on fabrics loaded with drugs (e.g. melatonin) for transport through skin membranes, the skin's barrier makes this challenging.⁶⁵⁸ Companies have patented contact-activated garments that release ingredients (e.g. over-the-counter pain relief, vitamins, or topical medicines) upon body heat and moisture⁶⁵⁹ but these are niche, limited-effect products rather than full nutritional solutions.

Ongoing research indicates that fabrics will be able to **deliver drugs or active compounds via the skin.**



Smart fabrics are available that can monitor health signals (**such as heart rate or sweat**) or add protective/functional surface properties



Smart fabrics that may autonomously release essential nutrients to meet daily requirements have not yet been commercialised and are **largely still under development**





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Research and Development

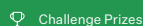
Smart fabrics and key materials are the subject of research and development. Investment and funding increase to develop potential use cases. Discussions begin on intellectual property, biosafety and policy.



Grants



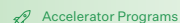
Stage-gate Grants



Challenge Prizes

Trials in Medical Settings

Smart fabrics receive regulatory approval for use in serious medical cases, being regulated as wearable technology in the health industry. Ethical and biosafety frameworks are established.



Accelerator Programs



Challenge Prizes



Grants



Stage-gate Grants

Regulatory Approval and Extension

Smart fabrics receive regulatory approval for use in prescribed settings, and their use is extended to communities at risk of malnutrition. Formalised regulatory pathways enable manufacturing capabilities and supply chains to be built.



Combination Grants



Accelerator Programmes



Venture Equity Investment



Convertible Loans



Social Impact Bond (SIB)



Service Contracts



17

2023

Preferable Future Scaling and Commercialisation

Smart fabrics are widely available and used in both the healthcare and clothing manufacturing and retail sectors.



Venture equity Investment



Scaling funds



Revenue-dependent Grants



Loans



Equity Investment



What Progress looks Like

With vitamins and nutrients dispersed directly through smart fabrics, vitamin deficiency is visibly reduced, improving public health and mitigating serious illnesses. Better general health results in reduced public healthcare expenditure. Longevity metrics improve and systems can be extended to drug delivery where needed.



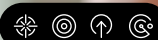
NECESSARY ENABLERS

- Interdisciplinary collaboration
- Effective regulatory and ethical frameworks
- Scalable and affordable manufacturing and supply chains
- Effective and non-invasive biosensors and effective closed-loop systems
- Effective fabric cleaning and e-waste mechanisms



CHALLENGES

- Non-invasive yet accurate and affordable biosensors
- Trust among vulnerable communities while appealing to mainstream consumers
- Environmental sustainability
- Durability and longevity of biosensors
- Integration with personal health records if needed



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





9

2024

What if oceans unlocked
innovations in health and food?

Aquatic Breakthroughs

Oceans, with their vast unexplored biodiversity, offer opportunities in marine biotechnology and pharmacology, enabling advances in medicine and food industries.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Advanced Health and Nutrition

Uncertainties

Technology, Nature

Trends

Biomaterials; Biotechnology
Blue Economy
Food Innovation
International Collaboration

Technologies

Artificial Intelligence
Biotechnology
Robotics

Category

Health Reimagined

Top Five Sectors

Agriculture & Food
Chemicals & Petrochemicals
Data science, AI & Machine Learning
Health & Healthcare
Materials & Biotechnology

Keywords

Blue Economy
High Seas Treaty
Marine Biotechnology
Oceanography
Pharmacology



Why It Matters Today

As global temperatures rise, ecosystems and disease landscapes shift. Wildlife species migrate north, while novel pathogens emerge, affecting everything from Arctic mammals to plants worldwide.⁶⁶⁰ This ecological transformation signals a risk of unpredictable pandemics in a warming world.⁶⁶¹ While more inclusive research covering a wide range of infectious diseases is needed for a better understanding of the impacts of climate change,⁶⁶² current research suggests that by 2030 climate-related health issues, such as malnutrition, malaria, diarrhoea, and heat stress, could cause 250,000 extra deaths annually with health-related costs possibly reaching up to \$4 billion each year.⁶⁶³

By 2030

climate-related health issues

such as malnutrition, malaria, diarrhoea, and heat stress could annually cause 250,000 extra deaths.



Benefits

Greater understanding and appreciation of the vital ecosystems that populate them, motivating sustainable blue economy technology and practice marine organisms unlock new drugs and treatments for disease.



Risks

Overuse of marine resources damages ocean ecosystems, threatening livelihoods dependent on them.



As global temperatures rise, ecosystems and disease landscapes shift.

By 2030, climate-related health issues, including malnutrition, malaria, diarrhoea and heat stress could cause

250,000

extra deaths annually



Status Today

Marine biotechnology and pharmacology have moved from a niche area of scientific exploration and research into a rapidly advancing field driving pharmaceutical development and new markets.

Marine-derived compounds that have been isolated from sponges, algae, microbes and invertebrates offer novel chemical structures and mechanisms unseen in terrestrial sources.⁶⁶⁴ Some marine-derived drugs such as cytarabine⁶⁶⁵ and monomethyl auristatin E⁶⁶⁶ treat oncology and neuropathic pain, while others target metabolic diseases and antibiotic-resistant infections.⁶⁶⁷

The marine biotechnology market is expected to grow significantly over the next decade, with forecasts showing double-digit growth across the pharmaceuticals, nutraceuticals, cosmetics and food sectors.⁶⁶⁸ However, the potential of the ocean is largely untapped because of physical, technological, economic and governance barriers. Extreme conditions in the ocean make exploration more challenging than space exploration. Some of these challenging deep sea conditions include very high pressures (crushing materials and organisms not adapted to them), darkness (making optical imaging difficult), and near-freezing temperatures.⁶⁶⁹

However, India, for example, is building a manned submersible capable of reaching 6,000 metres in depth and has developed an autonomous vehicle that was used to explore mineral-rich zones at 5,271 metres and map deep-sea biodiversity.⁶⁷⁰ In addition, the United Nations High Seas Treaty, which came into force in January 2026, is meant to manage governance challenges through what is now a legally binding framework for the conservation and sustainable utilisation of marine biodiversity in international waters. As two-thirds of oceans are beyond national borders, the Treaty facilitates scientific cooperation and sharing of benefits across global stakeholders.⁶⁷¹



Some marine-derived drugs such as cytarabine and monomethyl auristatin E **treat oncology and neuropathic pain**



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Map Opportunities

Countries establish a consortium, potentially under the High Seas Treaty, to map areas for exploring the ocean for novel compounds. Discovery driven by artificial intelligence supports initial research.

 Challenge Prizes

 Grants

Build Partnerships and Research Agenda

The consortium invites research partners, including universities, ocean institutes and biotechnology firms, to develop a research agenda that supports partnerships and implementation time frames.

 Combination Grants

 Accelerator Programmes

 Grants

 Challenge Prizes

 Early-stage capital and multiple funding partners

Secure Funding and Governance Structure

The consortium secures funding partners across industries to support research pipelines. It establishes shared governance for scientific research, builds and tests infrastructure for a marine biodiversity credit system.

 Venture Equity Investment

 Convertible Loans

 Grants

 Stage-gate Grants



9 2024

Preferable Future Scale Innovations and Advance Technologies

With increased funding and thriving biotechnology sector, advanced instruments and materials science support marine biotechnology development. Marine biodiversity credit system operates at scale. Consortium continues to coordinate activities.

 Scaling funds

 Loans

 Venture Equity Investment

What Progress looks Like

A growing marine biotechnology value chain delivers improved pharmaceutical and food products alongside novel drug discoveries and food techniques. Research institutions, previously working in silos, now collaborate with others to accelerate advances. Communities benefiting most from ocean exploration share the benefits of discoveries. Advanced engineering technologies for harsh ocean environments are accelerated and shared across partners, distributing both capabilities and risks.



NECESSARY ENABLERS

- Long-term research and development funding
- Equipment and systems to handle harsh ocean environments
- Global support for ocean research and equitable sharing of benefits
- Clear frameworks for data and intellectual property (IP) sharing
- Market demand for biodiversity credits



CHALLENGES

- Lack of skilled marine biotechnology talent
- Limited number of research institutions and teams involved in marine biotechnology discovery
- Inadequate sharing of discoveries and related data despite the High Seas Treaty
- Lack of, or inefficient, mechanisms to share marine genetic IP
- Slow development: marine compounds to commercialisation



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





14 2024

What if carbon nanomaterials ensured global access to clean water?

Carbon for Water

Carbon-based nanomaterials transform global access to potable water through their ability to effectively remove pollutants at the nanometre scale, in both small and large volumes, allowing for point-of-use applications and larger scale operations, reducing the cost and environmental impact of desalination processes.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Materials revolution

Uncertainties

Technology, Nature

Trends

Biomaterials
Food–Water–Energy Nexus
Graphene
Mobilising Innovation
Nanotechnology

Technologies

Advanced Manufacturing
Nanomaterials
Nanotechnology

Category

Nature restored

Top Five Sectors

Agriculture & food
Chemicals & Petrochemicals
Energy, Oil & Gas, & Renewables
Health & Healthcare
Utilities

Keywords

Carbon nanomaterials
Graphene
Nanofiltration
Nanotubes
Water

Why It Matters Today

In 2024, more than 2.1 billion people worldwide do not have access to safe drinking water.⁶⁷² Diarrhoea linked to unsafe drinking water, poor sanitation, and inadequate hand hygiene claims approximately one million lives each year.⁶⁷³ As demands grow for clean, safe water, the global market for water purification is forecast to rise from \$40.6 billion in 2026 to \$72.8 billion by 2034, with a CAGR of 7.6%.⁶⁷⁴ Almost 50% of schools in sub-Saharan Africa and one in every four healthcare facilities worldwide are without basic water services.⁶⁷⁵ In medium- to low-income nations, efforts to enhance clean water access face hurdles because of recontamination occurring between the point of collection and where it is used.⁶⁷⁶



Benefits

Enhances health and economies.
Reduces the cost and environmental impacts of desalination processes.



Risks

Adverse health outcomes and lack of water purification if carbon nanomaterial filters or processes are damaged and cause nanotubes or nanofibres to pollute water supplies.



Carbon-based nanomaterials, including graphene, graphene oxide (GO), carbon nanotubes (CNTs) and related composites, are studied extensively for water treatment, which improves pollutant removal.

Status Today

There is strong research momentum behind the applications of carbon-based nanomaterials in water purification and desalination, particularly in adsorption and membranes. Carbon-based nanomaterials, including graphene, graphene oxide (GO), carbon nanotubes (CNTs) and related composites, are studied extensively for water treatment due to their surface chemistry, which improves adsorption and the catalytic removal of pollutants.⁶⁷⁷ These materials are already used in advanced membranes and adsorbents that can capture heavy metals, organic pollutants, bacteria, and other contaminants, and recent research indicates that they are likely to have more applications for wastewater pollutant removal and freshwater purification.⁶⁷⁸

In lab environments, graphene and GO membranes can achieve very high salt rejection and water permeability, which are key for desalination.⁶⁷⁹ Research indicates graphene-type nanomaterials have near-complete salt rejection in some configurations, and they show potential for energy-efficient desalination, which is currently the core challenge for existing desalination technologies.⁶⁸⁰

Nevertheless, the use of carbon-based nanomaterials in desalination continues to be at the research stage and is yet to move into real life applications or commercialisation. This is largely due to scalability challenges in manufacturing large graphene membranes at industrial scale and potential ecological and health risks.⁶⁸¹

Graphene and graphene oxide (GO) membranes can achieve very high salt rejection and water permeability, **which are key for desalination.**





Energy-efficient desalination

is currently the core challenge for existing desalination technologies.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Research and Development

Strategic public-private R&D partnerships are created to advance work on carbon-based solutions for water pollutant removal. Impacts are tested and safety levels are mapped, using AI and digital twins to conduct toxicity and lifecycle assessments.

- Challenge Prizes
- Accelerator Programmes
- Grants
- Stage-gate Grants

Certification

Carbon-based nanofiltration systems are certified as safe, meeting identified certification requirements and regulations.

- Grants
- Stage-gate grants
- Combination grants
- Accelerator Programmes
- Early-stage capital and multiple funding partners

Prototyping

Prototypes and pilots are launched to test point-of-use and large scale operations, while exploring commercial opportunities with private sector partners and funders.

- Venture equity investment
- Convertible loans
- Grants
- Matched crowdfunding
- Service Contracts



14 2024

Preferable Future Deployment

Access to clean water is delivered, beginning with rural areas, through supply chains using carbon-based nanomaterials.

- Scaling funds
- Revenue-dependent grants
- Loans
- Venture equity investment

What Progress looks Like

Access to clean water is provided to a wide range of communities, relieving pressure on public health systems and governments through fewer waterborne diseases. Improved public health, due to clean water, opens opportunities for broader economic development. The need to invest in desalination goes down, and clean drinking water can be provided without the environmental impact of desalination waste streams.



NECESSARY ENABLERS

- Drinking water regulations that allow for and align with carbon-based material innovations for water
- Equitable, adaptable IP and licensing mechanisms based on community benefit
- Affordable toxicity, pollutant, and safety testing
- Discovery of carbon-based materials that can effectively deliver safe drinking water
- Funding competitive with desalination alternatives



CHALLENGES

- Affordability of toxicity verification techniques
- Water management and recyclability
- Tailoring logistics and deployment to different rural and urban contexts, and to both point-of-use and large-scale deployments
- Navigating differing regulations on safe drinking water



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





PILLAR

3

Technologies

Opportunities that capture value through disruptive and breakthrough innovation as a vehicle to implement and accelerate solutions.

Insights^K that emerge from the opportunities within this pillar

1

Advanced computing and AI are both key enablers of other technologies

More than 40% of the opportunities in this pillar rely on advanced computing or AI. Technological advances will continue to shape the future. The question will be: 'How should we balance investments and efforts to keep the long-term vision of growth, prosperity and well-being in mind?'

2

Health is a key area for the future when it comes to capturing value through technology

Over one-third of the opportunities in this pillar focus on reimagining health as an area of future opportunity. Personalised medicine, neuroscience, longevity, vitality, genomics, biotechnology and nanomedicine will be key areas.

3

Nanotechnology and 3D printing are key technologies shaping future energy, health and nutrition

Just over a quarter of the opportunities include Materials Revolution as a megatrend. Nanotechnology and 3D printing feature in nearly half of them. These technologies will enable regenerative ecosystems and next-generation energy, health and nutrition.

^K These insights are deduced from the 200 opportunities that were published in the previous editions of The Global 50. They are for informational, educational and guidance purposes and are non-exhaustive. Because these insights are based on opportunities, they may be generalisable to certain contexts but not others.



Most Significant Megatrend

Uncertainty

Trend

Technology

6 2022 Visionary

Energy Without End

What if energy was limitless?

Pushing the Boundaries on Energy

Nature

Collaboration

Transforming Energy

Next-Gen Energy

39 2022 Visionary

Designer Cells

What if biology replaced chemistry?

Materials Revolution

Technology

Systems

Cross-sectoral Partnerships

Net Zero

Future of Raw Materials

Nanomaterials

Sustainable Waste Management

Advanced Manufacturing

Sensor Technologies

23 2023 Transitional

Multipurpose Wheels

What if the next wave of car innovations was in the wheels?

Materials Revolution

Technology

Nature

Sustainable Waste Management

Net Zero

Future of Raw Materials

Air Pollution

Nanotechnology

New Materials

Sensor Technologies

44 2023 Transitional

Fresh Threads

What if we could make new materials in seconds?

Materials Revolution

Technology

Systems

Cross-sectoral Partnerships

Open Data

Future of Raw Materials

Mobilising Innovation

Ideaation, IP & Entrepreneurship

Robotics

Artificial Intelligence

Advanced Computing

47 2023 Visionary

Earth X-ploration

What if we could X-ray the whole planet?

Saving Ecosystems

Technology

Nature

Cross-sectoral Partnerships

Open Data

Future of Raw Materials

Government Agility

Restoration

Advanced Computing

Sensor Technologies

Quantum Technology

50 2023 Visionary

Telepossible

What if teleportation was a reality?

Future Humanity

Technology

Values

Cross-sectoral Partnerships

Digital Economy

Advanced Connectivity

Quantum Technology

International Collaboration

Advanced Connectivity

Quantum Technology

5 2024 Visionary

Organ Printing

What if organ transplant waiting lists were eliminated?

Advanced Health and Nutrition

Technology

Values

3D Printing

Genomics

Biomaterials

Biotechnology

Personalised Medicine

Genomics / Epigenetics

Bioprinting

Advanced Machine Intelligence

26 2024 Visionary

Balanced Books

What if we no longer needed monetary policy?

Boundless Multidimensional Data

Collaboration

Systems

Cross-sectoral Partnerships

Open Data

Digital Economy

International Collaboration

Artificial Intelligence

Edge Computing

Internet of Things (IoT)

40 2024 Transitional

40 2023 Transitional

Seeing is Feeling

What if contactless haptics transformed gaming and healthcare?

Digital Realities

Values

Technology

Advanced Connectivity

Extended Reality (XR)

Cross-sectoral Partnerships

Advanced Connectivity

Sensor Technologies

Internet of Things (IoT)

42 2024 Transitional

40 2023 Transitional

Perpetual Power

What if the future of batteries is internal?

Pushing the Boundaries on Energy

Technology

Nature

Artificial Intelligence

Net Zero

New Materials

Transforming Energy

Artificial Intelligence

Battery Technologies

Advanced Manufacturing

46 2024 Transitional

40 2023 Transitional

Finally Graphene

What if graphene were mass produced?

Materials Revolution

Technology

Nature

Artificial Intelligence

Transforming Energy

New Materials

Nanomaterials

Nanotechnology

Immersive Technologies & Wearables

Advanced Manufacturing

Sensor Technologies

2 2025 Transitional

40 2023 Transitional

Viral Solution

What if designer viruses eliminated the need for antibiotics?

Advanced Health and Nutrition

Technology

Values

Communicable & Non-Communicable Diseases

Genomics / Epigenetics

Longevity & Vitality

Precision/Personalised Medicine

Biotechnology

Nanomedicine

Real-Time Analytics

13 2025 Transitional

Sonic Sweep

What if ultrasounds eliminated microplastics from oceans and lakes?

Evolving Ecosystems

Technology

Nature

Food–Water–Energy Nexus

New Materials

Cross-sectoral Partnerships

Mobilising Innovation

Sustainable Waste Management

Sensor Technologies

ClimateTech

42 2025 Visionary

Better Water Meter

What if the world knew exactly how much water we use and could predict future water needs and shortages?

Boundless Multidimensional Data

Technology

Collaboration

ESG & Beyond GDP

Government Agility

Open Data

International Collaboration

Food–Water–Energy Nexus

Real-Time Analytics

Artificial Intelligence

Internet of Things (IoT)

43 2025 Visionary

Next-gen Geothermal

What if next-generation geothermal energy enabled universal energy access?

Pushing the Boundaries on Energy

Technology

Nature

Repurposing Assets

New Materials

Net Zero

Transforming Energy

Cross-sectoral Partnerships

New Materials

Artificial Intelligence

Real-Time Analytics

11 2022 Transitional

Power Without Limits

What if affordable electricity is universal?

Materials Revolution

Technology

Nature

Transforming Energy

New Materials

Next-Gen Energy

Sensor Technologies



6

2022

What if energy
was limitless?

Energy Without End

Daily life is transformed by a limitless
supply of energy through nuclear fusion.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Energy boundaries

Uncertainties

Nature, Collaboration

Trends

Transforming Energy

Technologies

Next-Gen Energy

Category

Nature restored

Top Five Sectors

Energy, Oil & Gas, & Renewables
Government Services
Infrastructure & Construction
Manufacturing
Utilities

Keywords

Decarbonisation
Deuterium
ITER
Nuclear fusion
Spherical tokamak

Why It Matters Today

By 2035, global energy demand may rise by roughly the equivalent of all the US energy consumed today, yet emissions are projected to remain the same at their 2024 peak of 38 Gt through to 2050 (without policy intervention).⁶⁸² Nuclear fusion (replicating the sun) generates massive energy without the long-lived radioactive waste of fission or the intermittency of solar and wind.⁶⁸³ Globally, 655 million people lack electricity;⁶⁸⁴ fusion could close this gap permanently while meeting increasing energy demand without emissions.



Benefits

Growth of new industries, particularly AI. Cheaper and less environmentally damaging travel and logistics, electricity, heating and cooling, meaning people can live more comfortably, efficiently and productively, increasing their quality of life.



Risks

Accidental or deliberate incidents with the handling of radioactive waste from fusion, despite its short half-life.



Status Today

Fusion is not yet commercially viable and is still in the experimental phase and focused on demonstrating viability at scale. Fusion's primary fuel sources are hydrogen isotopes – deuterium and tritium; while the former is extracted from seawater, the latter is produced from lithium within the reactor.⁶⁸⁵ Some of the most well-known initiatives include the ITER project and EUROfusion. The ITER project is an experimental fusion reactor under construction in Cadarache, France, with seven partners collaborating for 35 years (European Union, China, India, Japan, Korea, Russia and the USA).⁶⁸⁶ EUROfusion is a collaborative network of 31 fusion research organisations across 25 European Union (EU) member states in addition to Norway, Switzerland, Ukraine and the UK.⁶⁸⁷ ITER and EUROfusion teamed up at the end of 2025 with a high-level cooperation agreement on key fusion technical challenges for the next two years.⁶⁸⁸

The UK national fusion energy programme ('Spherical Tokamak for Energy Production') has a target to build a fusion power plant by 2040 in Nottinghamshire, UK that tests fusion energy generation using a unique spherical, as opposed to donut-shaped, design.⁶⁸⁹ Another is the Los Alamos National Laboratory's US Fusion Energy Sciences (FES) programme, testing foundational sciences for fusion energy development for what comes after ITER, focusing on materials, plasma control, tritium management and component durability.⁶⁹⁰ China's EAST tokamak also achieved plasma densities 30–65% above the Greenwald limit, a threshold that has constrained fusion reactors for decades.⁶⁹¹

Closer to reach, the Fusion Industry Association – established in 2018 – represents all the private sector players in the fusion space. The association has raised \$ 9.7 billion across 53 fusion research companies⁶⁹² with commercialisation targets in the early 2030s.⁶⁹³ In 2025, they called for risk-sharing and funding through PPPs, a distinct EU regulatory framework for fusion, and a shifting focus to deployment and commercialisation.⁶⁹⁴

While Commonwealth Fusion Systems' SPARC demonstration plant is scheduled to begin testing and demonstration in 2027,⁶⁹⁵ the world's first commercial fusion power plant, producing up to 400 MW, is planned to begin operations in early 2030 in the USA.⁶⁹⁶ Fusion could add up to \$175 trillion to global GDP and save \$119 billion per year in the US with over 40 fusion startups around the world.⁶⁹⁷

ITER project:



7 Partners

collaborating for
35 years.

\$9.7 Billion

invested across 53
private fusion companies



First commercial
fusion plant:

400 MW

planned for
early 2030





Fusion could add
GDP up to

\$175 trillion
to global GDP

and save

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per year in the US with
over 40 fusion startups
around the world.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Scientific Breakthrough

Research, regulation and private-public funding are aligned, enabling scalable prototypes, and a consistent net-energy gain in fusion reactors is achieved.

- Challenge Prizes
- Combination Grants
- Grants
- Stage-gate Grants

Commercial Demonstration

Grid-integrated demonstration power plants are built to prove commercial viability, safety, stable performance, and economic competitiveness, while designs for compact mini-fusion pods for residential use are explored and tested.

- Early-stage capital and multiple funding partners
- Convertible grants
- Stage-gate grants
- Challenge prizes
- Matched crowdfunding
- Combination grants
- Venture equity Investments
- Loans

Pilot Plants

Fusion performance is proven across different geographical, climate, and industrial settings worldwide to validate scalability and adaptability.

- Combination Grants
- Accelerator Programmes
- Venture equity Investment
- Loans



6

2022

Preferable Future Deployment and Scalability

Fusion energy is integrated into electrical grids and distributed to homes globally, reshaping economies and decarbonising industries.

- Convertible Grants
- Scaling Funds
- Loans
- Early-stage capital and multiple funding partners
- Equity Investment

What Progress looks Like

Energy is abundant. Fusion reactors power cities and rural communities, powered only by seawater. The growth of industries that have been limited by energy availability or are energy intensive is no longer limited as all can run on clean energy. With minimal short-lived radioactive waste and continuous power without intermittency, air clears, carbon capture mechanisms become much more effective, and manufacturing benefits. Lack of access to electricity becomes history.



NECESSARY ENABLERS

- Technological advances (seawater feed loops to extract deuterium, tritium fuel production and closed-loop fuel cycles)
- Ability to transfer experimental success into commercial success
- Advanced materials to withstand extreme heat and magnets to enable fusion reaction
- Availability of specialised engineering skill sets
- International multistakeholder cooperation and regulatory harmonisation



CHALLENGES

- Plasma consistency that allows constant fusion reaction and limit interruption
- Public perception on fusion versus fission and risks in the vicinity of plants
- Cost competitiveness compared to more affordable solar and wind energy today
- Attracting new PPPs for R&D especially if public sector R&D funding is limited
- Delays in grid connections



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





39 2022

What if biology
replaced chemistry?

Designer Cells

Bio-derived solutions replace chemicals in ways that transform industries, the environment and consumer habits.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Materials Revolution

Uncertainties

Technologies, Systems

Trends

Cross-sectoral Partnerships

Future of Raw Materials

Net Zero

Sustainable Waste Management

Technologies

Advanced Manufacturing

Nanomaterials

Sensor Technologies

Category

Transformational

Top Five Sectors

Materials & Biotechnology

Agriculture & Food

Communication Technologies & Systems

Consumer Goods, Services & Retail

Health & Healthcare

Keywords

Bioeconomy

Enzymes

Green Chemistry

Polymers

Synthetic Biology



Why It Matters Today

The chemicals industry is a fundamental building block of the global economy, used in more than 96% of manufactured goods⁶⁹⁸ and generated \$5.7 trillion in global sales.⁶⁹⁹ However, it is responsible for 7% of global greenhouse gas emissions, with petrochemicals alone accounting for 30% of industrial demand for energy, and other health and environmental costs amounting to more than 10% of global GDP.⁷⁰⁰ Without a transformation, the industry risks exacerbating the climate, hazardous chemicals and plastics crises while remaining vulnerable to oil price volatility and supply-chain disruptions.⁷⁰¹



Benefits

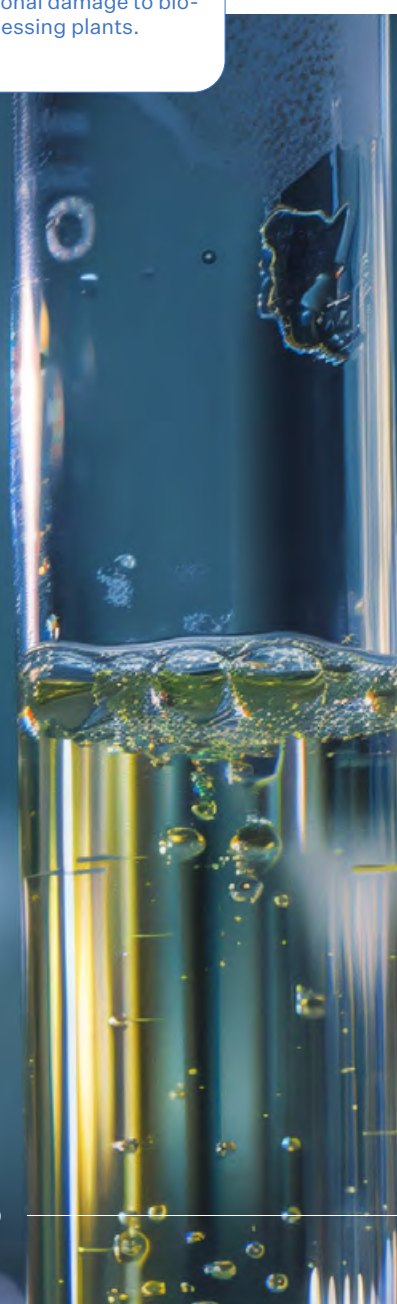
Greater availability and lower price volatility of raw materials used to make new bio-solutions, leading to more diverse and resilient supply chains; reduced pollution via the shift from chemical to biological waste.



Risks

Mishandling of biowaste, increasing emissions of methane; accidental creation of novel biohazards; biohacking; intentional damage to bio-foundries and processing plants.

The chemicals industry is used in **96% of manufactured goods, generating \$4 trillion in global sales.**





Status Today

The chemical industry is critical to everyday work and life. It supports 96% of global manufactured products across all sectors, including automotive, health, agriculture, construction and electronics.⁷⁰² The industry has been a leader in innovation developing new materials, now using AI, the Internet of Things (IoT) and advanced analytics to increase productivity and reduce its environmental footprint.⁷⁰³ However, it is facing several challenges including sustainability and efficiency.⁷⁰⁴

More critically, chemicals are the key to the energy transition, enabling renewable technologies such as solar photovoltaic, batteries and wind turbine blades.⁷⁰⁵

Bio-based products are one answer to the sustainability challenge. Derived from plants and renewable agricultural, marine and forestry materials and non-food waste,⁷⁰⁶ they are made using a process where catalytic enzymes convert plant waste into useful materials and alternatives to petroleum-based materials.⁷⁰⁷

Estimates for the global bio-based materials market vary, depend on scope and definitions, and are often quoted by volume. For context, in one estimate for the broader market, it was worth nearly \$52 billion in 2024 and is expected to grow to \$653 billion by 2035 – a compound annual growth rate of nearly 26%.⁷⁰⁸ In another estimate, focused on bio-based polymers, key input of bio-based materials, total production was 4.5 million tonnes in 2025, expected to grow to 8.5 million tonnes by 2030, i.e. nearly double.⁷⁰⁹ Proven innovations include natural-oil-derived detergents,⁷¹⁰ flexible electrochemical bio-based sensors to identify pollutants in water,⁷¹¹ fully degradable supercapacitors and microbial self-healing concrete,⁷¹² among others.⁷¹³

Despite this growth, bio-based materials have still captured very little of the chemical-equivalent market.⁷¹⁴ For example, bioplastics have captured less than 1% of the global plastics market compared to 8.6% for consumer-used recycled plastics.⁷¹⁵ Another aspect is cost. Bioethylene and biopropylene cost two to three times more than their fossil-fuel equivalents, which means they will remain uncompetitive without regulatory mandates.⁷¹⁶

In the meantime, bio-based chemicals continue to demonstrate the potential for widespread industry transformation⁷¹⁷ driven by environmental regulation and government incentives.⁷¹⁸

The Chemical industry

supports 96% of global manufactured products.



The global bio-based materials market was worth nearly

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by 2035



Bioplastics

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Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Incubation

Governments and industry launch R&D pilots to identify high-value chemical replacements. The focus is on synthetic biology innovation clusters, national bioeconomy strategies, and workforce retraining for a 'biology first' labour market.

- Challenge Prizes
- Accelerator Programmes
- Grants
- Stage-gate Grants

Scaling

National governments implement bio-innovation subsidies to help bio-based materials reach price parity with fossil-fuel equivalents. First-mover multinationals secure supply contracts, and decentralised bio-processing networks begin to replace centralised chemical plants.

- Combination Grants
- Early-stage capital with multiple funding partners
- Accelerator Programmes
- Scaling Funds
- Venture Equity Investment
- Revenue-dependent Grants

Sandbox

The United Nations or other leading authorities mandate a shift to bio-based inputs. Regulatory sandboxes allow for the testing of requirements for biological content in packaging and building materials, while enzymatic recycling protocols are standardised.

- Service Contracts
- Venture Equity Investment
- Equity Investment
- Scaling Funds
- Loans
- Early-stage capital and multiple funding partners



39 2022

Preferable Future Bio-based

Biology has replaced chemistry as the primary industrial driver. Fossil feedstocks have been eliminated. A global biocarbon trading system is active, and growing materials is the global norm. Production is fully circular, renewable and decentralised.

- Equity Investment
- Service Contract
- Loans
- Scaling Funds

What Progress looks Like

Everyday products – from packaging to clothes to building materials – are bio-based. Products and materials are renewable, affordable and of good quality. Bio-based products are now the default and not the premium paid product. The price of raw materials for bio-based chemicals is on par with the price of alternatives. Consumer plastics are replaced with bio-derived polymers that compost safely in home gardens, and recycling is completely reimagined into a biological process. Waste and municipal services are entirely reshaped.



NECESSARY ENABLERS

- Consumer demand and government policy to drive bio-based shifts
- Adaptation of global logistics to handle biomass
- Innovation and R&D around materials science
- Funding to scale emerging solutions
- Global rules that ensure safety irrespective of where products are produced



CHALLENGES

- Prevention of accidentally created novel pathogens
- Cyberbiosecurity
- Management of regulatory complexity
- Navigation of fragmented global laws



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





23 2023

What if the next wave of car innovations was in the wheels?

Multipurpose Wheels

A series of technological innovations in the wheels redefine the future of car transport – from maglev (magnetic levitation) solutions and drone-like technologies, to the replacement of rubber in tyres and new ways of conceptualising the function of wheels on a car.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Materials revolution

Uncertainties

Technology, Nature

Trends

Air Pollution

Future of Raw Materials

Net Zero

Sustainable Waste Management

Technologies

Nanotechnology

New Materials

Sensor Technologies

Category

Nature restored

Top Five Sectors

Automotive, Aerospace & Aviation

Chemicals & Petrochemicals

Infrastructure & Construction

Manufacturing

Materials & biotechnology

Keywords

Non-exhaust emissions

Particle-capture technologies

Low-wear materials

Why It Matters Today

Every time a vehicle accelerates, brakes or steers, its tyres wear and release particles into the environment. These particles extend beyond the road surface, entering the air we breathe, being carried by rainwater runoff, and accumulating in waterways, soil and agricultural systems over time. This form of pollution is independent of fuel type, meaning that even fully electric vehicles continue to generate tyre wear emissions. Globally, approximately six million tonnes of tyre wear particles are released each year,⁷¹⁹ an amount equivalent to the rubber from around 600 million tyres, assuming an average tyre mass of 10 kg.



Benefits

Improved urban air quality and potential public health benefits. Innovation pathways for advanced materials and smart wheel.



Risks

Increased cost and complexity of wheel systems, potentially slowing market adoption. Performance, safety and durability issues that limit real-world deployment.



Status Today

Major tyre manufacturers and innovators are addressing tyre wear emissions, though solutions are still emerging. Michelin invested \$896 million^L in R&D in 2024, with its tyres emitting 26% fewer particles than the average of premium competitors.⁷²⁰ Continental is collaborating with the Technical University of Braunschweig to develop wheel-mounted vacuum collectors for real-time analysis,⁷²¹ while Bridgestone has developed a device that covers the entire tyre and designed to collect tyre wear particles directly.⁷²²

Startups are also active. The Tyre Collective (UK) has been testing an electrostatic capture device mounted behind wheels since 2020.⁷²³ Named one of Europe's top clean mobility startups by the European Startup Prize for Mobility in 2025, it is preparing for product launch in 2026.⁷²⁴ The Smart Tire Company, featured in NASA's Startup NASA Series in 2021,⁷²⁵ is developing airless bicycle tyres that use approximately 50% less rubber than conventional tyres, with orders expected in Q3 2026.⁷²⁶

On the policy front, the European Union's Euro 7 regime, adopted in April 2024, will mandate tyre wear limits for passenger cars, with requirements coming into force in November 2026.⁷²⁷



Michelin invested **\$896 million** in R&D in 2024, resulting in its tyres emitting

26% fewer particles.

The Smart Tire Company is developing airless bicycle tyres that use approximately

50% less rubber



The European Union's Euro 7 regime (April 2024) will **mandate tyre wear limits** from November 2026.



^L Based on the EUR:USD exchange rate of 11 July 2026.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Research & Development

Collaborative R&D is progressing on capture technologies, low-wear materials and exploratory maglev-wheel hybrids. Euro 7 enforcement (November 2026) is creating regulatory pressure. Startups trial particle-capture and airless technologies.

- 🏆 Challenge Prizes
- 👥 Matched Crowdfunding
- 🚀 Accelerator Program
- 💰 Grants
- 📊 Stage-gate grants

Regulation & Standards

Standards for smart wheel protocols (data, energy, propulsion interfaces) are established, enabling testing of emissions and multifunctional wheel capabilities. Regulatory pilots for maglev-compatible infrastructure are launched in select routes.

- 📄 Combination grants
- 🚀 Accelerator programmes
- 📄 Service Contracts
- 📄 Convertible Grants

Pilot & Demonstration

Maglev routes are launched commercially for hybrid wheels that operate on both traditional roads and maglev infrastructure. Supply chains and manufacturing capacity are assessed and scaled for advanced wheel systems.

- 📊 Scaling funds
- 📄 Revenue-dependent grants
- 📄 Loans
- 👥 Venture equity investment
- 👥 Early-stage capital and multiple funding partners



23 2023

Preferable Future Commercialisation & Scale-up

Wheels are multifunctional systems that integrate energy capture, sensing and propulsion, with traditional rubber tyres being phased out in advanced markets. Maglev networks are expanding in urban and intercity routes.

- 👥 Equity investment
- 📄 Loans
- 📊 Scaling Funds



What Progress looks Like

Cities breathe cleaner air as wheels capture emissions at source. Maglev routes reduce urban traffic noise. Energy-harvesting wheels extend EV range, reducing charging infrastructure needs. Real-time pollution monitoring enables adaptive traffic management. Six million tonnes of annual rubber waste vanishes, replaced by circular manufacturing ecosystems.



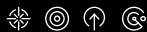
NECESSARY ENABLERS

- Cross-sectoral regulatory policy alignment
- Sustained funding
- Manufacturing systems transitioning from rubber to advanced composites
- Established safety records to communicate safety and adoption benefits

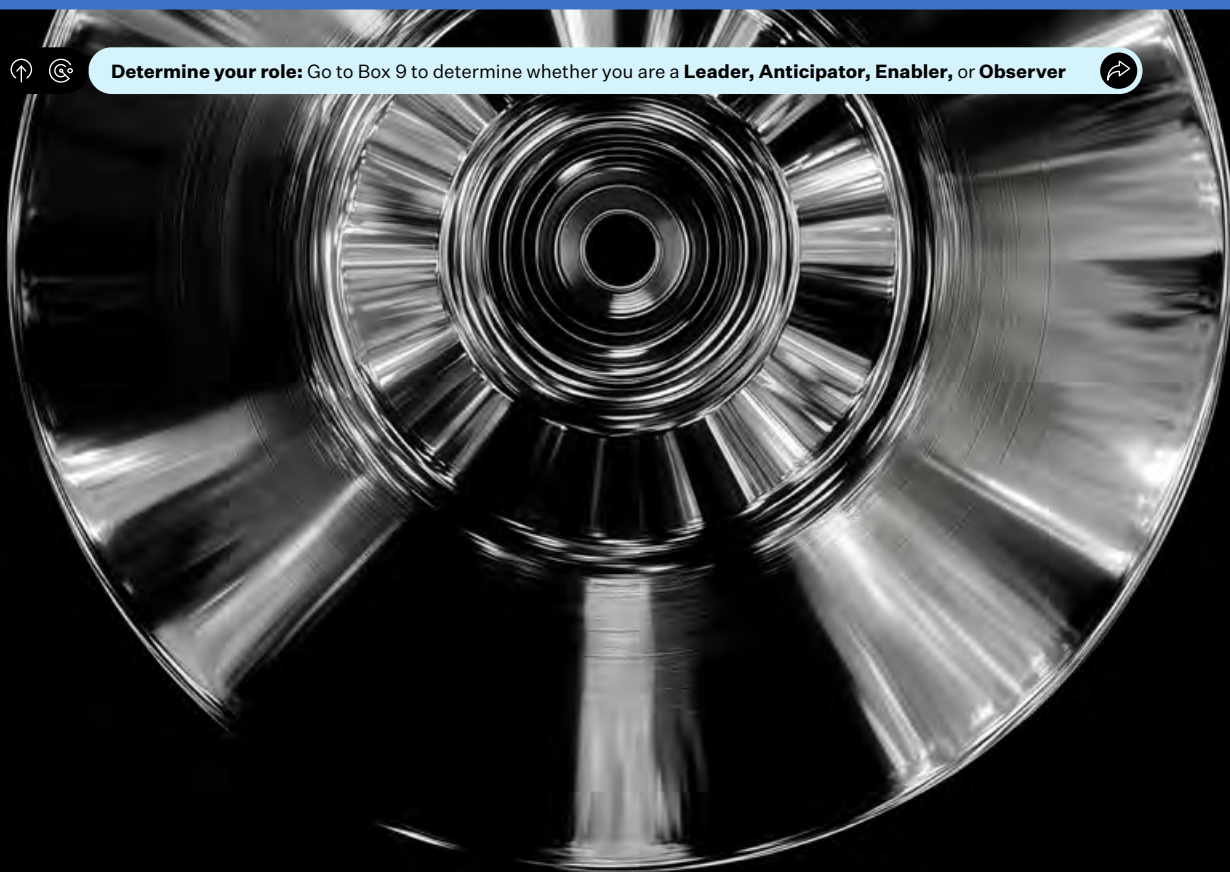


CHALLENGES

- Lack of interest in shifting to maglev system given road infrastructure investments
- Inconsistent growth trajectory and commercial viability
- Inequitable access to next-gen tyres
- Regulatory and insurance liability uncertainty
- Public resistance to potentially more expensive new wheels or hybrid maglev systems



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





44 2023

What if we could make new materials in seconds?

Fresh Threads

Advanced machine intelligence enables novel algorithmic models and techniques for predicting how new materials will function, accelerating the discovery of new materials.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Materials revolution

Uncertainties

Technology, Systems

Trends

Cross-sectoral Partnerships

Future of Raw Materials

Ideation

IP & Entrepreneurship

Mobilising Innovation

Open Data

Technologies

Advanced Computing

Artificial Intelligence

Robotics

Category

Transformation

Top Five Sectors

Automotive, Aerospace & Aviation

Data science, AI & Machine Learning

Energy, Oil & Gas, & Renewables

Manufacturing

Materials & biotechnology

Keywords

AI materials discovery

Autonomous experimentation

Next-gen materials

Self-driving laboratories (SDLs)



Why It Matters Today

Computer chips, solar panels, cutting tools, batteries and many other technologies exist because of the discoveries in materials science – where new materials turn scientific ideas into widely used technologies that shape how the modern world functions. In the past, taking a new material from the lab to real-world use could take up to 20 years.⁷²⁸ Today, AI-powered labs can operate autonomously and discover new materials up to ten times faster.⁷²⁹ Faster material discovery leads to more innovations across all sectors and opens pathways to solutions that were previously impossible.



Benefits

Faster, more cost-effective development of new materials. Reduced environmental impact and more versatile materials. Ability to identify and address the potential risks of novel materials before widespread use.



Risks

Delays to the regulatory reforms needed to aid innovation and discovery of new materials. Use of advances to do harm.



Today,
AI-powered
labs can
discover new
materials up to
10x faster.

In the past, taking
a new material **from
the lab to real-world
use** could take up to



years



Status Today

AI-driven materials discovery has reached a critical transition point: it has clearly demonstrated its power to generate and evaluate vast numbers of candidate materials, yet the large-scale translation of these predictions into experimentally validated and commercialised materials remains a challenge. Major public investments reflect growing confidence in this approach. The European Union's FULL-MAP project (February 2025–January 2029), with a budget of approximately \$22.75 million,^M aims to accelerate the discovery of sustainable next-generation battery materials through an autonomous, AI-driven materials acceleration platform.⁷³⁰ In November 2023, Google DeepMind's AI system GNoME predicted over 2.2 million new materials, including about 380,000 stable candidates suitable for experimental synthesis.⁷³¹ However, there are no updates on how many have been experimentally synthesised or advanced toward real-world applications.

A key emerging paradigm is the SDL, where AI systems autonomously design experiments, robotic platforms execute them, and results are continuously fed back into learning loops. *Nature* identified SDLs as a top technology to watch in 2025,⁷³² and they are already enabling discoveries with commercial potential.^{733,734} MIT's CRESt (Copilot for Real-world Experimental Scientists) platform used this approach to run over 900 compositions and more than 3,500 experiments, discovering a catalyst with record-breaking performance for fuel cells.⁷³⁵

Industry investment underscores this transition. The Toyota Research Institute launched a multi-million-dollar global research challenge in April 2024 to bridge AI-predicted materials and physical synthesis,⁷³⁶ while Nvidia,⁷³⁷ Microsoft⁷³⁸ and Schrödinger⁷³⁹ continue investing heavily in AI materials platforms.

Overall, AI in materials discovery is predictively powerful and experimentally promising, but not yet fully industrialised, with the coming years focused on closing the loop from prediction to scalable deployment.



MIT's CRESt platform ran over **900 compositions** and more than **3,500 experiments**, discovering a catalyst with record-breaking performance for fuel cells.



M Based on the EUR:USD exchange rate of 11 July 2026.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day AI Materials R&D Labs

Materials databases, AI models, and laboratories are shared across research institutions, governments and industry to accelerate discovery and screening.

- Challenge Prizes
- Combination grants
- Grants
- Accelerator programmes

Regulation & Standards

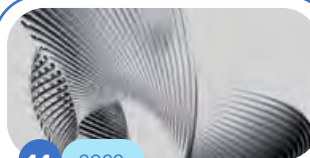
Data, safety and testing standards are defined, enabling trusted AI-driven development of materials.

- Challenge prizes
- Service Contracts
- Stage-gate grants

Automated Testing

Self-directed labs are set up that combine AI, robotics and real-time feedback to test and validate materials quickly.

- Early-stage capital and multiple funding partners
- Convertible grants
- Venture equity investment
- Convertible Loans



44 2023

Preferable Future Instant Materials-on- -Demand Era

Materials are designed, validated and manufactured on demand while tailored to specific performance needs.

- Scaling funds
- Loans
- Equity Investment
- Services Contracts

What Progress looks Like

SDLs are widely adopted, combining AI, robotics and human expertise to accelerate materials discovery from years to days. Scientists focus on creative problem-solving while autonomous systems handle experimentation. Validated, reproducible materials data is shared across institutions, enabling faster translation of discoveries into real-world applications across many sectors like energy, electronics, manufacturing and healthcare.



NECESSARY ENABLERS

- Open data-sharing platforms for global research communities
- Investment in AI, robotics and cloud computing for autonomous experimentation
- Clear policy frameworks for lab autonomy, IP and data sharing
- Cross-sector collaboration to align discovery, validation and deployment
- Regulations that allow for novel nano and biomaterials



CHALLENGES

- Loss of human expertise as AI automates experimental decision-making
- Difficulty validating AI-discovered materials before deployment
- High upfront costs limit access for smaller labs and institutions
- Lack of ethical frameworks for autonomous material design
- Provision of accessible, modular hardware and shared infrastructure to lower adoption costs



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





47 2023

What if we could X-ray the whole planet?

Earth X-ploration

Cosmic-ray imaging technology makes it possible to 'X-ray' the entire world, revealing new sources of water, energy, minerals and other resources while helping to identify geological and structural risks.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Saving ecosystem

Uncertainties

Technology, Nature

Trends

Cross-sectoral Partnerships
Future of Raw Materials
Government Agility
Open Data
Restoration

Technologies

Advanced Computing
Quantum Technology
Sensor Technologies

Category

Transformation

Top Five Sectors

Energy, Oil & Gas, & Renewables
Metals & mining
Insurance & reinsurance
Infrastructure & Construction
Materials & biotechnology

Keywords

Cosmic-ray muon imaging
Field-proven deployments
Emerging commercialisation

Why It Matters Today

Studying the Earth's interior helps identify resources and predict natural disasters, but conventional methods—such as drilling – are expensive, risky and limited.⁷⁴⁰ The deepest borehole ever drilled reached only ~12.3 km, and due to temperatures, pressures and size issues, it was not possible to send conventional X-ray devices to the bottom.⁷⁴¹ 'X-ray'—like techniques, such as cosmic-ray muon imaging, can overcome these limitations by revealing hidden underground structures, improving hazard prediction and enabling sustainable resource discovery without extensive drilling.



Benefits

Economically valuable information about natural resources below the Earth's surface. Improved understanding and management of resources. More targeted spending on infrastructure development and safety, contributing to economic growth and well-being.



Risks

Intense competition to use the technology to find new resources. Cosmic-ray imaging fails to scale or deliver results like other radiography techniques (despite increased funding). Resource depletion undermines efforts to protect and preserve the planet.



Status Today

Cosmic-ray muon imaging has progressed beyond early laboratory experimentation into demonstrated field use.⁷⁴² Its real-world applications span diverse domains, including the study of modern and ancient building, volcanic systems, and industrial structures; emerging use cases in nuclear security and safeguards;⁷⁴³ and assessing tunnel overburden conditions in active metro and infrastructure projects.⁷⁴⁴

On the commercial side, Ideon Technologies has demonstrated field-ready deployments in mineral exploration, delivering metre-scale subsurface imaging at depths of several hundred metres and identifying high-confidence drill targets.⁷⁴⁵ Decision Sciences International Corporation has advanced muon scattering systems for cargo and border security applications.⁷⁴⁶

Public and private investment signals a growing strategic interest, including a \$1.14 million^N KAKENHI Transformative Research grant in Japan (2025–2030) dedicated to advancing next-generation muon imaging systems,⁷⁴⁷ alongside early deep-tech commercialisation efforts such as a \$374,000^O seed round for muon imaging platforms.⁷⁴⁸ Overall, the technology can be characterised as field-proven and commercially emerging, but still in a transitional phase between niche applications and broad industrial adoption.



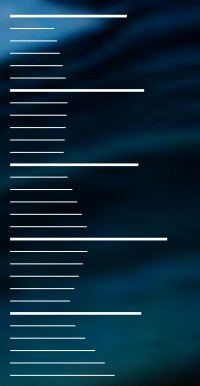
Cosmic-ray muon imaging has progressed beyond early laboratory experimentation into demonstrated field use.



Public and private investment signals a growing strategic interest in

next-gen muon imaging systems

^{N, O} Based on the YEN:USD exchange rate of 11 July 2026.



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delivering metre-scale subsurface imaging at depths of several hundred metres and **identifying high-confidence drill targets.**



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Building Momentum

With secure funding, reliable detectors are used to run more proof-of-concept tests, and connect researchers with potential end users to shape development around real-world needs.

-  Grants
-  Stage-gate Grants
-  Challenge Prizes

Deploy Vertical Pilots

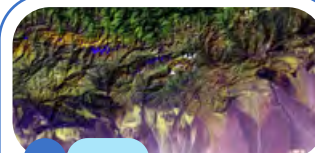
Run pilots in specific industries with findings openly shared to enable repeatable pilots and establishment of early industry standards.

-  Revenue-dependent Grants
-  Convertible Grants
-  Service Contracts

Establish Standards

Performance benchmarks, safety protocols and data standards are established across sectors, enabling regulated, interoperable muon imaging deployment

-  Early-stage capital with multiple funding partners
-  Equity Investment
-  Convertible Grants
-  Service Contracts
-  Convertible Loans



47 2023

Preferable Future Operations

Underground imaging supports routine decisions in resource discovery, hazard monitoring, and infrastructure planning

-  Accelerator Programmes
-  Service Contracts
-  Scaling Funds

What Progress looks Like

Communities gain safer infrastructure, reduced drilling and environmental disruption, earlier disaster warnings and smarter resource decisions. Governments, industry and insurers rely on trusted, non-invasive subsurface intelligence to cut costs, lower risk, accelerate permitting and enable sustainable development while protecting people and ecosystems.



NECESSARY ENABLERS

- Recognised performance and safety standards
- Certainty around data reliability, validation and comparability across projects and sectors
- Alignment between scientific validation, commercial timelines, and regulatory acceptance
- Reliable and deployable Muon imaging solution



CHALLENGES

- Long data-acquisition times
- Regulatory ambiguity slows adoption
- High upfront costs may limit access



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





50 2023

What if teleportation was a reality?

Telepossible

Leaps in quantum physics revolutionise communication, encryption and computation, transforming digital realities into true realities and one day enabling teleportation of people and things.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Future Humanity

Uncertainties

Technology, Values

Trends

Advanced Connectivity
Cross-sectoral Partnerships
Digital Economy
International Collaboration
Quantum Technology

Technologies

Advanced Connectivity
Quantum Technology

Category

Transformation

Top Five Sectors

Cyber & Information Security
Communication technologies & systems
Financial Services & Investment
Data science, AI & Machine Learning
Government Services

Keywords

Quantum teleportation
Quantum networking
Real-world quantum applications



Why It Matters Today

Teleportation is typically thought to be about moving people or objects; but it is about transforming how communication, encryption and computation operate at a global scale. Advances in quantum teleportation are already changing how digital transactions, secure communications, and trust are transferred across the world for banks, governments and critical systems. For example, IBM's cloud-based quantum computer enables algorithms that can accelerate applications by a factor of 120.⁷⁴⁹ As a foundational technology, quantum strengthens data security and enables new approaches to artificial intelligence and distributed computing, with quantum computing, quantum communication and quantum sensing expected to grow to \$97 billion by 2035.⁷⁵⁰



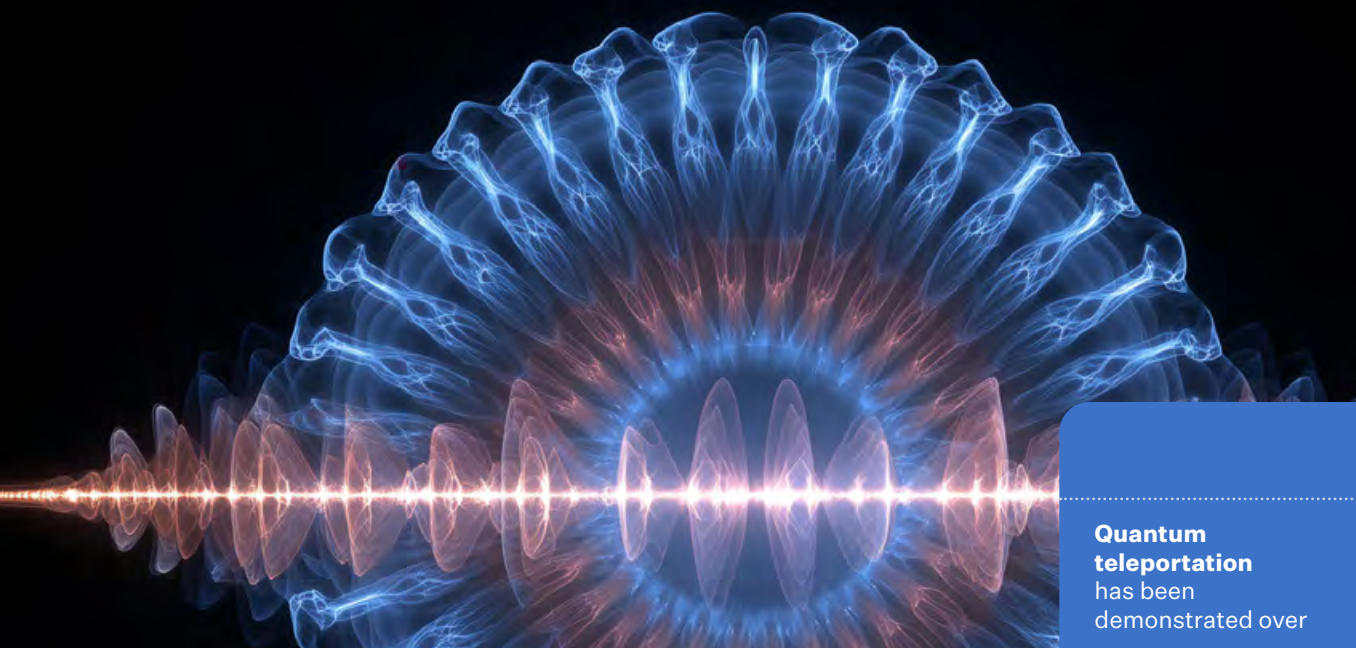
Benefits

Secure, instant and controllable transmission of people and materials, enabling realistic and secure experiences, communications and medicine.



Risks

Unintended consequences, such as sub-atomic damage to particles. Winner-takes-all use of teleportation technology. Physical extinction as a result of being everywhere, anywhere, at any time.



Quantum teleportation has been demonstrated over
12.3 km
of optical fibre.

Status Today

Quantum teleportation and networking are moving from laboratory experiments towards real-world applications in secure communication and computing.⁷⁵¹ Researchers have successfully teleported the quantum state of a single light particle (photon) between two separate quantum dots in devices connected over a city optical link, marking the first such demonstration over a distance.⁷⁵² Other teams have demonstrated photonic quantum teleportation over 12.3 km of optical fibre, showing practical chip-to-chip state transfer.⁷⁵³ Also, a group of researchers has successfully sent secure quantum information over 254 km of commercial fibre-optic cable, representing an important step towards real-world quantum networks.⁷⁵⁴

A global quantum internet does not exist yet, but significant progress in the underlying technology suggests that near-unhackable encryption and connected quantum computers could become a reality within the next decade.⁷⁵⁵ In July 2025, the European Commission announced a plan to make Europe a world leader in quantum technology by 2030.⁷⁵⁶ In healthcare, researchers identified 63 quantum sensing technologies that could improve diagnostics, imaging and treatment monitoring, though most remain at an early stage.⁷⁵⁷ By mid-2025, governments worldwide had committed approximately \$55.7 billion in public funding to quantum research, development and infrastructure.⁷⁵⁸



Governments worldwide committed approximately

\$55.7 Billion

to quantum research, development and infrastructure (by mid-2025).



Europe aims for global quantum leadership by 2030, with **63 healthcare quantum sensing technologies** identified.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Quantum Research Hubs

Interdisciplinary teams demonstrate reliable quantum teleportation, entanglement distribution, and error control in controlled research environments, focusing on use cases with the greatest potential.

- Challenge Prizes
- Accelerator Programs
- Grants
- Stage-gate grants

Quantum Technology Pilots

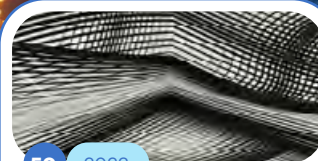
Quantum sensing and secure communication are deployed in real-world applications to test interoperability with existing classical infrastructure.

- Combination grants
- Accelerator programmes
- Early-stage capital with multiple funding partners
- Service Contracts

The Quantum Economy

Interoperable quantum networks are scaled for global finance, healthcare and AI, creating a mature, secure quantum-driven economy.

- Revenue-dependent grants
- Loans
- Scaling funds
- Equity Investment
- Venture equity investment



50 2023

Preferable Future Leap in Quantum Matter

Complex matter and living organisms are being teleported.

- Equity investment
- Loans
- Scaling Funds

What Progress looks Like

Quantum teleportation and networking enable secure digital transactions immune to cyberattacks, quantum-secure government communications, distributed quantum computing for AI and optimisation, resilient financial infrastructure, and trusted data exchange across borders. These technologies provide economic growth, national security, healthcare breakthroughs, and public confidence in digital systems. In the distant future, revolutionary advances in quantum physics transform our physical reality.



NECESSARY ENABLERS

- Governance and legal mechanisms for ethics, safety and privacy
- International quantum standards, network protocols and interoperability frameworks
- Mechanisms for effective cross-border and cross-sectoral research partnerships
- Skilled teams, appropriate education pathways and workforce reskilling
- Breakthrough physics enabling matter teleportation



CHALLENGES

- Cybersecurity risks during the transition period
- High infrastructure costs and the need for shared national quantum systems
- Interoperability challenges between classical and quantum systems
- Quantum talent scarcity
- Technological uncertainty restricting continued funding



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





5 2024

What if organ transplant waiting lists were eliminated?

Organ Printing

Personalised bioprinting and genomics transform organ transplantation, reducing or potentially eliminating waiting lists, reducing organ rejection and improving survival rates through 3D printed patient-identical tissues.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Materials revolution

Uncertainties

Technology, Value

Trends

3D Printing

Biomaterials

Biotechnology

Genomics

Personalised Medicine

Technologies

Bioprinting

Genomics / Epigenetics

Advanced Machine Intelligence

Category

Health Reimagined

Top Five Sectors

Data science, AI & Machine Learning

Government Services

Health & Healthcare

Insurance & reinsurance

Materials & biotechnology

Keywords

Bioprinting

Organ transplantation

Genomics

Tissue engineering

Regenerative medicine



Benefits

No dependency on organ donation.
No life-long anti-rejection treatment required following transplant.
Increased quality of life throughout society as new solutions to organ- and tissue-related medical challenges are discovered.



Risks

Unforeseen long-term health effects; potential medical or ethical misuse to manipulate physical capacities; high costs limiting access.

Why It Matters Today

In 2024, 173,727 organs were transplanted worldwide.⁷⁵⁹ Despite these numbers, there is a critical global organ-donor shortage. In the US, 17 people die each day waiting for an organ and a new person is added to the organ transplant waiting list every eight minutes.⁷⁶⁰ In the UK, more than three people die or grow too sick a day while waiting for an organ.⁷⁶¹ While the shortage is due to low registration rates, further underlying causes vary from family members reversing the registration of a deceased loved one, medical exclusions of some organs and strict criteria on age and state of health.⁷⁶² Beyond availability, between 10% and 15% of recipients experience signs of organ rejection,⁷⁶³ making an alternative solution important.



Status Today

Fully functional bioprinted organs do not exist yet even though funding agencies like ARPA-H⁷⁶⁴ in the US continue to fund projects focused on accomplishing that, such as UT Southwestern trying to 3D bioprint livers using patients' own cells.⁷⁶⁵ Bioprinted organs can be seen from two perspectives: full-organ printing; or restorative, using a combination of regenerative medicine and partial bioprinting.

3D printing in medical applications today are cell-free. After blood, bone is the second most transplanted tissue, with orthopaedic surgery using nearly 50% of medical 3D printing to print bone structures.⁷⁶⁶ Yet, bioprinting with live cells has not reached clinical use and success would require a combination of 4D stimuli-responsive nanomaterials, stem cell therapy,⁷⁶⁷ biosensing bio-inks, artificial intelligence and, most critically, vascularisation.⁷⁶⁸

Through SimVascular – a computational algorithm – Stanford most recently printed and tested a network of blood vessels to keep embryonic kidney cells alive, and designed a one-million-vessels vascular tree for human hearts in around five hours, translated into print instructions.⁷⁶⁹ Restorative bioprinting through patches that delay organ failure and regenerate damaged tissue using patients' own cells⁷⁷⁰ has also been an interesting area of progress. For kidney disease, the tenth leading cause of death globally, composite materials and stem cells enable drug delivery and post-surgical bleeding control. Preclinical trials show partial function restoration in tissue-engineered kidneys with scaffolds and seed cells.⁷⁷¹

Researchers at Stanford University took five hours to design a **one-million-vessel** vascular tree for human hearts.



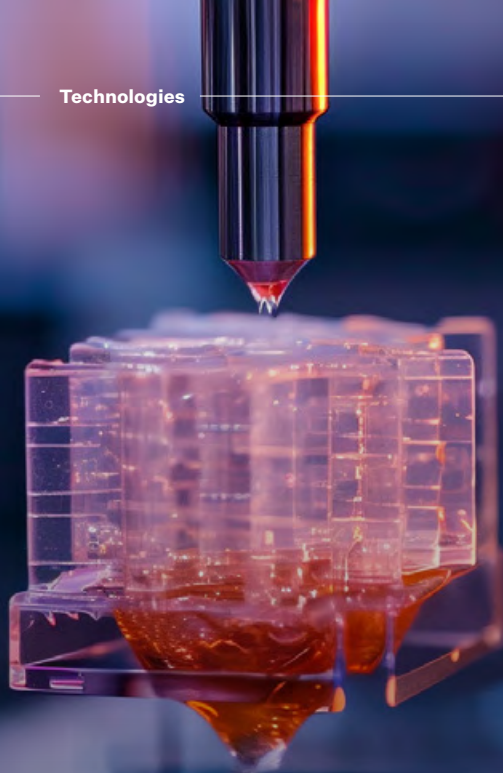
Bone is the second most transplanted tissue after blood, nearly

50%

of medical 3D printing used for orthopaedic bone structures.

Preclinical trials have achieved **partial function restoration in kidney disease.**





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Bioengineering Progress

Research in bio-inks and scaffolds is advanced through targeted funding to ensure structural integrity and biocompatibility. Breakthroughs in vascular scaffolds, perfusion systems and tissue printing precision are achieved.

- Challenge Prizes
- Accelerator Programs
- Grants
- Stage-gate grants

Bioprinted Vascular Networks

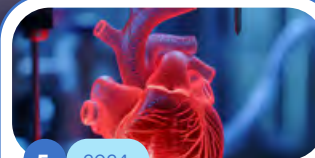
Worldwide clinical trials for printed tissues (retinas, skin) are conducted to validate safety and efficacy. Vascularised tissues function successfully in vivo. Regulatory frameworks and bioethics standards are established.

- Combination Grants
- Early-stage capital and multiple funding partners

Clinical Vascularised Organs

First full-organ transplants using bioprinting are completed with certified clinical protocols. Bioprinting becomes available in major hospitals as accepted treatment and can be used to prepare and produce multiple types of organs.

- Loans
- Stage-gate Grants
- Venture Equity Investment



5 2024

Preferable Future Full-Organ Prints

On-demand organ printing facilities are deployed globally. Bioprinting is integrated into hospital supply chains and insurance coverage. Organ transplant waiting lists are eliminated with near-zero rejection risk.

- Social Impact Bonds
- Service Contracts
- Loans
- Scaling Funds



What Progress looks Like

Bioprinting has transformed healthcare by solving vascularisation and immune-matching through regenerative medicine, AI and synthetic biology. Patients receive organs printed from their own cells within days, with no waiting lists, no rejection and no immunosuppressants. Survival rates soar. Fully effective treatments for burns, heart damage and blindness are routine, saving millions of lives globally.



NECESSARY ENABLERS

- Development of reliable, scalable bioprinting technology
- Clinical-grade bio-ink standardisation (includes stem cell differentiation protocols)
- AI-driven perfusion and oxygenation modelling
- Integrated regulatory pathway for organ-grade constructs
- Cross-border IP and ethics agreements

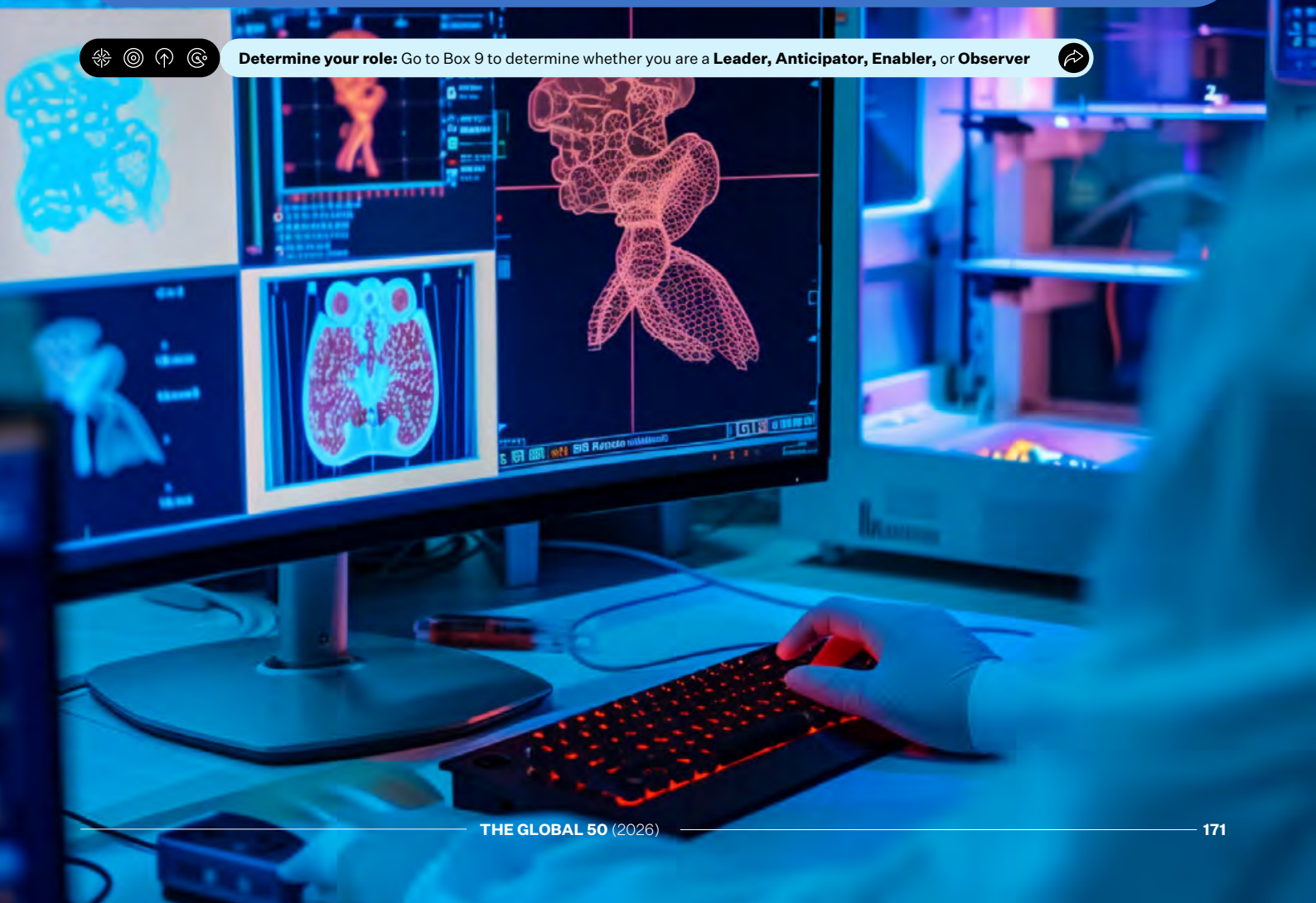


CHALLENGES

- Inequitable access between wealthy and developing nations
- Reliable, scalable bio-ink supply chains
- Insurance/payment models for synthetic organs
- Long-term viability of printed organs post-implantation
- Ethical concerns regarding 'enhancement' versus 'therapy'



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





26 2024

What if we no longer needed monetary policy?

Balanced Books

Advanced machine intelligence, edge computing and the Internet of Things (IoT) make traditional methods like interest-rate adjustments obsolete, enhancing financial stability and fostering sustainable growth.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Boundless Multidimensional Data

Uncertainties

Collaboration, Systems

Trends

Cross-sectoral Partnerships

Digital Economy

International Collaboration

Open Data

Technologies

Artificial Intelligence

Edge Computing

Internet of Things (IoT)

Category

Systems Optimised

Top Five Sectors

Consumer Goods, Services & Retail

Data science, AI & Machine Learning

Financial Services & Investment

Government Services

Real Estate

Keywords

Central Bank Automation

Digital Twin

Financial Stability

Macroeconomics

Responsible AI



Why It Matters Today

Through interest rates, monetary policy deeply impacts society, but not necessarily equitably: wealthier households benefit from inflation-focused policy while lower-income households benefit from unemployment-focused policy.⁷⁷² Higher interest boosts asset prices and makes saving attractive, yet it also impacts employment conditions, affects income prospects and increases mortgage rates.⁷⁷³ Global instability and unsustainable fiscal trajectories in government balance sheets are driving calls to rethink how central banks and government fiscal policies operate and interact.⁷⁷⁴ Central banks are allocating budgets to AI projects, with some institutions allocating up to 20% of their total budgets, and central banks planning to discuss AI more extensively over the next three years.⁷⁷⁵



Higher interest boosts asset prices and savings returns, yet also affects employment conditions, income prospects and mortgage rates — benefiting wealthier households differently from lower-income households.



Benefits

Monitoring of economic shifts in real time, enabling stable growth through interconnected policies and price certainty benefiting all sectors.



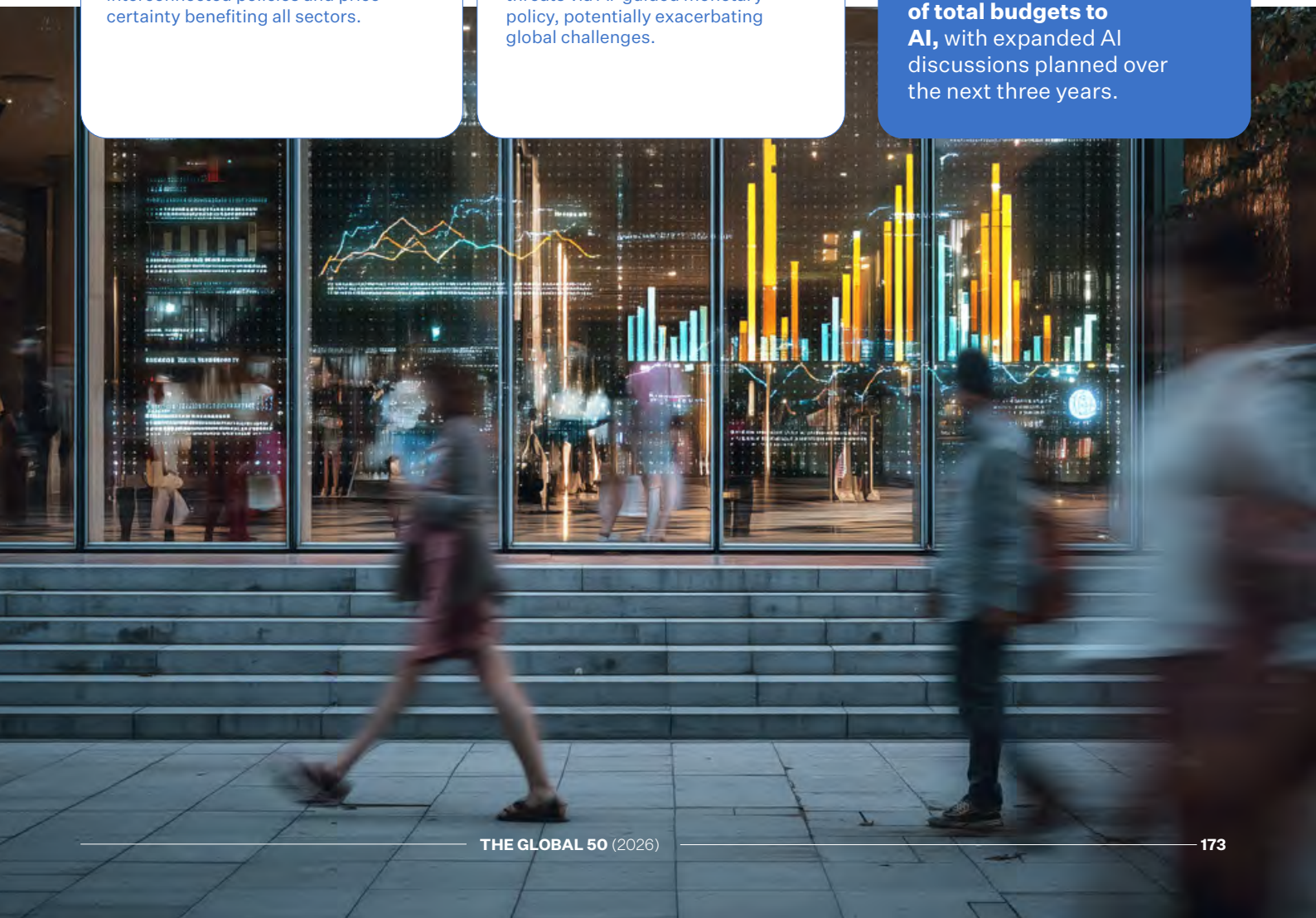
Risks

Embedding of bias, inaccurate information and cybersecurity threats via AI-guided monetary policy, potentially exacerbating global challenges.

Central banks are allocating up to

20%

of total budgets to AI, with expanded AI discussions planned over the next three years.





Status Today

While AI is being adopted in regulatory, supervisory and analytical processes in the financial sector, it is increasingly being explored and used in policy settings.⁷⁷⁶ Central banks are increasingly using AI and machine learning to improve their forecasts for key indicators that inform monetary policy, such as inflation, unemployment and GDP.⁷⁷⁷ This involves processing non-traditional data in real time to estimate risks and correlations more quickly.⁷⁷⁸

Central banks are also using AI to improve data quality, analyse unstructured information and refine economic signals.⁷⁷⁹ Additional focuses include ‘suptech’ (supervisory technologies) which central banks are using to enhance compliance, risk detection and oversight, enabling regulators to better monitor financial stability and systemic risk.⁷⁸⁰

International standard-setters – such as the Basel Committee, the International Organization of Securities Commissions (IOSCO), the Financial Stability Board (FSB) and the International Association of Insurance Supervisors (IAIS) – do not advocate for new AI-specific regulation in the financial sector on the basis that the existing frameworks address most risks.⁷⁸¹ Many jurisdictions – beyond the OECD – endorsed the Organisation for Economic Co-operation and Development’s AI principles:⁷⁸² human-centricity, transparency, robustness, security and accountability.⁷⁸³ However, ethical, legal and accountability challenges remain due to the ‘black box’ nature of proprietary models, reinforcing the consensus among policymakers that AI should be used to optimise processes and inform policy – not replace human decision-making.⁷⁸⁴

Various central banks, including the Reserve Bank of Australia,⁷⁸⁵ have explicitly stated that AI supports research and analysis but does not set policy independently. In the United Kingdom, around 75% of financial services firms use AI, with the highest adoption rates among insurers and international banks.⁷⁸⁶ This led the Treasury Select Committee to call on the Bank of England and the Financial Conduct Authority in January 2026, to conduct AI-specific stress-testing and produce guidance on accountability, consumer protection measures and the designation of AI as a critical supplier.⁷⁸⁷ A critical supplier in the UK is bound to mandatory cybersecurity and compliance requirements.⁷⁸⁸

Nevertheless, as widespread use of AI continues, it brings with it the risk of bias and poor data quality, which complicates related policymaking⁷⁸⁹ and challenge existing regulatory frameworks,⁷⁹⁰ especially as new financial instruments and products emerge in the future.



In the United Kingdom,
around

**75% of
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use AI,**

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international banks.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Sensing

Build and operate edge AI infrastructure that standardises, secures and governs real-time economic data in supply chains, energy, transport and finance.

- Accelerator Programmes
- Service Contracts
- Grants
- Combination Grants

Simulation Model

Deploy an economic simulation model that fuses financial and IoT data to pilot granular, sector-specific policy actions (e.g. setting dynamic loan terms) alongside traditional tools and levers, simulating impact.

- Service Contracts
- Challenge Prizes
- Grants
- Stage-gate Grants

Digital Twin

Transfer the economic simulation model into a continuously synchronised digital twin by integrating real-time data, simulating spillovers, validating AI decisions and authorising policy execution through explainable control layers that formally delegate monetary policy decisions.

- Service Contracts
- Loans



26 2024

Preferable Future Scaling

Operate a secure, decentralised edge AI-IoT system that continuously senses economic activity and executes real-time fiscal and credit interventions, making interest-rate adjustments obsolete.

- Service Contracts
- Loans

What Progress looks Like

Central banks evolve from reactive rate-setters into expert supervisors of autonomous economic systems. Instead of waiting for lagging inflation reports, an AI system continuously analyses billions of real-time signals – from grocery prices captured via the IoT to supply-chain throughput. The system executes targeted, micro-scale economic adjustments, preventing inflationary spikes before they propagate. Recessions become rarer and less severe, and monetary policy is no longer transmitted through interest rates alone.



NECESSARY ENABLERS

- Audit framework for policy decisions
- Edge computing and IoT sensors that can capture real-time consumption and production signals
- Secure, interoperable data-sharing frameworks between public and private organisations
- Legal frameworks that permit automated economic policy interventions



CHALLENGES

- Data privacy risks
- Algorithmic bias skewing policy outcomes and economic priorities
- Cybersecurity and critical infrastructure
- Resistance to delegating policymaking authority to automated systems
- Uneven global adoption and international governance frameworks



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





40 2024

What if contactless haptics transformed gaming and healthcare?

Seeing Is Feeling

Contactless haptic technology enhances gaming, digital realities, healthcare and everyday life, offering immersive, wearable-free experiences for both sighted and visually impaired individuals.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Digital Realities

Uncertainties

Values, Technology

Trends

Advanced Connectivity

Cross-sectoral Partnerships

Extended Reality (XR)

Technologies

Advanced Connectivity

Internet of Things (IoT)

Sensor Technologies

Category

Transformational

Top Five Sectors

Communication Technologies & Systems

Consumer Goods, Services & Retail

Education

Health & Healthcare

Immersive Technologies

Keywords

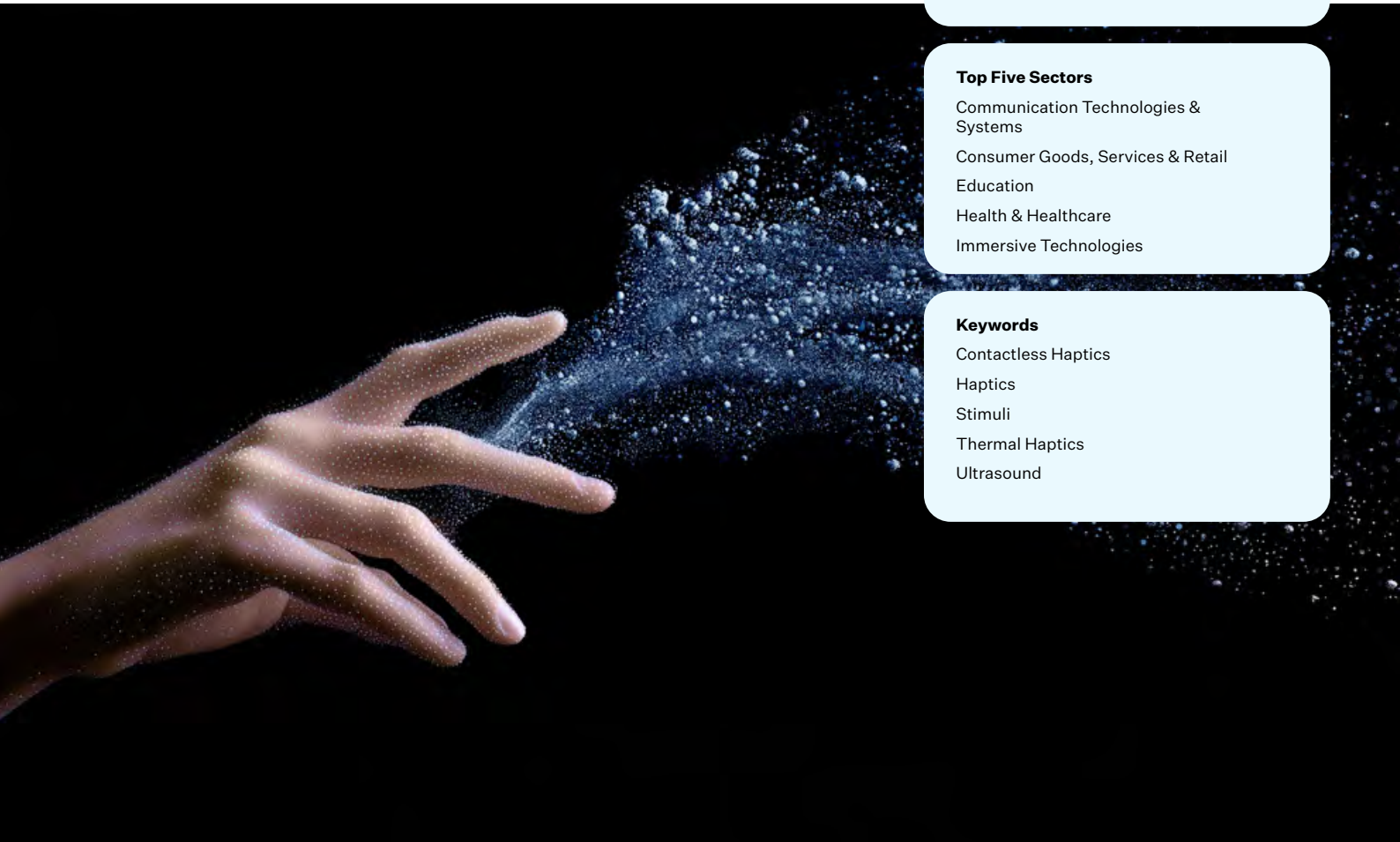
Contactless Haptics

Haptics

Stimuli

Thermal Haptics

Ultrasound





Why It Matters Today

Haptic technology consists of systems and devices that simulate touch by providing tactile feedback through vibration, pressure or temperature changes. Haptic technology is important in gaming, virtual reality, healthcare and the automotive industry.⁷⁹¹ While improving, early haptic systems are mostly contact-based, bulky, unhygienic and lack sensitivity. For example, over 2.2 billion people have sight impairment,⁷⁹² and haptic aids can quickly turn into an irritation or distraction.⁷⁹³ While data are lagging when it comes to surgeries,⁷⁹⁴ inaccurate or absent tactile feedback in robot-assisted minimally invasive surgery risks tissue damage and increases the risk of complications.⁷⁹⁵ Globally, 20 million people have already benefitted from the da Vinci robot-assisted surgery system since its launch 30 years ago, with more than 3.1 million procedures performed in 2025 alone.⁷⁹⁶



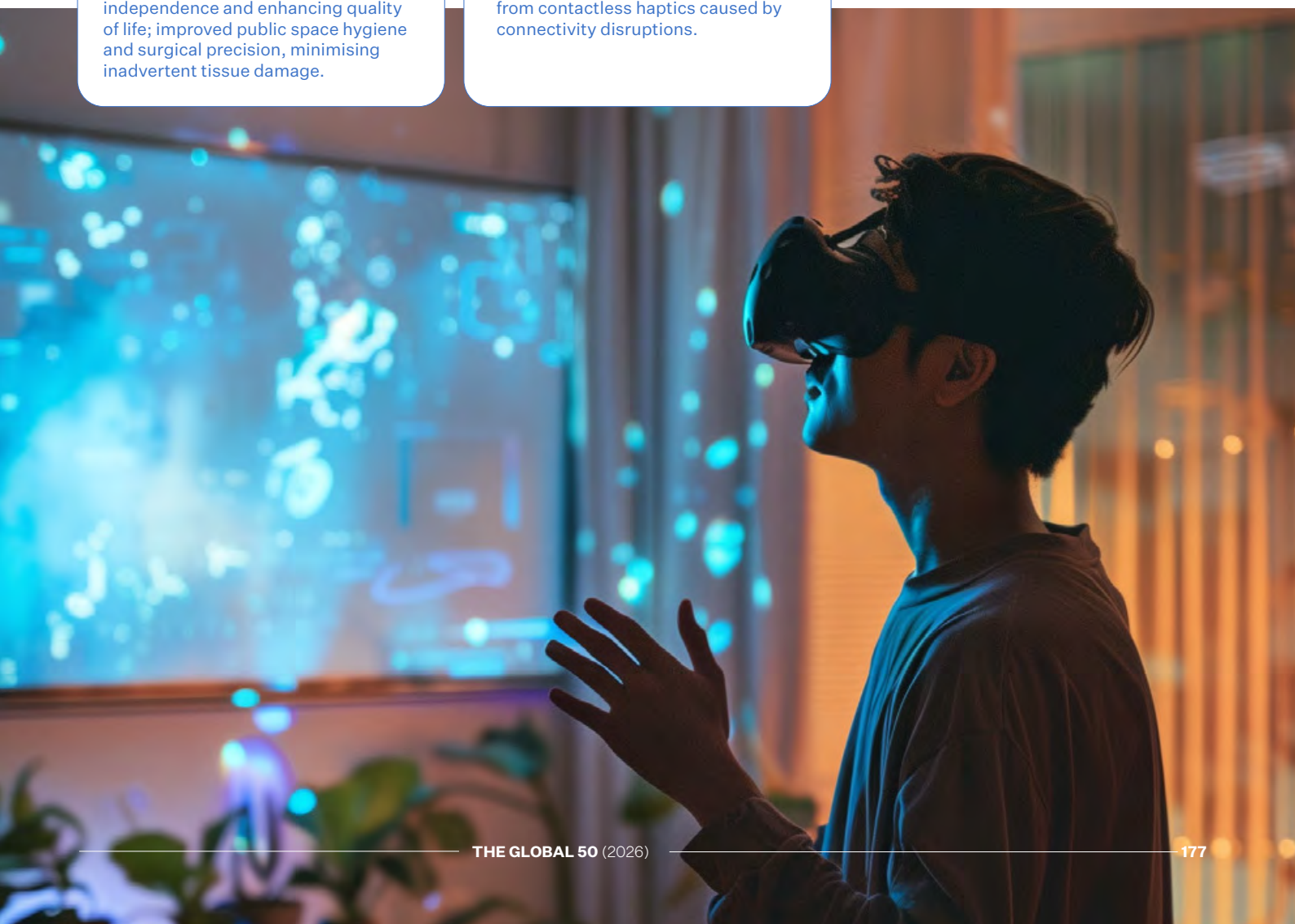
Benefits

Better ability of people with vision impairment or blindness to engage with their surroundings, ensuring independence and enhancing quality of life; improved public space hygiene and surgical precision, minimising inadvertent tissue damage.



Risks

Misuse or data privacy and ethics breaches, leading to false user perceptions; inadvertent harm from contactless haptics caused by connectivity disruptions.





Status Today

Mid-air, or contactless, haptics is not yet widespread in mainstream applications. However, recent experiments and demonstrations have advanced innovation in this space, particularly focusing on mapping connections between stimuli and experience. One study mapped five mid-air haptic stimuli to 17 sensations and 23 experiences ranging from blowing sensations and phone vibrations to feather touches and the feeling of having someone drawing on the hand.⁷⁹⁷ Participants exposed to the same haptic stimuli had varied experiences based on frequency (16 Hz, 125 Hz or 250 Hz), pattern (brush, circle, point or random) and repetition used.⁷⁹⁸ Such findings can help haptics designers choose stimuli variables based on a particular feeling or experience they want to invoke.⁷⁹⁹

The Japanese telecommunications company NTT has developed a novel ultrasound haptic technology that involves rotating the focal point of ultrasound.⁸⁰⁰ This increases perceived force by a factor of twenty, making it six times more effective than stationary vibration.⁸⁰¹ The ultrasound haptic synthesiser combines three key frequencies (5 Hz, 30 Hz and 200 Hz) to simulate various textures, including slimy, smooth and rough.⁸⁰² In another study, mid-air thermal haptics, combining fans and heated elements to resemble stroking sensations on the forearm noticeably reduced anxiety, with 92% of the participants reporting emotional comfort.⁸⁰³

Researchers have also tested an ultrasound haptic system that sends warnings to autonomous car passengers' palms as a car approaches a driving movement.⁸⁰⁴ Their goal was to develop a practical, non-intrusive solution for motion sickness, which can occur with the use of self-driving cars.⁸⁰⁵ The results showed significantly decreased motion sickness and longer tolerance times, reducing motion sickness dropout rates from 62% to 41% compared to a placebo.⁸⁰⁶

The key barriers to scaling haptic technology are related to perception thresholds (i.e. the point at which a user detects a sensation), which can vary between users. For example, ageing can increase perceptual thresholds by up to 50%, making it harder for older people to sense haptic technologies.⁸⁰⁷ Additionally, current systems still deliver weak or ambiguous stimuli, lack personalisation options and provide insufficient multimodal feedback (i.e. audio or visual confirmations).⁸⁰⁸ The haptics field remains in need of further standardisation, shared perceptual metrics and empirical validation across diverse user populations.⁸⁰⁹



Experiences of haptic stimuli vary based on **frequency, pattern and repetition.**

Rotating-focus ultrasound can be

6x more effective than stationary vibration.

Motion sickness dropout rates reduced from

62% to 41%, while ageing can raise perception thresholds by up to 50%.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Research

Fund research teams to develop mid-air haptic technologies. Support pilot prototypes in museums and therapy. Validate sensory algorithms and proof-of-concept systems despite their high cost and challenges around low precision.

- Challenge Prizes
- Combination Grants
- Accelerator Programmes
- Grants
- Stage-gate Grants

Prototyping

Identify use cases, such as surgical training, an immersive telepresence conveying human touch or in-car controls to reduce driver distraction. Test mid-air haptics in real-world settings while designing adaptive feedback frameworks for scalability.

- Combination Grants
- Accelerator Programmes
- Grants
- Stage-gate Grants
- Challenge Prizes
- Early-stage capital with multiple funding partners

Standardisation

Partner with the consumer electronics industry to establish contactless haptics as features in cars, gaming and smart homes. Create standardised software tools enabling developers to integrate tactile effects into any media form or interface.

- Scaling Funds
- Loans
- Venture Equity Investment
- Matched Crowdfunding
- Accelerator Programmes



40 2024

Preferable Future Scalability

Embed mid-air haptic technologies into built environments, vehicles and nature, generating precise pressure and temperature fields. Enable intuitive tactile feedback across all types of interactions. Scale contactless haptics throughout gaming, healthcare and daily life.

- Equity Investment
- Venture Equity Investment
- Service Contract
- Loans

What Progress looks Like

During a remote procedure, a surgeon can feel the difference between healthy and diseased tissue through mid-air ultrasound waves, without wearing gloves. A visually impaired person navigates a new city, feeling the shape of the route and obstacles projected onto their hands by smart infrastructure. Gamers feel the texture of virtual objects in thin air be it slimy, smooth or rough.



NECESSARY ENABLERS

- Reliable acoustic wave manipulation to create precise, contactless tactile sensations in mid-air with rapid user body movements
- Standardisation of haptic feedback protocols
- Ability for machine learning to interpret contextual data into distinguishable, meaningful tactile patterns
- Advanced connectivity (e.g. 6G) to minimise latency so as to ensure safe haptic feedback for surgeries and autonomous cars
- Integrated sensors to detect user position and environmental context with high accuracy



CHALLENGES

- Technical difficulty aligning ultrasound waves with moving body parts in real time
- Ability to create strong sensations without causing discomfort or raising safety issues
- Physical harm if a connection drops during a critical task, such as surgery
- Ethics and data privacy
- High cost of deploying ultrasound arrays in public spaces



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





42 2024

What if the future of batteries is internal?

Perpetual Power

Innovative battery energy storage redesign – using non-lithium or minimal-lithium materials and advanced machine learning – offers opportunities for flexibility, reliability and sustainable applications in various sectors.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Pushing the Boundaries on Energy

Uncertainties

Technology, Nature

Trends

Artificial Intelligence
Net Zero; New Materials
Transforming Energy

Technologies

Advanced Manufacturing
Artificial Intelligence
Battery Technologies

Category

Transformational

Top Five Sectors

Automotive, Aerospace & Aviation
Chemicals & Petrochemicals
Consumer Goods, Services & Retail
Data science, AI & Machine Learning
Energy, Oil, Gas & Renewables

Keywords

Battery Digital Twins
Magnesium-Ion
Non-lithium Energy Storage
Sodium-Ion
Solid State

Why It Matters Today

The global energy storage market is expected to expand at a compound annual growth rate of 14.7% through 2035.⁸¹⁰ Solar panel prices have dropped 85% since the early 2000s and lithium-ion battery costs fell nearly 90% during the decade prior to 2020.⁸¹¹ As such, hybrid solar and storage systems are now economically viable particularly in markets with high electricity prices.⁸¹² Solar power will account for 80% of new global renewable energy capacity by 2030,⁸¹³ and demand for batteries can be expected to grow alongside this expansion but scaling is not straightforward. Many battery defects remain undetectable during production testing, and improving battery quality and safety often requires compromises in energy density, cost and performance.⁸¹⁴ With battery factories operating on profit margins of 2–3% and high scrap rates,⁸¹⁵ alternatives are needed. While these challenges primarily related to lithium-ion batteries, which will make up 86% of battery demand by 2030,⁸¹⁶ the principles apply broadly to electrochemical battery production.



Benefits

Innovative battery technologies improve climate-friendly mobility, connecting remote areas sustainably and advancing decarbonised transport, including electric aeroplanes.



Risks

The diverse range of available battery technologies prevents any one battery innovation from scaling up, achieving cost reductions and reaching its full potential. Redesigns face supply-chain challenges and issues with new materials, leading to increased battery waste.



Status Today

Lithium-ion batteries are expected to account for about 86% of total battery demand by 2030, with sodium-ion, lead-acid and other battery technologies accounting for the remaining 14%.⁸¹⁷ However, advances in AI and materials science may shift this in the future.

Microsoft's M3GNet AI model can screen 32 million battery material candidates in 80 hours and has identified a novel electrolyte requiring 70% less lithium than current commercial rechargeable batteries.⁸¹⁸ IBM's digital twins can predict long-term battery degradation in as few as 50 power cycles, dramatically reducing testing time.⁸¹⁹ And researchers have built an active learning AI model that explored one million potential battery electrolytes starting from only 58 data points, identifying four high-performance candidates without exhaustive testing.⁸²⁰

Developments are also occurring in battery materials. In April 2025, China's leading energy technology company, CATL,⁸²¹ launched its 'Naxtra' sodium-ion batteries, which it plans to scale across passenger vehicles, commercial vehicles and energy storage in 2026⁸²² beginning with the first mass-produced car, the Changan Nevo A06.⁸²³ CATL's sodium-ion batteries were the first to pass China's GB 38031-2025 standard – taking effect in mid-2026⁸²⁴ – and are significantly cheaper than lithium-ion equivalents.⁸²⁵ Recent advances in materials science have produced solid electrolytes (ceramic, polymer and composite materials) with ionic conductivity that can now match their liquid counterparts, eliminating the need for flammable liquid electrolytes.⁸²⁶

Meanwhile, solid-state batteries are likely to transition from laboratory breakthroughs to commercial viability as they overcome manufacturing scalability and cost-effectiveness challenges.⁸²⁷ Likewise, while they are in the early stages of development, being demonstrated on a small scale, magnesium-ion batteries have achieved energy densities comparable to those of lithium-ion batteries.⁸²⁸ Finally, researchers developing lithium-sulphur batteries have managed to stabilise the sulphur cathode (a long-standing challenge) and improve the operational lifespan through nanoengineering, incorporating conductive carbon materials and porous structures.⁸²⁹

These breakthroughs signal a future with a diversified battery ecosystem beyond lithium-ion dominance. AI-driven discoveries could create entirely novel configurations.⁸³⁰ The remaining critical challenges involve manufacturing scalability and how to replacing existing battery systems.

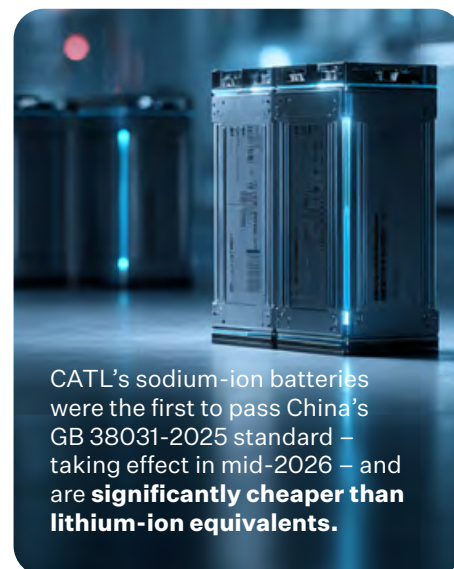
Lithium-ion batteries are expected to account for about **86%** of total battery demand by 2030



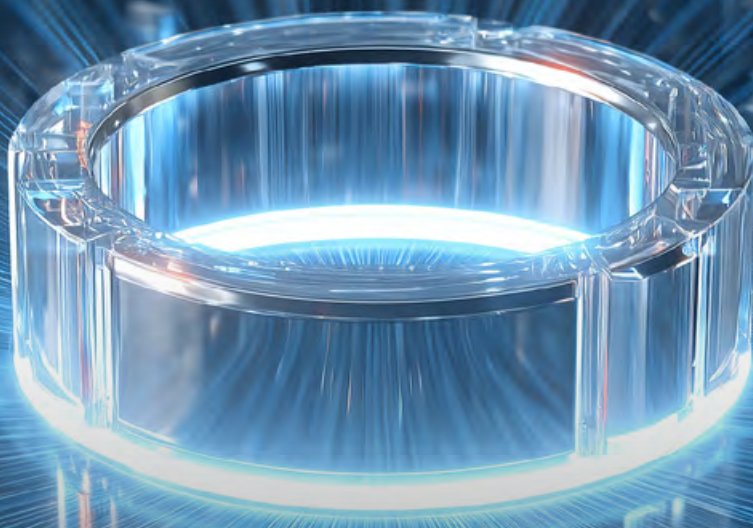
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32 million

battery material candidates in **80 hours** and has identified a novel electrolyte requiring **70% less** lithium than current commercial rechargeable batteries.



CATL's sodium-ion batteries were the first to pass China's GB 38031-2025 standard – taking effect in mid-2026 – and are **significantly cheaper than lithium-ion equivalents**.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Baseline

Existing industry players establish technology-specific consortiums leveraging current research infrastructure. National laboratories validate alternatives through pilot programmes. Established standards organisations create new protocols. Current manufacturers assess factory conversion requirements and supply chains.

- Challenge Prizes
- Accelerator Programs
- Grants
- Stage-gate Grants

Standards and Early Deployment

Regional government and industry alliances harmonise existing regulations around alternative chemistries. Manufacturers scale production alongside their lithium-ion lines. Priority sectors adopt proven alternatives. Established certification bodies validate new technologies. Component suppliers develop interchangeable specifications.

- Combination Grants
- Accelerator Programs
- Early-stage capital with multiple funding partners

Scaling

Non-lithium technologies capture a growing market share. Manufacturers license alternative chemistries through consortiums. Factories adapt their production equipment. Regional supply chains integrate locally abundant materials such as sodium and potassium. Established recycling networks expand infrastructure commercially.

- Scaling Funds
- Venture equity Investment
- Loans



42 2024

Preferable Future Next-Gen Battery Economy

Regions operate self-sufficient battery economies using AI-designed non-lithium chemistries. Existing lithium-ion infrastructure is converted to circular systems that can recover materials locally. Legacy battery factories retrofit production lines. Specialised applications retain lithium-ion selectively.

- Equity Investment
- Loans



What Progress looks Like

Batteries are reformulated and/or redesigned using advanced machine intelligence to optimise energy generation and storage, reduce safety risks, and lessen environmental impact. Vehicles run on sodium-ion or solid-state batteries, which are safer and less reliant on critical minerals. Remote communities access off-grid energy, powering their education and health services without relying on scarce lithium.



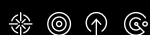
NECESSARY ENABLERS

- Machine learning and digital twins to accelerate materials testing
- Ability to retrofit existing factories for non-lithium chemistries at acceptable levels of risk and cost
- Globally aligned international safety standards
- A clear roadmap and protocols for integrating novel batteries into legacy grids and goods
- Secure local supply chains for sodium, sulphur, magnesium and other minerals

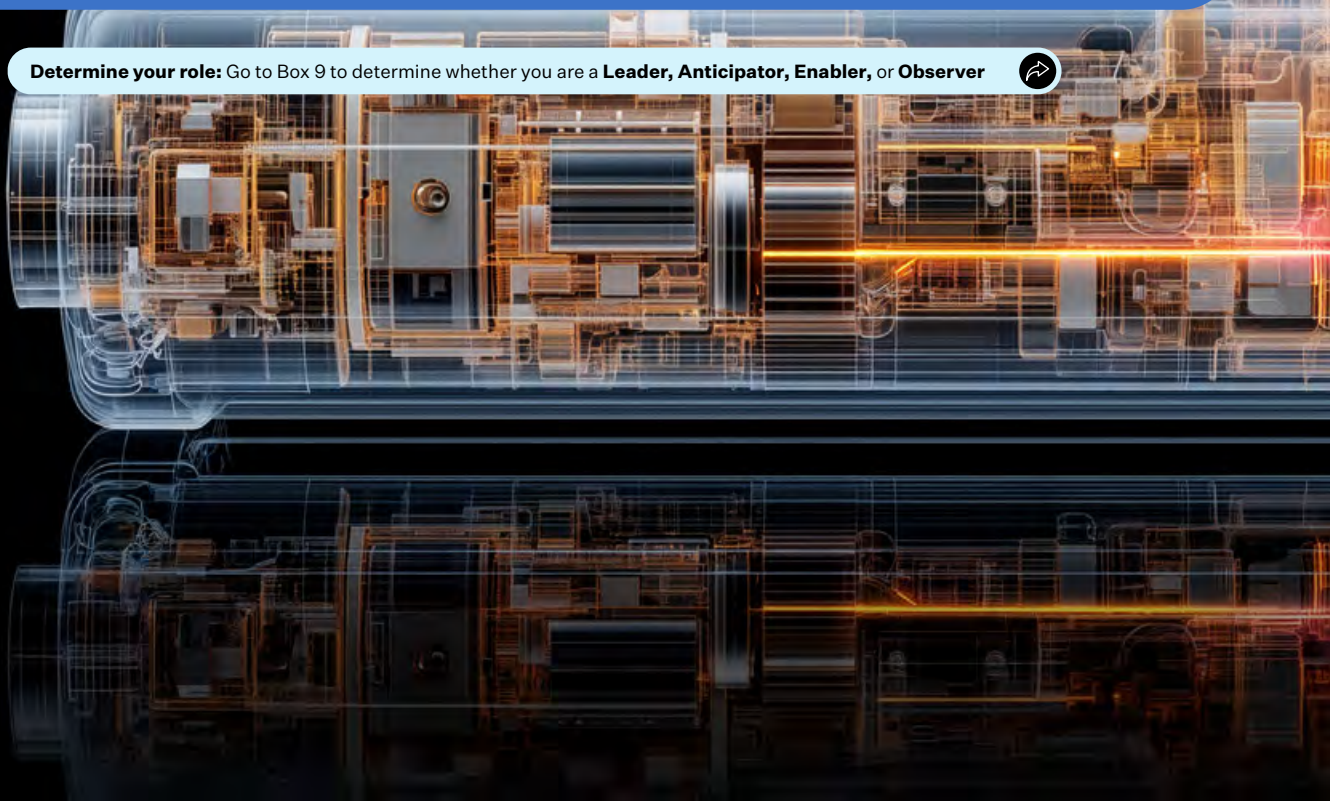


CHALLENGES

- Difficulty scaling up any single innovation due to a diverse range of available technologies and chemistries
- Limits on scaling alternatives due to the existing lithium-ion infrastructure and falling prices
- High R&D and startup costs, making competing with existing mass manufacturers difficult
- Difficulties setting up and /or converting new recycling processes for novel chemistries
- Novel environmental risks associated with new batteries



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





46 2024

What if graphene were mass produced?

Finally Graphene

By unlocking solutions for mass production, graphene could transform energy storage, hydrogen fuel efficiency, air filtration, water desalination, sensor technologies and healthcare (particularly drug delivery and personalised medicine).

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Materials Revolution

Uncertainties

Technology, Nature

Trends

Artificial Intelligence
Immersive Technologies & Wearables
Nanomaterials
New Materials
Transforming Energy

Technologies

Advanced Manufacturing
Nanotechnology
Sensor Technologies

Category

Transformational

Top Five Sectors

Communication Technologies & Systems
Consumer Goods, Services & Retail
Energy, Oil, Gas & Renewables
Health & Healthcare
Immersive Technologies

Keywords

Commercialisation
Graphene Sensors
Nanomaterials
Private–Public Partnerships
Semiconductors

Why It Matters Today

Graphene is the thinnest material known, yet it is 200 times stronger than steel and highly conductive.⁸³¹ Despite being discovered 22 years ago,⁸³² graphene's development has been slow and mass production of defect-free layers remains expensive.⁸³³ However, unlocking this potential has a total addressable market worth \$190 billion,⁸³⁴ with applications across data-processing and communications⁸³⁵ as well as transport, medicine, electronics, energy, sensors, and water and air purification.⁸³⁶



Benefits

Thanks to its strong, stretchy, conductive and atom-thin properties, graphene transforms everything from batteries to water and air purification, healthcare, wearables and electronics.



Risks

Graphene's disruptive impact may affect jobs. Its toxicity may pose health risks and create new challenges in environmental sustainability.



Status Today

Graphene continues to demonstrate exceptional properties across scientific fields, although achieving cost-effective mass production remains an obstacle to commercial deployment. Recent developments indicate some progress in addressing production scalability while simultaneously expanding the material's potential applications.

Researchers have discovered that layering graphene between other materials creates more powerful electrical conductivity, enabling memory devices thinner than a human hair.⁸³⁷ The Georgia Institute of Technology created the first functional graphene semiconductor in 2024 by growing graphene on silicon carbide wafers, solving the decades-old problem that graphene couldn't be switched off.⁸³⁸ This enables devices to run ten times faster than those using silicon semiconductors, with less heat and lower energy consumption.⁸³⁹

On the biotechnology side, in 2024 a group of researchers developed Engineered Graphene for Neural Interface (EGNITE) – nanoporous graphene-based microelectrodes that are 25 μm in diameter and that efficiently transmit electrical signals to and from the brain with minimal interference.⁸⁴⁰ In preclinical trials, the electrodes recorded brain activity with a signal quality 30 times stronger than background noise, enabling highly accurate readings.⁸⁴¹

Graphene coatings can boost material performance across existing applications. Graphene-infused copper reaches 105–110% on the International Annealed Copper Standard, exceeding the conductivity of pure copper and retaining its structure above copper's melting point.⁸⁴² Graphene-coated sand and gravel aggregates could enable smart concrete whose structural health can be monitored and that can conductively de-ice pavements and wireless charge electric vehicles.⁸⁴³ Other promising applications include graphene-coated nanofiber air filters⁸⁴⁴ and graphene-coated membranes for water desalination.⁸⁴⁵

In industrial applications, a UK facility produces graphene sensors for electric vehicles and biosensing at a rate of nearly 150,000 units per day, even if at a loss.⁸⁴⁶ Laboratory-scale rapid joule heating has enabled gram-scale graphene production within minutes at a low energy cost, allowing previous production volumes to be superseded.⁸⁴⁷ Nevertheless, the process remains complex and cost-effective industrial-level production is still under development.⁸⁴⁸



Layering graphene

between other materials creates more powerful electrical conductivity, **enabling memory devices thinner than a human hair.**

Graphene coatings

can boost material performance across existing applications



A UK facility produces
**graphene sensors for
electric vehicles** and
biosensing at a rate of nearly

150,000

units per day.





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Partnerships

Innovation ecosystems establish proof-of-concept collaborations between research institutions and industry. AI-driven platforms have their parameters optimised. Standards bodies develop quality and safety frameworks prior to scaling.

- Challenge Prizes
- Accelerator Programs
- Grants
- Stage-gate Grants

Pilot

An industry-based consortium is established. It selects and operates pilot production lines demonstrating scalability and safety standards. Material innovation hubs develop coating technologies and cross-sector demonstrators validate applications, building an evidence base for wider adoption.

- Combination Grants
- Accelerator Programmes
- Service Contracts
- Early-stage capital with multiple funding partners
- Venture Equity Investment

Industrial Scaling

Public-private partnerships are established for mass production. Manufacturing sectors integrate graphene components into production processes. Municipal systems deploy graphene membrane technologies and semiconductor industries transition towards graphene-based computing, supported by policy frameworks.

- Scaling Funds
- Revenue-dependent Grants
- Loans
- Venture Equity Investment



46 2024

Preferable Future Scaling

Cross-sector stakeholders scale graphene deployment as standard infrastructure. Urban authorities integrate smart monitoring infrastructure. Other sectors, from healthcare to consumer products, continue to deploy new graphene-based production.

- Equity Investment
- Loans
- Service Contracts

What Progress looks Like

Public-private scaling efforts transform graphene from a laboratory material into an accessible industrial standard, supporting economic growth and climate goals. Graphene becomes the new steel: the ubiquitous structural foundation for production systems, products and infrastructure. Mass-produced graphene components – from energy-efficient semiconductors and desalination systems to hydrogen aviation and nanomedicine technology – enable breakthrough performance.



NECESSARY ENABLERS

- Scalable manufacturing that is both technically and economically viable
- Sustained public-private funding
- Alignment on global quality and safety standards
- Sufficient number of cross-sector pilot demonstrations to prove viability



CHALLENGES

- Persistently high production costs versus alternatives
- Need for comprehensive safety assessments and monitoring of nanomaterial toxicity
- Ongoing challenges in managing production toxicity, waste disposal and health-related risks
- Uncertain impacts on the environment
- Workforce disruption as graphene displaces traditional materials supply chains



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





2

2025

What if viruses eliminated the need for antibiotics?

Viral Solution

Bacteriophages, bioengineered viruses, serve as a form of precision treatment for bacterial infections, eradicating antibiotic-resistant infections and eliminating the need for antibiotics.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Advanced health and nutrition

Uncertainties

Technology, Values

Trends

Communicable & Non-Communicable Diseases

Genomics / Epigenetics

Longevity & Vitality

Precision/Personalised Medicine

Technologies

Biotechnology

Nanomedicine

Real-Time Analytics

Category

Health Reimagined

Top Five Sectors

Agriculture & Food

Data science, AI & Machine Learning

Health & Healthcare

Insurance & Reinsurance

Materials & Biotechnology

Keywords

Antimicrobial Resistance (AMR)

Bacteriophages

CRISPR-Cas

Phage Therapy

Precision Medicine



Why It Matters Today

Antimicrobial resistance (AMR) is a top global health threat, projected to cause 10 million deaths annually by 2050,⁸⁴⁹ more than cancer.⁸⁵⁰ Sepsis accounts for approximately 31.5% of total global deaths,⁸⁵¹ and 56% of sepsis deaths in 2019 were caused by just 33 types of bacteria.⁸⁵² Antibiotics are failing due to misuse and by 2035, AMR to antibiotics of last resort could more than double compared to 2005 in OECD countries.⁸⁵³ Phage therapy, which uses viruses to target specific bacteria, offers a precision alternative, but it requires vast quantities of data to match the right phage to the right infection. In some cases, phage therapy may be the only viable option to treat patients with AMR infections.



Benefits

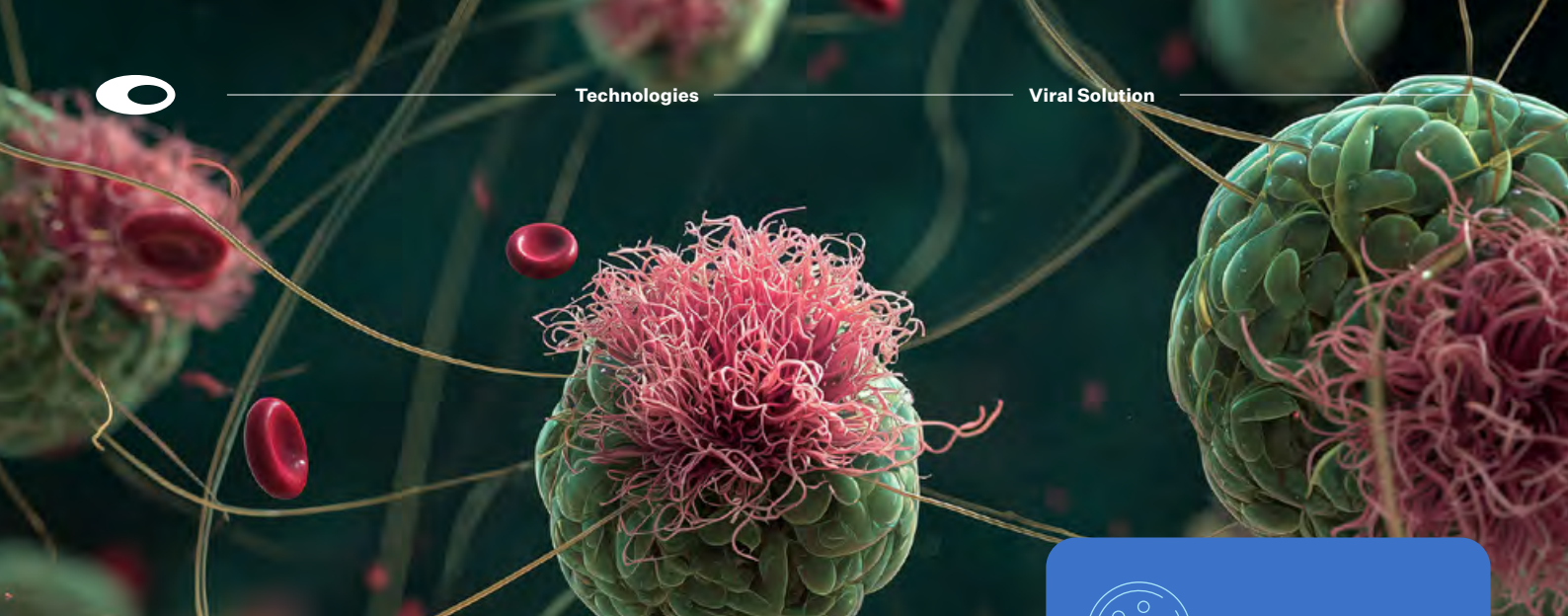
Precision treatment of bacterial infections; Reduced risk of antibiotic resistance and need for antibiotics; increased food safety; enhanced global health security.



Risks

Bacterial resistance to phages; regulatory challenges; viral mutations reducing effectiveness of treatment; increased health access inequality as antibiotic production stops; potential misuse; limited evidence on long-term effects on human health; lack of social acceptance.

Antimicrobial
resistance (AMR) is
**projected to cause
10 million deaths
annually by 2050**



Status Today

There has been growing interest in phage therapy around the world, yet the interest and related infrastructure is spread and fragmented. After years of decline, the AMR challenge is driving renewed interest in phage therapy.⁸⁵⁴ There are at least 13 countries with established international phage banks,^{855,856} with the oldest countries like Georgia and the UK.⁸⁵⁷

In March 2024, the UK government noted phages as a key medical and scientific priority in the fight against AMR bacteria.⁸⁵⁸ It was integrated in the 2024–2029 UK National Action Plan on AMR, as an area of innovation priority under the focus on evidence-based therapies.⁸⁵⁹ There are currently nine FDA-approved and three European Food Safety Authority (EFSA)-approved uses for phages for companion animals.⁸⁶⁰ In agriculture, EPA-approved AgriPhase achieved up to 88% wilt reduction in tomatoes, targeting pathogens while preserving soil microbiota, demonstrating commercial viability beyond clinical applications.⁸⁶¹

In October 2025, the European Medicines Agency (EMA) released a paper on phage therapy medicinal products (PTMPs), classified as a form of advanced therapy, as part of a 6-month public consultation.⁸⁶² The public consultation aims to unpack the quality and manufacturing requirements for phage products to eventually regulate phage therapies in Europe.⁸⁶³

Today, there are on-going debates about whether or not there should be a global centralised phage bank with the necessary intellectual property laws and funding needed to maintain them.⁸⁶⁴ It is also interesting to note two key technological drivers that have created increased interest in this century-old approach to treating bacterial infections: CRISPR and AI. A cocktail of four bacteriophages were engineered with CRISPR-Cas to eliminate *E. coli* in experimental settings.⁸⁶⁵ As a precision antibiotic, the aim was for the cocktail to target the pathogen without harming the gut microbiome.⁸⁶⁶ It was found to be effective against 89% of two key strains while preserving good gut bacteria.⁸⁶⁷

Some early successes using AI include being able to reduce the time needed to match a phage to a patient's specific bacterial infection.⁸⁶⁸ In addition, the AI model AlphaFold2-Multimer was used to screen 30 million phage genes, achieving a 50% success rate in identifying proteins that inhibit bacterial immune systems,⁸⁶⁹ and AI software DeepLysin, developed by researchers at Huazhong Agricultural University in China, predicted that lysin genes identified by AI in seven of 17 samples would show immediate effectiveness in destroying bacterial cell walls.⁸⁷⁰ Bacterial identification relies on whole-genome sequencing and databases like GenBank. AI tools now enable rapid pathogen profiling from patient samples, while phage-host prediction algorithms match sequenced bacteria to appropriate phages from biobanks within hours rather than weeks.



There are currently at least
13 countries
with established
international
phage banks

In agriculture,

88%

EPA-approved
AgriPhase achieved wilt
reduction in tomatoes



30 million

phage genes screened
by AlphaFold2-Multimer
achieving a

50%

success rate in identifying
proteins that inhibit bacterial
immune systems



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Metadata

Global phage banks share metadata on phages, under a formal cooperation agreement, supported by a global sandbox or regulations.

- Combination Grants
- Accelerator Programmes
- Grants

Pilots

Trials using AI and CRISPR-augmented phages are run in various clinical settings in joint research agreements between jurisdictions, research institutions, public health authorities and/or climate and environmental authorities.

- Grants
- Stage-gate Grants
- Challenge Prizes
- Accelerator Programmes
- Venture Equity

Biorepositories

Regulatory frameworks are harmonised across jurisdictions, based on pilot outcomes and sandbox recommendations. Regional biobanks establish shared protocols and open-access standards. Modular phage production-as-a-service (PaaS) platforms emerge to support clinical and agricultural applications.

- Early-stage capital with multiple funding partners
- Service Contracts



2 2025

Preferable Future Global Bacterial Databank

A universal databank enables precision phage therapies, biomanufacturing and rapid AMR response. Networks of accessible biotech facilities support global deployment.

- Social Impact Bonds (sibs)
- Service Contract
- Loans
- Scaling Funds

What Progress looks Like

A patient with an infection has the offending bacteria rapidly identified and matched via AI to the most effective phage treatment from a global databank. Treatment is designed, produced and administered within 48 hours, curing them in days. Farmers use precision phages instead of antibiotics, eliminating AMR risks in agriculture. Healthcare systems confidently treat once-untreatable infections. The fear of superbugs disappears as treatments become adaptable, precise and globally accessible.



NECESSARY ENABLERS

- Standardised clinical trial protocols for phage therapies
- AI and CRISPR integration with bacteriophage-host mapping
- Intergovernmental agreements on data sharing and ethics frameworks
- IP model adaptive – subject to context and conditions – to phage therapy as a public good
- Sustainable funding for expanding phage banks
- Research on effects of large-scale population-level use of phage on novel AMR



CHALLENGES

- Fragmented phage data repositories
- Lack of, or inability to develop, clinical-grade phages on site
- Managing the transition and impact on the pharmaceutical industry
- Limited real-time diagnostic and phage development platforms
- Rapid diagnostic platforms for bacterial strain identification



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





13 2025

What if ultrasound eliminated microplastics from oceans and lakes?

Sonic Sweep

A chemical-free and scalable solution, ultrasonic waves remove microplastics from water, creating cleaner oceans and safer drinking water globally.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Evolving Ecosystems

Uncertainties

Technology, Nature

Trends

Cross-sectoral Partnerships
Food–Water–Energy Nexus
Mobilising Innovation
New Materials
Sustainable Waste Management

Technologies

ClimateTech
Sensor Technologies

Category

Nature restored

Top Five Sectors

Agriculture & Food
Chemicals & Petrochemicals
Health & Healthcare
Materials & Biotechnology
Utilities

Keywords

Maritime Pollution
Remote Sensing
Ultrasonic
Water Treatment
Waves

Why It Matters Today

Globally, plastic production and waste doubled between 2000 and 2019.⁸⁷¹ They are forecast to more than double by 2040⁸⁷² and triple by 2060.⁸⁷³ Microplastics have been detected in over 1,300 species – including humans – and have been linked to immune system disturbances, inflammation and vascular diseases.⁸⁷⁴ Although measurement is a challenge, it is estimated that humans ingest up to 52,000 microplastic particles per year, and when combined with inhalation, up to 121,000.⁸⁷⁵ The problem is that plastics cannot be destroyed, only broken down, meaning that everyone is exposed to them in some form – big, small or micro – most of the time.⁸⁷⁶



Benefits

Environmentally friendly solution to water contamination by microplastics; cleaner water; reduced use of chemicals; improved public health.



Risks

Energy-intensive implementation; limited impact; scalability challenges; high costs due to subsequent waste removal.



Status Today

Ultrasound, or ultrasonic waves, is a high-frequency, inaudible (to humans) sound that has an effect on materials; its field of study is called sonochemistry.⁸⁷⁷ The idea that ultrasound could be a water purification solution is not new. It has been explored to kill or break up bacteria and help control algae, with success rates dependent on frequency of use, exposure time and volume.⁸⁷⁸

Acousweep, developed by HKRITA with support from the H&M Foundation, uses high-frequency sound waves to remove microplastics from wastewater without chemicals. As wastewater passes through a special shaped chamber, sound waves trap and separate the microplastics into a collection tank for treatment.⁸⁷⁹ Current lab-scale systems process approximately 20 litres per hour, with plans to reach 5,000 to 10,000 litres hourly.⁸⁸⁰

Fixed webcam systems and drone-based survey systems are used in routine monitoring programmes but are usually project based rather than mass-market products.⁸⁸¹ Satellite monitoring – for example, in NASA’s PACE mission⁸⁸² – can detect dense surface accumulations of macro- and microplastics. However, plastic-detection algorithms are currently experimental and no global, standardised, automated service is commercially available.⁸⁸³ While AI models perform well (removing up to 90% of microplastics) in controlled settings, they are context specific; furthermore, high costs and the lack of standard datasets currently prevent commercial scaling of consumer-ready products.⁸⁸⁴ Ultrasound can effectively treat concentrated sources (e.g. industrial waste) but cannot economically address ocean-scale dispersion.⁸⁸⁵ In essence, the lack of policy around monitoring microplastic levels means the market is small, giving vendors very little incentive to commercialise end-to-end systems.⁸⁸⁶

Health concerns are also relevant, as studies have linked higher intensities or prolonged exposure to ultrasound to cellular damage, tissue injury, headaches, fatigue, high-frequency hearing loss and other outcomes.⁸⁸⁷ There is no globally harmonised regulation of airborne or contact ultrasound exposure.⁸⁸⁸



Current lab-scale systems process **approximately 20 litres per hour**, with plans to reach

5,000 to 10,000 litres hourly



90%
of microplastics
detected in controlled settings

Ultrasound effectively treats concentrated sources (e.g. industrial waste) but cannot economically address ocean-scale dispersion.





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Technical Demonstrations

Researchers validate the use of ultrasound to collect and capture microplastics at wastewater outlets, establish standard metrics, pilot maintenance models, and publish open data proving safe reduction of the net amount of microplastics in water flows.

- Challenge Prizes
- Accelerator Programs
- Grants
- Stage-gate Grants

Industrial Scaling

Governments procure pilot systems, scale fixed installations and test modular capture systems. They also certify designs, enable maintenance hubs, and embed monitoring standards and metrics to validate sustained reductions across diverse water systems.

- Combination Grants
- Service Contracts
- Early-stage capital with multiple funding partners
- Accelerator Programmes

Expansion

Monitoring systems autonomously map pollution hotspots and guide deployment of modular systems while continuously improving ultrasonic capture performance worldwide.

- Scaling Funds
- Venture Equity Investment
- Service Contracts
- Loans



13 2025

Preferable Future Global Scaling

Ultrasonic collect and capture functions as standard infrastructure across water and maritime systems, delivering chemical-free oceans and safer drinking water by permanently preventing microplastic pollution globally.

- Equity Investment
- Loans
- Service Contracts



What Progress looks Like

Ultrasonic wave generators operate at wastewater and industrial discharge points, separating microplastics from flowing water without chemicals. Particles move into collection zones for removal. Combined with reduced plastic use, these measures cause ocean microplastic levels to return to the ecological baseline, supporting healthy marine ecosystems and widespread access to safe drinking water.



NECESSARY ENABLERS

- Ability to repurpose the existing wastewater and industrial waste streams
- Standardised sensing and measurement of the flow of microplastics
- Sustainable collection, disposal and recycling pathways for captured plastics
- Coordinated governance, financing and partnerships enabling scalable deployment
- Alternative biomaterials to support the switch from plastics



CHALLENGES

- Inability for ultrasonic operation capacity to meet demand
- Difficulties scaling from pilots to systems that can handle industrial water volumes
- Costly handling and processing of concentrated microplastic waste
- Limited effectiveness beyond controlled discharge points



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





42 2025

What if we knew exactly how much water we use and could we predict future water needs and shortages?

Better Water Meter

Industrial Internet of Things (IIoT) and satellite data form an automated and comprehensive water accounting system that provides insights into water usage and flows and a better understanding of how much water we really need to support more informed decisions on global water policies and conservation efforts.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Boundless Multidimensional Data

Uncertainties

Technology, Collaboration

Trends

ESG & Beyond GDP
Food–Water–Energy Nexus
Government Agility
International Collaboration
Open Data

Technologies

Artificial Intelligence
Internet of Things (IoT)
Real-Time Analytics

Category

Transformational

Top Five Sectors

Agriculture & Food
Energy, Oil & Gas, & Renewables
Manufacturing
Metals & Mining
Utilities

Keywords

Droughts
Green Water
Satellite Water Monitoring
Water Accounting
Water Scarcity



Why It Matters Today

Approximately 2.1 billion people lack access to safe drinking water,⁸⁸⁹ and by 2030 freshwater demand is expected to exceed supply by 40%.⁸⁹⁰ By 2050, this shortage could reduce gross domestic product (GDP) by 8% in high-income countries and between 10% and 15% in low-income countries.⁸⁹¹ Water shortages also threaten food security, putting half of global food production at risk.⁸⁹² Current water accounting practices are fragmented: they lack integration into decision-making, often rely on one-off assessments, and besides the lack good-quality data, they do not capture green water (soil moisture) as effectively as blue water (surface and groundwater) sources.⁸⁹³



Benefits

Improved water accounting; forecasting droughts and floods; access to data that support scalable water management solutions; foundation for international cooperation and data sharing agreements.



Risks

Extensive resource requirements; data and system interoperability; complex sensor networks; cybersecurity and potential misuse; data manipulation; incorrect predictions.

2.1 billion

do not have access to safe drinking water.



By 2030, global water demand is expected to exceed supply by

40%



Water shortages

also threaten food security, putting half of global food production at risk



Status Today

Further improvements in technology and data collection, quality and comparability are necessary. In some cases, data do not exist, while in others, data exist at various scales but lack coordination, with insufficient funding and a reluctance to share data publicly.⁸⁹⁴ This masks the true scale of water-related economic risks, which are estimated to be 7% to 9% of global GDP.⁸⁹⁵

Green water (soil moisture and evapotranspiration) monitoring remains overlooked.⁸⁹⁶ For example, soil moisture data are limited to 220 moisture stations from just two countries (Spain and the United States) in the World Meteorological Organization database.⁸⁹⁷ This increases the reliance on model estimations that incorporate data from, among other sources, the Gravity Recovery and Climate Experiment (GRACE),⁸⁹⁸ a satellite mission that measured changes in Earth's gravity field to monitor changes in terrestrial water storage.⁸⁹⁹ GRACE data are already integrated with ground station information and hydrological models but integration with IIoT sensors is limited.

Policy drivers reinforce this need. The European Union's (EU) 2024 Nature Restoration Regulation, which came into effect in August 2024, requires, among other things, the restoration of 25,000 km of rivers,⁹⁰⁰ the monitoring of which needs more widespread and robust implementation of the IIoT. The Water Framework Directive across the 27 countries in the EU was commissioned in 2022, calling for coordination, interoperable data, and public access to the status of water bodies.⁹⁰¹

The Global Water Monitor Consortium, involving 13 research organisations from 8 countries⁹⁰² and combining satellite and ground precipitation, soil moisture, river flow, and lake-level data, has called on financial institutions to integrate water-related risks into financial stability frameworks.⁹⁰³

Agricultural irrigation accounts for around 70% of all global water use, but water management risks extend beyond agriculture across multiple sectors.⁹⁰⁴ Recently, the Baku Dialogue on Water for Climate Action launched the first water-focused political declaration, which was subsequently adopted at the United Nations Climate Change Conference in Baku, Azerbaijan (COP29) building toward the 2026 UN Water Conference taking place in the UAE in December 2026.⁹⁰⁵

Water-related economic risks are estimated at
7–9%
of global GDP



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Testing and Coordination

Deploy prototype soil moisture sensors across agricultural contexts with the greatest impact on water. Establish regional data sharing protocols to address coordination gaps.

- Challenge Prizes
- Matched Crowdfunding
- Stage-gate grants
- Grants
- Accelerator Programmes

Integration

Install IIoT sensor networks connecting ground stations with satellite hydrological models for comprehensive blue and green water monitoring. Synchronise real-time monitoring systems across industrial water users.

- Combination Grants
- Service Contracts
- Accelerator Programmes
- Early-stage capital with multiple funding partners

Economic and Legal Integration

Embed water-risk metrics into global supply chains and trade agreements. Launch pricing mechanisms penalising unsustainable extraction. Achieve widespread adoption of standardised water accounting frameworks across major economies.

- Scaling Funds
- Loans
- Service Contracts
- Venture Equity Investment



42 2025

Preferable Future Governance

Implement real-time water accounting systems, enforcing precise usage limits. Deploy predictive conservation mandates through automated frameworks. Establish international treaties with interoperable data standards governing water allocation and compliance worldwide.

- Loans
- Equity Investment
- Services Contracts

What Progress looks Like

A global platform monitors green, blue and grey (household water) water footprints in real time. Satellites track soil moisture while IIoT sensors monitor underground aquifers and industrial usage. Advanced machine intelligence predicts droughts before they occur, allowing local communities to adjust consumption proactively. Water accounting becomes transparent, enabling a true understanding of the water required for the global food trade.



NECESSARY ENABLERS

- IIoT sensor networks that track groundwater and consumption
- Satellite monitoring of precipitation, soil moisture, and water cycles
- Advanced machine intelligence for predictive analytics
- Protocols enabling interoperable global data standards
- Legal and regulatory cross-border collaboration frameworks



CHALLENGES

- Data sovereignty and privacy concerns
- High deployment costs in low-income, water-stressed regions
- Cybersecurity vulnerabilities
- Interoperability challenges standardising diverse monitoring system data



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





43 2025

What if next-generation geothermal energy enabled universal energy access?

Next-Gen Geothermal

Innovative approaches to geothermal energy combined with advanced machine intelligence and materials make geothermal energy accessible, cost-effective and less dependent on location, promoting a sustainable source of renewable energy.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Pushing the Boundaries on Energy

Uncertainties

Technology, Nature

Trends

Cross-sectoral Partnerships

Net Zero

New Materials

Repurposing Assets

Transforming Energy

Technologies

Artificial Intelligence

New Materials

Real-Time Analytics

Category

Transformational

Top Five Sectors

Data science, AI & Machine Learning

Energy, Oil & Gas, & Renewables

Financial Services & Investment

Infrastructure & Construction

Utilities

Keywords

Carbon-Free

Enhanced Geothermal Systems

Geothermal Cost Parity

Lithium Extraction

Renewable Energy



Why It Matters Today

Geothermal is potentially one of the most reliable renewable energy source,⁹⁰⁶ yet it accounts for approximately 1% of global electricity.⁹⁰⁷ As global power demand is expected to increase by 33% over the next 10 years⁹⁰⁸ and more than double by 2050,⁹⁰⁹ geothermal power can both meet rising demand and ensure that net-zero goals are met.⁹¹⁰ Repurposing semi-abandoned oil wells for geothermal can reduce carbon emissions by 34% compared with conventional geothermal.⁹¹¹



Benefits

Scalable renewable energy; progress towards the Sustainable Development Goals; valuable by-products



Risks

High implementation costs; failure of materials in high heat conditions; unintended triggering of earthquakes

Geothermal is the most reliable renewable energy source, **yet it accounts for approximately 1% of global electricity**



Status Today

Next-generation geothermal financing reached \$2.2 billion in 2025, an 80% increase year on year from \$22 million in 2018.⁹¹² Conventional geothermal power projects attracted \$5 billion in 2025, four times that of 2018.⁹¹³ While equity financing declined from 70% between 2018 and 2020 to just over 50% between 2023 and 2025, debt-based financing reached nearly 30% while public grants reduced to around 9%.⁹¹⁴ Next-generation geothermal solutions face high upfront financial costs and exploration risks and require government support to scale.⁹¹⁵

Next-generation geothermal technologies can unlock clean, reliable power that is available around the clock, tapping into Earth's heat in places where conventional geothermal has never been possible before.⁹¹⁶ Three main types are now in development: enhanced geothermal systems, closed-loop systems, and super-hot geothermal systems (furthest from commercialisation).⁹¹⁷ Next-generation geothermal has already seen large reductions in costs. For example, Fervo Energy has seen drilling costs reduce from \$1,000 to \$400 per foot.⁹¹⁸ Also, between 2017 and 2022, drilling rates improved by 500% at the Utah site of the US Department of Energy's Frontier Observatory for Research in Geothermal Energy initiative.^{919,920}

Technology companies have been exploring geothermal to manage data centre and computing energy needs, with two major corporate deals demonstrating potential demand: Google–Fervo (115 MW)⁹²¹ and Meta–Sage Geosystems (150 MW starting 2027).⁹²² Fervo's Cape Station – the world's largest next-generation geothermal project – will deliver 100 MW in 2026, expanding to 500 MW by 2028.⁹²³ In December 2025, Fervo completed an (oversubscribed) Series E funding round in which it raised \$462 million.⁹²⁴

Besides energy, geothermal is also being used for lithium extraction in projects such as Vulcan Energy's Lionheart (Germany), which secured \$284.5 million^P Phase One financing from the European Investment Bank in 2025.⁹²⁵ By 2030, this phase of the project is expected to provide approximately 12% of Europe's expected lithium hydroxide demand.⁹²⁶

P Based on the EUR:USD exchange rate of 11 July 2026.



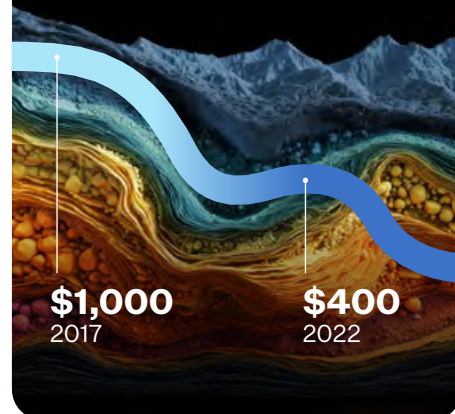
in 2025.

**\$2.2
billion**

**Geothermal
financing reached**

**Drilling
costs fell**

from \$1,000 to \$400 per
foot (2017–2022).





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Pilots and Demonstration

Governments provide grants and guarantees, while investors shift towards debt financing. Public programmes de-risk exploration, next-generation pilots scale to demonstrate commercial viability, drilling performance improves, and early markets emerge across all economies.

- Challenge prizes
- Combination Grants
- Grants
- Stage-gate Grants

Initial Deployment

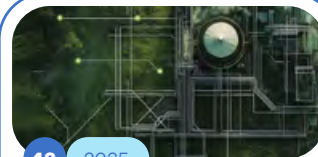
Developers expand commercialisation projects while signing corporate purchase agreements. They apply advanced machine intelligence to reduce drilling costs and improve success rates. They also start to produce lithium (as a by-product), build supply chains, and accelerate global deployment in new regions.

- Combination Grants
- Service Contracts
- Accelerator Programmes
- Early-stage capital with multiple funding partners

Commercialisation

Companies scale geothermal from pilots to commercial deployment, expanding closed-loop systems and achieving cost parity. They standardise drilling operations, mobilise debt financing, and deploy power for industrial and municipal clients.

- Scaling Funds
- Service Contracts
- Venture Equity Investment
- Loans



43 2025

Preferable Future Scaling

Governments mandate geothermal integration while utilities deploy standardised geothermal grid systems globally. Cities provide heat-as-a-service, industries transition to geothermal power, and energy poverty ends through universal access to energy alongside other sources of energy.

- Equity Investment
- Service Contracts
- Loans
- Scaling Funds

What Progress looks Like

Next-generation geothermal delivers clean, continuous power anywhere through advanced drilling techniques and advanced system designs. Costs now rival other renewables per kWh and repurposing oil wells accelerates deployment while mitigating some geographical/geological constraints; for example, the use of oil wells expands geothermal from only a few to many viable locations. This transforms energy from scarcity to abundance, making energy accessible globally, limited only by financing, not geology.



NECESSARY ENABLERS

- Drilling technologies that can unlock deeper, hotter geothermal resources
- Advanced materials that can withstand extreme temperatures
- Drilling insurance to de-risk early exploration phases
- Streamlined permitting processes
- Early-stage funding and government grant schemes



CHALLENGES

- Induced seismicity risks⁹²⁷
- High temperature environments rapidly corrode and degrade equipment
- Grid connection delays



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





11

2022

What if affordable electricity was universal?

Power without Limits

Energy is transported without loss, through advanced superconducting materials, linking populations and industries everywhere.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Materials revolution

Uncertainties

Technology x Nature

Trends

Transforming Energy

New Materials

Technologies

Next-Gen Energy

Sensor Technologies

Category

Societies Empowered

Top Five Sectors

Communication Technologies & Systems

Education

Health & Healthcare

Manufacturing

Utilities

Keywords

AI Energy Demand

Energy Transition

Power Grids

Power Transmission and Distribution

Superconductor materials

Why It Matters Today

Around 655 million people still lack access to electricity.⁹²⁸ While this means that around 92%⁹²⁹ of the world have access to electricity, distribution is uneven. Eighteen of the 20 countries with the greatest lack of access are in sub-Saharan Africa⁹³⁰ and 500 million of those without access live in rural areas worldwide.⁹³¹ Besides access, transmission and distribution losses average 6% worldwide; this is the lowest since 1990⁹³² but there are still operational inefficiencies where more power is generated than needed and higher rates of loss are seen in peak periods, and non-renewable sources continue to have environmental impacts.⁹³³



Benefits

Reduce energy costs, pollution, and infrastructure needs while boosting economic growth in energy-limited regions globally.



Risks

Wider distribution of power systems is vulnerable to attacks, monopolisation of related superconducting technologies and intellectual property.



Status Today

Transmission and distribution losses vary by region. The latest numbers (2022) show rates of loss of 24% in sub-Saharan Africa, 16% in the Arab world, 7% in the Gulf Cooperation Council countries, 5% in North America and 3% in China.⁹³⁴ Losses also shift with urban or rural coverage⁹³⁵ and with demand, reaching up to 20% during US peak periods versus 3% during low-load periods.⁹³⁶ Transmission and distribution are critical for the transition to clean and renewable energy and for meeting future AI energy needs that are expected to more than double from 2024 levels by 2030.⁹³⁷

Transmission and distribution mechanisms include transformers, transmission poles predominantly found in rural areas, underground cables predominantly found in urban areas and smart meters,⁹³⁸ which also connect various generation sources like hydropower, solar, space solar⁹³⁹ or wind. However, there are bottlenecks: while 1.5 million kilometres of new transmission lines were built over the last decade,⁹⁴⁰ 80 million kilometres will be needed by 2040 to meet climate commitments, which is nearly twice the size of existing grids.⁹⁴¹ Building new transmission and distribution networks takes five to fifteen years, compared to one to five years to build wind or solar projects,⁹⁴² and in Europe, some projects have to wait nine years to receive grid connection permits.⁹⁴³

From a materials perspective, annual metal use for transmission and distribution is expected to grow by around 50% between 2022 and 2030, with copper demand reaching nearly 20% of total global copper production by 2030.⁹⁴⁴ Five countries (China, Japan, Korea, Russia and the United States) control 85% of global electrical steel production⁹⁴⁵ and, since 2019, cable prices have doubled and transformer prices increased by 75%.⁹⁴⁶

Innovation in superconductors, nanomaterials and advanced insulation are critical. Bismuth-based superconductors, carbon nanotubes and graphene show promise but are not cost-effective yet.⁹⁴⁷ Penn State University is screening a database of 5 million materials to identify room-temperature superconductor candidates using a new unified theory that combines three different theories, including quantum mechanics.⁹⁴⁸

Transmission losses

Sub-Saharan Africa	24%
Arab world	16%
Gulf countries	7%
North America	5%
China	3%

1.5 million km

of **new transmission lines** were built in the last decade.





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Materials Discovery

A global consortium is established to prioritise areas for developing stable, scalable superconducting materials that operate at (near-)ambient temperatures (reducing the cooling cost barrier).

- 🏆 Challenge Prizes
- 🚀 Accelerator Programs
- 💰 Grants
- 📊 Stage-gate Grants

Prototype and Partnerships

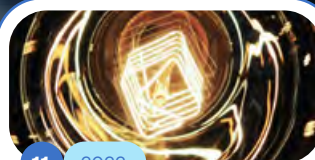
Prototypes are tested to find cost-effective ways to fit superconducting materials in existing and new grids.

- 📄 Combination Grants
- 🚀 Accelerator Programmes
- 📊 Stage-gate Grants

Pilot and Regional Integration

Superconducting cables are deployed in high-loss regions (eg, sub-Saharan Africa) and high-demand zones (eg, powering AI data centres).

- 📄 Social Impact Bonds (SIBs)
- 📄 Service Contract
- 📄 Loans
- 👤 Early-stage capital and multiple funding partners
- 📄 Equity Investment
- 📄 Convertible Grants



11

2022

Preferable Future Grid Integration and Universal Access

Grids are built or retrofitted with superconducting materials, supported by AI-driven load balancing to monitor and manage distribution, enabling global electrification.

- 📄 Social Impact Bonds (SIBs)
- 📄 Service Contract
- 📄 Equity Investment
- 📊 Scaling Funds
- 📄 Loans



What Progress looks Like

Energy can be reliably accessed anywhere in the world, enabling education and health development goals. With optimised energy grids, transmission losses run at 6% (see *why it matters today*) or near zero everywhere, potentially creating excess power without the need to build new power plants. Rural areas access electricity without overhead power lines and cities no longer need high-voltage substations. Renewable energy hubs are seamlessly integrated into grids and across borders, if and when needed.



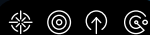
NECESSARY ENABLERS

- Discovery of new cost-effective (or room-temperature) superconductor materials
- Streamlining governance for grid connection permits and procedures
- Standards for grid interoperability
- Effective models for partnerships and energy sharing



CHALLENGES

- Increased cyber-physical security vulnerabilities
- Infrastructure costs in replacing existing lines
- The risk of limited access to critical materials IP, concentrated among a few players



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





PILLAR

4

Partnerships

Opportunities that capture value by establishing effective cross-sectoral alliances, ecosystems and/or strategies to align interests and implement solutions at scale.

Insights^Q that emerge from the opportunities within this pillar

1

Value capture through partnerships is predominantly within reach

Among the opportunities in this pillar, 85% are considered either within reach or transitional, with a nearly equal split between these two categories. Across all five pillars, this one stands out as the most ready for action, with many of the key enablers already in place.

2

More than half of these opportunities depend on global collaboration and shared values

The extent to which governance and international collaboration will advance is a key uncertainty, as is the extent to which global communities will converge on a shared understanding of the meaning of 'quality of life'. Both factors will influence how well value is captured through partnerships.

3

A focus on people and planet is central

More than half of these opportunities focus on people and planet, whether driven by the Future Humanity (40%) or Evolving Ecosystems (15%) megatrends.

Q These insights are deduced from the 200 opportunities that were published in the previous editions of The Global 50. They are for informational, educational and guidance purposes and are non-exhaustive. Because these insights are based on opportunities, they may be generalisable to certain contexts but not others.



Most Significant Megatrend

Uncertainty

Trend

Technology

20 2022 Transitional

A Medical Library for Planet Earth

What if health data went macro?

Boundless Multidimensional Data

Collaboration

Technology

Advanced Computing

Open Data

Data Protection & Privacy

Artificial Intelligence

Advanced Computing

Data Protection & Privacy

19 2023 Transitional

The Ultimate Climate Calculator

What if we built a digital climate catalogue?

Saving Ecosystems

Technology

Nature

International Collaboration

Open Data

Food–Water–Energy Nexus

Net Zero

ESG & Beyond GDP

Sensor Technologies

Artificial Intelligence

Internet of Things (IoT)

21 2023 Transitional

Crossing the Divide

What if no one was left behind in the transition to digital realities?

Digital Realities

Technology

Values

Cross-sectoral Partnerships

Digital Economy

Future of Purpose & Work

Transforming Education

Human–Machine Interaction

Digital Realities

Advanced Connectivity

Immersive Technologies & Wearables

50 2024 Transitional

The Network of Networks

What if we had a global, seamless internet?

Borderless world Fluid Economies

Collaboration

Technology

Government Agility

Open Data

Future of Space

Digital Economy

International Collaboration

SpaceTech

Artificial Intelligence

Advanced Connectivity

28 2025 Transitional

A Catalyst for Common Good

What if a global equity fund unlocked solutions to the biggest uncertainties we face?

Future Humanity

Collaboration

Systems

Cross-sectoral Partnerships

Tokenisation

International Collaboration

Mobilising Innovation

Food–Water–Energy Nexus

Predictive Analytics

Decentralised Autonomous Organisation (DAO)

Distributed Ledger Technologies (DLTs)



20 2022

What if health data
went macro?

A Medical Library for Planet Earth

Medical data goes global through the sharing of datasets combined with advanced computational power.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Boundless Multidimensional Data

Uncertainties

Collaboration, Technology

Trends

Open data
Advanced computing
Data protection & privacy

Technologies

Advanced Computing
Artificial Intelligence
Data Protection & Privacy

Category

Health reimagined

Top Five Sectors

Agriculture & food
Data science, AI & Machine Learning
Health & Healthcare
Education
Materials & biotechnology

Keywords

Personalised medicine
Precision medicine
Bioinformatics
Biomarkers
Internet of things (IoT)

Why It Matters Today

The availability of healthcare data will continue to grow due to advances in technologies, including artificial intelligence (AI), analytics and electronic health records, genomics and wearables.⁹⁴⁹ Today, a single patient can generate 6 terabytes of biomedical data (clinical and genomic) across a lifetime,⁹⁵⁰ and by the early 2030s, data from the healthcare industry is expected to cover 30% of global data generated.⁹⁵¹ Unlocking healthcare data across borders will usher in a new era of innovation, not only in the health sector but also in sectors that can extend learning from this data. Only 3% of data produced by hospitals globally is effectively used⁹⁵² and often is key during crises and emergencies.



Benefits

Modelling for clinical trials based on vast user-generated datasets, speeding up drug development, enabling better health outcomes and improving real time monitoring for infectious disease outbreaks.



Risks

Attacks that deliberately corrupt datasets. Loss of individual control over personal health data.



Status Today

Several global health institutions host and populate large-scale (global or multi-country) population-health datasets. The World Health Organization (WHO), for example, hosts the Health Inequality Data Repository (HIDR) in order to provide disaggregated health data across many countries and populations. The HIDR includes approximately 2,000 indicators, grouped across 22 dimensions of inequality – including age, gender, socioeconomic status and geography – and covers a wide range of health domains, such as maternal/child health, immunisation, non-communicable diseases and environmental health.⁹⁵³ Through its broader data platform, Global Health Estimates, WHO provides cross-country comparable data on mortality, disease burden and health system indicators.⁹⁵⁴

Similarly, with data going back to 1980 allowing for comparative insights across countries and regions, the on-going Global Burden of Disease (GBD) study (carried out by the Institute for Health Metrics and Evaluation) provides estimates of 463 different health metrics, including disease burden, mortality and risk factors, across 204 countries and territories worldwide.⁹⁵⁵

Nevertheless, gaps in global health-data sharing persist. While global datasets like GBD produce standardised estimates across many of the countries, not all countries have equally high-quality primary data.⁹⁵⁶

In addition, a lot of data available in the health sector is not utilised or benefitted from because of fragmented legal bases, regulatory frameworks that span jurisdictions, inconsistent definitions of key terms,⁹⁵⁷ or lack of interoperability between digital systems.⁹⁵⁸ For example, in 2021, 62% of hospitals in the US were engaged in all four interoperability domains, sending, receiving, querying and integrating data across systems, and 72% reported challenges exchanging data across different vendor platforms. Rural and small hospitals tend to lag behind, 57% have difficulty matching patients across systems and 43% pay additional costs to exchange with organisations outside their system.⁹⁵⁹ In the growing AI race, the barriers to cross-border data flows are set to increase.⁹⁶⁰

**2,000
indicators**



in WHO's Health Inequality
Data Repository

Interoperability & System Barriers

62%

of US hospitals engaged in all
4 interoperability domains

72%

face cross-vendor data
exchange challenges

57%

struggle with patient
matching

43%

pay extra to exchange data
externally



While global datasets like GBD produce standardised estimates across many of the countries, **not all countries have equally high-quality primary data**





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Alignment

A coalition of key stakeholders sets out shared principles for health-data sharing, including its use in training AI models, taking into account documented barriers around interoperability, conflicting laws and accessibility.



Grants

Piloting

Pilot programmes are launched across diverse global settings, using shared standards and definitions, to test technical solutions and platforms. Conflicting health data laws begin to be aligned.



Combination Grants



Accelerator Programmes



Service Contracts



Convertible Grants

Aligned Health Platforms

Countries have shared frameworks on health data sharing, standards and interoperability protocols, aligning existing datasets into scalable platforms.



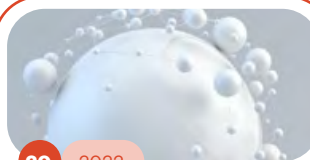
Social Impact Bonds (SIB)



Early-stage capital and multiple funding partners



Loans



20 2022

Preferable Future Global Health Data Platform

Cross-border health data is shared seamlessly through secure, interoperable systems. AI analyses global datasets while protecting privacy, enabling better treatments for everyone everywhere.



Equity Investment



Loans



Service Contracts

What Progress looks Like

Scientists, doctors and policymakers have access to global health data, helping them understand how various dimensions impact health factors and build better treatment therapies and medicines as a result. AI models that are focused on health have access to the same data, increasing the chances that better models come through. Opening up health data has not reduced competitive advantage as competition is now based on better innovation.



NECESSARY ENABLERS

- Cross-border data-sharing agreements
- Effective IoT and wearable device availability
- Legal protections, governance and trust
- Protocols for data privacy and cybersecurity



CHALLENGES

- Cybersecurity
- Energy and data centre needs
- Vendor and underlying system interoperability



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





19 2023

What if there was
a digital climate catalogue?

The Ultimate Climate Calculator

Going beyond the carbon footprint, a digital climate catalogue allows governments, businesses and even individuals to calculate their environmental impact in real time. Fully automated, this valuation system reveals the likely impacts of potential policy and investment choices.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Evolving ecosystems

Uncertainties

Technology, Nature

Trends

ESG & Beyond GDP
Food–Water–Energy Nexus
International Collaboration
Net Zero
Open Data

Technologies

Artificial Intelligence
Internet of Things (IoT)
Sensor Technologies

Category

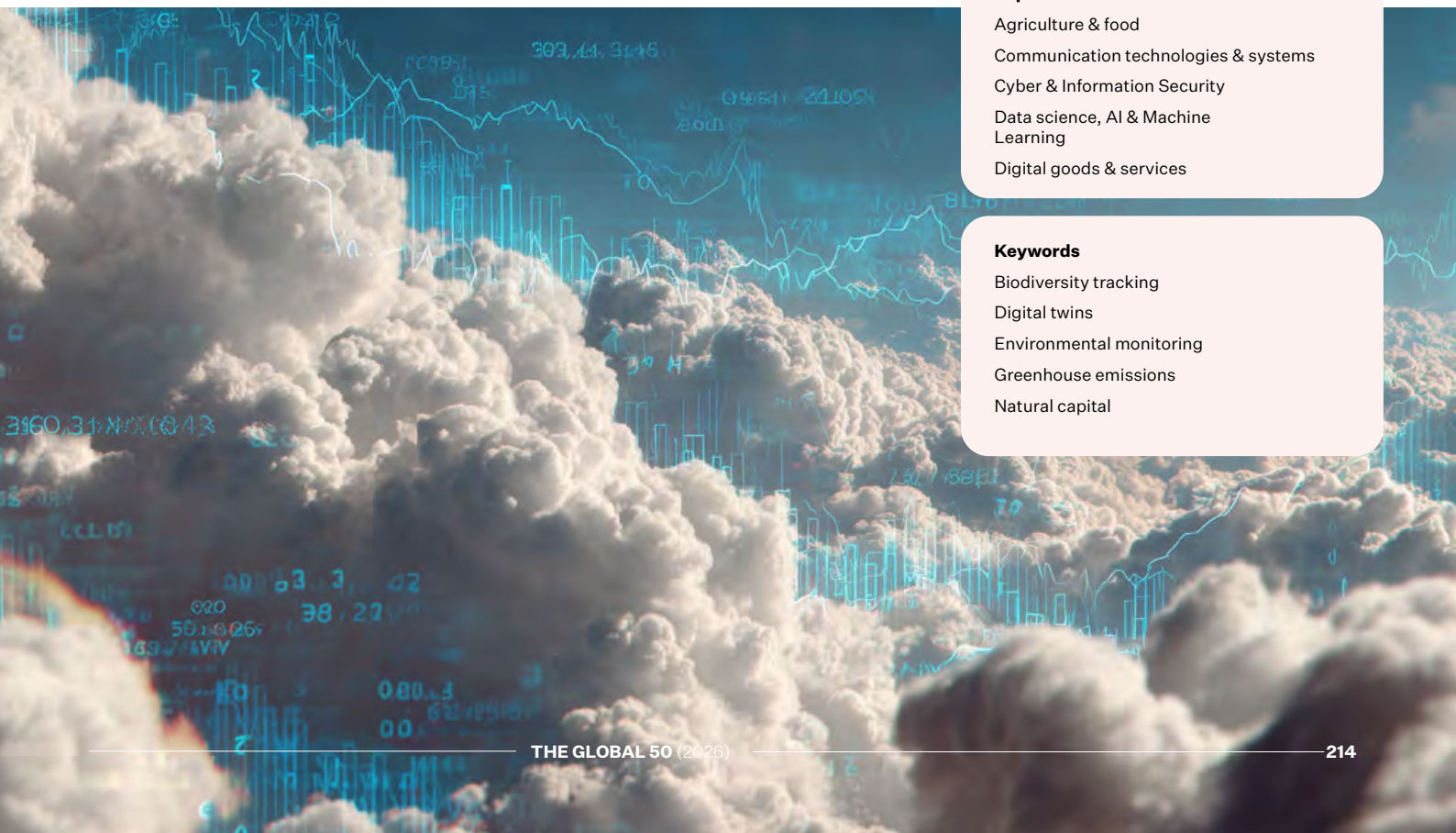
Collaboration Advanced

Top Five Sectors

Agriculture & food
Communication technologies & systems
Cyber & Information Security
Data science, AI & Machine Learning
Digital goods & services

Keywords

Biodiversity tracking
Digital twins
Environmental monitoring
Greenhouse emissions
Natural capital





Why It Matters Today

The negative impacts of climate inaction comes from exposure to extreme heat, water/food crises and disease spread. Between 2012 and 2021, extreme heat caused the death of just over half a million people, or one person every minute.⁹⁶¹ In 2024, extreme weather caused at least 16,000 deaths and affected 166 million people.⁹⁶² For one type of mosquito for example, climate change has made conditions more than 50% favourable for spreading dengue compared to the 1950s,⁹⁶³ with over 14.6 million cases reported in 2024 compared to over half a million in 2000.⁹⁶⁴ Water scarcity affects 2.7 billion people for at least one month per year, while 1.1 billion lack water access entirely.⁹⁶⁵



Benefits

Possibility to compare measurements through a common metric and model(s) available to all. Potential to reveal new sources of value and revenue streams.



Risks

Undervaluation or overvaluation of certain forms of capital in relation to climate impact. Incorrect picture of progress through distorted metrics.



Europe is warming up at

**twice the
global rate**



over **80% of its habitats**
are damaged



and **60 to 70% of
soils** degraded.

Status Today

Digital twin technology has been advancing through AI, real-time data and autonomous sensing technologies.⁹⁶⁶ However, the landscape still faces challenges in implementation: knowledge gaps in ecological relationships and variables, insufficient investment and the need to adopt FAIR data principles⁹⁶⁷ (findable, accessible, interoperable and reusable⁹⁶⁸) for effective environmental monitoring.

Enabling digital twins, the IoT landscape has significantly improved from a security perspective since the early design in 2017.⁹⁶⁹ The number of connected IoT devices reached 18.5 billion in 2024, projected to grow to 21.1 billion in 2025 and 39 billion by 2030, with Wi-Fi, Bluetooth and cellular making up 80% of all connections.⁹⁷⁰ This makes reliable connectivity both an enabler and a vulnerability.

While environmental accounting was integrated into the National System of Accounts' new guidance published in 2025,⁹⁷¹ the global regulatory landscape regarding environmental accounting and monitoring is diverging. The EU pursues deregulation, even though Europe is warming up at twice the global rate, and over 80% of its habitats are damaged and 60 to 70% of soils degraded.⁹⁷² The US EPA announced 31 deregulatory actions in March 2025⁹⁷³ and the US withdrew from the Paris Agreement, giving priority to the economy.⁹⁷⁴

The number of **connected
IoT devices** reached
18.5 billion in 2024
projected to grow to
21.1 billion in 2025
and
39 billion by 2030





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Foundation Building

Prototype sensing technologies continue to be built, underpinned by partnerships, protocols and seed funding. Responsibility for monitoring and responding to flags is assigned to an existing or newly established policy coordination body.

- Accelerator Programs
- Challenge Prizes
- Combination Grants
- Grants
- Matched Crowdfunding
- Stage-gate Grants

Technology Development

Regional pilots are launched to test and validate advanced sensing technologies and predictive models.

- Accelerator Programs
- Combination Grants
- Matched Crowdfunding
- Stage-gate Grants
- Service Contracts

System Integration

The IoT sensor networks that feed predictive environmental models are integrated, and infrastructure is scaled up.

- Convertible Grants
- Early-stage capital and multiple funding partners
- Equity Investment
- Loans
- Revenue-dependent Grants
- Scaling Funds



19 2023

Preferable Future Digital Climate Catalogue

The operational system supporting the climate digital dialogue is being maintained, governed and developed, alongside continued expansion of IoT sensor networks.

- Loans
- Scaling Funds
- Service Contracts
- Equity Investment

What Progress looks Like

Early warning systems for resource threats are deployed worldwide; greater data visibility drives community awareness and immediate action across many levels. Leading indicators and proxies for water, food and heat risks are monitored in real time so evidence-based environmental policies can adapt to changing conditions.



NECESSARY ENABLERS

- Reliable sensors that can pick up data in a consistent and accurate manner
- Remote-area sensing capabilities, including effective connectivity and energy supply
- Energy-efficient data analysis that counteracts AI-related energy consumption where possible
- Accurate, validated predictive models with global consensus



CHALLENGES

- Data privacy concerns and cybersecurity
- Over-emphasis on data collection rather than holistic action; measurement bias
- Unequal and geographic gaps in digital access and coverage
- Lack of interoperable and unified global climate data standards
- High maintenance costs for distributed sensor networks and digital infrastructure



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





21 2023

What if no one was left behind in the transition to digital realities?

Crossing the Divide

A global task force adopts a 'nexus' approach (access to wearables and devices, access to the internet, and digital literacy) to ensure that every person on Earth is included in the transition to digital realities.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Digital realities

Uncertainties

Technology, Values

Trends

Cross-sectoral Partnerships
Digital Economy
Future of Purpose & Work
Human-Machine Interaction
Transforming Education

Technologies

Advanced Connectivity
Digital Realities
Immersive Technologies & Wearables

Category

Collaboration advanced

Top Five Sectors

Communication technologies & systems
Cyber & Information Security
Digital goods & services
Education
Immersive technologies

Keywords

Connectivity
Digital divide
Digital literacy
Gig economy
Immersive technologies

Why It Matters Today

Globally, 2.2 billion people (26.6%) remained offline in 2026.⁹⁷⁵ The World Economic Forum's survey of global employers to inform the Future of Jobs report found that by 2030, 59% of employees will need to reskill and 11% are unlikely to receive the reskilling they need.⁹⁷⁶ Meanwhile, the same survey found that 63% of global employers consider skills gaps in labour markets to be the top barrier to business transformation and 50% see these gaps as the top barrier to the adoption of artificial intelligence (AI).⁹⁷⁷ Shipments of augmented- and virtual-reality (AR/VR) headsets and smart glasses will grow at a compound annual growth rate (CAGR) of 31.8% annually, reaching 43.1 million units by 2029 compared to 14.3 million in 2025,⁹⁷⁸ risking further digital exclusion for those without access to these technologies. Closing the connectivity gap by 2030 alone could cost the world \$1.6 trillion.⁹⁷⁹



Benefits

No one left behind when digital realities become critical to life, education and work.



Risks

Limited adoption, funding and support.



Status Today

The United Nations' Global Digital Compact (GDC) was adopted in September 2024 at the UN Summit of the Future by 193 member states.⁹⁸⁰ Collectively, the countries that signed up to the framework committed to increasing their data monitoring in relation to the Sustainable Development Goals (SDGs) by 50%, connecting 2.6 billion people to the internet by 2030, setting up an independent scientific panel on AI, connecting all schools and hospitals to the internet, and promoting safe and secure digital spaces with the overarching aim of closing digital divides.⁹⁸¹ A high-level review is planned to take place between July and September 2027⁹⁸² and stakeholder meetings most recently took place on 24 October 2025.⁹⁸³

The World Economic Forum launched the Edison Alliance in 2021. Concerned with digital inclusion, the alliance initially focused on connecting 1 billion people to health, education and financial services by 2025.⁹⁸⁴ With more than 200 partners across public and private sectors globally, it concentrated on underserved populations, particularly those in low-income countries.⁹⁸⁵ In January 2024, out of the 784 million who had been connected, 59% gained access to digital financial services, 18% to digital healthcare services and 12% to online education access, with people accessing multiple services.⁹⁸⁶ In September 2024, the alliance announced that the goal of connecting 1 billion people had been achieved ahead of the 2025 target.⁹⁸⁷

However, the concept of an inclusion divide in digital realities (i.e. AR/VR) has not yet been widely considered. Nevertheless, digital inclusion must precede digital realities inclusion, so these developments represent a positive step forward.

The United Nations' Global Digital Compact (GDC) was adopted in September 2024 at the UN Summit of the Future by



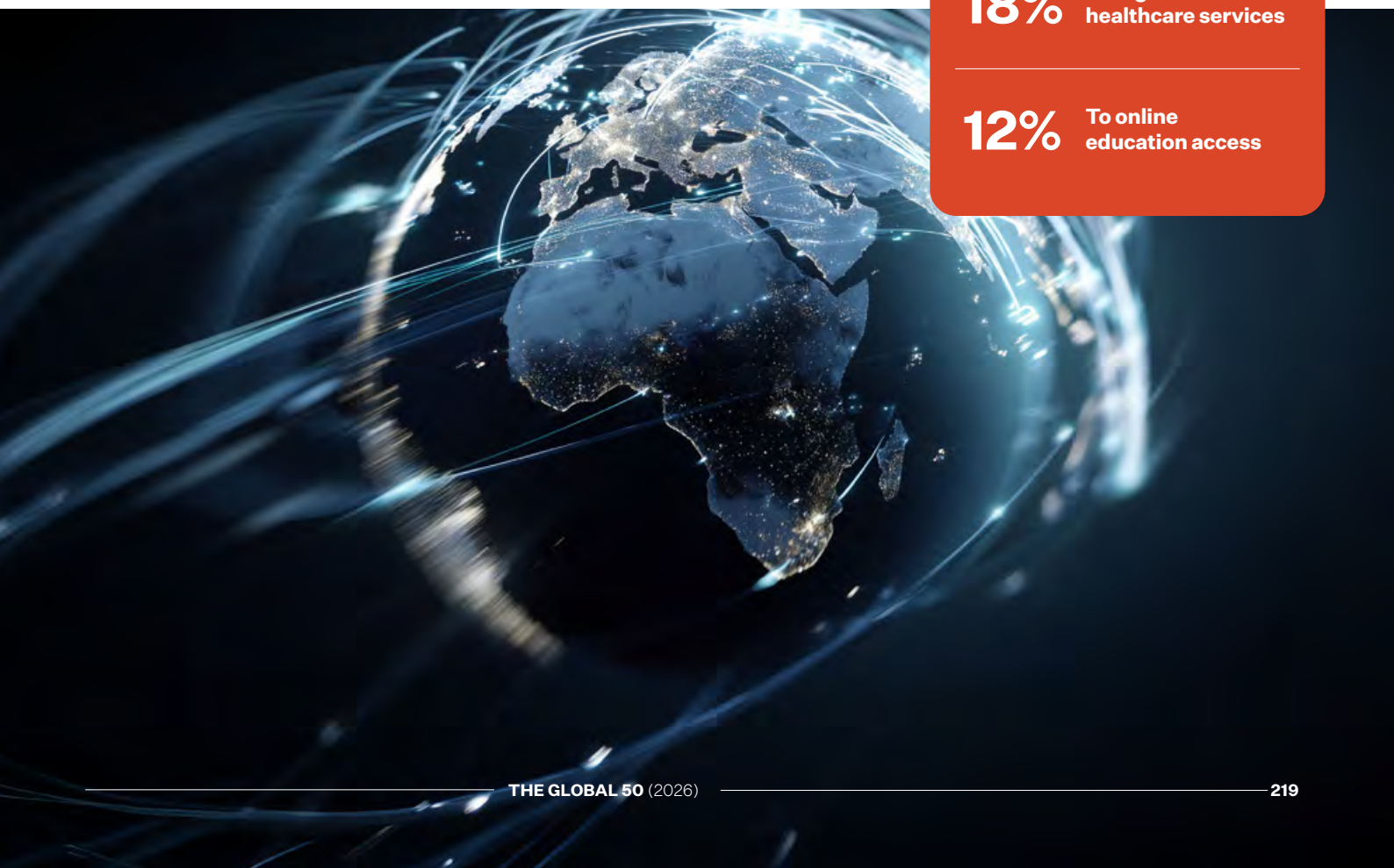
193
Member States

By January 2024, the **EDISON Alliance** had connected **784 million people**

59% To digital financial services

18% To digital healthcare services

12% To online education access





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Task force and Framework Formation

Partners convene to develop the nexus model, establish metrics and secure pilot funding while building consensus on principles and approach.

-  Grants
-  Stage-gate Grants
-  Challenge Prizes

Pilot Implementation

The nexus model is validated in diverse pilot communities, documenting pathways and identifying implementation challenges and success factors.

-  Accelerator Programmes
-  Challenge Prizes
-  Combination Grants
-  Grants
-  Matched Crowdfunding
-  Social Impact Bonds (SIB)

Regional Deployment

Connectivity, devices and literacy programmes are deployed, reaching the majority of populations who are not connected across multiple regions and diverse contexts.

-  Equity Investment
-  Convertible Grants and Loans
-  Loans
-  Revenue-dependent Loans
-  Scaling Funds
-  Service Contracts



21 2023

Preferable Future Full-Scale Deployment

Universal digital reality access is embedded in policies and infrastructure, reaching all populations through coordinated implementation across nations and sectors.

-  Loans
-  Service Contracts
-  Scaling Funds
-  Equity Investment



What Progress looks Like

Every person who wants or needs to access devices, connectivity and immersive environments can do so. Historically underserved regions have access to the internet and to the infrastructure needed to participate in digital realities. Literacy in digital realities becomes a universal baseline, enabling growth in remote employment. Local manufacturing and repair ecosystems emerge and/or grow.



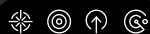
NECESSARY ENABLERS

- Data privacy and cybersecurity
- Immersive technologies and wearable device availability and affordability
- Institutional and market adoption
- Internet access and connectivity
- Provision of strategies for digital literacy and education



CHALLENGES

- Increase in e-waste
- Interoperability across systems
- Multi-stakeholder collaboration
- Necessary regulation for device-as-a-service if affordability is not resolved
- Need for harmonised cross-border governance and regulation



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





50 2024

What if we had a global,
seamless internet?

The Network of Networks

Advances in satellites and advanced machine intelligence enable seamless, global internet access, supporting the internet of things and reducing network disruptions through intelligent transitions between cellular and satellite networks.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Borderless-world fluid economies

Uncertainties

Collaboration, Technology

Trends

Digital Economy
Future of Space
International Collaboration
Government Agility
Open Data

Technologies

Advanced Connectivity
Artificial Intelligence
SpaceTech

Category

Transformational

Top Five Sectors

Art, media, sports & entertainment
Communication technologies & systems
Cyber & Information Security
Data science, AI & Machine Learning
Government Services

Keywords

Direct-to-cell (D2C) or direct-to-device (D2D)
End-of-life disposal of satellites
Internet connectivity
Low-Earth-orbit satellites (LEO)
Seamless networks



Why It Matters Today

Since 2022, 95% of the world's population has access to mobile broadband of 3G or above, but geographic disparities underlie this figure; for example, while 88% of the global population have 4G coverage, only 50% of the population on the African continent have access to 4G.⁹⁸⁸ While satellite internet speeds have, historically, been slow, connection speeds have jumped from 0.08 megabits per second (Mbps) in 1997⁹⁸⁹ to a median of 104 Mbps today, with Starlink nearly doubling its speeds between 2022 and 2025.⁹⁹⁰ Satellite internet continues to gain traction worldwide, with the global satellite industry worth \$293 billion in 2024.⁹⁹¹ SpaceX's Starlink is the world's largest satellite internet provider⁹⁹² with just over 4,500 active Starlink satellites,⁹⁹³ with lifespans of around five years each.⁹⁹⁴

Today

95%

of the world's population has **access to mobile broadband of 3G or above**



Benefits

Universal communications, optimised for sustainability and connectivity. Borderless connectivity, enabling new lifestyle and problem-solving opportunities.



Risks

Expense of implementing and maintaining satellite internet, both hardware and functioning speed. Complexity of allocating costs per user, requiring intricate user charging mechanisms that restrict access and may be monopolised by specific operators.



While 88% of the global population have 4G coverage only

50%

of the population on the **African continent have access to 4G**



Status Today

Satellite internet is a key component of mainstream global telecommunications infrastructure, driven by LEO mega-constellations. Big players include Starlink, which offers the largest active LEO constellation of more than 7,800 satellites for global consumers and enterprise service,⁹⁹⁵ and OneWeb/Eutelsat, which offers full global coverage for enterprise, government, maritime and aviation.⁹⁹⁶ Satellite internet is increasingly integrated through D2D or D2C technologies, making seamless connectivity accessible even on smartphones.⁹⁹⁷

Satellite and ground-based networks are increasingly converging to integrate satellite connectivity with 5G enabling seamless connectivity between Earth and space. The European Space Agency (ESA), MediaTek Inc., Eutelsat, Airbus Defence and Space, Sharp, the Industrial Technology Research Institute (ITRI) and Rohde & Schwarz (R&S) have conducted the world's first successful trial of satellite-to-ground 5G connectivity over low-earth orbit satellites.⁹⁹⁸

These tests pave the way for commercial deployment of 5G-Advanced Non-Radio NTN standards, which are leading to future satellite and terrestrial interoperability within a large ecosystem, lowering the cost of access and enabling the use of satellite broadband for NTN devices around the world. Standards bodies and industry groups are now working on open NTN architectures for future 6G, aiming for seamless connectivity and hybrid networks that integrate satellites as a core component of future networks.⁹⁹⁹ Nevertheless, global networks are not yet fully seamless and still operate in fragmented technical and regulatory environments as national sovereign telecommunications and data requirements evolve.



Expected to continue to grow, the global satellite industry was worth **\$293 billion in 2024**





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Define Requirements

Baseline conditions for cross-border connectivity are specified, including satellite coverage, cellular interoperability, device compatibility, governance arrangements and constraints affecting continuity across national networks.

- Grants
- Stage-gate grants
- Challenge prizes

Infrastructure

Technical and institutional arrangements are established for coordinated satellite-cellular interaction, including modes of use, data handling standards and operational roles across jurisdictions.

- Convertible grants
- Early-stage capital with multiple funding partners
- Combination Grants

Piloting

Pilots are launched to test disruption, AI performance, how different services are managed, and governance limitations across borders.

- Social impact bonds
- Service contract
- Convertible Loans

**50** 2024

Preferable Future Seamless Global Networks

Infrastructure and operations are widely adopted, reducing dependence on location-bound networks and supporting continuous communication even during emergencies.

- Scaling funds
- Revenue-dependent grants
- Loans
- Equity Investment

What Progress looks Like

Seamless access to connectivity opens up significant channels, not only for communication but also for commerce, education and growth. More affordable access to connectivity strengthens economic opportunities across the board, as well as creating societal benefits.



NECESSARY ENABLERS

- Affordable and effective hardware to manage switch between connectivity modes
- Policies on space debris and environmental impacts of launching/replacing satellites
- Cross-border agreements to enable borderless connectivity
- Existing telecommunication operators integrate communications and connectivity
- Managing data sovereignty frameworks within borderless connectivity



CHALLENGES

- Ability to respond to disruptions in satellite connectivity
- Cybersecurity threats targeting satellites and cross-border data flows
- Fragmented regulatory environments across jurisdictions
- Global coordination in regulating the shared cyberspace
- Technological complexity in developing seamless satellite-terrestrial integration



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





28 2025

What if long-term uncertainty
became the greatest
investment opportunity?

A Catalyst for Common Good

A global equity fund tackles humanity's greatest long-term challenges by combining decentralised governance for transparency with multilateral development bank (MDB) capital to scale breakthrough innovations for climate, energy, food and water security.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Future Humanity

Uncertainties

Collaboration, Systems

Trends

Cross-sectoral Partnerships

Food–Water–Energy Nexus

International Collaboration

Mobilising Innovation

Tokenisation

Technologies

Decentralised Autonomous Organisation (DAO)

Distributed Ledger Technologies (DLTs)

Predictive Analytics

Category

Systems Optimised

Top Five Sectors

Agriculture & food

Communication technologies & systems

Cyber & Information Security

Energy, Oil & Gas, & Renewables

Utilities

Keywords

Blended finance

Decentralised Autonomous
Organisations

Impact investing

Multilateral development banks

Sustainable development



Benefits

Move towards addressing critical long-term uncertainties. Mobilisation of global innovation. Evolution of MDBs.¹⁰⁰⁴ Alignment with global goals and commitments.

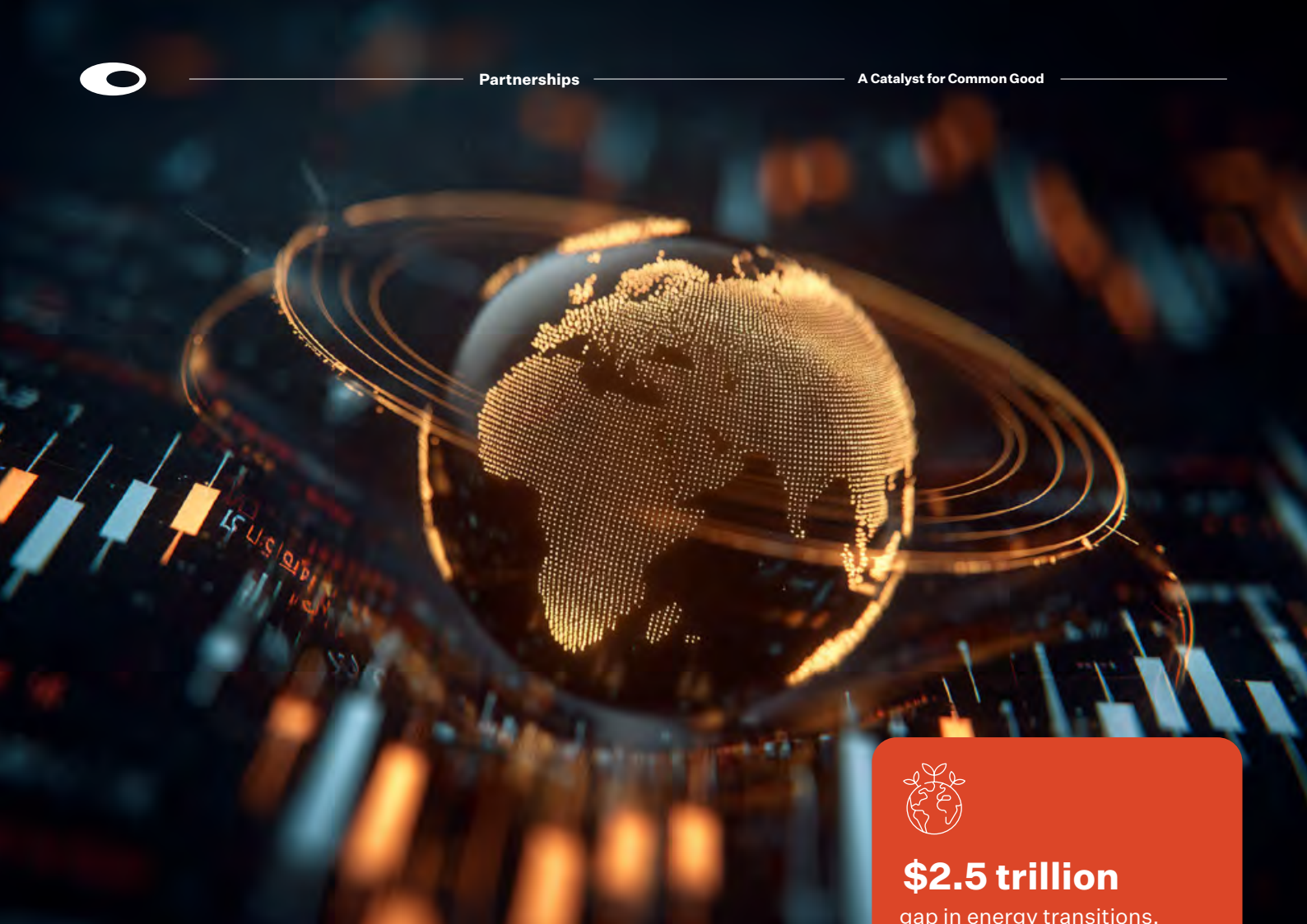


Risks

Repeating challenges that public goods already face; complexities in managing a fund with decentralised governance; funding sustainability and continuity; managing global investments and innovations across different countries.

Why It Matters Today

There is a gap in our ability to fund and address long-term global challenges. Energy transitions, climate resilience, and development in low- and middle-income countries face an estimated \$2.5 trillion annual gap.¹⁰⁰⁰ Global challenges, such as climate stability and food, water and energy insecurities, are interconnected and require sustained investments. The Paris Agreement,¹⁰⁰¹ the Sustainable Development Goals (SDGs)¹⁰⁰² and the UN Pact for the Future (which incorporates the UN Declaration on Future Generations and the UN Global Digital Compact)¹⁰⁰³ are all designed to adopt a long-term lens, yet existing investment structures remain focused on shorter time horizons.

**\$2.5 trillion**

gap in energy transitions, climate resilience, and development in low- and middle-income countries.

Status Today

There are a number of global public and private equity funds addressing longer term challenges such as climate change, sustainability and development. Examples include HSBC GIF Global Equity Climate Change¹⁰⁰⁵ and Schroder ISF* Global Climate Change Equity,¹⁰⁰⁶ which are largely thematic equity funds with a climate or climate-transition focus and look at significant long-term trends in decarbonisation, climate adaptation, low-carbon technologies, energy transition technologies, and ESG criteria. Similarly, funds such as BlackRock's BGF Emerging Markets Sustainable Equity Fund¹⁰⁰⁷ and Allianz Emerging Markets Equity SRI¹⁰⁰⁸ focus largely on long-term development in low- and middle-income countries and work towards integrating equity, climate solutions and broader SDGs.

Nevertheless there are no public equity funds, UCITS, mutual funds or ETFs focusing on longer-term challenges such as climate change and development that are structured as DAOs or that have acquired relevant patents to allow for innovative licensing models and eventually share critical technologies. Currently, public equity funds are bound by certain regulatory conditions in most countries such as the requirement to have a licensed fund manager, a depositary/custodian, and governance that is regulated by a national body.¹⁰⁰⁹



Currently,

public equity funds

are bound by certain regulatory conditions in most countries such as the requirement to have a licensed fund manager, a depositary/custodian, and governance that is regulated by a national body.



There are no public equity funds, UCITS, mutual funds or ETFs focusing on longer-term challenges such as climate change and development





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Establish Framework

A global consortium establishes shared principles on what constitutes long-term challenges, patent acquisition and licensing models, and agrees criteria for collective investment.

- Challenge Prizes
- Matched Crowdfunding
- Grants
- Stage-gate Grants

National DAO

Institutional, legal and technical requirements and setups are specified, including fund architecture, DAO governance, patent-holding structures, eligibility rules and initial development bank participation.

- Combination Grants
- Service Contracts
- Early-stage capital and multiple funding partners
- Convertible Grants

Regional DAO

A pilot is launched for one use case to test governance processes, capital deployment and licensing mechanisms, monitoring arrangements under real conditions.

- Combination Grants
- Accelerator Programmes



28 2025

Preferable Future Global DAO

A refined fund and DAO model is broadly adopted, and replicated across regions and sectors with similar public-benefit goals.

- Scaling Funds
- Loans
- Service Contracts

What Progress looks Like

Long-term uncertainties are no longer left to chance; they are invested in and acted upon. The multinational development bank (MDB) and members of the public participate in capital allocation and addressing global challenges in a way that is transparent. Communities that are most exposed to long-term risks operate within defined arrangements where risk management responsibilities and decision processes are clearly defined.



NECESSARY ENABLERS

- Agreement on criteria defining eligible global challenges
- Aligned fund structures, investment criteria, DAO governance rules and token distribution
- Availability of MDB capital for investments identified as high uncertainty
- Laws and regulations and possibly new legal classifications for DAO-based funds
- Verification and reporting systems to assess underlying innovations and activities



CHALLENGES

- Long-term investment horizons may risk fund liquidity and financial sustainability
- Exit mechanisms that could destabilise projects or shift risks to vulnerable communities
- Cybersecurity risks on DAO platforms and smart contracts
- Governance and operational challenges as DAOs grow



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





PILLAR

5

Agility

Opportunities that capture value by building strategic capabilities and resilience to adapt to rapid, disruptive change, complexity and uncertainty.

Insights^R that emerge from the opportunities within this pillar

1

In the context of these opportunities, technology and, more specifically, AI are the dominant drivers

Technology emerges as a key uncertainty, appearing in 28 of the 38 opportunities within this pillar. This underscores that the ability to implement and manage technological change is critical for future agility, with AI the most cited technology across these opportunities (appearing 22 times).

2

It is crucial to enable real-time agility

Real-time analytics and the Internet of Things (IoT) are each mentioned in 9 of the 38 opportunities in this pillar. They are often mentioned in tandem with the megatrend Boundless Multidimensional Data, signalling their role in enabling real-time agility.

3

Government is central to agility

Government Services is one of the most impacted sectors, appearing in 24 out of 38 opportunities. This underscores the potential role of policy, regulation and government in value capture and future growth, prosperity and well-being.

R These insights are deduced from the 200 opportunities that were published in the previous editions of The Global 50. They are for informational, educational and guidance purposes and are non-exhaustive. Because these insights are based on opportunities, they may be generalisable to certain contexts but not others.



Most Significant Megatrend

Uncertainty

Trend

Technology

15 2022 Transitional

Life-In-A-Box

What if we never had to leave our homes?

Future Humanity

Technology

Systems

Autonomous Living

Future of Purpose & Work

Food-Water-Energy Nexus

SpaceTech

Artificial Intelligence

Internet of Things (IoT)

30 2022 Transitional

The Real-Work-From-Anywhere Revolution

What if we had perfect interoperability?

Digital Realities

Technology

Collaboration

International Collaboration

Open Data

Artificial Intelligence

Internet of Things (IoT)

33 2023 Transitional

A Policy's True Measure

What if social policies were designed and monitored at a community level in real time?

Future Humanity

Technology

Systems

Cross-sectoral Partnerships

Open Data

ESG & Beyond GDP

Government Agility

Community-Based Solutions

Edge Computing

Real-Time Analytics

Internet of Things (IoT)

34 2023 Transitional

Calling out the Herd Mentality

What if hybrid intelligence reduced group think?

Future Humanity

Systems

Values

Human-Machine Interaction

Data Protection & Privacy

Artificial Intelligence

Edge Computing

Sensor Technologies

Artificial Intelligence

42 2023 Transitional

Accounting for Innovation

What if accounting reinvented itself?

Boundless Multidimensional Data

Systems

Values

Future of Purpose & Work

Artificial Intelligence

Cross-sectoral Partnerships

International Collaboration

Quantum Computing

Artificial Intelligence

Internet of Things (IoT)

45 2023 Transitional

Going All-Digital

What if the Fortune Global 500 was purely virtual?

Digital Realities

Collaboration

Values

Cross-sectoral Partnerships

Digital Economy

Future of Purpose & Work

International Collaboration

Ideation, IP & Entrepreneurship

Cybersecurity

Advanced Connectivity

Distributed Ledger Technologies (DLTs)

6 2024 Transitional

The Power of Radio

What if the future of radiology was personalised?

Advanced Health and Nutrition

Technology

Values

Artificial Intelligence

Sensor Technologies

Genomics / Epigenetics

Personalised Medicine

Human-Machine Interaction

Sensor Technologies

Artificial Intelligence

Genomics / Epigenetics

14 2024 Transitional

Virtual Nature

What if digital biodomes shaped eco-policies?

Saving Ecosystems

Nature

Technology

Artificial Intelligence

ClimateTech

International Collaboration

Restoration

AI-Simulated Ecosystems

Real-Time Analytics

27 2024 Transitional

Zero Margin

What if mobile edge computing (MEC) made data centres obsolete?

Boundless Multidimensional Data

Technology

Systems

Advanced Computing

Data Protection & Privacy

Edge Computing

Mobilising Innovation

Edge Computing

Advanced Computing

Data Protection & Privacy

32 2024 Transitional

Data Helix

What if synthetic DNA met our need for indefinite and unlimited data storage for critical information?

Boundless Multidimensional Data

Technology

Systems

Advanced Computing

Bioinformatics

Biotechnology

Data Protection & Privacy

Advanced Computing

Nanotechnology

Synthetic DNA

45 2024 Visionary

Forever Machines

What if machines could self-repair?

Life with Autonomous Robots and Automation

Collaboration

Technology

Advanced Computing

Automation

New Materials

Artificial Intelligence

Cross-sectoral Partnerships

Advanced Sensors

Self-Healing Metals & Polymers

Stretchable Electronics

30 2025 Visionary

Beyond Classification

What if new economic classifications unlocked development and progress?

Future Humanity

Collaboration

Systems

ESG & Beyond GDP

Government Agility

Cross-sectoral Partnerships

Open Data

International Collaboration

Real-Time Analytics

Artificial Intelligence

Distributed Ledger Technologies (DLTs)

34 2025 Visionary

Adaptive Patent

What if patents adapted in real-time?

Borderless World – Fluid Economies

Technology

Systems

Cross-sectoral Partnerships

Open Data

International Collaboration

Mobilising Innovation

Ideation, IP & Entrepreneurship

Artificial Intelligence

Advanced Computing



15 2022

What if we never had to leave our homes?

Life-In-A-Box

Self-sufficient homes, inspired by space research, provide life's essentials and unburden the planet.

SCOPE

Within Reach

Transitional

Visionary

New

2022

Most Significant Megatrend

Materials Revolution

Uncertainties

Technology, Systems

Trends

Autonomous Living
Food–Water–Energy Nexus
Future of Purpose & Work

Technologies

Artificial Intelligence
Internet of Things (IoT)
SpaceTech

Category

Future Humanity

Top Five Sectors

Agriculture & Food
Communication Technologies & Systems
Infrastructure & Construction
Real Estate
Utilities

Keywords

Closed-loop systems
Off-grid Living
Atmospheric Water Harvesting
Vertical Farms
Smart Homes

Why It Matters Today

Despite progress, over 2 billion people lack access to adequate food,¹⁰¹⁰ one in four globally do not have access to safe drinking water¹⁰¹¹ and 655 million lack electricity.¹⁰¹² Despite declining fertility rates in some countries and regions,¹⁰¹³ the population is expected to reach a peak of 10.3 billion by mid-2080;¹⁰¹⁴ this means 55 years of increasing demand for food, water and energy. Resilience against future pandemics, climate disasters or any events that could disrupt resources is important.



Benefits

Homes acting as survival capsules in the face of catastrophes or existential threats. Fewer demands on natural resources and physical transport networks, bringing greater environmental benefits and new growth opportunities.



Risks

Social isolation and the fracturing of physical communities, potentially harming people. Malicious harm due to potentially higher vulnerability to physical attacks and cyberattacks on closed-loop resource systems.



Status Today

For more than 30 years, ESA's MELiSSA project has focused on developing regenerative life support systems for space missions, a closed-loop system recycling carbon dioxide and organic waste into food, oxygen and water. It is the most advanced setting to date to develop closed-loop life support systems.¹⁰¹⁵ On Earth, we are seeing the early stages of this with solar homes and atmospheric water generation, but fully autonomous, closed-loop 'life-in-a-box' systems are currently niche or in R&D phases in separate technologies.

There are thought to be 2,000 homes in the UK that are off-grid. It can cost up to \$668,000^Q to be connected to the energy grid, while it costs about \$1,070 per month^Q to run an off-grid system – a combination of solar panels, batteries and generators.¹⁰¹⁶ With the running costs and maintenance being a concern among older populations in particular,¹⁰¹⁷ the case for off-grid living is not so clear. Yet, living off-grid is not limited to those who choose to do it as it can provide critical access to some communities.

Water harvesting has been a growing area of interest. Besides rainwater and floodwater harvesting, there is growing interest in atmospheric water harvesting. Earth's atmosphere holds 12,900 billion tonnes of freshwater as moisture in the air.¹⁰¹⁸ The global market for atmospheric water harvesting is valued at approximately \$800 million, with an annual growth rate of up to 12% extracting water from air, for applications ranging from farm irrigation to cooling data centres, with the key issue being energy requirements.¹⁰¹⁹ Startups and experimentation continue in this area.

MIT developed an ultrasonic device that recovers water in minutes instead of hours or days; it is 45 times more efficient than traditional heat-based thermal designs and can generate potentially 3.25 L/m²/day.¹⁰²⁰ Water recycling has also been an area of interest as 3.6 billion people face water shortages at least one month per year and urban water demand will increase 80% by 2050.¹⁰²¹ The World Economic Forum and Imperial College London devised a systems-based framework to boost innovation in water in urban cities, using six global cities as the foundation for a digital prototype to support strategic planning.¹⁰²²

Vertical farming has also been a growing area of interest, assessed to potentially provide up to 20 times the yield of farms and year-round indoor crop production.¹⁰²³ Vertical farming could potentially provide 50% of leafy green markets in the US in the next decade, often without the need for pesticides.¹⁰²⁴

^Q Based on the GBP:USD exchange rate of 13 July 2026

Earth's atmosphere holds **12,900 billion** tonnes of freshwater, and the atmospheric water harvesting market is valued at approximately



\$800 million with up to **12% growth**.

3.6 Billion

people face **water shortages** at least once a month, and urban water demand will increase **80%** by **2050**.



Vertical farming could provide up to **20 times** the yield of farms and potentially **50%** of leafy green markets in the US in the next decade.



There are thought to be **2,000 homes in the UK that are off-grid**. It can cost up to

\$668,000

to be connected to the energy grid, while it costs about

\$1,070 per month

to run an off-grid system





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Innovation Development

Startups generate ideas for leveraging SpaceTech and devise ways to enhance self-sufficiency in food, water and energy.

- Challenge Prizes
- Matched crowdfunding
- Combination Grants
- Grants
- Stage-gate grants

Piloting and Prototyping

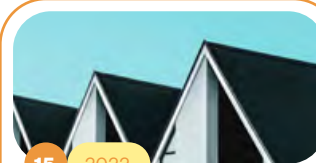
Modular 'plug-and-play' units for generating water and food are piloted in existing homes, to test efficiency, including smart home IoT needs for monitoring and improvement.

- Combination grants
- Accelerator programmes
- Grants
- Stage-gate grants
- Challenge prizes
- Matched crowdfunding

Regulatory Reform and Health & Safety

Changes to regulations and building codes are made and response mechanisms for ensuring services meet health standards are identified.

- Combination grants
- Accelerator programmes
- Loans
- Service Contracts



15 2022

Preferable Future Scalable Deployment

Housing developments that require no external utility connections are built and existing houses are adapted.

- Scaling funds
- Equity Investment

What Progress looks Like

Homes produce their own food, recycle water for drinking and generate power without grid connection. Households can survive a supply chain collapse or pandemic lockdown. Utility bills are eliminated, and global resource consumption drops drastically. Low-income countries now have access to reliable food, water and energy. Self-sufficient homes become a standard.



NECESSARY ENABLERS

- Affordable and accessible closed-loop technologies
- Regulations that allow for decentralised utilities
- Rigorous real-time testing to ensure recycled water and food safety standards
- Effective smart home IoT integration
- Management of transition from centralised to decentralised utilities



CHALLENGES

- High cost of retrofitting existing housing and installing closed-loop systems
- Rising maintenance complexity and shifting burden on households
- Contamination risk
- Cybersecurity risks



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





30 2022

What if we had perfect interoperability?

The Real Work-From-Anywhere Revolution

Global software applications operating seamlessly and collaboratively across borders and sectors.

SCOPE

Within Reach

Transitional

Visionary

New

2022

Most Significant Megatrend

Digital Realities

Uncertainties

Technology, Collaboration

Trends

Open Data

International Collaboration

Technologies

Artificial Intelligence

Internet of Things (IoT)

Category

Systems Optimised

Top Five Sectors

Communication Technologies & Systems

Data science, AI & Machine Learning

Financial Services & Investment

Government Services

Health & Healthcare

Keywords

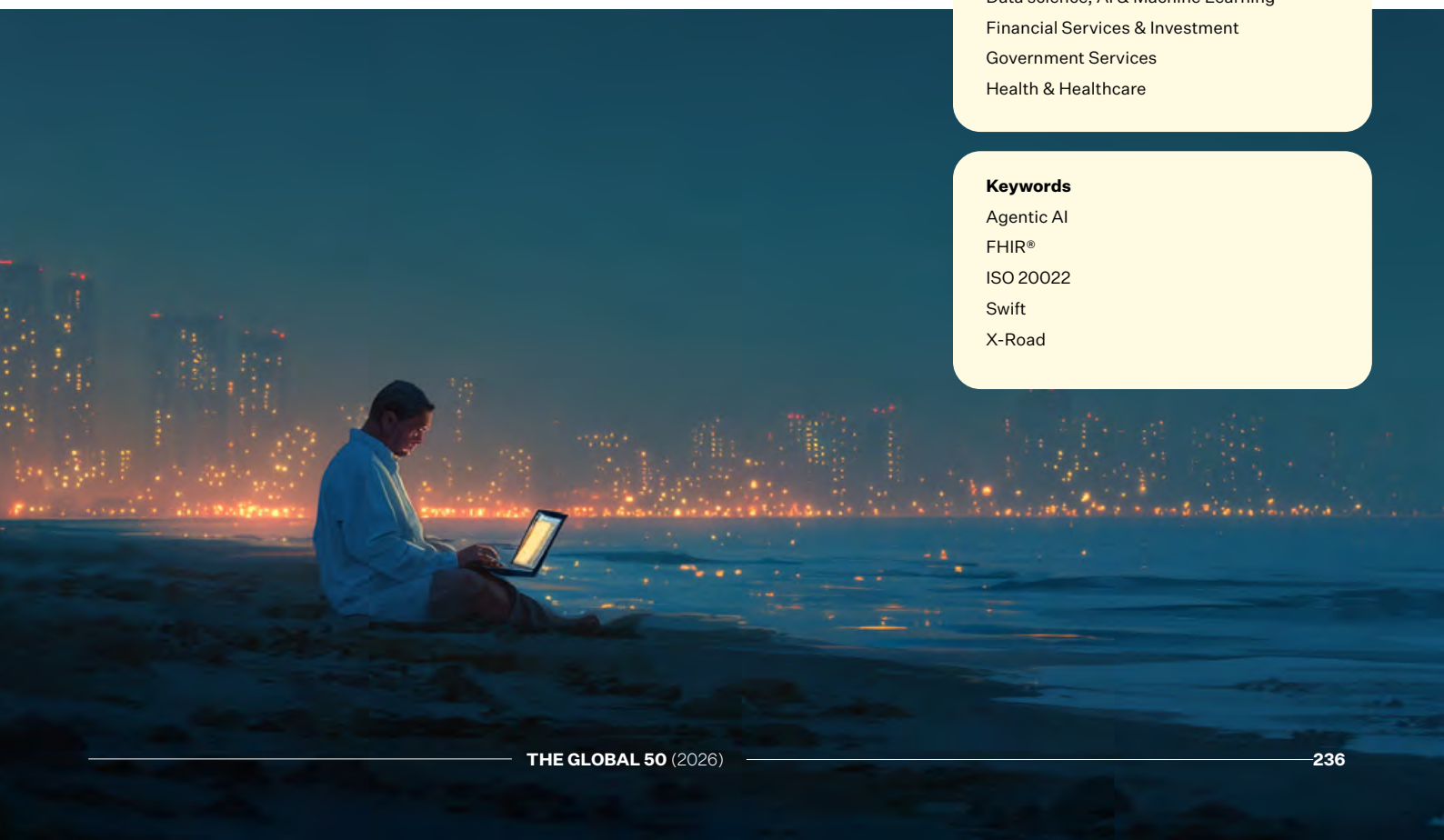
Agentic AI

FHIR®

ISO 20022

Swift

X-Road





Why It Matters Today

Interoperability gaps exist across organisations, governments, businesses, cities and countries. Well functioning interoperability ensures that users of software applications are able to access, explore and use data from different sources to make and/or execute decisions.¹⁰²⁵ There is no standard measure for interoperability beyond identifying (potential) failure points.¹⁰²⁶ While cloud-based services partially reduce the interoperability gap, they do not fully resolve it, an issue is growing at a faster pace as AI pushes organisations to switch software providers more frequently to not be left behind.¹⁰²⁷ Even though other initiatives exist, such as Estonia's 'X-Road',¹⁰²⁸ EU interoperability strategies,¹⁰²⁹ Fast Healthcare Interoperability Resources (FHIR®) for standard health records¹⁰³⁰ and the ISO20022 standard for finance,¹⁰³¹ no effective global solution has emerged.



Benefits

More intuitive and user-friendly technological environments;
Lowers the financial and time costs of data sharing; New opportunities for innovation.



Risks

Dominant public or private players, who become the de facto standard setters; Fewer or more-deeply integrated systems, increasing the potential impact of malicious attacks or accidental outages.



Status Today

The premise of this opportunity is that by solving interoperability, we move from digital silos to a unified global operating system for work and life. However, sectors vary in their progress towards interoperability to date, and the concept remains a challenge despite AI, interoperability remains a challenge despite AI.

In health, the Health Level Seven International (HL7) remains the primary global non-profit standards organisation.¹⁰³² FHIR® – developed by HL7 – was recently updated in 2023 with Europe maintaining a lead in adoption.¹⁰³³ In 2024, the US Office of the National Coordinator for Health IT announced a federal plan to adopt the FHIR® interoperability standards for Application Programming Interface (API)-enabled health information exchange across the country.¹⁰³⁴

The G20 group of countries endorsed a roadmap developed by the Financial Stability Board in 2020 to improve cross-border payments including the implementation of harmonised ISO 20022 data requirements for cross-border payment instructions, with a target for adoption by the end of 2027.¹⁰³⁵ It became a required standard for cross-border payments in November 2025 for SWIFT's network¹⁰³⁶ of more than 11,500 institutions and 220 countries.¹⁰³⁷

In terms of digital public infrastructure (DPI), Estonia's X-Road has served more than 25 countries since 2000.¹⁰³⁸ X-Road enables Estonia–Finland cross-border data transfers across registers,¹⁰³⁹ and it is the base of Cambodia's CamDX that processes one million monthly eKYC transactions, cutting registration from up to 60 days to nearly instant across 20 services.¹⁰⁴⁰ Similarly, Singapore's Government Data Architecture, which includes the DataHive platform, aims to reduce cross-agency sharing from months to one week.¹⁰⁴¹

The ISSB sustainability standards are an example of indirectly enabling interoperability. Ranging from voluntary to legally mandated in over 40 jurisdictions,¹⁰⁴² the standards drive supply-chain data integration and enable reporting on sustainability data. Through certification, the global cross-border privacy rule (CBPR) system and global privacy recognition for processors (PRP) system enable trusted data flows.¹⁰⁴³

Another interesting angle is the rise of AI agent protocols. Multiple agent interoperability protocols emerged in 2025, creating new risks of fragmentation: Google's Agent2Agent (A2A) protocol launched in April 2025 with more than 50 technology partners,¹⁰⁴⁴ Anthropic, Block and OpenAI co-founded the Agentic AI Foundation (AAIF), with Anthropic contributing its Model Context Protocol (MCP),¹⁰⁴⁵ and Salesforce expanded its AgentExchange marketplace to support both MCP and A2A standards.¹⁰⁴⁶ Without convergence, competing standards risk replicating today's interoperability challenges at the agent layer.

ISO 20022 became a required standard for cross-border payments in November 2025 across SWIFT's network of more than

11,500
institutions in
220 countries.



Cambodia's CamDX processes one million monthly eKYC transactions, **cutting registration from up to 60 days** to instantaneously across 20 services.



Multiple AI agent interoperability protocols emerged in 2025, including Google's A2A with 50 technology partners.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Minimum Viable Interoperability (MVI)

MVI is defined (by a consortium) and controlled prototypes are launched to test essential cross-system functions, using APIs, AI bridges and DPI extensions to prove the ability to bridge systems.

- Service contracts
- Grants
- Challenge prizes
- Stage-gate grants

Piloting

City- and/or country-led sandboxes co-develop and prove functional prototypes that simulate real-world cross-border events, generating the regulatory insights and validated models needed to align fragmented systems across jurisdictions.

- Accelerator programmes
- Stage-gate grants
- Combination grants
- Service Contracts

Scaling

Mandatory standards (health, finance, government), based on validated pilot results, are integrated and revised for AI-readability, enabling private and public data to merge into a single, user-governed stream.

- Scaling funds
- Revenue-dependent grants
- Early-stage capital and multiple funding partners



Preferable Future Interoperable Ecosystems

An MVI solution is integrated into the national DPIs of cities and countries worldwide, with personal AI agents orchestrating cross-border processes.

- Equity investment
- Service contract
- Loans
- Scaling Funds

What Progress looks Like

Moving between countries and jobs is seamless, with nearly no administrative friction. Health records, tax history, professional certifications and pension contributions are updated instantly through autonomous AI agents, regardless of the local software used. A global, secure and user-centric data commons is formed.



NECESSARY ENABLERS

- Global certification frameworks to recognise and enforce digital signatures and identities
- Effective AI bridge translating data between legacy and AI or newer systems
- Decentralised Trust Networks to enable sovereign nodes for verification and independence
- Global testing sandboxes
- Clear laws and regulations that clarify liability in cross-border use



CHALLENGES

- Resistance due to loss of organisational competitiveness or data sovereignty
- Fragmented data localisation mandates, privacy laws, and sector regulations across countries
- High cost of upgrading outdated infrastructure, especially in resource-limited contexts
- Poor quality data leading to AI errors, mapping mistakes, and costly corrections



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





33 2023

What if social policies (education, health, welfare) were designed and monitored at a community level and in real time?

A Policy's True Measure

Advanced machine intelligence helps policymakers design and implement effective social programmes and policies at a community level that are adjusted in real time, taking into account people's diverse characteristics and backgrounds while protecting the privacy of all.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Future Humanity

Uncertainties

Technology, Systems

Trends

Community-Based Solutions
Cross-sectoral Partnerships
ESG & Beyond GDP
Government Agility
Open Data

Technologies

Edge Computing
Internet of Things (IoT)
Real-time Analytics

Category

Societies Empowered

Top Five Sectors

Communication Technologies & Systems
Cyber & Information Security
Data science, AI & Machine Learning
Government Services
Health & Healthcare

Keywords

Adaptive policymaking
Artificial Intelligence
Community-based policies
Inclusion
Real-time data

Why It Matters Today

A one-size-fits-all approach that relies on aggregate data to inform social policy could mask community realities on the ground¹⁰⁴⁷ and cannot effectively guide all social policies.¹⁰⁴⁸ For example, aggregate data risks missing gender, disability or cultural differences critical to effective social policies; excluding people with disabilities and women comes at an opportunity cost of up to 7% of GDP in some economies¹⁰⁴⁹ and \$342 trillion by 2050,¹⁰⁵⁰ respectively. National metrics also overlook that 708 million women are excluded from labour markets due to unpaid care work, and that only 57% of needed gender data exists.¹⁰⁵¹ Community-level metrics are key to designing effective social policies.



Benefits

Avoids the problems of 'one-size-fits-all' policymaking at one end and complex individual-level policies at the other; More effective and efficient use of funds through the use of real-time monitoring and progress reports.



Risks

Inaccuracies in aligning community and individual-level indicators; Community-level data too aggregated to match some individuals, particularly in diverse communities.



Status Today

Social policies using aggregate data may miss nuances within user and beneficiary communities.¹⁰⁵² With AI, governments can incorporate real-time data into social policy design¹⁰⁵³ to benefit more people within a community,¹⁰⁵⁴ including women and people with disabilities. AI-enabled digital twins¹⁰⁵⁵ inform policy development through a better understanding of needs and behaviours, enabling more targeted and personalised approaches to Government Services.¹⁰⁵⁶

Digital twins improve public sector efficiency, accessibility and performance¹⁰⁵⁷ and identify potential issues before policy implementation. Government agencies have used digital twins to achieve \$100 million in energy savings and up to 30% improvement in operational efficiencies,¹⁰⁵⁸ as well as, in Dubai, identifying – on average – AED 1 million in potentially fraudulent healthcare claims per audit cycle.¹⁰⁵⁹ While AI readiness within the public sector continues to grow, AI had the biggest potential to improve services in transportation (34%), infrastructure (24%), public safety (21%), environment and climate (21%) and public schools (18%).¹⁰⁶⁰ AI projects across 46 UN agencies had increased by 57% from around 260 (2020) to 408 (2023).¹⁰⁶¹

Despite these advances, there are recognised challenges when it comes to using AI in policymaking, particularly social policymaking, that limit its application. AI in emerging markets ranges from early strategies to advanced digital-twin applications optimising urban power systems, climate modelling, mobility and grid forecasting, and cross-governmental coordination in emergencies,¹⁰⁶² but with limited AI in social policymaking. In OECD countries, 70% are using AI to improve public service delivery or internal operations, while only 33% use AI for policy design and implementation.¹⁰⁶³ Yet, AI in policymaking will need to address public concerns as fewer than half of people surveyed in a recent Ipsos poll (48% and around 23,000 respondents across 32 countries) believed that AI companies will protect their personal data,¹⁰⁶⁴ dropping from 50% in 2023¹⁰⁶⁵ and nearly 47% in 2024.¹⁰⁶⁶



Government agencies have used **digital twins** to achieve

\$100 million

in energy savings and up to **30% improvement** in operational efficiencies.

57%



AI projects across 46 UN agencies increased by **57%** from around **260** (2020) to **408** (2023).

In OECD countries,

70%

use **AI for public service** delivery, but only

33%

use **AI for policy** design.





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Clarify Requirements

Privacy considerations, data standards and governance needs are explored, alongside efforts to build awareness and shared understanding across different governments and communities.

-  Challenge Prizes
-  Matched Crowdfunding
-  Accelerator Programs
-  Grants
-  Stage-gate Grants

Design

AI models and governance approaches are developed using local policy contexts, alongside agreed criteria for policy review triggers and secure inter-government data sharing.

-  Social Impact Bonds (SIBs)
-  Service Contract
-  Accelerator Programs
-  Convertible Grants

Pilot

Pilots are launched to inform AI explainability, reporting, communications and acceptable uses of AI in social policy decision-making across communities.

-  Early-stage capital with multiple funding partners
-  Scaling Funds
-  Revenue-dependent Grants
-  Loans
-  Convertible Loans



33 2023

Preferable Future Launch

AI-enabled systems support autonomous identification of social policy needs, with human oversight ensuring ethical compliance, transparency, accountability and sustained public trust.

-  Equity Investment
-  Scaling Funds
-  Service Contract



What Progress looks Like

Social policies are designed on the basis of real-time data that captures the needs of various community stakeholders. Policy design and implementation is efficiently carried out, and learning from one social policy or context can be leveraged for another. Budgetary reallocation is flagged in real time. Communities' trust of AI improves and, with edge computing and IoT, social policies start to intervene before problems occur; if problems do occur, they are flagged earlier rather than later.



NECESSARY ENABLERS

- Clear regulations and expectations on data privacy
- Community trust related to AI fairness
- Demonstrated quick wins to enhance community trust
- Mechanisms to overcome challenges in data interoperability



CHALLENGES

- AI literacy for policymakers managing the risk of over-reliance
- Algorithmic bias, AI model drift and real-life complexity
- Consistency in data quality
- Privacy safeguards managing trade-offs between community-level detail and privacy
- Sufficient computing capacity especially in regions that have lower connectivity



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





34 2023

What if hybrid intelligence
reduced groupthink?

Calling Out Herd Mentality

Advanced machine intelligence and new conceptual models of social psychology inform decision-making, reducing the impact of groupthink.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Future Humanity

Uncertainties

Systems, Values

Trends

Human–Machine

Data Protection & Privacy

Artificial Intelligence

Technologies

Artificial Intelligence

Sensor Technologies

Edge Computing

Category

Societies Empowered

Top Five Sectors

Communication Technologies & Systems

Cyber & Information Security

Education

Financial Services & Investment

Immersive Technologies

Keywords

AI Ethics

Cognitive Diversity

Groupthink

Multimodal Detection

Social Psychology



Why It Matters Today

Groupthink arises when members of a cohesive group prioritise consensus over alternative, less-biased perspectives, leading to suboptimal or undesirable decision-making.¹⁰⁶⁷ The causes of groupthink include lack of cognitive diversity, of impartial leadership and of outside perspective, intensified by stress and time constraints.¹⁰⁶⁸ Besides poor decision-making, groupthink leads to self-censorship, inefficient problem solving, and an inability to see other solutions.¹⁰⁶⁹ AI is often pushed as a tool that can enable objective or close to bias-free decision-making, however, recent research depicts deep and varied sources of bias in AI models where human perception of the outputs may risk blind acceptance of an output from AI.¹⁰⁷⁰



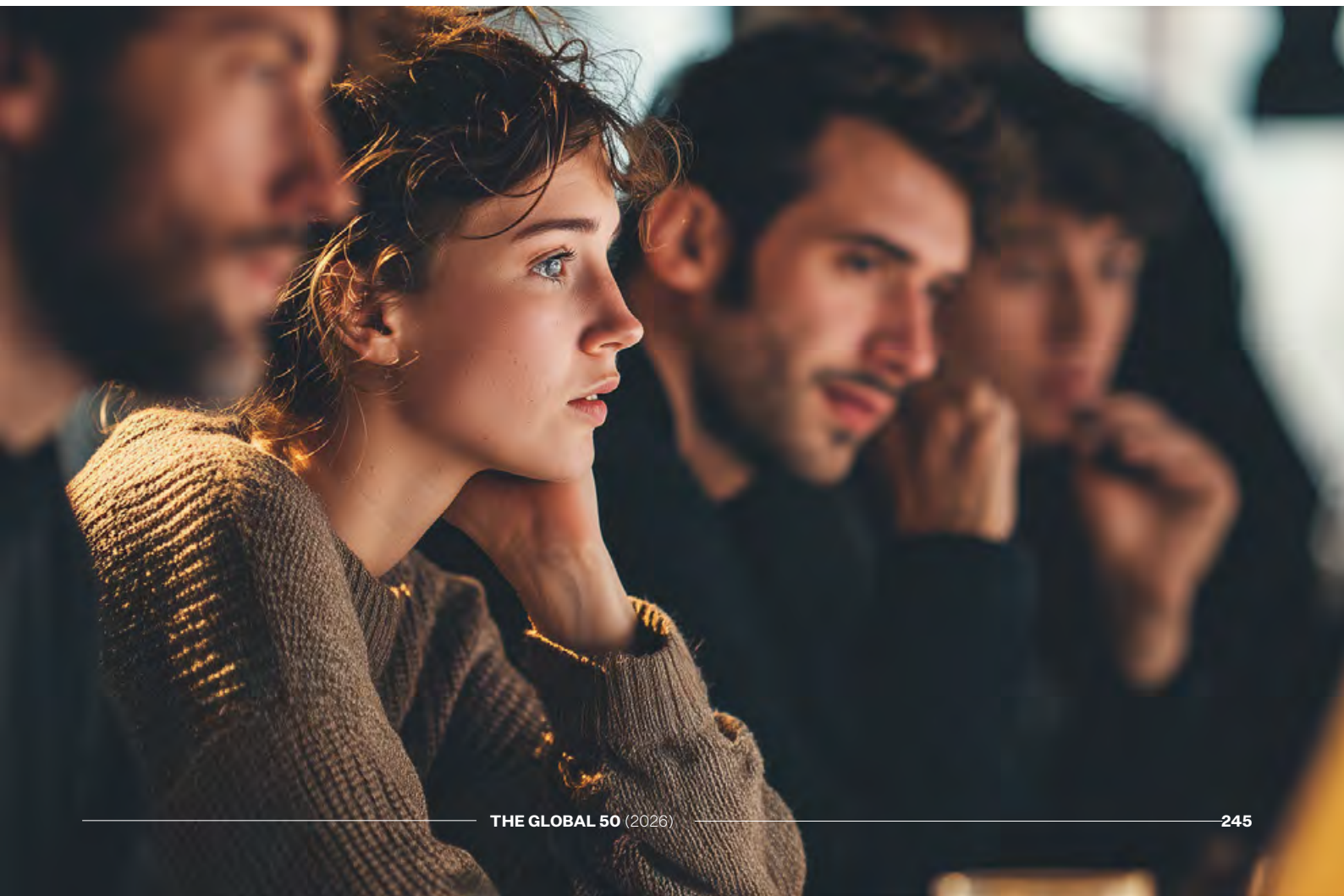
Benefits

Improved decision-making that factors in a greater diversity of thinking and perspectives.



Risks

Dilution of optimal choices due to in-group dynamics mistaken for groupthink.





Status Today

Research on AI bias is still in the early stages. Nevertheless, there are some cases that reveal bias in AI: Amazon's AI recruitment tool discriminated against women; facial recognition error rates are up to 34% for darker-skinned women, and the Airbnb booking platform had name-based racial bias.¹⁰⁷¹ Currently, no evidence demonstrates AI reduces groupthink; instead, research shows AI amplifies existing biases and creates new forms of discrimination.¹⁰⁷²

Besides built-in bias, AI systems themselves may exhibit groupthink behaviour. Models sometimes select the most popular answers as opposed to factually correct ones, select what is common even if wrong and, over time, can be less reliable in its answers.¹⁰⁷³ AI can also create new undetectable biases, like excluding certain demographics, and the assumption that AI could mitigate human biases is not consistently confirmed.¹⁰⁷⁴

In one study with university students, an AI agent was used to add controversial responses into health students' team discussions.¹⁰⁷⁵ It was found that AI can reduce groupthink when it is programmed to challenge the group and introduce different perspectives, when it is used strategically, designed to reduce groupthink and is not always in the conversation, such as when teams are new and vulnerable to groupthink.¹⁰⁷⁶

However, this single successful case has significant limitations: the AI responses were read aloud (not part of an on-going conversation), the intervention lasted only 60 minutes (potentially too brief for novelty effects to wear off), and students felt the AI lacked real-world experience that comes from peer collaboration.¹⁰⁷⁷ The researchers acknowledge these limitations noting that models were not trained for this collaborative approach.¹⁰⁷⁸

The current state of research suggests AI's relationship with groupthink is dual-natured: as a passive tool, AI amplifies existing biases and creates new forms of algorithmic groupthink; as an active agent, when deliberately designed and carefully controlled, AI shows preliminary potential to disrupt human groupthink. Bias will continue to be an ongoing risk in the next 10 years, which is exacerbated by model drift (as a model degrades over time). Yet, it is not clear how to detect or address it.¹⁰⁷⁹ Patches via Model Context Protocol (MCP),¹⁰⁸⁰ connecting models to external platforms, for example, could in principle, one day automate anti-groupthink interventions, but this requires further development, taking into account cross-platform interoperability, conversation management, real-time detection and ways of embedding grounded theories in groupthink behaviour.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Theoretical Foundation

A model is built by social science researchers and algorithm developers that integrates social psychology, cognitive diversity, and groupthink theories, translating frameworks into testable scenarios with defined indicators.

- Challenge Prizes
- Combination Grants
- Grants
- Stage-gate Grants

Real-Time Intervention

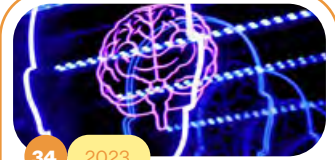
Focus groups test models and how AI would respond, using methods like NLP and sensors to monitor speech patterns and other signals, testing AI interventions, and extracting patterns to identify optimal timing windows, effective prompts, trigger thresholds, and unsuccessful approaches.

- Accelerator Programmes
- Grants
- Stage-gate Grants
- Challenge Prizes

Sensing Integration

A pilot is launched of a patch, coded using open standards that enables cross-platform AI agent communication, to test the system in organisational settings, measuring decision quality and satisfaction.

- Social Impact Bonds (SIBs)
- Service Contract
- Combination Grants



34 2023

Preferable Future Model Development

Open-source software using refined algorithms is available that can be adapted across contexts and aggregates anonymised data to improve effectiveness through network effects, as well as ensuring there are agreements on feedback loops to avoid model drift.

- Convertible Grants
- Venture equity Investment
- Early-stage capital and multiple funding partners
- Equity Investment

What Progress looks Like

Corporate boards and teams receive real-time alerts when their discussions lack diverse perspectives. Sometimes even if discussions are going well, AI intervenes to suggest ways where teams can work better and asks questions to ensure cognitive, gender and other forms of diversity. As a result, decisions made are more effective and innovative.



NECESSARY ENABLERS

- Interoperability across diverse AI models, platforms and sensor technologies
- Multimodal, machine-detectable markers of groupthink (voice, tone, face, mannerisms)
- Diverse, good quality training data to limit introduction of bias
- Ethics and governance protocols
- Grounded social science theories effective for different contexts or adjusted accordingly



CHALLENGES

- Managing model drift over time
- Monetising tools without incentivising manipulation for revenue gain
- Public perception and acceptance
- Ethical concerns regarding the surveillance of human thought and interaction



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





42 2023

What if accounting
reinvented itself?

Accounting for Innovation

New means of valuation, measurement and reporting, enabled by a range of technological advances, make historical accounting approaches redundant and open up new opportunities for innovation in problem-solving and fraud detection.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Boundless Multidimensional Data

Uncertainties

Systems, Values

Trends

Artificial Intelligence
Future of Purpose & Work
International Collaboration
Cross-sectoral Partnerships

Technologies

Internet of Things (IoT)
Artificial Intelligence
Quantum computing

Category

Transformational

Top Five Sectors

Financial Services & Investment
Government Services
Insurance & Reinsurance
Logistics, Shipping & Freight
Manufacturing

Keywords

Blockchain
Distributed Ledger Technologies (DLTs)
Environment, Society and Government (ESG)
Real-time analytics
RegTech



Benefits

Improved transparency, efficiency and resource allocation. Efficiency in detecting fraud and embedding new regulations and flows into accounting and reconciliation processes.



Risks

Vulnerability of systems to cyberattacks due to heavy reliance on automated analysis. Issues from barriers to adoption, such as resistance to change and the high price of technology.

Why It Matters Today

The global AI market is expected to grow to \$4.8 trillion by 2033, representing a 25-fold increase in a decade.¹⁰⁸¹ This will change the accounting industry, where many processes are or will be automated.¹⁰⁸² In parallel, the landscape of regulatory compliance and accounting is changing as businesses need to increasingly measure and report on sustainability metrics or meet new regulatory requirements such as ISSB¹⁰⁸³ at the same level of accuracy as financial reporting. In addition, there are challenges in attracting early career talent to the accounting profession¹⁰⁸⁴ – CPA exam candidates dropped 33% between 2016 and 2021 and accounting graduates declined by up to 8.4% – while 75% of CPAs are near retirement.¹⁰⁸⁵



Status Today

Traditional accounting has largely been reactive and manually intensive. Financial crime reached crisis levels in 2023: \$3.1 trillion in illicit funds flowed through the global financial system¹⁰⁸⁶ and fraud losses totalled \$485.6 billion globally, 52% of which came from real-time payment fraud, prompting calls to increasingly leverage data analytics for prevention.¹⁰⁸⁷ Manual processes cannot keep pace with increasing fraud, some of which is coming through AI-powered attacks.¹⁰⁸⁸ This is particularly the case for smaller firms, which face a disproportionate burden with a cost-to-revenue ratio of 2.3%, five times higher than their larger counterparts.¹⁰⁸⁹

AI adoption in the sector, up from 9% in 2024 to 41% in 2025,¹⁰⁹⁰ has become embedded in core workflows like bookkeeping automation and document summarisation.¹⁰⁹¹ AI-enabled RegTech has been reducing false positives by up to 40% and enabling real-time monitoring.¹⁰⁹² Accountants using AI finalise monthly statements 7.5 days faster¹⁰⁹³ and firms using generative AI saw a 12% rise in reporting granularity.¹⁰⁹⁴ Automation has reduced Know Your Customer (KYC) costs from 22% to 15% of total spend.¹⁰⁹⁵

At the same time, institutional investors are increasingly demanding greater transparency and accountability regarding ESG practices, making this a critical accounting and compliance priority.¹⁰⁹⁶ ESG reporting and integration continues to shift in both breadth and depth, and between mandatory and voluntary.¹⁰⁹⁷ ESG data is challenging to verify and report on because of data fragmentation, greenwashing risks, and high integration costs, particularly burdening SMEs.¹⁰⁹⁸

Once seen as the future of finance, blockchain adoption in accounting remains slow compared to AI and is still in pilot phases globally.¹⁰⁹⁹ While predicted to transform auditing through triple-entry (credit, debit and timestamped encrypted transaction record) bookkeeping, unchangeable ledgers, and smart contracts,¹¹⁰⁰ widespread disruption has not materialised despite the Big Four firms (Deloitte, EY, KPMG, PwC) investing since 2016; the smaller firms are generally relying on external blockchain solutions rather than internal development.¹¹⁰¹



Financial crime reached crisis levels in 2023:

\$3.1 trillion
in illicit funds and
\$485.6 billion
in fraud losses.



AI adoption in accounting rose from

9% (2024) to
41% (2025)

5X



Smaller firms face a cost-to-revenue ratio of 2.3%,
five times higher than larger counterparts.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day AI Integration

Standards bodies and auditing firms establish related AI reliability certification. Governments and private firms use AI to automate routine bookkeeping and track public spending.

-  Challenge Prizes
-  Combination Grants
-  Accelerator Programmes
-  Grants
-  Stage-gate Grants
-  Early-stage capital and multiple funding partners

Digital Ledgers

Public and private organisations move financial data to shared digital ledgers as digital currencies grow globally, shifting verification to digital certification and making traditional accounting approaches redundant.

-  Combination Grants
-  Accelerator Programmes
-  Service Contracts
-  Social Impact Bonds (SIBs)
-  Service Contract
-  Combination Grants

IoT

Sensors enable real-time data inputs on natural resources and other accounting lines into shared digital ledgers, keeping public accounts in step with environmental changes and generating automated national resource reports.



42 2023

Preferable Future Autonomous Accounting

Automated systems are adopted to manage finances, detecting fraud in real-time and reconciling accounts flagging anomalies. Automated national progress reporting spreads across countries.

-  Equity Investment
-  Service Contract
-  Loans
-  Scaling Funds



What Progress looks Like

Credit, debit, spending and economy are continuously monitored and, as algorithms reconcile 100% of transactions instantly, 'monthly closing' is now eliminated and reports can be produced at any time. Boards receive automated alerts, while IoT-linked ledgers automate national wealth reports, making natural capital as liquid and verifiable as cash. Accountants are no longer focused on 'bookkeeping'; instead, they are strategic team members and leaders who design automated assurance frameworks and validate algorithmic integrity. They interpret continuous data streams with auditors performing a human-oversight function on the system.



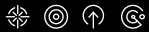
NECESSARY ENABLERS

- Agreed international standards for financial and non-financial metrics
- Interoperable data platforms
- Funding for building and/or deploying new systems for accounting and reporting
- Accountants become strategic experts and play an oversight role on AI
- Scalable accounting infrastructure



CHALLENGES

- Verification & trust in ESG data (combatting greenwashing)
- Avoiding model drift in real-time fraud detection algorithms
- Keeping solutions affordable for SMEs
- Regulatory alignment across jurisdictions
- AI literacy and upskilling in accounting and new career entrants



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





45 2023

What if the Fortune Global 500 was purely virtual?

Going All-Digital

Born and operating entirely in digital realities, virtual companies generate more revenue than physical ones.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Digital Realities

Uncertainties

Collaboration, Values

Trends

Cross-sectoral Partnerships

Digital Economy

Future of Purpose & Work

Ideation, IP & Entrepreneurship

International Collaboration

Technologies

Advanced Connectivity

Cybersecurity

Distributed Ledger Technologies (DLTs)

Category

Transformational

Top Five Sectors

Communication Technologies & Systems

Consumer Goods, Services & Retail

Financial Services & Investment

Immersive Technologies

Art, Media, Sports & Entertainment

Keywords

Algorithmic Audits

Decentralised Autonomous Organisation (DAO)

Digital Asset

Digitally Native Brands (DNB)

Micro-entrepreneurship





Why It Matters Today

Digitally native brands (DNBs) grow at triple the rate of the overall e-commerce market.¹¹⁰² The fastest have scaled from \$50 million to \$1 billion in revenue in just four to eight years.¹¹⁰³ Over 73% of the global population accesses the internet and the average adult spends over 18 hours per week on social and video feeds.¹¹⁰⁴ Based on the latest numbers from the World Bank, there were between 154 to 435 million gig workers in 2023¹¹⁰⁵ and the global platform economy is expected to rise to \$2.5 trillion by 2035.¹¹⁰⁶



Benefits

An open business environment that enables company agility to improve consumer choice and offer opportunities and flexibility in employment. Creation of space for greater entrepreneurship. Accelerated growth due to the ability to transcend borders.



Risks

Fraudulent behaviour in less regulated spaces, reducing trust in such companies. Increase in cybersecurity risks. Return to the multinational corporation model if brands evolve back to having a physical presence.



The global platform economy is expected

**to rise to
\$2.5 trillion
by 2035**



Status Today

In 2021, DNBs were expected to grow three times faster than e-commerce businesses.¹¹⁰⁷ As social commerce surged 575% in the same period between 2019 and 2024, DNBs started to disrupt traditional Consumer Packaged Goods (CPG) players through authentic storytelling and purpose-driven narratives, with US DNBs launching IPOs or successful exits within 8 to 10 years.¹¹⁰⁸ Direct-to-Consumer (D2C) businesses have relied on well-known personalities or social media influencers and have expanded into physical stores and pop-ups.¹¹⁰⁹

In cosmetics, for example, DNBs become valuable assets for corporate groups seeking fast-growing segments through celebrities or influencers and loyal Millennial/Gen Z customer bases.¹¹¹⁰ The key success factors include direct customer engagement or crowdsourcing product ideas, an authentic founder story, strategic partnerships, product or operational transparency, fast go-to-market, and outsourced manufacturing models.¹¹¹¹ The same is key in fashion and clothing (nearly 93% of the D2C industry), footwear, home and furniture.¹¹¹² In parallel, DNBs are increasingly opening bricks-and-mortar stores, driven by experiential shopping with a near 7% increase in online sales when stores open in trade areas.¹¹¹³ From 'bricks-and-mortar', DNBs are also increasingly evolving into 'click-and-mortar' businesses where customers view physical stores as an extension of their online experience.¹¹¹⁴

Perhaps the next phase of DNBs is about responding to the impact that AI is going to have on the future of work by becoming a catalyst of entrepreneurship, especially as AI threatens to eliminate 50% of entry-level white-collar jobs and increase unemployment by up to 20% within one to five years.¹¹¹⁵ Platforms used today in the gig economy are also increasingly being run by AI assigning tasks, managing payments and mediating communication, potentially deepening income inequality, heightening job insecurity, and having a negative impact on gig workers without proper regulation.¹¹¹⁶ As traditional white-collar roles vanish, a new class of virtual enterprises may arise not out of choice but out of the necessity.

Even though entrepreneurship is known to thrive in turbulent times¹¹¹⁷ and uncertainty remains a key underlying global risk until 2036,¹¹¹⁸ starting a business is becoming harder. While 68.6% of economies had over 40% of those surveyed in the annual Global Entrepreneurship Monitor survey say it was easy to start a business, the fear of failure jumped from 68.0% in 2019 to 84.3% in 2024,¹¹¹⁹ and 70% of economies lack a sufficiently supportive environment for entrepreneurs.¹¹²⁰

Social commerce surged

575%

(2019–2024), accelerating DNB disruption of traditional CPG players.



Opening physical stores drives nearly **7% higher online sales** in trade areas.



AI could eliminate

50%

of entry-level white-collar jobs and raise unemployment by up to

20%

within five years.





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Global Sandbox Launch

A global sandbox is launched as a cross-border testing environment for DNBs to pilot virtual business models that would compete at the G500 level.

- Combination Grants
- Accelerator Programmes
- Service Contracts
- Grants

Blueprint for Global 500

High-potential DNB sectors are identified and structured for institutional-grade growth, setting the stage for a fortune 500 sized company. Legal structures are designed for entities crossing \$10 billion in the future.

- Combination Grants
- Accelerator Programmes
- Challenge Prizes
- Service Contracts
- Grants

Piloting DNB Models

New DNBs are launched in several partner cities or countries and piloted as models and possibly as DAOs.

- Service Contract
- Venture Equity Investment
- Convertible Loans
- Early-stage capital and multiple funding partners



45 2023

Preferable Future Global Licensing and Scaling

A universal 'Digital Passport' licence enables DNBs to operate globally without physical headquarters. The global sandbox evolves into a network that enables such business models.

- Equity Investment
- Convertible Loans

What Progress looks Like

A global DNB is the standard for growth, outperforming physical peers through algorithmic replication, where successful DNB models scale across physical realities instantly. AI empowers job creation through micro-entrepreneurship enabled by DNBs. Success is no longer about influencer culture; instead, it is about tangible on-the-ground impact and plug-and-play tools that allow anyone to become a micro-entrepreneur.



NECESSARY ENABLERS

- Blockchain business IDs for smart contracts and decentralised autonomous governance
- Digital Passport licences for virtual operations and tax alignment
- Real-time audit trails
- Decentralised insurance pools for automated consumer protection



CHALLENGES

- Digital workers require novel, portable benefits and virtual labour protections
- Countries compete to attract digital companies with special virtual zones
- Legal frameworks must define accountability for autonomous AI business decisions
- Ensuring corporate integrity
- Virtual opportunities may not reach those who have poor connectivity



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





6

2024

What if the future of radiology was personalised?

The Power of Radio

Advances in imaging, genomics and advanced machine intelligence enable personalised radiology, improving diagnoses, treatment and public health policies on communicable and non-communicable diseases.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Advanced Health and Nutrition

Uncertainties

Technology, Values

Trends

Artificial Intelligence
Genomics / Epigenetics
Human–Machine
Personalised Medicine
Sensor technologies

Technologies

Artificial Intelligence
Genomics / Epigenetics
Sensor Technologies

Category

Health Reimagined

Top Five Sectors

Cyber & Information Security
Data science, AI & Machine Learning
Government Services
Health & Healthcare
Materials & Biotechnology

Keywords

Multimodal AI Diagnostics
Personalised Radiology
Precision Diagnostics
Predictive Imaging
Radiogenomics

Why It Matters Today

Chronic diseases may cause 86% of deaths annually by 2050,¹¹²¹ but evolving diagnostics through genomics and radiology may make treatment of these diseases more effective. At the same time, there is a global shortage of radiologists¹¹²² and, more generally, significant burnout among medical professionals.¹¹²³ In the US, demand for radiologists has grown 30% since 2017, and in the UK demand increases 5% annually while the workforce only grows 3%.¹¹²⁴ AI is expected to reduce radiologists' workload to 53%, decrease reporting time by 63% and improve accuracy.¹¹²⁵ During a standard eight-hour shift, radiologists are typically expected to interpret one image every three to four seconds.¹¹²⁶



Benefits

Improved treatment. The development of improved public health policies. Greater efficiencies in the diagnosis process.



Risks

Data privacy concerns. Anomalies being overlooked due to over-reliance on machine learning, increasing patient risks. Possible restriction of benefits to wealthier nations when medical images are combined with genetic information.

Status Today

Radiogenomics combines medical imaging with genomic data to predict disease characteristics without invasive procedures, avoiding the complications, sampling errors and high costs associated with traditional biopsies.¹¹²⁷ Using deep learning algorithms, radiogenomics can predict molecular mutations, forecast treatment responses and stratify patient prognosis in cancer care.¹¹²⁸

While applications show impressive accuracy in glioma, lung cancer and breast cancer molecular subtyping,¹¹²⁹ several challenges remain. These include maintaining model stability across different imaging centres, ensuring AI systems can explain their reasoning, obtaining sufficient paired imaging-genomic datasets, and conducting multicentre validation studies to confirm that models work reliably beyond single institutions.¹¹³⁰

As radiologists transition from traditional image interpreters to information specialists,¹¹³¹ they must integrate diverse data streams – including imaging, genomics, pathology, wearable sensors, and electronic health records – using multimodal AI systems that outperform single-data-source approaches.¹¹³² Multimodal AI creates comprehensive patient profiles across entire lifespans, with capabilities like predicting breast cancer years before it appears and assessing pancreatic cancer risk using only electronic health records.¹¹³³ However, there's a real risk: we might simply replace traditional information overload with a new kind of overload at the results and interpretation level, potentially overwhelming radiologists' cognitive capacity.¹¹³⁴

Addressing the knowledge gap is critical for success. Traditional radiology training, focused solely on interpreting images, is no longer sufficient. A comprehensive curriculum overhaul is essential, one that integrates data science, bioinformatics, systems biology and genomics.¹¹³⁵ Radiologists must take the lead in defining and creating AI tools that align with their workflows while ensuring equitable data access, transparent systems and updated regulatory frameworks, and building trust through real-world evidence.¹¹³⁶

Radiogenomics combines medical imaging with genomic data to predict disease characteristics without invasive procedures.



Despite radiogenomics showing high accuracy in identifying cancers like glioma, lung, and breast cancer, **challenges remain around validation, data availability, and AI explainability**



Radiologists must transition into data-driven information specialists supported by multimodal AI and updated training frameworks.



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Framework Development

A multi-stakeholder group establishes ethical frameworks for data sharing and AI governance. Cross-sector pilots continue to integrate imaging, genomics and machine learning to demonstrate proof of concept for major diseases.

- Challenge Prizes
- Accelerator Programs
- Grants
- Stage-gate Grants

Clinical Integration and Validation

Controlled testing environments establish imaging and genomics databases with shared data standards. Clinical trials validate AI diagnostic accuracy informing data-sharing agreements and preparing radiologists for new roles.

- Combination Grants
- Accelerator Programmes
- Service Contracts
- Early-stage capital and multiple funding partners

Pilot Networks

Regional pilot networks deploy AI diagnostics across multiple data types, testing clinical accuracy and cost. More radiologists transition into new roles.

- Scaling Funds
- Social Impact Bonds (SIB)
- Venture Capital Investments



6

2024

Preferable Future Fully Integrated Personalised Radiology

Personalised radiology is global standard practice, with imaging, genomics and AI integrated across health systems. Radiologists focus on complex cases and public health policies are enhanced with aggregated diagnostic data.

- Equity Investment
- Loans
- Scaling Funds



What Progress looks Like

Diagnostic accuracy and speed have improved dramatically, enabling earlier, less-invasive interventions. Radiologists work as clinical strategists, helping to diagnose complex cases across specialties. Automated reporting is reducing burnout while improving outcomes. Public health surveillance enables targeted disease interventions. Treatment plans are personalised instead of trial-and-error.



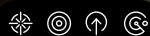
NECESSARY ENABLERS

- Interoperable systems
- Regulatory frameworks on validation, liability, and AI approval pathways
- Training programmes preparing radiologists
- Diverse, high-quality, privacy-assured datasets
- Real-time computational infrastructure processing imaging and genomic data efficiently

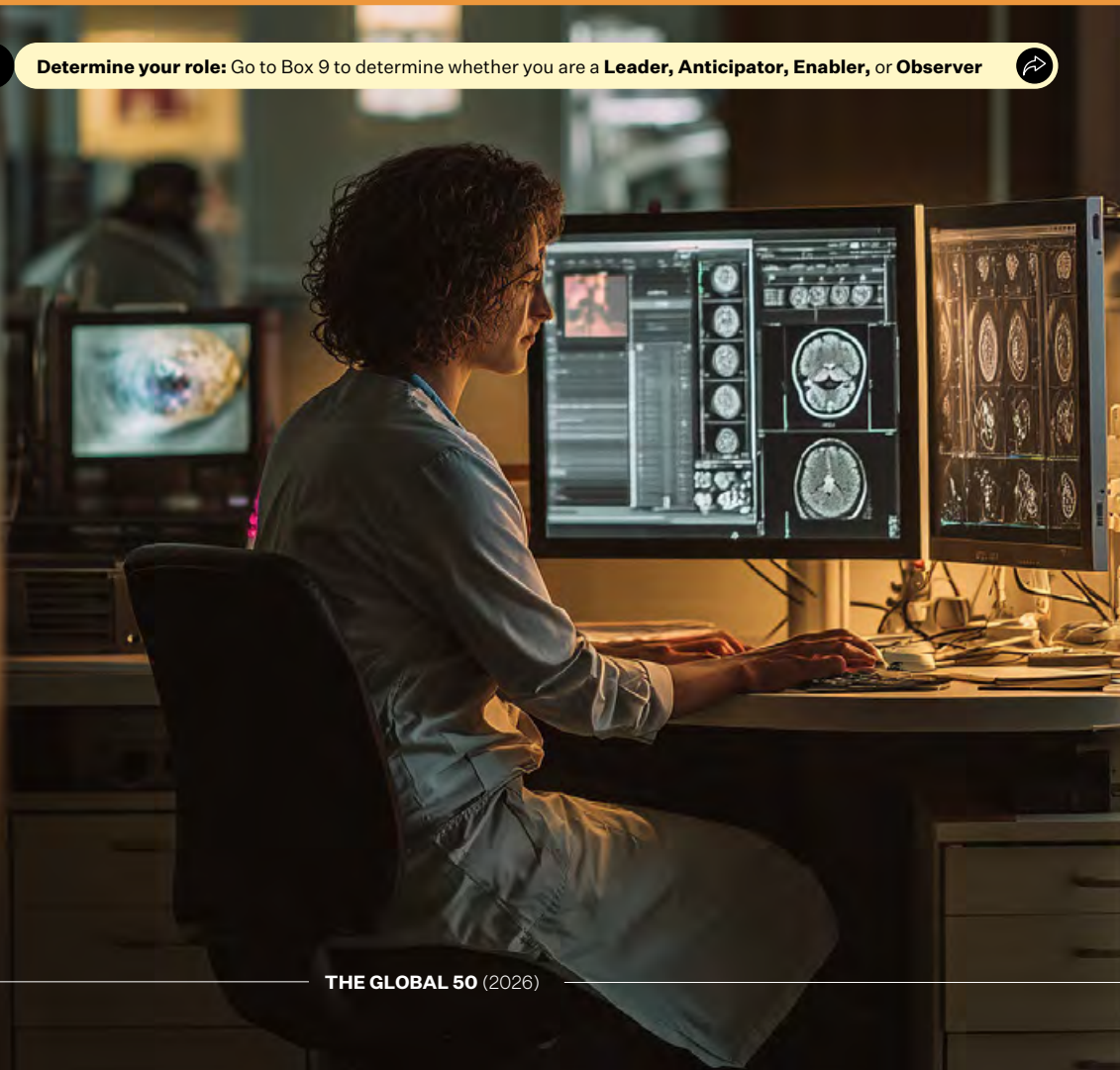


CHALLENGES

- Data privacy risks integrating sensitive imaging and genetic information cross-border
- Algorithm bias causing inconsistent AI performance
- Radiologist resistance to workforce transformation
- High costs and complexity integrating legacy systems with AI platforms
- Regulatory uncertainty around liability for AI-assisted diagnostic errors and omissions



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





14 2024

What if digital biodomes shaped eco-policies?

Virtual Nature

Digital biodomes, simulated using advanced machine intelligence, provide a basis for policies where nature conservation and restoration are a priority for the future, aligning human activities with nature's health.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Evolving Ecosystems

Uncertainties

Nature, Technology

Trends

Artificial Intelligence
ClimateTech
International Collaboration
Restoration

Technologies

AI-Simulated Ecosystems
Real-Time Analytics

Category

Nature Restored

Top Five Sectors

Agriculture & Food
Government Services
Financial Services & Investment
Infrastructure & Construction
Materials & Biotechnology

Keywords

Biodiversity
Biodome
Digital Twins
FAIR Rules
Planetary Boundaries



Why It Matters Today

Biodiversity is in sharp decline, with 48,646¹¹³⁷ species threatened with extinction – 4,646 more than was reported in the Global 50 in 2024.¹¹³⁸ In 2024 alone, we lost 67,177 km² ^S (slightly smaller than Ireland)¹¹³⁹ of primary rainforests, approximately 18 soccer fields per minute.¹¹⁴⁰ Ocean acidification has led to the declaration that seven out of the nine planetary boundaries have been breached in 2025.¹¹⁴¹ Traditional conservation often lacks the real-time data needed to experiment with policy outcomes, and using the internet of things (IoT) may be too slow to deploy for critical decisions on nature.



Benefits

A basis for environmentally sustainable decision making. A greater appreciation of nature's intrinsic and extrinsic value. Shared output data on nature and climate, aiding diverse scientific research communities.



Risks

Limited funding and flawed biome models, leading to misrepresented biological, ecological and environmental behaviours, in turn impacting on output quality and limiting updates to virtual biomes.

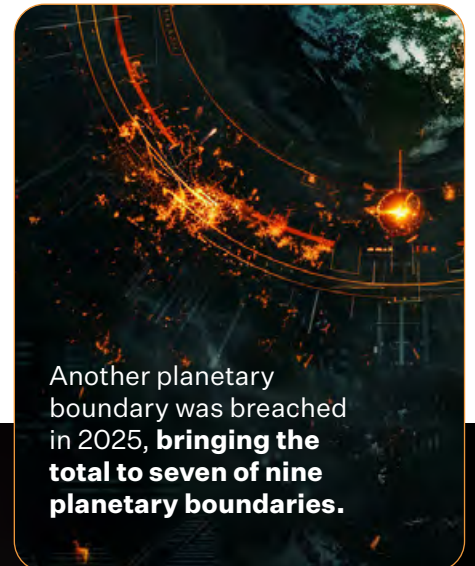
Biodiversity is in sharp decline, with

48,646 species

threatened with extinction and

67,177 km²

of primary rainforest lost in 2024 alone.



Another planetary boundary was breached in 2025, **bringing the total to seven of nine planetary boundaries.**

^S Converted from 16.6 acres



Status Today

There are several prominent physical biodomes used for research, conservation and public education, including The Green Planet in Dubai, UAE,¹¹⁴² the Montreal Biodome in Canada,¹¹⁴³ the Eden Project in the UK,¹¹⁴⁴ Gardens by the Bay in Singapore,¹¹⁴⁵ and the world's first underwater biodome – Nemo's Garden – in Italy.¹¹⁴⁶ Biodomes typically represent five major biome types: aquatic, desert, forest, grassland and tundra.¹¹⁴⁷

While virtual simulations are increasingly used in environmental science, fully operational digital twins remain rare in national policymaking and biodome management.¹¹⁴⁸ The first example of a biodome powered using digital twin technology (the Siemens Xcelerator) is in Nemo's Garden.¹¹⁴⁹ The digital twin simulates biosphere design, growing conditions, environmental impact on water bodies, and full installation environments.¹¹⁵⁰ Machine learning systems analyse real-time sensor and video data via cloud dashboards and edge computing devices, reducing reliance on manual data collection and enabling automated optimisation of biodome operations.¹¹⁵¹

The global digital twin market is projected to grow from \$21 billion in 2025 to \$150 billion by 2030, driven especially by healthcare¹¹⁵² and urban planning.¹¹⁵³ Digital twins require constant internet connectivity for IoT sensors, face data quality issues, and incur high cloud storage costs, especially in countries where connectivity is expensive and intermittent to begin with.¹¹⁵⁴ Building digital twins takes years, with ongoing maintenance costs requiring decades of investment, relying on ecologists, software developers, sociologists, and end-user involvement. Today, digital twins lack physical/virtual collaboration spaces for knowledge sharing and coordination, as a result, stakeholders must act on insights for them to be meaningful.¹¹⁵⁵

Based on some use cases,¹¹⁵⁶ key areas of focus for digital twins policy are data privacy, algorithmic ambiguity, bias, equity and lack of a legal accountability frameworks for algorithmic decisions.¹¹⁵⁷ While a code of conduct for ethical digital twin design is a start, digital twins for policy form a sandbox environment where policymakers can test interventions before implementation.¹¹⁵⁸ However, without trust, ethical frameworks, and long-term funding, even technically advanced digital twins risk failing to influence real-world policy or environmental outcomes.¹¹⁵⁹



The global **digital twin market** is projected to grow from **\$21 billion** in 2025

to **\$150 billion** by 2030



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Studio Prototype Hub

Policy sandboxes are established by a multi-stakeholder consortium to pilot localised biodomes, test assumptions, align standards and demonstrate value across sectors.

Grants

Stage-gate Grants

Challenge Prizes

Studio Scaling

A distributed network of digital biodomes connects local simulations worldwide, utilising generative synthetic data to bridge sensor gaps while aligning validation methods and governance across ecosystems and jurisdictions.

Combination Grants

Accelerator Programmes

Early-stage capital and multiple funding partners

Biodomes for Policy

International standards, open protocols and multilateral mandates enable biodomes to scale globally, embedding their outputs into policy, finance and planning systems.

Scaling Funds

Revenue-dependent Grants

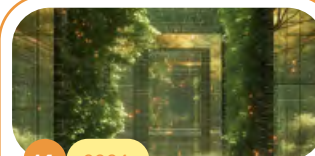
Loans

Social Impact Bonds (SIBs)

Service contract

Loans

Venture Equity Investments



14 2024

Preferable Future Global Virtual Biome Expansion

Interoperable digital biodomes operate globally, informing international biodiversity targets while guiding regionally tailored policies, investments and public narratives.

Equity Investment

Loans

What Progress looks Like

Digital biodomes offer real-time, AI-driven ecological simulations that support proactive, evidence-based policymaking. They help internalise nature's value into economic systems, visualise outcomes for public engagement, and avoid costly ecological missteps, while also shaping policy debates around the world. Measurable benefits include declining biodiversity loss and, as a plug-and-play, any government can use it to play out decisions.



NECESSARY ENABLERS

- Shared charter on digital biodomes (data privacy, algorithmic clarity, accountability)
- Alignment of ethical and legal frameworks validating simulations
- Stable and secure distributed network of digital biodomes



CHALLENGES

- Ensuring model accuracy amid ecological complexity, data limitations, avoiding model drift
- Building public trust in AI-driven, simulation-based decision making
- Bridging fiscal and economic metrics with ecological simulation outputs
- Creating effective public-facing visual tools and engaging interfaces
- Standardising biodome tools



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





27 2024

What if mobile edge computing (MEC)^T made data centres obsolete?

Zero Margin

Mobile Edge Computing (MEC) and the internet of things (IoT) merge to accelerate signal and data processing, enhancing real-time decision making and enabling seamless, latency-free digital services across various sectors so centralised data centres become obsolete.

SCOPE

Within Reach

Transitional

Visionary

New

2024

Most Significant Megatrend

Boundless Multidimensional Data

Uncertainties

Technology, Systems

Trends

Advanced Computing
Data Protection & Privacy
Edge Computing
Mobilising Innovation

Technologies

Advanced Computing
Data Protection & Privacy
Edge Computing

Category

Systems Optimised

Top Five Sectors

Communication Technologies & Systems
Cyber & Information Security
Health & Healthcare
Logistics, Shipping & Freight
Utilities

Keywords

5G/6G
Data Residency/Sovereignty
Edge AI
Edge Computing
Low Latency

^T Also commonly now known as Multi-access edge computing (MEC)



Why It Matters Today

The number of IoT devices is expected, while falling behind previous predictions,¹¹⁶⁰ to reach 39 billion by 2030 and more than 50 billion by 2035.¹¹⁶¹ While data sovereignty is the legal right for governments to regulate data within borders, data residency is the physical location where data is stored, determining the regulatory authority.¹¹⁶² Current centralised cloud models suffer from latency¹¹⁶³ and struggle to meet varying local data residency and privacy laws.¹¹⁶⁴



Benefits

Direct access to raw and processed data in real time, increasing opportunities for innovation in organisations and better day-to-day decision making for individuals. Improved data privacy and security.

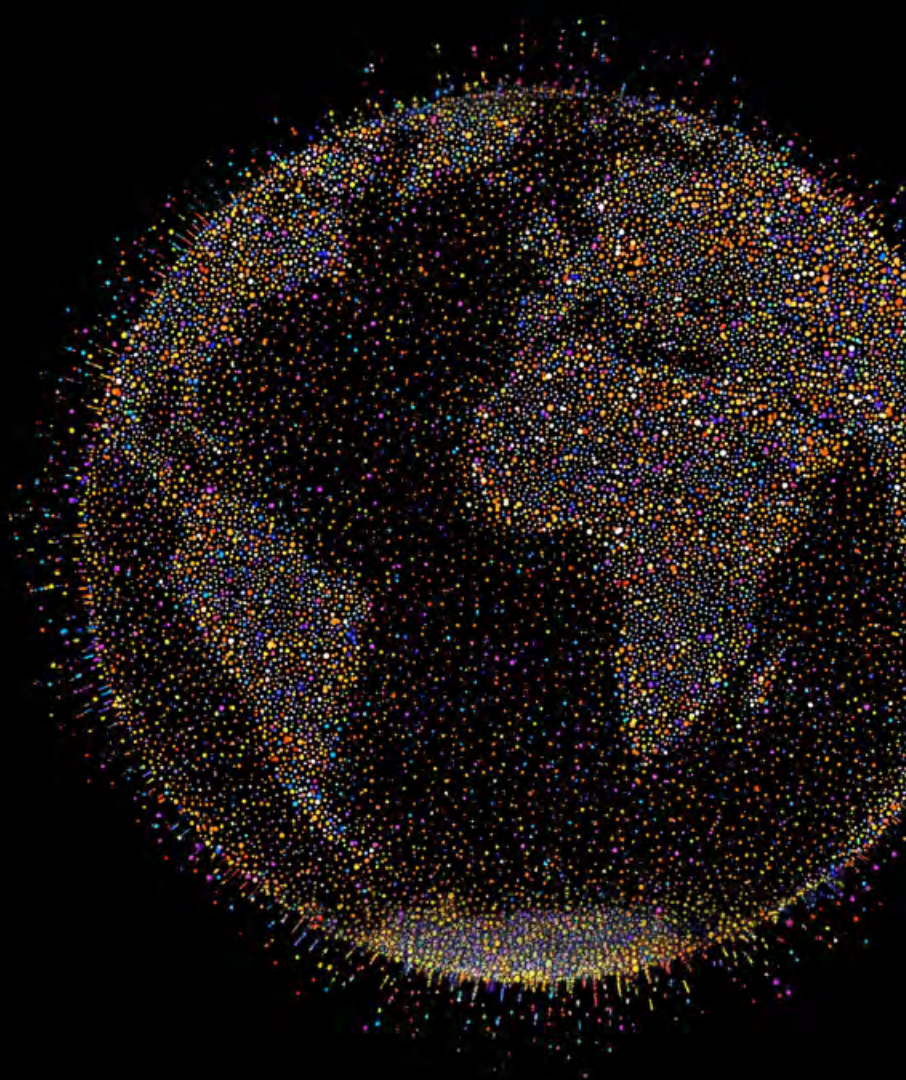


Risks

Lack of the robust physical security measures typically found in centralised data centres, making edge networks more susceptible to hacking and misuse.



The number of IoT devices is expected to reach **39 billion by 2030**





Status Today

As cross-border data flows increase globally, edge computing distributes data processing to optimise performance by addressing latency, data transfer costs, data sovereignty and security.¹¹⁶⁵ Data centre capacity needs to triple by 2030 to meet growing demand, at 22% per year between 2023 and 2030, as AI workloads require more data collection, processing and storage.¹¹⁶⁶ MEC is deployed at the edge of mobile networks or sensors with basic computing and storage.¹¹⁶⁷ Edge computing moves computer capabilities closer to where the data is generated or consumed, enabling gaming and entertainment, real-time analytics, autonomous and connected vehicles and video optimisation.¹¹⁶⁸

Real-world implementation of MEC has occurred in specific events like sports,¹¹⁶⁹ with 5G deployments enabling faster streaming, lower latency and improved stability. MEC significantly improves 5G performance versus non-MEC through route shortening and better traffic handling, proving essential for Industry 4.0 smart factory applications,¹¹⁷⁰ but scaling remains limited. Despite promises in 2018 of rapid growth, markets were not ready and use cases did not materialise at scale. Viability remains unproven after years of development.¹¹⁷¹ Edge computing saves only 1 millisecond compared to 30 to 40 milliseconds by 5G implementation more broadly and customers will not yet pay higher premiums¹¹⁷² for edge computing, despite the promise of responsiveness in under 20 milliseconds.¹¹⁷³

Nevertheless, AI may bring another hope for growth. Powering up autonomous systems, such as mobility, homes and cities more generally,¹¹⁷⁴ MEC and AI are converging into Edge AI. Edge AI can enable real-time parking detection, autonomous vehicles and energy systems, patient monitoring, traffic management, predictive maintenance and better real-time sensor data processing.¹¹⁷⁵ MEC devices with 5G/6G, neural networks and machine learning frameworks power Edge AI,¹¹⁷⁶ potentially defining the next wave of computing innovation.

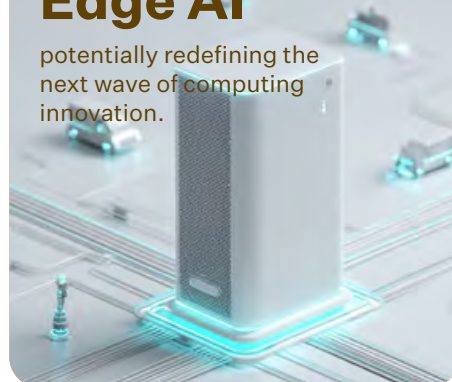


Data centre capacity needs to triple
by 2030 to meet growing demand for data capacity

MEC devices with 5G/6G neural networks and machine learning frameworks power

Edge AI

potentially redefining the next wave of computing innovation.





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Merging Edge AI

5G/6G networks and satellite internet expand coverage globally. Edge AI pilots prove technical feasibility in select sectors. Industry collaborations establish frameworks for edge computing scalability and security standards.

- Challenge Prizes
- Venture equity Investment
- Convertible Loans
- Grants
- Stage-gate Grants

Demonstrable Edge AI

Industry coalitions publish benchmarks for Edge AI (eg, transport, energy, healthcare) and governments mandate edge computing for critical infrastructure. Private sector investment matches public sector funding for deployment.

- Combination Grants
- Venture equity Investments
- Early-stage capital and multiple funding partners
- Convertible Grants

Scale

Telecommunications companies install edge nodes cell towers and satellite ground stations. Manufacturing plants replace cloud connections with on-site edge processing. Healthcare systems adopt edge AI for patient monitoring.

- Venture equity Investment
- Convertible Loans
- Service Contract
- Loans
- Scaling Funds



27 2024

Preferable Future Seamless Edge

Fully autonomous edge networks are running with AI-driven protocols, legacy centralised data centre infrastructure has been decommissioned or repurposed, and universal edge AI protocols enable real-time services.

- Service Contract
- Loans
- Scaling Funds

What Progress looks Like

Data clouds have now migrated to the periphery and the world is now connected through trillions of nodes all around us that autonomously organise and decide on computer power and need. Universal edge protocols ensure zero-latency digital services, complete data residency and total obsolescence of legacy mega-data centres.



NECESSARY ENABLERS

- AI protocols that allow nodes to autonomously split
- Cybersecurity and cyber-physical protection
- Payment capabilities and a framework for sharing computing power
- 5G/6G network capabilities and access
- Demonstrable ROI for Edge AI



CHALLENGES

- Interoperability across systems and locations
- Securing hardware that is distributed across cell towers and public spaces
- Upfront capital costs that may still exceed costs of cloud services
- Internet-connected devices with minimal power needs



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





32 2024

What if synthetic DNA met our need for indefinite and unlimited data storage?

Data Helix

Synthetic DNA chips meet humanity's increasing need for durable, large-scale data storage, by offering a solution that can preserve information indefinitely while also reducing the environmental footprint of the digital world.

SCOPE

Within Reach

Transitional

Visionary

New

2024

Most Significant Megatrend

Boundless Multidimensional Data

Uncertainties

Technology, Systems

Trends

Advanced Computing
Bioinformatics
Biotechnology
Data Protection & Privacy

Technologies

Advanced Computing
Nanotechnology
Synthetic DNA

Category

Systems Optimised

Top Five Sectors

Chemicals & Petrochemicals
Cyber & Information Security
Data science, AI & Machine Learning
Health & Healthcare
Manufacturing

Keywords

DNA Data Storage
DNA Data Storage Alliance
DNA Synthesis
Storage Networking Industry Association (SNIA)
Storage-D

Why It Matters Today

In recent years, the world has witnessed a significant increase in data generation, the majority of which is unstructured.¹¹⁷⁷ The global datasphere was expected to grow to 163 zettabytes (ZB) in 2025, from nearly 2 ZB in 2010, with 25% of data generated in real-time.¹¹⁷⁸ However, precise measurement today is a challenge, partly because much of the data are transient and do not get stored.¹¹⁷⁹ Today's magnetic, optical and mechanical storage media¹¹⁸⁰ degrade within 5 to 20 years, depending on media type and conditions,¹¹⁸¹ risking the loss of knowledge.



Benefits

Indefinite, durable storage of an unlimited amount of data in less space and without interoperability issues.



Risks

Ongoing complexity around accessing data with limited safeguards, risking inefficiencies and storage of erroneous data; interoperability issues with historical data and where nations do not use DNA storage; limitations around implementation and worsening global inequalities due to high costs.

Status Today

DNA storage encodes data (code, images, text and videos) into synthetic DNA strands using bases (labelled A, T, C and G) to represent binary content. This DNA is created in labs, stored indefinitely in vials and then sequenced back to binary when needed.¹¹⁸²

The DNA Data Storage Alliance was established in 2020 to raise awareness of the use of DNA for storage, develop standards and one day enable interoperable DNA-based storage solutions.¹¹⁸³ In 2022 it joined the Storage Networking Industry Association (SNIA), which has a membership of 200 data storage organisations.¹¹⁸⁴ DNA storage has transitioned from proof-of-concept demonstrations to early end-to-end prototypes with functional components along the entire pipeline (codec, synthesis, storage, retrieval and sequencing).¹¹⁸⁵ DNA is 300 times more durable than magnetic tape and can be stored at room temperature.¹¹⁸⁶ Multiple startups are working on synthesis, sequencing and storage.¹¹⁸⁷

Academic research centres such as the Wyss Institute at Harvard are advancing DNA storage.¹¹⁸⁸ One notable project is Storage-D, a web-based platform whose developers have used their own ‘Wukong’ patented algorithm to store COVID-19 treatment protocols (1.78 million bits total) with 100% data recovery. Storage-D has also allowed data to be encoded into genes and stored in *Escherichia coli* and genetically engineered *Halomonas bluephagenesis* – both bacteria – with 100% accurate decryption maintained over seven days of stable growth.¹¹⁸⁹ Storage-D allows users to convert any data format (text, images, audio or video) into DNA sequences and back.¹¹⁹⁰ In another example, Intelligence Advanced Research Projects Activity’s (IARPA) Molecular Information Storage (MIST) programme in 2019 – which is now closed – was a four-year programme with aims to demonstrate systems that can write 1 terabyte (TB) and read 10 TB daily using DNA storage under a cost of \$1,000 and with less than 1 kilowatt of power.¹¹⁹¹

Current challenges of DNA storage include the high cost of chemical synthesis (\$3,500 per MB¹¹⁹²) compared to traditional media and a slow writing speed (400,000 times slower than magnetic tape).¹¹⁹³ The SNIA has published DNA data stability evaluation standards, but no others are known to be in the pipeline.¹¹⁹⁴ The best applications today are in rarely read archives (where data are retained for compliance) and contexts focused on reducing the environmental impact of storage.¹¹⁹⁵



DNA is

300 times

more durable than magnetic tape and can be stored at room temperature.



Storage-D

a web-based platform whose developers have used their own ‘Wukong’ patented algorithm to store COVID-19 treatment protocols with **100% data recovery**.

Current challenges of DNA storage include the high cost of chemical synthesis

\$3,500

per MB compared to traditional media and a slow writing





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Cost Reduction

Fund laboratory programmes and field pilots to demonstrate DNA storage capabilities and recovery rates and demonstrate effectiveness.

- Challenge Prizes
- Accelerator Programs
- Grants
- Stage-gate Grants

Scaling

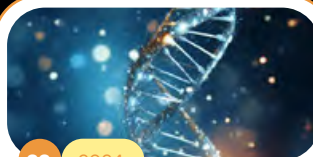
Install systems in national libraries, research institutes, and governments, as pilots for DNA-based data writing and automate vault storage.

- Service Contracts
- Combination Grants
- Convertible Grants

Standards

Achieve cost parity and comparable – if not better – reliability and durability. Enable data retrieval, adopt international operating and certification standards.

- Convertible Loans
- Venture Equity Investment
- Early-stage capital and multiple funding partners



32

2024

Preferable Future Commercial Adoption

Run large commercial, certified, DNA storage facilities worldwide, replacing tape and digital libraries, offering low-cost and long-term (potentially indefinite) preservation contracts.

- Equity Investment
- Scaling Funds
- Loans
- Service Contracts



What Progress looks Like

Humanity secures its collective knowledge against digital decay. Data centres transition from energy-intensive monoliths to carbon-neutral, compact bio-vaults. Cultural, scientific and personal legacies remain accessible for millennia, ensuring durable, low-maintenance and decentralised information preservation.



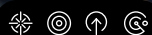
NECESSARY ENABLERS

- More efficient and cost-effective DNA synthesis
- Global interoperable standards between classical and DNA storage
- Advanced technologies for rapid, accurate data retrieval
- Scalable production of enzymes and reagents used for DNA synthesis
- Protocols for synthetic biology and ethics



CHALLENGES

- Cyberbiosecurity
- Teams skilled in DNA synthesis, storage and retrieval
- Management of different approaches (classical vs DNA storage) across borders



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





45 2024

What if machines
could self-repair?

Forever Machines

Self-repairing machines, integrating preventative maintenance, smart materials and advanced sensors, enable downtime-free manufacturing and sustainable, long-lasting consumer products and robotics.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Life with Autonomous Robots
and Automation

Uncertainties

Collaboration, Technology

Trends

Advanced Computing
Artificial Intelligence
Automation
Cross-sectoral Partnerships
New Materials

Technologies

Advanced Sensors
Self-Healing Metals & Polymers
Stretchable Electronics

Category

Transformational

Top Five Sectors

Automotive, Aerospace & Aviation
Energy, Oil, Gas & Renewables
Health & Healthcare
Logistics, Shipping & Freight
Manufacturing

Keywords

Autonomous Systems
E-waste
Humanoids
Right to Repair
Smart Materials



Why It Matters Today

Lack of repairability causes around 35 million tonnes of waste annually in the European Union,¹¹⁹⁶ of which 4.7 million tonnes is electronic waste (e-waste).¹¹⁹⁷ Globally, the issue causes up to 2.3 billion tonnes of solid municipal waste per year,¹¹⁹⁸ including 62 million tonnes of e-waste (2022), which since 2010 has been outpacing formal recycling by around five times.¹¹⁹⁹ On a larger scale, many essential systems (such as satellites¹²⁰⁰ and deep-sea cables¹²⁰¹) are challenging, dangerous or impossible for humans to reach for repairs. Finally, as robots age, they will add to the accumulation of e-waste except for parts that are recyclable or reusable. By 2050 the number of humanoid robots is expected to reach one billion, with 90% deployed in industrial and commercial spaces.¹²⁰²



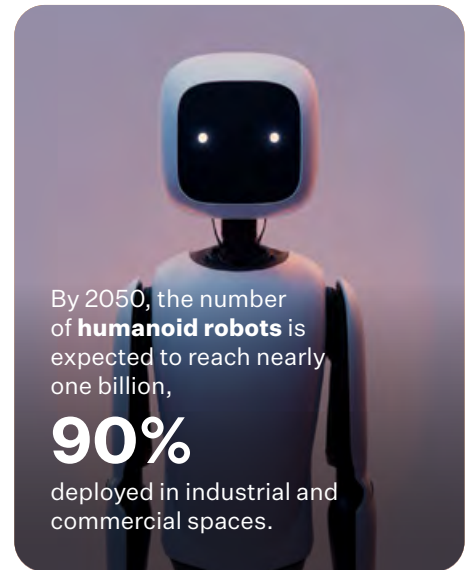
Benefits

Enhanced safety, reduced downtime, and extended machine and robot lifespans, lessening maintenance costs and improving the quality of products and service automation; opportunities for remote exploration and a near-perfect supply chain; preservation of IP-protected aspects of machines.



Risks

Inadvertent harm to users and the surrounding environment from malfunctioning self-repair mechanisms; cyber threats; increased costs and effort, and diminished benefits, from complex design.



By 2050, the number of **humanoid robots** is expected to reach nearly one billion,

90%

deployed in industrial and commercial spaces.

Globally,

2.3 Billion

tonnes of waste per year



62 million tonnes

of e-waste (2022)





Status Today

Self-healing robots are capable of preventative maintenance, autonomous healing through materials, and repairability by design without dependencies. This has significant environmental benefits: eighty percent of a robot's environmental impact is locked in during the design phase.¹²⁰³ Highly reliable robots require fewer service interventions¹²⁰⁴ and longer robot service life leads to lower replacement rates and reduced electronic waste.¹²⁰⁵

When used alongside a combination of smart sensors, the Industrial Internet of Things (IIoT), AI and digital twins, generative AI (GenAI) can rapidly transform maintenance from reactive to predictive.¹²⁰⁶ In robots, preventative maintenance can reduce unplanned downtime by up to 50%.¹²⁰⁷ GenAI can decrease unplanned downtime by up to 90% and increase robot lifespans by up to 40%.¹²⁰⁸

Biologically inspired research at the University of Nebraska–Lincoln led to the development of a soft electronic skin that can detect, isolate and autonomously repair cuts and punctures, mimicking biological healing.¹²⁰⁹ In this process, the skin senses damage through liquid metal droplets that form a temporary electrical network at the injury site while an electrical current heats the damaged area, melting and resealing the material thereby restoring its original insulating state.¹²¹⁰

Enabling many of these advances are AI and GenAI. “Self-repair” is already feasible in limited ways, such as the case of a robot tightening its own screw in 2019.¹²¹¹ However, we are still far from scalability. In the future, the possibilities may expand to include robot swarms that have the collective capacity to self-repair or repair other robots.¹²¹²

In robots,
preventative
maintenance
can **reduce**
unplanned
downtime by
up to 50%



Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day R&D

R&D embeds modular design, predictive maintenance standards and right-to-repair compliance, removing black-box hardware and locking in circularity and long-term sustainability outcomes.

- Grants
- Stage-gate Grants
- Challenge Prizes

Component Testing

Robots shift from reactive repairs to predictive maintenance using embedded sensors, digital twins, and agentic AI to manage structural stress and prevent failures.

- Service Contract
- Revenue-dependent Grants
- Convertible Grants

Deployment

Robots achieve hardware self-sufficiency through modular swapping, self-healing sensor skins, and autonomous repair decisions enabled by continuous condition monitoring and onboard intelligence.

- Service Contract
- Loans
- Equity Investment
- Convertible Loans
- Venture Equity Investment



45 2024

Preferable Future Circular Robots

Robot swarms autonomously reclaim materials, reprint components and self-heal, virtually eliminating e-waste and external supply dependence through closed-loop, biologically inspired robotic ecosystems.

- Equity Investment
- Scaling Funds
- Venture Capital Investment

What Progress looks Like

Robots behave like living ecosystems, constantly mending themselves. In manufacturing, downtime is nearly zero because machines self-repair and automatically schedule self-maintenance when needed. When repairs require more complex intervention, swarms of robots work together to repair a single unit, which signals when it needs to be removed from production or use. There is very little robotic e-waste. Designing fully repairable robots becomes a highly skilled discipline combining multiple areas of engineering, science and psychology, ultimately incorporating robots' own observations of themselves.



NECESSARY ENABLERS

- Effective GenAI and AI for preventative and real-time maintenance
- Materials that can self-heal
- Interoperable diagnostic data that can be shared across robots
- Right-to-repair mandates across jurisdictions



CHALLENGES

- Keeping the number of unrecyclable robot parts to a minimum
- Cybersecurity
- Potential for cascading failure via AI or GenAI
- Model drift causing robot maintenance to cost more than throwing the robot away



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





30 2025

What if new economic classifications unlocked progress?

Beyond Classifications

Dynamic metrics replace traditional country development and income classifications, driving greater global cooperation, more effective trade flows, and innovation aligned with shared global goals and challenges and enabling progress beyond financial aid.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Future Humanity

Uncertainties

Collaboration, Systems

Trends

Cross-sectoral Partnerships

ESG & Beyond GDP

Government Agility

International Collaboration

Open Data

Technologies

Artificial Intelligence

Distributed Ledger Technologies (DLTs)

Real-time Analytics

Category

Systems Optimised

Top Five Sectors

Data science, AI & Machine Learning

Education

Financial Services & Investment

Government Services

Professional Services

Keywords

Beyond GDP

Inclusive Growth

Least Developed Countries

Progress

Sustainable Growth



Why It Matters Today

Traditional metrics like gross domestic product (GDP) fail to capture complex, interconnected challenges such as climate change and social inequality.¹²¹³ At the same time, official development assistance is expected to drop by up to 17% in 2025 and to fall to 2020 levels by 2027.¹²¹⁴ Even when aid is provided, research suggests that its effectiveness is mixed,¹²¹⁵ particularly when major organisations such as the International Monetary Fund (IMF), World Bank, and the United Nations Development Programme do not agree on classifications for 61 out of 200 countries, i.e. one-third,¹²¹⁶ affecting eligibility for aid and creating allocation inefficiencies.¹²¹⁷



Benefits

Enhanced global cooperation;
progress beyond GDP; better resource
allocation;

accelerated progress towards shared
global goals.



Risks

Increased complexity in
international relations and aid;
difficulty achieving consensus on

new metrics; shift away from the
needs of local populations.





Status Today

Today's global classification systems, whether the United Nations list of least developed countries (LDCs), the World Bank's income tiers, or the FTSE Russell market categories, are not just classifications, they are lines that affect how each of the country's aid, development and, in some cases, even future potential, are assessed. While 44 LDCs represent 15% of the global population, they only represent less than 2% of GDP and around 1% of global trade.¹²¹⁸ In addition, when LDCs graduate, meaning they are no longer considered an LDC, they often lose critical support, including trade access and financing,¹²¹⁹ which are critical for development and well-being. Graduation does not guarantee middle-income status or eliminate development needs.¹²²⁰

Country classifications drive capital and finance flows with reinforcing effects. For example, when Greece upgrades to Developed market status in September 2026 in the FTSE Russell Quality of Markets framework,¹²²¹ developed market index-tracking funds will be required to buy Greek equities.¹²²² Also, when Nigeria was downgraded to Unclassified market status in 2023, it led to an accelerated financial outflow and investment withdrawal.¹²²³ Better classifications attract capital and enable development, while downgrades trigger downward spirals.¹²²⁴

Furthermore, these classifications often mask the reality on the ground. UN Trade and Development's Inclusive Growth Index, covering 134 countries (95% of global population, 97% of GDP), reveals that while developed economies score twice as high overall, significant variations challenge traditional boundaries.¹²²⁵ For example, Singapore's living conditions score outperforms that of most developed economies, while Chile, China, Thailand, the United Arab Emirates and Uruguay score closer to the developed median (89.3) than the Global South median (46.4).¹²²⁶ Meanwhile, developed economies generate twice the per capita waste of developing nations.¹²²⁷

Between 1987 and 2024, the number of low-income countries that the World Bank classifies decreased from 30% to 12%, while high-income countries rose from 25% to 40%.¹²²⁸ As such, classifications are not fixed and revisiting them is inevitable.¹²²⁹



While

44 LDCs

represent 15% of the global population, they only represent 2% of GDP and 1% of global trade.





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Consensus

Policymakers and researchers establish universal principles for progress beyond GDP. They build global consensus around a new classification model, shifting narratives from financial wealth alone to include broader measures of well-being.

Challenge Prizes

Grants

Model Design and Test

A global working group co-designs a flexible classification model. Early adopters test this model in diverse real-world contexts, championing uptake of new metrics to ensure practical, scalable application.

Grants

Service Contracts

Challenge Prizes

Pilots

Regional blocs begin testing the new classification model using real-time, data-driven indicators. These pilots support more responsive economic strategies, tailored to local conditions while remaining aligned with broader global challenges.

Combination Grants

Accelerator Programmes

Service Contracts



30 2025

Preferable Future New Classifications

Dynamic indicators replace static income-based classifications. Advances in technology allow international and local organisations to integrate these indicators into decision-making, improving understanding and aligning efforts around shared global goals.

Service Contract

Grants

What Progress looks Like

Transparent, adaptive classification systems enable smarter resource allocation and strategic partnerships. Dynamic metrics replace rigid income tiers, assessing countries and communities by actual capabilities and needs rather than geography. Financial support flows to specific challenges based on impact assessment. Effectiveness and resilience supersede GDP rankings. Regional economies define context-appropriate success indicators, recognising diverse strengths and unlocking sustained growth.



NECESSARY ENABLERS

- Advanced machine intelligence that tracks dynamic metrics in real time
- Cross-border and interoperable data systems
- Global agreement on multidimensional progress indicators
- Strong data privacy and sovereignty protections
- Global consensus on the need for a review of country classifications



CHALLENGES

- Managing increased complexity in international relations and aid
- Increasingly aggregated metrics obscuring local population needs
- Aligning legacy institutions (IMF, World Bank) with dynamic frameworks
- Maintaining cross-border and interoperable data systems



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





34 2025

What if patents were adaptive?

Adaptive Patent

An adaptive intellectual property (IP) system ensures equitable access to essential technologies, driving social-impact-focused innovation while enhancing transparency and supporting sustainable development for societal progress.

SCOPE

Within Reach

Transitional

Visionary

Most Significant Megatrend

Borderless World – Fluid Economies

Uncertainties

Technology, Systems

Trends

Cross-sectoral Partnerships
Ideation, IP & Entrepreneurship
International Collaboration
Mobilising Innovation
Open Data

Technologies

Advanced Computing
Artificial Intelligence

Category

Systems Optimised

Top Five Sectors

Energy, Oil, Gas & Renewables
Government Services
Health & Healthcare
Materials & Biotechnology
Professional Services

Keywords

Adaptive Licensing
Explainable IP
IP-NFTs
Patent Pledges
Public Goods

Why It Matters Today

Just under a decade ago, it was noted that nearly 97% of patents never recover their filing costs, 50% expire prematurely due to unpaid fees and less than 20% of university technology transfer offices break even.¹²³⁰ By default, patents function statically as they freeze technological solutions, granting exclusive control for up to 20 years. They can block incremental innovation and essential use in communities that need access the most – for example, for climate¹²³¹ and health.¹²³²



Benefits

Accelerated innovation; improved global societal outcomes; more equitable distribution of IP benefits.



Risks

Increased complexity in IP management; cybersecurity vulnerabilities; challenges determining fairness around the disruption of value in established industries.



Status Today

In 2024, the number of patents filed globally reached 3.7 million, up 4.9% from the previous year (the largest increase since 2018).¹²³³ China accounted for 49% – three times more than the United States.¹²³⁴ The total number of active patents around the world in 2024 was 19.7 million, a 6% increase over 2023.¹²³⁵ At the same time, the IP system is under increasing pressure from accelerating technological change (which is challenging inventorship, authorship, enforcement and the role of IP offices) and the growth of intangible assets (which is also challenging enforcement as well as IP valuation and small and medium enterprises' access to IP systems).¹²³⁶

IP is increasingly recognised as critical to supporting sustainability, climate action, pandemic preparedness, and other challenges that humanity and the planet face,¹²³⁷ including around energy, food security and financial growth that prioritises well-being.¹²³⁸ Nevertheless, IP can hinder access to essential medicines, vaccines and technologies. In 2024, 85% of all patent applications (3.7 million) were filed in China (49%), the United States (16%), Japan (8%), South Korea (7%) and Europe (5%),¹²³⁹ yet the greatest need is often found in low- and middle-income countries.¹²⁴⁰

These concerns have given rise to renewed interest in new ways of regulating IP, including voluntary mechanisms. While their legal status is uncertain, patent pledges are one example. These are used by industry as a form of public commitment that a business will not sue others for patent infringement in certain cases,¹²⁴¹ usually limited by field or time period.¹²⁴² Moderna, OpenAI and Tesla are recent examples of companies that have used patent pledges.¹²⁴³ However, the 2024 UK High Court decision in *Moderna v Pfizer* highlighted that while patent pledges are legally recognised, companies can back out of them through disclaimers.¹²⁴⁴ This may discourage their use in the future.



3.7 million

patents filed
globally in 2024

In 2024,

**85% of all patent
applications were
filed in:**

49% China

16% United States

8% Japan

7% South Korea

5% Europe





Pathway to Impact

This is one of many pathways towards a preferable (desirable) future. Speed and development will depend on funding, leadership, enablers and external conditions; therefore, no timeframes are specified.



Present Day Proof of Concept

Research institutions and IP organisations develop adaptive licensing frameworks. Proof of concept demonstrates technology access improvements in pilot sectors. Multi-stakeholder coalitions convene innovators, patent holders, development agencies and governments. Classification criteria are established.

 Challenge Prizes

 Service Contracts

 Grants

Sandboxing

Regulatory sandboxes test adaptive licensing models for medicines, climate tech and agricultural innovations. International standards define 'essential technology' classifications. Early-adopter countries establish bilateral agreements. Legal frameworks address enforcement and dispute resolution.

 Service Contracts

 Grants

Implementation

Governments implement adaptive patent frameworks nationally. Regional patent pools are established for essential technologies. AI-powered patent office systems classify applications and calculate dynamic pricing. Verification mechanisms are deployed using existing government databases.

 Service contract

 Grants

 Social Impact Bonds (SIBs)



34

2025

Preferable Future Scaling

Patent offices globally integrate AI classification systems with automatic adaptive licensing. The World Intellectual Property Organization coordinates a federated database enabling real-time verification. Technology transfer mechanisms are embedded in all patent applications for essential innovations.

 Service contract

 Social Impact Bonds (SIBs)



What Progress looks Like

Adaptive IP platforms make filing affordable and IP sharing secure. AI assesses public good potential prior to filing, adjusting patent specificity automatically as circumstances evolve (no courts are needed). Patent pledges become legally enforceable. Adaptive licensing adjusts in real time based on use cases, geography and income, accelerating technology transfer to support climate, health and food security innovations globally.



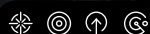
NECESSARY ENABLERS

- Regulatory harmonisation or sandbox flexibility enabling cross-border IP experimentation
- Clearly defined critical sectors with documented future innovation and access needs
- Flexible licensing models that can adjust by sector, geography and public-interest conditions
- Interoperable AI classification systems and government databases supporting adaptive licensing at scale



CHALLENGES

- Creation of user-friendly, interoperable, and explainable AI classification systems and licensing
- Resistance to adaptive and shared IP models
- Integration of adaptive IP with legacy patent offices and registries
- Maintenance of innovation incentives while expanding equitable global access



Determine your role: Go to Box 9 to determine whether you are a **Leader, Anticipator, Enabler, or Observer**





Methodology

This 2026 edition of The Global 50 takes a different approach from previous years. As opposed to introducing new opportunities, the focus was on analysing the existing Global 50 opportunities through the lens of value creation and value capture (with the exception of the opportunity – National Cognitive Potential – introduced in the Dubai Future Forum 2025).

Our approach this year consisted of three main stages: a metareview that supports the update to Our View of the Future; futures roundtables and follow-up survey with Dubai Future Foundation communities to explore and triangulate their perception of, and feelings about, global uncertainties; and deeper analysis of 50 opportunities extracted from previous editions from the perspective of value capture.

On GenAI

We continue to document our experience and approach to foresight research and generative AI (GenAI). We treat GenAI as a deliberate method within the research process, carefully selecting when and how to adopt or incorporate it within a research function. Our approach is underpinned by the aim of producing high-quality foresight research outputs as opposed to efficiency gains alone.

When considering the use of GenAI, our approach prioritises research quality: credibility through data verification, transferability through detailed contextual descriptions, dependability through consistent methodological application, and confirmability through transparent documentation.¹²⁴⁵ While large language models (LLMs) are effective analytical agents, the substantive intellectual work in this report – our approach to foresight, primary research, forming and updating Our View of the Future, identifying areas of future opportunity in the megatrends, and writing – remains grounded in human expertise.





Annual Metareview

Identify reputable global and regional organisations that publish trends- or future-oriented reports, seeking a balance across international governmental organisations, governments, academia and private sources.



Extract publications issued between August 2024 and September 2025.



Review publications for completeness, credibility and authenticity.



Analyse report contents, and extract insights and data.



Fact check, analyse and extend outputs as and where needed.

THIS YEAR

We conducted a detailed review of 52 reports from 38 publishers (out of an initial total of 185 reports from 64 publishers), including ones from the Middle East and North Africa region. Twelve of the 52 reports were co-published and were included after identifying each publisher's role, whether explicitly attributed or inferred, to ensure clarity of perspective.

We ensured that the initial report list included as many regions as possible, irrespective of quality, to establish the most comprehensive coverage possible of perspectives on the future. We used GenAI to help with the review and analysis of reports. We used one LLM model for consistency.

References (Metareview)



Futures Roundtables and Survey with Dubai Future Foundation Communities

Identify both Dubai-based and global experts and members from existing Dubai Future Foundation communities (see Acknowledgements).



Conduct in-person and virtual roundtables (under the Chatham House Rule) focusing on future growth, prosperity and well-being, seeking answers to open-ended questions such as 'Where are we today?', 'Irrespective of where the world is today, what might it look like 50 years from now?', 'What is your vision of the future?', and 'What do you hope will happen in the future?'



Identify themes from fully anonymised transcripts and extract key questions for the future, use the output to cross-validate the findings from the metareview, and review dimensions of change with selected communities.



Between 6 and 15 January 2026, survey roundtable participants alongside Global 50 experts to triangulate their perception of, and sentiments about global uncertainties.

THIS YEAR

We conducted 11 roundtables between 7 July 2025 and 20 January 2026, involving a total of 174 experts and community members. Seventy, including Global 50 experts, responded to the survey. Roundtables were conducted under the Chatham House Rule to encourage open dialogue and minimise groupthink. The approach was slightly modified for youth roundtables to ensure relatable engagement.¹²⁴⁶

We also used GenAI to help with the thematic coding and to identify common and divergent themes. We used one LLM model for consistency.



Value Capture Pillars, Backcasting and Unpacking Opportunities

Assign a value capture pillar to each of the 200 opportunities from the past four years and select 49 for deeper analysis, along with one new opportunity unveiled at the Dubai Future Forum 2025.

In selecting 49 opportunities to be detailed, focus on ones that are classified as ‘transitional’ or ‘visionary’ in scope, as they depend on key sociotechnological developments as opposed to those ‘within reach’. Each opportunity selected from previous editions of The Global 50 is systemic, impacting at least five sectors.

-  Carry out a non-exhaustive, desk-based analysis of the current status of the opportunities.
-  Imagine a four-stage backcast for the opportunity between now and the opportunity’s preferable future and identify necessary enablers and challenges.
-  Assign funding instruments based on the purpose of each high-level stage of the backcast and validate the choice of funding instruments through financial experts stress-testing instruments against sector logic, risk profile and stage-appropriate funding levels supporting a pathway that goes from early stage exploration to global scale implementation.

THIS YEAR

The breakdown of opportunities by pillar is

New Definitions of Value	11
New Markets	5
Technologies	16
Partnerships	5
Agility	13

We used GenAI to help manage bias, unpack internal consistencies (i.e. what is common across different LLMs), and improve on outputs related to necessary enablers and challenges.

We used three LLM models to add alternative perspectives and enable us to reflect more deeply on future pathways.¹²⁴⁷ In this way, we were able to see where pathways have similar enablers and challenges, strengthening the rigour of our analysis.



This research was undertaken by Dubai Future Research, the research arm of the Dubai Future Foundation. The Dubai Future Foundation produces insights and foresight reports using evidence-based analysis and imagination that enable stakeholders to anticipate and better navigate the future.

Our publications can be found at
www.dubaifuture.ae/research/



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We thank all those from around the world for their engagement in futures roundtables, the uncertainties survey and their continued support of the Dubai Future Foundation. We also wish to recognise our various communities that, with us, are shaping future growth, prosperity and well-being.

We have made every effort to ensure names and affiliations accurately reflect individuals' DFF community memberships as they stood in 2025. Any inaccuracies are unintentional.

DEEP ALUMNI (DUBAI FUTURE EXPERT PROGRAM)

DEEP is an annual programme designed and convened by the Dubai Future Foundation with a focus on developing and establishing a network of Emirati futurists in different sectors in the Dubai Government.

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The Dubai Future Fellowship is a programme that brings together a selected group of Dubai-based leaders, entrepreneurs, and representatives of international organisations across sectors, providing insights on future trends, challenges and opportunities for Dubai.

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FEEL is a four-week immersive futures leadership program designed and convened by the Dubai Future Foundation to enable future-ready mindsets through foresight, innovation, and hands-on experiences for global and local participants.

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The Global 50 is the flagship research foresight report by the Dubai Future Foundation outlining its view of the future and 50 future opportunities shaping growth, prosperity, and well-being over the next 50 years.

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The Global Futures Society is a global network convened by the Dubai Future Foundation bringing together futurists and foresight institutions to exchange insights and collaborate on future-focused opportunities.

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A Dubai Government-only network convened by the Dubai Future Foundation, meeting twice per year to share foresight insights, explore global and local signals and emerging trends and exchange best practices across government entities.

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** Participated in DFF's FEEL programme



THE KNOWLEDGE SOCIETY (TKS) STUDENTS AND ALUMNI

Across the UAE and globally, TKS (The Knowledge Society) is a 10-month innovation programme empowering high-potential teens aged 13 to 17 to build real projects and solve global challenges using emerging technologies.

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Glossary

Glossary written by the **Dubai Future Foundation**

A

Advanced Machine Intelligence

A product of algorithms, data, and processing power – including quantum computing – that enables computers to learn from data and to analyse and model vast datasets at speed in order to carry out advanced problem-solving and complex tasks.

NEW

Agentic AI

AI built on frontier models to work autonomously on specific tasks and undertake functions across platforms and applications online.

NEW

Anti-Money Laundering (AML)/Combating Financing of Terrorism (CFT)

A set of global regulations and standards that dictate best practices for countering money laundering and the financing of terrorism in financial services, covering funds, companies and markets.

NEW

Application Programming Interface (API)

A set of code that enables the automated sharing of data and specific operations from one platform or application to another, sometimes for free and sometime for a service fee.

B

NEW

Backcasting

A normative foresight method used to map a preferable future back to the present through a set of stages and/or scenarios unpacking both future pathways and conditions to make it happen.

Bacteriophages (phages)

Also referred to as phages, they are viruses that can be used to target and neutralise bacteria.

Biosensors

Sensors that are covered with, or entirely made of, biological substances that can detect changes in states, whether in air, water or land.

Bioprinting

Bioprinting is a technology where bioinks and biomaterials are 3D printed to construct natural tissue-like 3D structures.

Blackboxing

A concept in value capture related to gaining competitive advantage and extracting value by keeping some aspects about an organizational process or backend of a service hidden.

Blue water

A measure or estimate of water in lakes, rivers and groundwater.



NEW

Carbon Footprint

While there is no single method for calculating it, the carbon footprint represents the impact that an individual, organisation, community, city, country or region has on the environment based on the amount of greenhouse gases emitted from everyday work and life.

NEW

Clean Energy Systems

Energy systems that do not produce emissions (or near-zero) during operations.

NEW

Closed-loop Systems

Systems that do not have waste streams as they are recycled back into the system.

Cobots

A collaborative robot, or a cobot, is an industrial robot that can safely operate alongside humans in a shared workspace.

NEW

Cognitive Load

Framework for how the brain processes information during learning. High cognitive loads means great intellectual struggle, low cognitive loads means lower intellectual struggle.

NEW

CRISPR

Technology used to edit or program genetic sequences.

NEW

Cryptoassets

Assets that rely on cryptography; be it cryptocurrencies, NFTs, tokens, etc.

C

NEW

Direct-to-Consumer (D2C)

A way of business that refers to how a business sells direct to consumer without third-parties.

Decentralised Autonomous Organizations (DAO)

An organisation that is governed by smart contracts and not a chief executive officer or board of directors. Governance tokens are held by various stakeholders who have an interest in a particular project or the organisation and who subsequently vote on decisions.

NEW

Decentralised Science (DeSci)

Enabled by secure distributed ledger technology (DLT) and digital wallets, DeSci empowers researchers and innovators to carry out peer-to-peer intellectual property and payment exchanges.

Digital literacy

The ability to use technology in order to acquire knowledge and engage in work and life, to critically assess and interpret digital content and to protect personal information through implementing cybersecurity practices.

D

**Digital native brand (DNB) (ADJUSTED)**

Digital native brands are brands that are born and operate entirely online. While they initially do not establish a physical presence, many such companies move to a Direct-to-Consumer model with a physical retail presence. Also called native virtual company (NVC).

NEW

Digital Public-Private Partnerships (DPPPs)

Public-private partnerships that focus on developing and managing digital infrastructure, services and solutions.

NEW

Digital Reality Divide

The gap between those who have access and those who do not have access to stable connectivity, digital skills, access to 3D and 4D (immersive) environments and technologies where real-world tasks and behaviours are mimicked limiting access to learning and work opportunities.

Distributed Ledger Technology (DLT)

A distributed ledger is a database of information that is simultaneously duplicated across a network of computers in different locations. Blockchain, an example of a DLT, promises to deliver flexibility, security and efficiency in recording and retrieving information. In contrast to a centralised ledger, it is a flexible system for recording information. A distributed ledger is a decentralised database that processes, validates and records transactions that have been agreed upon by all parties involved. Validated transactions are timestamped with a unique encrypted signature. All participants on the distributed ledger can view all records.

NEW

Edge AI

Like edge computing, edge AI that operates at the edge of where data is captured.

Edge Computing

The ability to capture, analyse, store data and transmit insights as close to source as possible, enabling real-time analytics and decision-making and minimising the need for cloud storage and other centralised storage solutions.

eDNA/eRNA

Genetic material shed by organisms into surroundings ('e' stands for environmental).

NEW

Elliptic curve cryptography (ECC)

Encryption technique that uses elliptic curves as the basis of encryption and is more sophisticated than RSA cryptography methods used today and to be challenged by post-quantum cryptography (PQC).

Epigenetics

The branch of genomics research related to how internal and external factors influence – if at all – changes in gene expression without changing the DNA sequence.

E



NEW

Era of quantum shifts

Our current era, defined by the rapid, disruptive and dramatic changes that may shape the future of business, communications, culture, government, medicine, technology and other domains. In the intertwined, complex relations and interconnections that will determine how the future unfolds, the same forces can drive societies in opposite directions, and the same innovations may either enable societies to move forward or prevent them from doing so.

ESG

The concept of combining environmental, social and governance (ESG) aspects as part of organisational reporting and performance to illustrate corporate social responsibility.

NEW

exaFLOPS

One quintillion (10^{18}) floating point operations per second. A metric used to depict the exascale level of supercomputer performance.

NEW

Explainability

A feature of AI that provides information about the basis of the algorithm that is understandable the user.

NEW

FAIR principles

Findable, Accessible, Interoperable, Reusable data standards that are not an international standard but is a benchmark that data providers and analyses use as a basis.

NEW

Flavonoids

Compounds found in plants that have potential health benefits

NEW

Frontier Model

A large-scale model that is the basis of many other models or AI applications. It is frontier, because it is the most advanced and new, posing new risks.

NEW

Futures

The future is relative. A future can be preferable (desirable), which is how we frame the opportunities. A future can also be predicted – typically by funders and those who forecast and extrapolate causality. A probable future represents the most likely outcome; this is relevant when we know somebody or an organisation will take the lead on an opportunity. A plausible future is one that could occur and that we should probably be prepared for. Finally, a possible future is any outcome that could feasibly come to pass. These are all different lenses that can be used to anticipate what may happen.

NEW

Geroscience

The science of ageing.

NEW

Geroprotectors

Enzymes, drugs or therapy that prevent ageing.

F

G



NEW

Generally Recognized As Safe (GRAS)

FDA food/medicine component classification.

NEW

Green water

Measure or estimate of water found in soil.

NEW

Healthy life expectancy (HALE) at Birth

The number of years (healthspan) a person can expect to live in full health free of disease and disability.

H

NEW

Healthspan

See Healthy life expectancy (HALE) at Birth.

NEW

Horizon Scanning

A foresight method of reviewing signals, be they financial, social, technological, or any area.

NEW

Intellectual property non-fungible tokens (IP-NFTs)

Unique tokens that represent intellectual property and are secured by smart contracts and reside on a blockchain with codes and metadata that distinguish IP from one another.

I**Internet of Things (IoT)**

A concept referring to the many devices and sensors that are connected to the internet. In this way, captured data can be collected, shared and analysed for various purposes, such as health monitoring, improvement and delivery; managing smart cities; monitoring and improving manufacturing; and administering transportation.

NEW

Legacy systems

Technological systems and applications that are based on an old base of computing.

L**Large Language Model (LLM)**

A deep learning algorithm that can interpret, translate, and generate text from other text.

NEW

Material passports

Documentation that depicts all raw materials and compounds in a given product.

M

NEW

Microentrepreneurship

Entrepreneurship undertaken by individuals and small groups, often informal and operating at a very small scale.

NEW

Model Drift

When a machine learning algorithm starts to shift over time because either the model itself changes because of real-world conditions or the input data changes.



NEW

Nanoencapsulation

Method of protecting nanoparticles with a thin layer of materials to enable their movement and application in different areas.

NEW

Nanoneutraceuticals

Nanoscale vitamins and minerals used for target delivery of nutrients.

NEW

Natural Assets

These are assets that are linked to the environment, provide benefit and are naturally found on and within the earth. It could include things like trees, crops, rivers and lakes that are renewable, and also non-renewable resources like minerals, fossil fuels and geothermal energy sources.

Net Zero

Net zero refers to the state in which the amount of greenhouse gases (GHGs) emitted into the atmosphere is equal to and balanced by the amount of GHGs removed from the atmosphere.

NEW

Network effects

When a product, service or idea increases in value because more people use it within a network. An example is Uber.

NEW

Nexus Approach

An approach to managing a challenge by balancing three or more factors that involve trade-offs with each other but ensures that progress will not be restricted by focusing too much on one at the expense of the other.

Natural Language Processing (NLP)

Natural language processing is a branch of AI focused on how computers process language.

Non-fungible tokens (NFTs)

Non-fungible tokens represent real or digital assets that are secured by smart contracts and reside on a blockchain with unique codes and metadata that distinguish them from each other. NFTs can be exchanged with cryptocurrencies. Assets include animations, images, text, tweets, in-game items, tickets and others.

NEW

Nootropic

Drugs – natural or synthetic – that aim to enhance memory or concentration or other cognitive functions. Caffeine is an example of a nootropic.

NEW

Participatory backcasting

Like backcasting but involves multiple players to enhance the foresight method.

NEW

Phages

See Bacteriophages.

N**P**



NEW

Physico-chemical

Properties that are physical but induce chemical reactions in organisms.

NEW

Post-Quantum Cryptography (PQC)

Cryptography that is designed to withstand quantum algorithms and computing.

NEW

Predictive Model

A mathematical model that predicts outcomes based on a set of inputs. A predictive model can be based on any mathematical formula that represents the underlying phenomena that one intends to capture. A predictive model can also be produced from the observation of many data points and underlying patterns.

NEW

Programmable money

Money that is programmed based on a specific set of conditions.

NEW

Psychobiographies

Detailed life story analysis combining psychology and history

NEW

People with Disabilities (PWD)

People who have a partial or full physical disability that can restrict their use or access to products and services as designed.

NEW

RegTech

Regulatory technologies support the design, review and implementation of regulations.

NEW

Renewable energy systems

Energy systems that are based on renewable sources like wind, solar and waves.

NEW

Rivest–Shamir–Adleman (RSA) algorithms

Existing and long time cryptography methods used today in financial services.

R**Self-healing materials**

Self-healing materials are polymers, metals, ceramics, and their composites that, when damaged by an operational use, can fully or partially recover.

NEW

Sense-making

Foresight method used to make sense of signals picked up in the horizon scanning to understand how and if they apply to certain contexts, stakeholders or value propositions.

NEW

Shadow AI

AI used in organisations that is not licensed or approved by the organisation.

S

**Signals (Foresight)**

Events, hypes, new technologies, products and services, local and regional data and disruptions that have the potential to grow to become drivers or trends.

NEW

Soft Robots or Robotics

Robots that are designed to reach hard to reach place that are malleable.

NEW

Stablecoins

Cryptocurrencies pegged to stable assets (typically US Dollar)

NEW

Swarm Robots

Decentralised robot groups that self-organise like natural swarms (bees, fish, birds).

NEW

System of National Accounts (SNA)

A set of methods, recommendations and rules related to the calculation of national accounts covering things like imports, exports, well-being, sustainability, digital assets and others. Published by the United Nations Statistical Commission (UNSC), the recent update in 2025 marks the latest update since 2008.

NEW

Tokenisation

Process of converting assets into digital tokens by representing an asset in digital form and splitting it into parts called tokens that can be bought and sold.

NEW

Total-factor productivity

Set of productivity measures that together give an overview of productivity for an organisation, city or country. They include, but are not limited to, labor and capital.

NEW

Fourth Industrial Revolution (4IR)

Current era of technological development characterised by a set of technologies including AI and IoT, robotics and autonomous systems.

NEW

Value Capture

When a product or service and their value proposition is converted into profit in the case of the private sector, or impact in the case of the public sector, and sometimes both in the case of civil society.

NEW

Value Creation

The development and offering of new ideas, products or services that are meant to generate perceived value to users, customers or beneficiaries.

NEW

Zoonotic

Diseases that are originally found in animals and that can transfer to humans.

T

V

Z



About the Dubai Future Foundation

The Dubai Future Foundation aims to realise the vision of His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai, for the future of Dubai and consolidate its global status as a leading city of the future. In partnership with government entities, international companies, start-ups and entrepreneurs in the UAE and around the world, the Dubai Future Foundation drives joint efforts to collectively imagine, design and execute the future of Dubai.

Under the supervision and with the support of His Highness Sheikh Hamdan bin Mohammed bin Rashid Al Maktoum, Crown Prince of Dubai, Chairman of the Executive Council of Dubai and Chairman of the Board of Trustees of Dubai Future Foundation, the Dubai Future Foundation works on a three-pronged strategy: to imagine, design and execute the future. It does this through the development and launch of national and global programmes and initiatives, preparing plans and strategies for the future, issuing foresight reports and supporting innovative and qualitative projects. These contribute to positioning Dubai as a global capital for the development and adoption of the latest innovative solutions and practices to serve humanity.

The Dubai Future Foundation focuses on identifying the most prominent challenges facing cities, communities and sectors in the future and transforming them into promising growth opportunities by collecting and analysing data, studying global trends, and keeping pace with and preparing for rapid changes. It is also looking at future sectors, their integration, and the reshaping of current industries.

The Dubai Future Foundation oversees many pioneering projects and initiatives, such as the Museum of the Future, Area 2071, The Centre for the Fourth Industrial Revolution UAE, Dubai Future Accelerators, One Million Arab Coders, Dubai Future District, Dubai Future Solutions, Dubai Future Forum and Dubai Metaverse Assembly. Its many knowledge initiatives and future design centres contribute to developing specialised local talent for future requirements and empowering them with the necessary skills to contribute to the sustainable development of Dubai.



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Any Arabic translation of The Global 50 is solely for convenience. While efforts have been made to ensure accuracy, the English version shall prevail in case of any discrepancies or inconsistencies between the two translations.



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