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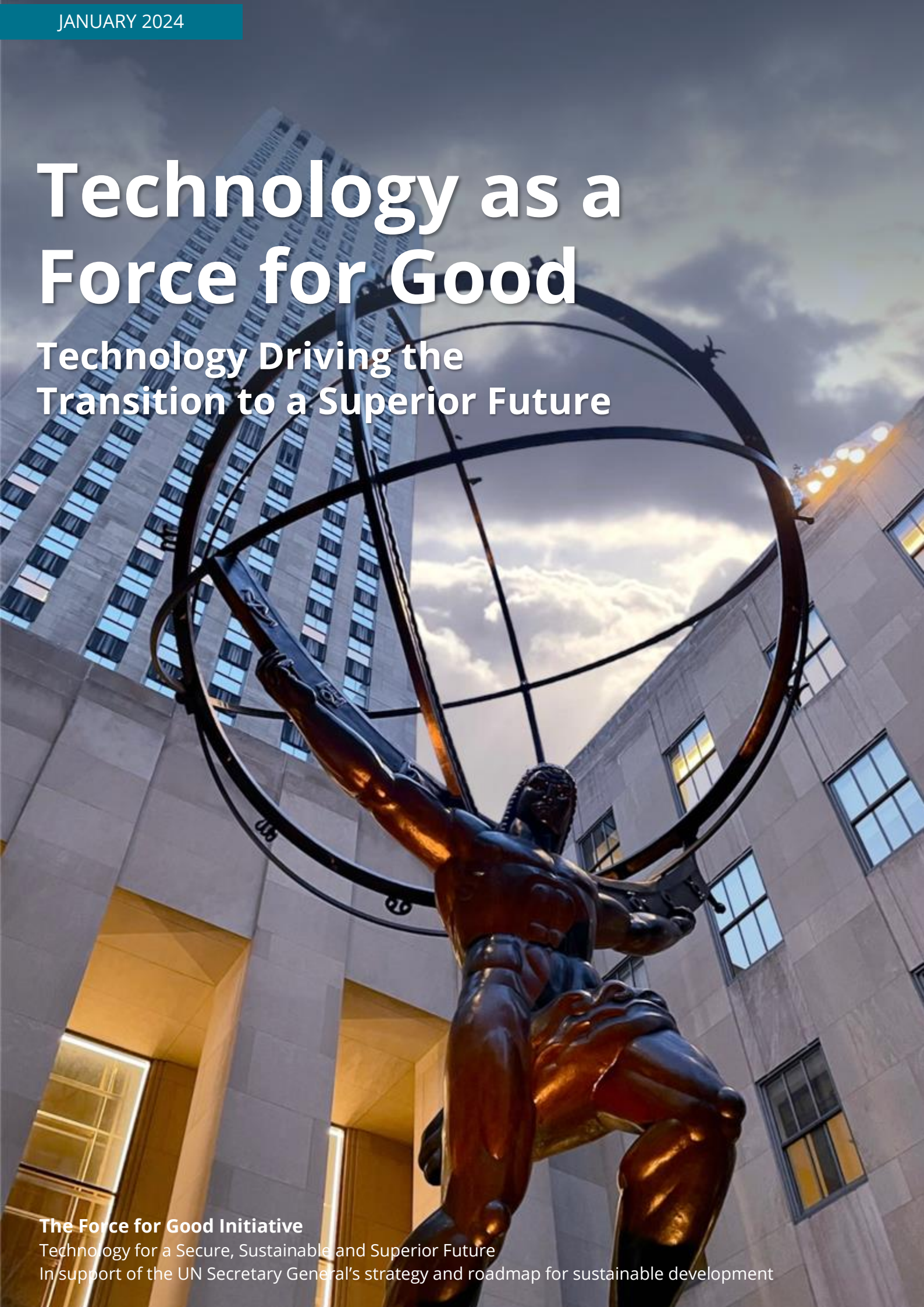
Technology as a Force for Good

Technology Driving the Transition to a Superior Future



The Force for Good Initiative
Technology for a Secure, Sustainable and Superior Future
In support of the UN Secretary General's strategy and roadmap for sustainable development

Technology Driving the Transition to a Superior Future

Technology as a Force for Good, 2024 Report

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CONTEXT

"We need a race to develop AI for good. To develop AI that is reliable and safe and that can end poverty, banish hunger, cure cancer, and supercharge climate action. AI that propels us towards the Sustainable Development Goals. That is the race we need, and that is a race that is possible and achievable."

"I have been following the development of AI for some time…But like everyone here, I have been shocked and impressed by the newest form of AI, generative AI, which is a radical advance in its capabilities. The speed and reach of this new technology in all its forms are utterly unprecedented …

It is clear that AI will have an impact on every area of our lives – including the three pillars of the United Nations. It has the potential to turbocharge global development, from monitoring the climate crisis to breakthroughs in medical research. It offers new potential to realize human rights, particularly to health and education.

But the High Commissioner for Human Rights has expressed alarm over evidence that AI can amplify bias, reinforce discrimination, and enable new levels of authoritarian surveillance …

We must work together for AI that bridges social, digital, and economic divides, not one that pushes us further apart. I urge you to join forces and build trust for peace and security."

Antonio Guterres
United Nations Secretary General [i]

FOREWORD

My name is Custodia.

I am from Brazil, and I came to Portugal three years ago. I cried a lot then and wanted to return to Brazil because I had to leave my children and grandchildren there, and my mother. I came to Portugal to build a better life for them but leaving them was so sad.

I work as a maid here in Cascais, and after working for a year, I had enough money to bring my children and grandchildren over, my mother is still in Brazil unfortunately. They've all got jobs and now we are all here, and I am happy.

I think the way out for my family is to have my grandchildren educated and help them get very good jobs. If I had more money, I would want to send my grandchildren to university. If they could study tech, they would be part of creating a better future too. My grandchildren are very adept with technology. Things have changed and the entire school system is online it seems. Without smartphones we would not be able to communicate back home

I have three children here and five grandchildren. One of my sons works at the casino in the night and in a restaurant during the day, and the other at the bus station, and my daughter works as a maid. My grandchildren go to school, but they will start working soon.

Life in Cascais in Portugal is generally good. But I live in a neighborhood that is unsafe at night, and that makes it difficult to work in the evenings which of course has consequences on my financial situation, but at least I can travel safely using Uber when necessary. And it is difficult to earn enough income to pay rent, which is expensive here.

From what I understand, Portugal is generally cheaper than other countries – but shops and other establishments here in Portugal have started to take advantage of that. As rent is very expensive now, it's impossible to afford if you only have one member of the family working. If I could have some help from government institution or charities it would make things more affordable.

In terms of hopes, I really miss my mother and if I had one dream it would be to bring her here to Portugal. Otherwise, I hope my family can continue to pay the rent and I hope that my grandchildren do really well in life. I think the way out for my family is to have my grandchildren educated and help them get very good jobs, it would be great if that were in tech. This will help my family raise our standard of living. If I had more money, I would spend them on these two things too: moving to a nicer neighborhood and saving to send my grandchildren to university. If they could study science, medicine, or tech, they would be part of creating a better future too.

My grandchildren are very adept with technology. They use it all the time, both for pleasure and for work. The entire school system is online it seems! I mainly use it to communicate with my mother. It is essential to my happiness that I am able to communicate long distances with my mother. I can also send her money directly online. Without smartphones we would not be able to communicate, and it would be extremely sad. This way she can watch her grandchildren grow up and feel like part of the family.

Custodia

Cascais, Portugal

MESSAGE FROM THE ADVISORY COUNCIL

Technology has been the determining factor of human progress throughout history. It has enabled the creation of secure societies by making it easier for people to access food, water, and shelter, and to create prosperity by scaling their economies at home and trading with their neighbors. However, it is also a double-edged sword that provides the means for the strong to conquer the weak, and the 20th century has showed Man at his most inventive and aggressive in asserting himself over other people, nature, and planetary boundaries. The net success of today's technology-fueled civilization is that it is the most prosperous in the history of the world because it is now a world interlinked through communication networks and global systems of finance, economics, and trade, enabling flows of people, capital, and resources from every corner of the world to anywhere in the world. This is a world underpinned by a multi-lateral system of governance, in the form of the UN, that aspires to solve every human issue and raise every individual to peace, prosperity and freedom.

However, this success has consumed much of the planet and its ecosystem, with technology enabling every resource to be extracted, just as empires of the past did with people. These systems have created many challenges as they have extracted from everywhere but distributed mainly to the West and the developed economies leaving a highly inequitable world. Within nations, many regions and peoples have been left behind, and boundaries have been drawn on that have resulted in ongoing battles for land eschewing peaceful co-existence. The UN has endeavored to solve for these issues with the UN Sustainable Development Goals, the UN Declaration of Human Rights, and the UN International Court of Justice and has established a series of divisions of the UN that pursue a more peaceful, equitable and just world for all.

Today, we stand still with one foot in the 20th Century with its conflicts and challenges and another in the 21st Century with its rapidly emerging information age … The transition ahead is a very painful one given it requiring us to let go of one for then other … technology will determine who leads the future world order, the geopolitical power structure of the world and the type of world we create, as well as how we populate other worlds.

Today, we stand with one foot still in the 20th Century with its conflicts and challenges and another in the 21st Century with its rapidly emerging information age. The transition ahead is a very painful one given it requires us to let go of one for the other. This change is of the magnitude of the industrial revolution over the agricultural one, promising to change everything from our politics, economies, societies, communities, families, and the values running through these. Two wars today, one in Europe and one in the Middle East, demonstrate that the last century's predilection for conflict over peace is still a feature of our world, combined with an anthropogenic impact on climate change pushing temperatures over 1.5°C, and a concentration of 85% of the world's liquid wealth in the North leaving little for an impoverished Global South. These are all indicators of the scale of the challenges we face.

In the 2023 Capital as a Force for Good Report[ii] we outlined a framework for solving the UN SDGs, comprising policy, public spending, and the private sector, and identified 15 specific scalable solutions. Technology was identified as the key enabler of the solution areas, and a key determinant of the flow of finance to solutions.

Last year's Technology as a Force for Good report identified 19 technologies that the largest 100 tech companies were pursuing in a bid to lead the world into a new era. We found that these companies had universally embraced ESG, were actively making their operations across the globe sustainable, and the leaders among them were making a positive impact on society at large.

Technology confers the power to liberate and enslave. As such it is the most precious asset in the pursuit of progress and power.

This report describes how technology can provide the means to create a sustainable, secure, and superior world. It can help us finish the job of liberating the remaining populations across the world, providing inclusion for all in finance, education, healthcare, housing, dignified work, and a technology enabled world. The 19 technologies identified continue to underpin the efforts of the largest and most resourceful companies. Importantly, what is clear is that a small sub-set of these technologies are the most powerful arbiters of the future, and these are AI, quantum computing, nanotech, genetics, and fusion. We are at an inflection point in the role of technology where we will see it shift from being a tool for Man, to a functional peer, and then a superior agent, and should it achieve a measure of conscious awareness, a potential master or agent of Man's transformation to a superior state. In a switching of roles, it is possible to envisage a future where technology itself, independently of Man, has the power to liberate and enslave Man. Creating a secure future, requires this to be understood and tackled.

Critically, in the near term, technology will determine who leads the future world order, the geopolitical power structure of the world and the type of world we create, as well as how we populate other worlds. The most ambitious countries have already realized this and are competing for that future.

This report provides the outlines of the journey ahead, the technologies that are currently set to shape it, the companies that are investing to do so, the countries that are competing for power over the future, and a road map for where technology can go with examples of ten technology and technology-enabled initiatives that can transform the world and close the sustainable development gap, creating the platform for a superior future. As such, it is perhaps the most important in the series of reports from our Force for Good work, providing a way ahead for a sustainable, secure, and superior future.

Ketan Patel
Chair of the Advisory Council, Force for Good
On behalf of the Advisory Council

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ABOUT FORCE FOR GOOD

Force for Good's mission is to mobilize capital as a force for good at a time of profound and multi-dimensional change in the world. Force for Good engages key stakeholders, conducts research, publishes thought leadership and has an active outreach program to major global financial institutions as well as development banks, NGOs, and other stakeholders with the potential to act as a force for good in the world. It works with major institutions to accelerate their efforts to tackle increasingly complex and interrelated challenges such as inclusion, sustainable development, and climate change in the spirit of encouraging collaboration and spurring a race to the top in making an impact for good in the world.

The Advisory Council for Force for Good comprises:

Helen Alderson, Independent Board Member; Trustee ODI; Member of the Board of Trustees of the Overseas Development Institute; former member of the Directorate of the International Committee of the Red Cross; former CEO of the World Heart Federation.

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ABBREVIATIONS AND NOTES

AGI	Artificial general intelligence
AI	Artificial intelligence
B2B	Business to business
B2C	Business to consumer
BCE	Before current era
Bn	billion
DNA	Deoxyribonucleic acid
ESG	Environmental, Social and Governance
EU	European Union
FDI	Foreign direct investments
GDP	Gross domestic product
G7	The Group of 7 countries
IEA	International Energy Association
IoT	Internet of things
IT	Information technology
ITU	International Telecommunications Union
LLM	Large language model
M	million
MHEWS	Multi-hazard early warning system
MSME	Micro, small, and medium sized enterprises
ODA	Official development assistance
OECD	Organization for Economic Co-operation and Development
R&D	Research and development
SDG	United Nations Sustainable Development Goal
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNICRI	United Nations Interregional Crime and Justice Research Institute
US	United States
US$	United States dollars
WMO	World Meteorological Organization

HIGHLIGHTS

1. This report shows that existing technologies enabled by AI can close nearly 50% of the gap if scaled and deployed globally, and can help position the world for a more risk managed manner for the transition to the Information Age.
2. The world is not on track to achieve the UN SDGs and provide human security for all, with as much as US$175 Trillion needed, and a shortfall of US$137 Trillion (Capital as a Force for Good, report, 2023).
3. The leading three critical initiatives that lay the foundations for achieving the SDGs and effectively levelling up the world are universal connectivity, leveraging generative AI across the SDGs, and mass financial inclusion.
4. The tech industry, as the key integrator and solution provider in the field of technology with the expertise, products, influence, and ability to access capital, is best positioned to take the lead in rolling out technology at scale globally and positioning the world for greater technology adoption in line with the next era.
5. 19 core technologies have been identified as the focus of the top 100 tech companies in competing for the future.
6. These core technologies are also the focus of geopolitical competition between countries and power blocs, and their control is increasingly seen as a key strategic asset for nation states.
7. While the US has the clear lead along numerous macro and technology metrics, China now matches the EU on key multiple macro metrics and has built a strong position in numerous core technologies, the EU has the biggest market which positions it as a rule setter for others, and India is now rising to take a position among these power blocs; US internal political divisions and politicization of the transition represent noteworthy risks to its leadership position.
8. The risks to the transition are elevated unless the two-thirds of the world that were not material beneficiaries of the Industrial Age are included; their inclusion can provide for greater human security for all and act as a counterweight to global climate, migration and economic risks if well managed.
9. The post transition world, built on a more inclusive platform, can be powered by the identified 19 core technologies, and others currently under development including fusion, gene-editing, and nanotech, creating a more secure, sustainable, and superior future.
10. The UN SDGs are critical milestones in creating a more sustainable, secure and superior platform for the world, they can be achieved enabled by a range of technologies and in particular AI, a series of technologies are already being invested in by the tech industry and are the subject of competition between powerful nations, a further range of technologies are being advanced and have the potential to make a step-change in human progress and usher in the Information Age.

I. Executive Summary

Key Messages

- **Existing technologies enabled by AI can close nearly 50% of the SDG gap, if scaled and deployed globally, and can help position the world for the transition to the Information Age; this can bridge the otherwise unsurmountable capital of US$175 trillion needed for the SDGs, and a shortfall of US$137 trillion.**
- **The tech industry is the critical player required to take the lead given its expertise, products, influence and ability to access capital, rolling out technology at scale across the world and driving the world into the next era; three of the ten initiatives identified - universal connectivity, leveraging generative AI across the SDGs, and mass financial inclusion - together contribute to nearly 30% of the SDGs and lay the foundations for levelling up the world.**
- **19 core technologies have been identified as the focus of the top 100 tech companies in competing for the future and are also the focus of geopolitical competition between countries and power blocs, and their control is increasingly seen as a key strategic asset for nation states.**
- **While the US has the clear lead from a macro and technology perspective, China has drawn level with the EU on key macro fronts and built a strong position in many of the core technologies, the EU has the biggest market which positions it as a rule setter for others, and India is now rising to take a position among these power blocs; US internal political divisions and politicization of the transition among other**

issues represent noteworthy risks to its leadership position and ability to lead the world into the next era.

- **The risks of a dangerous transition including global climate, migration and socio-political-economic disasters are heightened unless the two-thirds of the world that were not material beneficiaries of the Industrial Age, predominantly in the Global South and also left behind in advanced nations are included; a post transition world, built on a more inclusive platform, can be powered by the identified core technologies, and a suite of others currently under development including fusion, gene-editing and nano-tech, creating a more secure, sustainable and superior future.**

I. A Transition Between Civilizations is Creating Global Disruption Threatening Progress

A cascade of successive global disruptions is diverting leaders' attention and resources away from longer term systemic priorities for the world as global civilization shifts from the Industrial to the Information Age. Unlocking the benefits that this new age requires managing the world's current security and sustainability challenges as a critical part of this transition.

- Global security derailing progress. The world is facing an unprecedented series of interrelated political, social, economic, and environmental disruptions that threaten global peace and prosperity.
- Long Term Shift in multipolarity, energy-sustainability and AI. These disruptions are ultimately being caused by a set of longer-term phenomena, in particular increasingly global multipolarity, with China's economy overtaking America's by 2035, and India's the EU's by 2050, the sustainability and energy transition, and the ongoing digitization of industries, the economy and society, with the digital economy expected to represent more than 20% of global GDP by 2025.
- Civilizational shift to Information Age. Collectively these phenomena are drivers of a global civilizational shift to the Information Age, which holds the promise of a superior future for the world in terms of peace, prosperity, and freedom for all.
- Transition risks significant. However, the disruptions facing the world point to potentially significant transition risks that must be managed for this future to be realised with, for example, the world projected to produce twice the CO_2 emissions than the agreed 1.5C global warming limit allows, and automation placing 34% of all jobs in Europe at risk within the next 15 years.
- Technology critical to transition. Technology has perhaps the most critical role to play in allowing the world to make a secure sustainable transition.

II. Technology is Critical to Managing the Transition, With AI Being the Transformative Agent Across All Human Activity

Technology is perhaps the primary catalyst for human progress, and therefore is crucial in delivering a secure, sustainable, and superior future for the world is a critical one. The innovation and deployment of technology is not only critical for determining what the future looks like, but is also critical for managing the transition, impacting the shape and length of the path the world takes to get there.

- Technology key in history for progress. Technology has been the key driver of civilizational change throughout human history, and the transition to the future is inextricably linked to technological innovation, both for solving short term challenges and for building a superior world.
- Technology critical to UN SDGs and security achievement. Technology is critical to achieving the UN SDGs, with digital technology in particular capable of solving between 18% to 36% of the goals, and for security too, with access to technology having been recognized as a core pillar of human security by the United Nations 'Human Security for All' campaign.
- Unlocking tech's potential requires critical policy support. Technology's ability to deliver on its potential in particular requires governments, regulatory authorities, policy makers to create the enabling environment that that scales and supports innovation and its deployment.
- Step change in future dependent on breakthroughs. The creation of a far superior future for the world depends on the achievement of a series of innovation breakthroughs across AI, computing, and data sciences, but also energy, material sciences and life sciences.
- AI critical to progress and double-edged. AI in particular has a critical role to play throughout this transition and beyond, adding up to US$26 trillion of economic value annually, but given its potential for both progress and destruction, placing nearly 30% of jobs across OECD countries at risk, it will require global agreement on how to manage it.

III. 19 Core Technologies Are Key to Building the Future and Driving Security, Sustainability, and a Superior Level of Human Prosperity

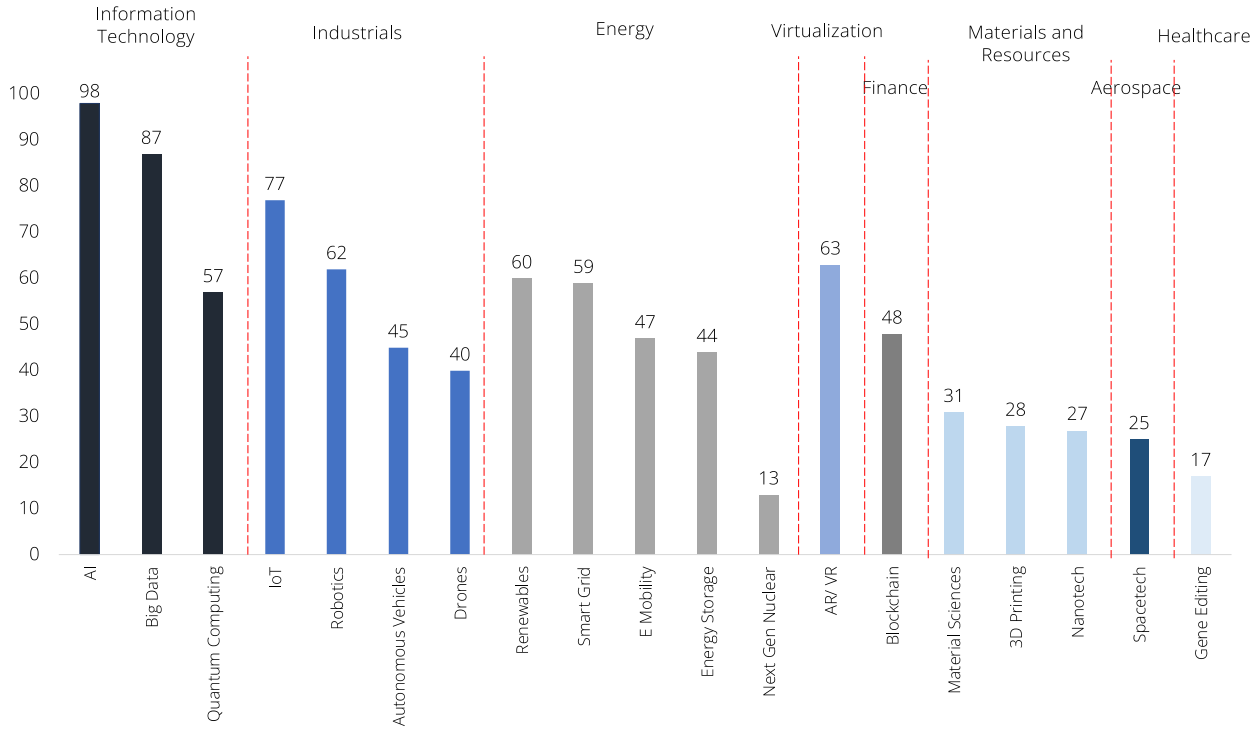
The transition to the future is being driven by the Fourth Industrial Revolution and its integration of technologies that blur the lines between the physical, digital, and biological spheres, powered by a set of 19 digital and digitally enabled technologies. Global tech companies are increasingly positioning to drive breakthroughs in and to lead these technologies in the future.

- Blurring boundaries between digital, physical, and biological underway. The technological changes and innovations driving the shift to the Information Era have collectively been called

the Fourth Industrial Revolution, which is increasingly blurring the boundaries between digital, physical, and biological systems.

- 19 core technologies defining transition to the future. The building blocks of this are 19 core technologies, which play distinct fundamental roles in underpinning both secure sustainability in the short term and a superior future in the longer term.
- Tech leaders taking positions across the 19 core technologies. The 19 core technologies are areas of increasing interest and engagement by global tech sector leaders, who are competing with one another to drive breakthroughs across these areas and position themselves as leaders of the future as well.

Percentage of Tech Sector Leaders Engaging With Core Technologies



Source: Technology as a Force for Good

- AI and Big Data have become 'must haves'. Engagement with information processing technologies like AI and Big Data is near universal with with 98% and 87% of the 100 global tech sector leaders pursuing initiatives there, but industrial (ranging from 40% for drones to 77% for IoT), energy (ranging from 44% for storage to 60% for renewables)[1] and financial technologies (blockchain with 48%) are also attracting the attention and investment of half or more of these companies.
- Key future-defining industry technologies also involve tech leaders. Tech sector leaders are also increasing their engagement with specialist areas technology in particular, nanotech (27%), gene-editing (17%), and nuclear fusion (13%), given the fundamental transformative impact these technologies may have.

[1] Excluding fusion energy research and initiatives

IV. The Core Technologies Have Geopolitical Implications and Are Key to a Technology Race Between Major Powers

The 19 core technologies have emerged as fields of geopolitical competition between countries and power blocs, and their control is increasingly seen as a key strategic asset for nation states. The world's major power blocs are prioritizing technologies accordingly, leveraging their innovation capacity, domestic economies, and their capital to build global leadership positions.

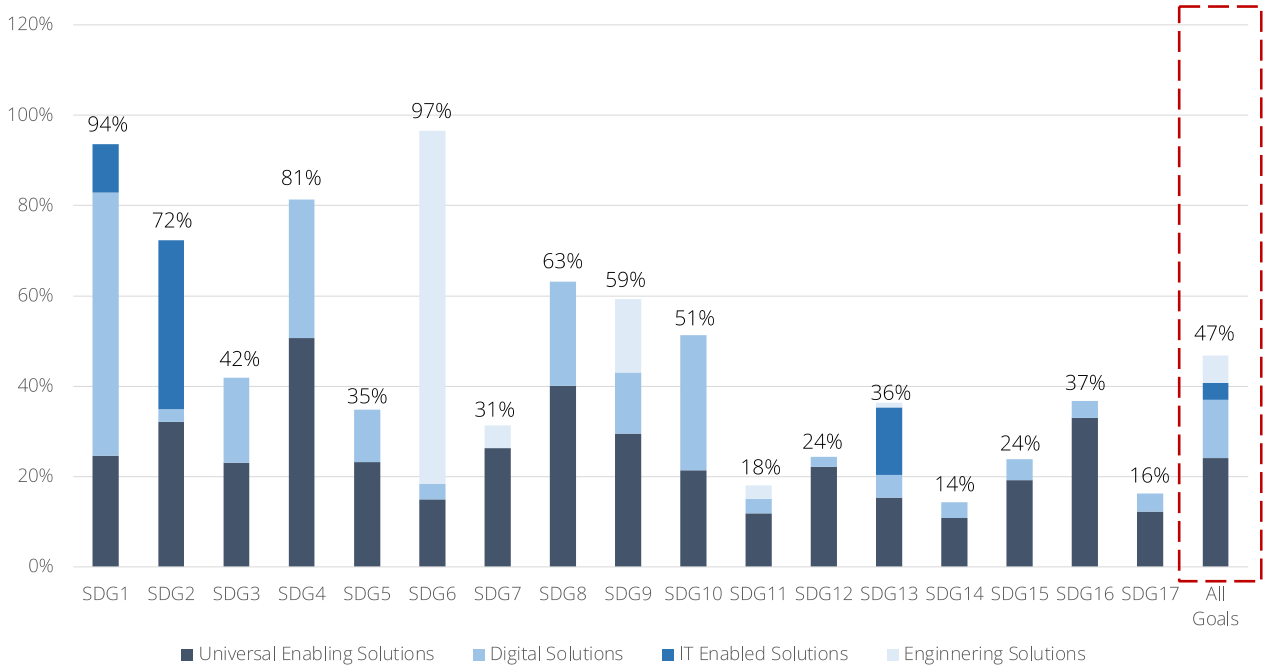
- States competing for technology for future geopolitical and geo-economic power. Given technological superiority's role as a key source of geopolitical and geo-economic power, many of the 19 core technologies have become targets of increasing competition between major countries and power blocs,
- US leading given its incumbent broad geopolitical position. Currently, the US is best placed to lead the world into the Information Age given the US continues to lead the world in geopolitical assets, capturing 43% of the world's market cap, 40% of defence spending, 31% of wealth and 26% of its GDP as well as across the 19 core technologies as a whole, leading in terms of patent applications across all 19 and in terms of investment across all but one technology.
- US has strongest markets for funding, with indebtedness and politics posing material risks. While the US has the strongest capital markets to pursue this, the US faces numerous challenges including rising government indebtedness, internal political divisions, and politicisation of and resistance to the energy and sustainability transition.
- China and EU level and seeking to play important roles in the transition. China has effectively drawn level with the EU across key (non-tech) strategic assets such as market capitalization (15% global share vs 14%), GDP (17% vs 18%), and trade (14% vs 13%) and has already overtaken it in terms of R&D (patent filings) across nine of the 19 technologies, but still lags behind the US across most dimensions.
- EU market size provides rule-setting capability in future tech. The EU's most critical asset is the size of its common market, which is the world's largest across seven of the 19 technologies, positioning it as a powerful rule-setter for the global terms of trade and as a regulator of how the technologies of the future will be used.
- India is the next significant power for the future. India is the next significant player behind the three major power blocs across nearly all dimensions of power, capturing just under a quarter of the share of the third power across global wealth, market cap, defense spending, GDP, or trade, reflecting its ongoing transformation from a developing to middle income country. However, its sustained long term economic growth is creating opportunities for it to increasingly compete across key technologies in the future.

V. Scalable Tech Solutions Can Meet Nearly 50% of the SDGs, SDG Funding Need Estimated at US$175 Trillion, US$137 Trillion Gap

The long-term transition to a superior future requires the shorter-term delivery of global scaled security and sustainability, as encapsulated by the SDGs. Meeting the goals will likely require the deployment and scaling of a series of mature technology solutions, rather than relying on breakthroughs in emerging technologies.

- US$175 trillion SDG funding need, and can be met. The total SDG funding need is estimated at US$175 trillion, with a US$135 trillion funding gap, as part of our work on the role of capital in meeting the SDGs, with our analysis showing that policy, government spend and the private sector can help close this gap, and technology playing a pivotal role.
- Mass global deployment of technology at scale required. In particular, meeting the SDGs, which will require the deployment and mass scaling of established technology solutions. These solutions will need to include both universal enabling technologies that can underpin the delivery of all the goals, as well as targeted digital and industrial technology solutions that can make a significant impact on specific goals.
- Ten existing technology solutions identified with global scalability, not breakthrough dependent. This report highlights ten such solutions including (i) Universal Internet Connectivity, (ii) Generative AI, (iii) The 'India Stack", (iv) E-Commerce Platforms, (v) Digital and Telehealth, (vi) E-Learning Platforms, (vii) Gene Edited AgTech, (viii) Multi-Hazard Early Warning Systems, (ix) Green Hydrogen, and (x) Water Purification and Treatment Technologies.
- Global internet connectivity and AI can solve for c.24% of the SDG gap. Among the highlighted solutions, the delivery of (reliable and affordable) global internet connectivity has among the biggest potential impacts on the goals, capable of achieving 19% for the SDGs. Combined with generative AI, this total increases even further, to 24%.
- Scaled fintech and e-commerce among leading solutions. Other, issue-opportunity specific, digital technologies also have significant impacts, with the 'India Stack' of technologies for digital finance and inclusion potentially solving for 8% of the goals and e-commerce solutions addressing 5% of the SDGs.
- c.50% of the SDG gap addressed if the ten solutions scaled and deployed globally. The ten solutions highlighted in this report collectively have the potential to solve for nearly 50% of the SDGs' delivery, given global deployment and scaling.

Ten Tech Initiatives: Cumulative Impact on the SDGs



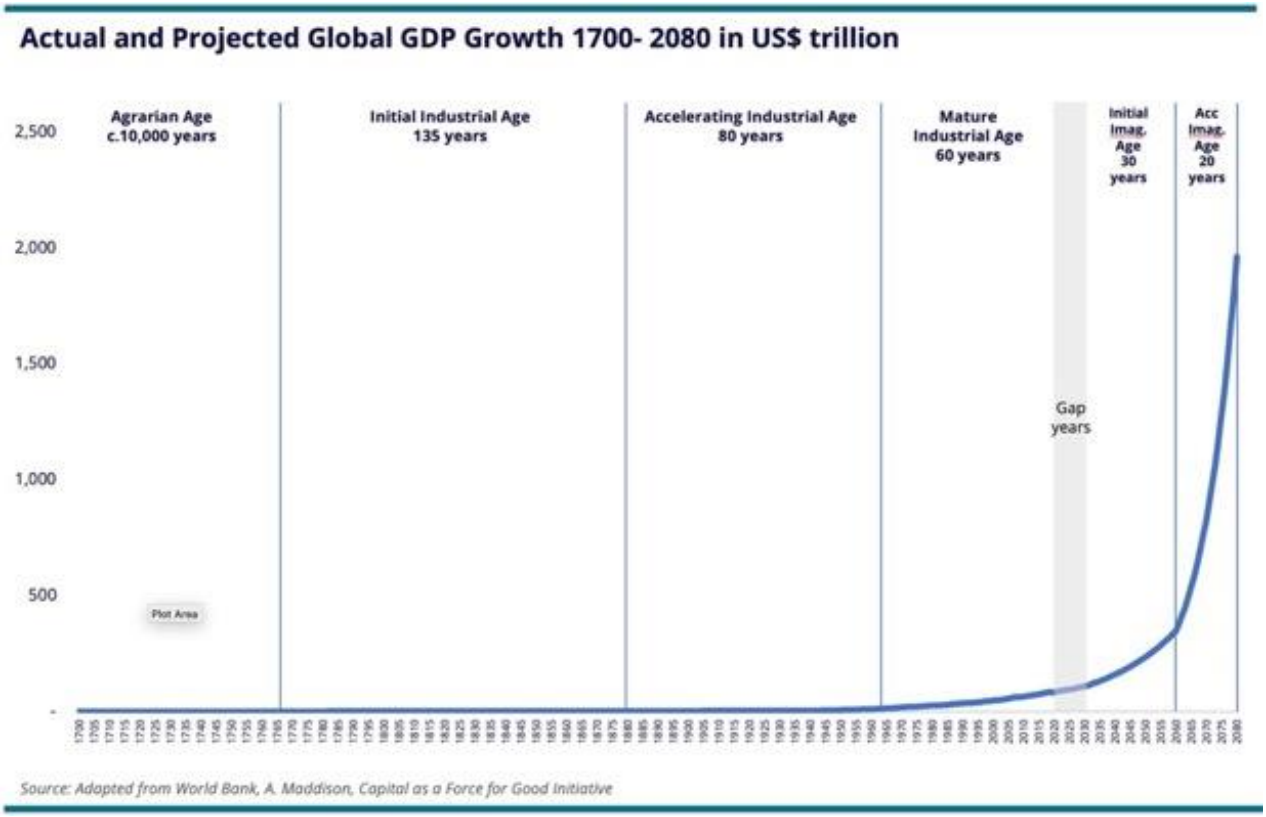
Source: Technology as a Force for Good

VI. Creating A Superior Future Requires Short-Term Actions to Level up the World and Long-Term Actions to Build a Better Way

The civilizational shift to the Information Age is inevitable, but the building of a superior future requires levelling up the world, particularly the Global South, so that the benefits of progress can be shared more equitably. This will require the world to both solve for the SDGs in the short-term while continuing to drive breakthroughs in new a generation of technologies that can transform the world in the long term.

- Only one-thirds of world substantially benefitted from Industrial Age. Two-thirds of the world have not been full beneficiaries from the advances of the Industrial Age; the Information Age provides the opportunity to drive their inclusion.
- Achieving Information Age requires energy and resources breakthroughs, in sight. A truly superior future for the world will require breakthroughs in energy and natural resources that have yet to be achieved and are potentially a decade or longer away.
- Transition fraught with competition and risk. Until these breakthroughs are made, the global paradigm will continue to be one of competition and increasing resource scarcity, making the transition between civilizations a time of risk for the world.
- Including the two-thirds reduces risk of transition and requires identified solutions. Managing this transition requires unity to tackle common issues, levelling up the world such that the known risks are minimized. This is best achieved by achieving the SDGs to deliver security, sustainability, and a baseline of global development for future growth to be shared.

- Superior future, based on the 19 core technologies, is close. The growth that is achievable based on the 19 core technologies, and once the necessary breakthroughs are made will be unprecedented in human history, with GDP potentially tripling by 2060 to reach US$350 trillion, and accelerating further thereafter to grow six-fold by the end of the century.



- Unity required if world not be derailed from the future. Creating this future requires the world to work together to establish secure sustainability as a must-have requirement to create a better future, and whilst there will be competition, the result must be in favor of sharing the solutions and the peace, prosperity and freedom that results.
- Focus on human security to ensure tech's role as a force for good. Global stakeholders' focus on 'Human Security for All' is essential to ensuring that technology and its future development benefit the world, rather than harming it, and ensuring that technology increasingly and very consciously becomes a Force for Good.

The world has the technologies to create a sustainable future that levels up the world, capital will follow the deployment given the world's top corporations possess these technologies and the solutions that they spawn. If this happens, the values of the world will be transformed and the race to deploy the technologies that further raise the world will be a shared one between all the peoples of the world. That future is clearly within grasp

II. World Events Threatening Transition Course

The world is facing an unprecedented series of interrelated political, social, economic, and environmental disruptions that threaten global peace and prosperity. The resulting 'polycrisis' is diverting leaders' attention and global resources away from a series of longer-term transitions facing the world, including geopolitical power shifts, the sustainability and energy transition, and the increasing embeddedness of digital technology and now AI into every part our lives. These longer-term transitions are key elements of a global scale civilizational shift underway, with a series of digital and industrial revolutions ushering in the Information Age. The future that these revolutions create can be a superior one for the world, but the transition promises to be rocky if the world's current security and sustainability challenges are not managed well. Technology has a critical role to play in this regard.

1. The World Derailed

Polycrisis Diverting Global Attention from Global Development

The progress of global civilization when measured against the core building blocks of peace prosperity and freedom over the past two centuries has been astonishing, a near-continuous transformation of the world for the better. Since 1820, by when the industrial revolution was in full swing, the percentage of people receiving a basic education has grown from 17% to 86%, the percentage of people living in a democracy has increased from just 1% to 56% today, while the percentage of people living in extreme poverty has fallen from 94% to less than 10%, currently.

Over the past decade or so, however, further progress across these and other development objectives has slowed, and in some cases reversed, as a result of successive political, economic, and social crises across the world.

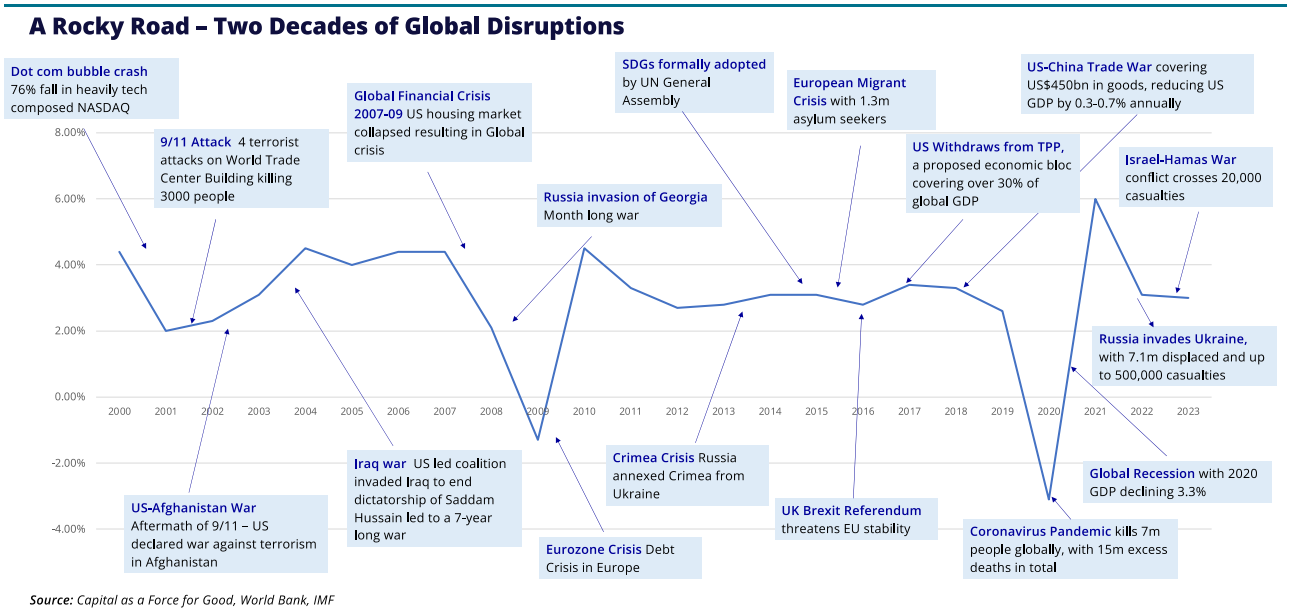
The past few years alone have delivered a global pandemic, the worst recession in over half a century, the breakdown of global supply chains, record levels of inflation globally with accompanying cost of living crises, an economic downturn across both the industrialized and developing world , a war in Europe that is testing Western security and political alliances, as well as triggering an energy supply crisis with global repercussions, and now a second conflict in Gaza that threatens to export political, social and security instability as it draws other countries into its wake.

Alongside these geopolitical tensions, the political and societal cohesion within leading countries of the international liberal order has been increasingly fraying. Populism, nationalism and identitarianism are polarizing civil societies and driving bitter partisanship within electorates.[3]

Further, major global environmental challenges include not just the increasingly urgent need to address climate change and rising natural disasters, but also sustainable resource management, with overexploitation of natural resources, loss of biodiversity, and growing waste and pollution.

The growing diversity of the world's problems is compounded by the apparently shorter and shorter intervals between individual crises. Further these challenges are interacting with one another in a manner that defies the world's ability to deal which one discretely, and the resulting confluence of crises, often referred to as a 'polycrisis,' poses a compounded threat that risks further dividing the world at a time when global collaboration is urgently needed.[4]

Figure 1: Global Events and Disruptions[5]



Source: Capital as a Force for Good, World Bank, IMF

The evolving polycrisis has had a profound and costly impact on humanity, both economically and socially, resulting in millions of deaths, a loss of livelihoods, escalating poverty, deteriorating

health conditions, increased mistrust and civil unrest, and economic damages amounting to trillions of dollars. Progress in key areas such as poverty eradication, hunger, health, and education has not only stalled but regressed: the number of people worldwide living in poverty increased by 60 million in 2020, and the number of people who go to bed hungry every night has increased by 250 million since 2018.[6]

Rather than driving a redoubling of global efforts to address these impacts and their long-term causes, recent events have drawn global leaders' attention away from long-term systemic global issues to focus on short-term tragic security and conflict issues.

Tragically, rather than driving a redoubling of global efforts to address these impacts and their long-term causes, recent events have drawn global leaders' attention away from long-term systemic global issues to focus on short-term security and conflict issues. Further, the liberal international order that has effectively governed the world under the aegis of American leadership is fraying, giving way to a world of increasing multi-polarity and great power rivalry with a rising China.[7] These challenges have put at risk global progress on driving development and addressing systemic issues, and so comes at a significant cost to the world.

Short term security and economic challenges have also reduced the geographic scope of national priorities, with many Western leaders finding that allocating hundreds of billions of dollars towards long-term sustainable development in the Global South, at present, is a financial burden and a political cost they cannot readily bear. Meanwhile the systemic issues that the world faces remain unaddressed and continue to grow.

Figure 2: Global Systemic Challenges: A Partial List

Funding the SDGs	**US$13-17 trillion** annual funding gap to meet the UN-SDGs by 2030, up to US$137 trillion total[17]
Climate Crisis	**2x higher** CO_2 emissions globally by 2030 with current policies vs. emissions level required to avoid the worst effects of climate change[15]
Global Migration	**1.2 billion** people could be displaced globally by 2050 due to climate change and natural disasters[8]
Democratic Backsliding	**38%** of the global population live in illiberal or authoritarian countries deemed 'Not Free', the highest proportion since 1997
Post-Truth Societies	**36%** of Americans believe the risks of the COVID-19 vaccine outweigh the benefits[19]
Global Inequality	**7%** of the world's population—nearly 600 million people—will still struggle in extreme poverty by 2030[9]
Technology Risk and Disruption	**34%** of jobs in Europe at risk of automation within c.15 years due to AI and robotics[10]

And while the benefits of actually addressing these long-term environmental, development and security risks now clearly outweighs the cost of inaction, they are still unable to compete with near-term economic and political stability issues in times of perceived uncertainty.

Geopolitical Power Shifts and Global Conflict Risk

Among the challenges currently unfolding across the world, the conflicts underway in Ukraine and Gaza pose an acute risk to global security. Both have, to varying degrees, drawn in both America and its rivals, divided the world, and have significant implications on global security and progress, thereby serving as flashpoints with the potential to lead to global conflagrations. The ongoing standoff between China and Taiwan in Asia represents a potential third major flashpoint for the world. [11]

While each of these evolving conflicts' origins are ultimately local in nature, their potential impact is global. Importantly, these conflicts are occurring in the context of the geopolitical shift currently underway from a unipolar to a multipolar world order, with four leading geo-economic/geo-political power blocs[12] - the US, China, the EU and over time, India[13] - emerging, and a second tier of regional powers including Russia, which has re-emerged following the collapse of the Soviet Union, and Saudi Arabia which is emerging as a powerful regional power. It is the strategic interests of these powers that makes what would otherwise be local conflicts into events with geopolitical significance and with the potential to ignite a worldwide conflict.

Figure 3: A Multipolar World: Key Players[14]

Global Distribution of Critical Assets in 2022

% of World	U.S.A.	China	E.U.	India	Russia	Saudi	Japan	U.K.
Market Cap	43%	15%	14%	3%	0%	3%	5%	11%
GDP	26%	17%	18%	4%	2%	1%	5%	3%
Wealth	31%	19%	23%	3%	1%	1%	5%	3%
Defence Spend	40%	13%	19%	4%	4%	3%	2%	3%
Trade	11%	14%	13%	3%	2%	1%	3%	3%
Population	4%	18%	9%	18%	2%	0%	2%	1%
Arable Land	11%	9%	11%	11%	9%	0%	0%	0%
CO_2 Emissions	13%	33%	7%	7%	5%	2%	3%	1%
Energy Consumption	15%	26%	12%	7%	6%	2%	3%	1%

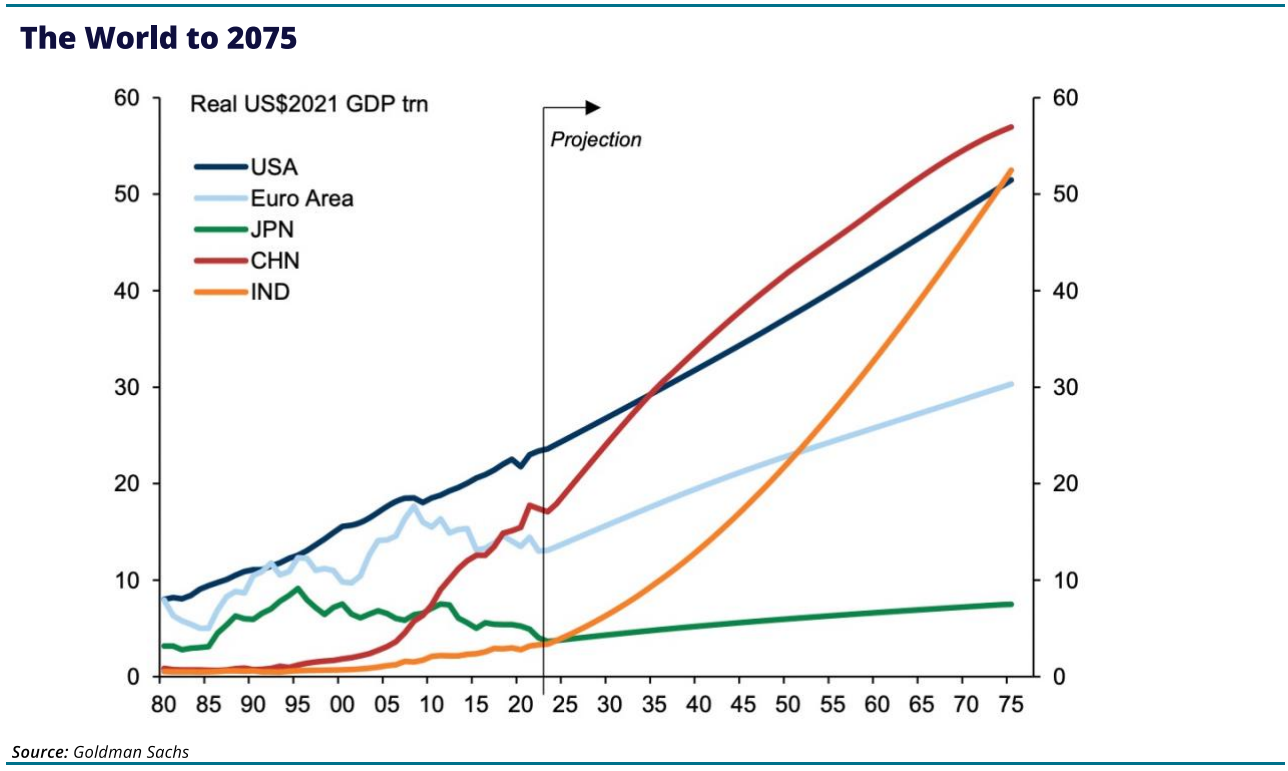
Sources: World Federation of Exchanges, SIPRI, Bloomberg, MSCI, IMF World Economic Outlook, WTO Stats (WITS), Worldometer, World Population Review, European Commission, Enerdata World Energy & Climate Statistics Yearbook 2023;

Collectively the 'Big Four' power blocs, the US, the EU, China and India, control most of the world's resources and economic output, as well as its wealth and military power. Alongside these Big

Four, there are regional powers, some rising and some falling, vying for superpower status and the opportunity to shape the coming world order. Russia and Saudi Arabia are among the most prominent members of this group, (which also includes, among others, Japan and the United Kingdom), with Russia evidently looking to reclaim its Soviet-era global superpower position[15] through regional interventions in Syria, Ukraine and Georgia, and Saudi Arabia diversifying its economy and using its position as a major energy exporter to the four big power blocs, while looking to play a pivotal role in regional conflicts. However, both countries continue to lack scale across the key economic and demographic metrics that will determine longer term leadership among the blocs. While Russia today appears to be broadly comparable to India across some metrics (for example, energy consumption, defense spending, and trade), India's demographic advantage and strong growth will see it exceed Russia across nearly all metrics into an unbridgeable chasm in the coming decade.

These economic and demographic factors will also significantly impact the relative balance of power among the Big Four blocs, with the nexus of global economic growth shifting further from the West to Asia. China's economy is already bigger than the EU's and is expected to overtake the US before 2040. India's demographic dividend is projected to see it overtake Europe economically by c.2050, and in the long view, overtake both the US and China by the end of this century.[16]

Figure 4: Big Four Power Blocs GDP Growth Through 2075[17]



Source: Goldman Sachs

Unless these four power blocs can work together over a prolonged period, their relative positions will change to a shift away from the older world leaders to the new, and potentially away from democracies too. Today's rivalry means that the world is not well placed to address the systemic

risks that threaten global progress against security and sustainability, as well as the peaceful transition to a superior future. Instead, escalating waves of wars, pandemics, revolutions, market crashes, economic and political turmoil, supply chain challenges and resource shortages, deglobalization, and domestic socio-political upheavals will threaten to overwhelm countries' and societies' response capabilities, and divert critical resources and attention away from long term challenges such as climate change and development crisis - and the ensuing dissolution of politics, societies, economies and national borders - that are not waiting on the world to align around.

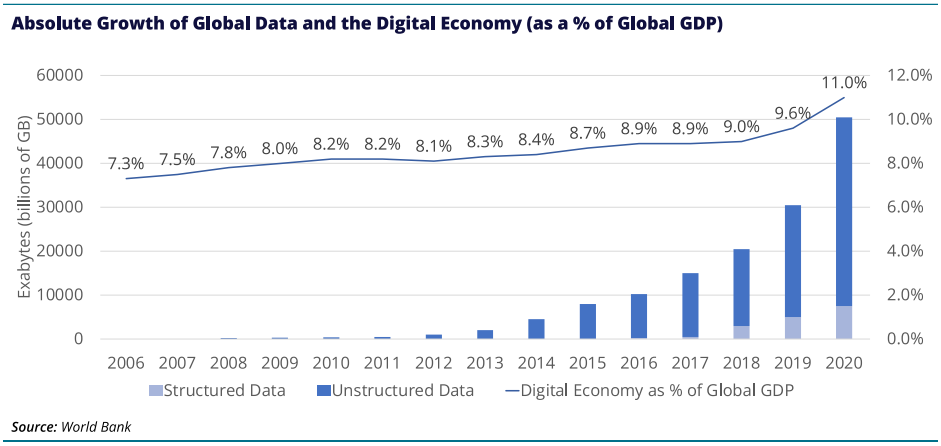
The world is not well placed to address global systemic risk, with escalating waves of disruption threatening to overwhelm countries' and societies' response capabilities and divert critical resources and attention away from long term challenges such as climate change and development crisis.

In addition to the geopolitical shift to the multi-polar world described here, there are two other major long-term trends, with significant socio-economic and political implications for the world order. These are artificial intelligence (AI) and global sustainability, which with the geopolitical shift underway will redefine the global landscape we operate in, positively and negatively.

Artificial Intelligence Embedded Everywhere

The breakthroughs of the Digital Revolution are continuing to reshape our world on a scale comparable to that of the Industrial Revolutions of the late 18th and 19th centuries. Universal connectivity and rapidly growing processing power is increasingly integrating physical, digital, and human systems through tools in the form of core technologies such as the internet of things, data analytics, and particularly artificial intelligence, and in turn this will fundamentally transform industries, governments, communities, and individuals' realities across the world.

Figure 5: The Cambrian Explosion – of Digital Data[18]

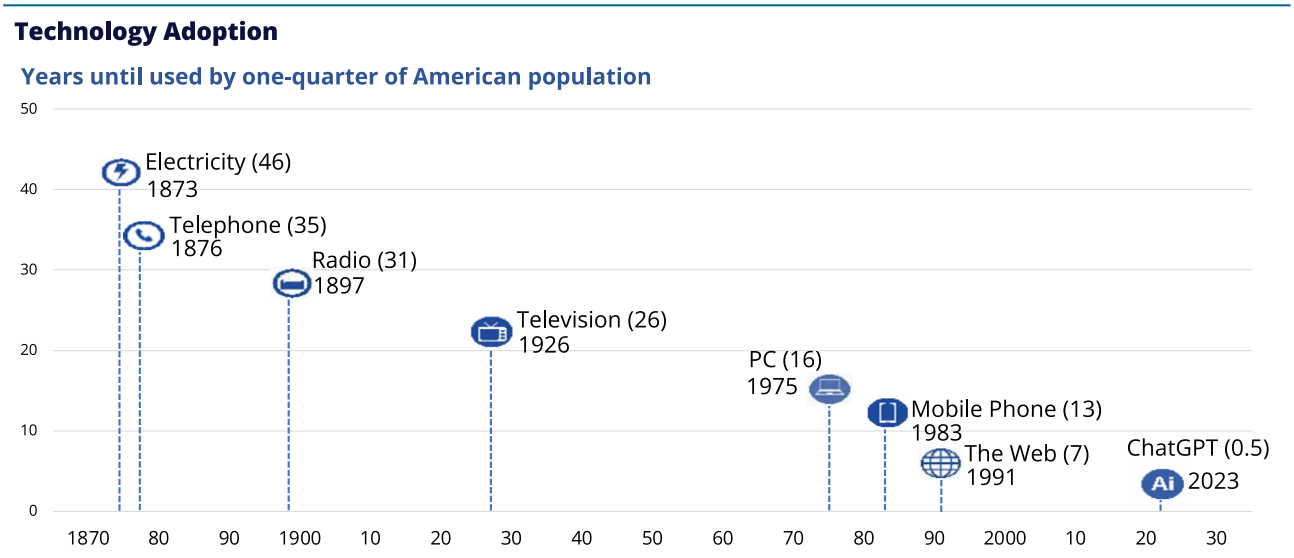


Source: World Bank

The explosive growth of digital data illustrates the scale of the transformation underway, with data being the critical ingredient of a digital economy making up more than 15% of global GDP already, having outgrown global physical economic output by 2.5x times over the past decade.[19] The rapid

advances being made in artificial intelligence leveraging deep learning, machine learning and neural networks, position it as the digital technology with perhaps the most disruptive impact potential on almost everything. By embedding intelligence into every product, service, and process, AI has practical use-cases and applications across all facets of human activity. Moreover, as a highly adaptive general-purpose technology, AI is poised to fundamentally transform not just the global economy but global society too, potentially altering political, social, commercial, and even ethical decision-making beginning with richer countries and as the internet reaches most of the world's people, rapidly gaining share in developing countries too. The speed of adoption of AI technologies exceeds that of every other technology on record in human civilization. ChatGPT – a type of AI known as a large language model – is the fastest-growing consumer application of all time, achieving 100 million global users in only two months.[20]

Figure 6: Accelerating Speed of Tech Adoption[21]



Sources: *The Economist, OpenAI*

A heightened level of anxiety and alarm has been raised by tech leaders[22] given that the performance of highly autonomous AI systems is beginning to approach, and is potentially expected to exceed that of humans, in most economically valuable work (a widely used definition of artificial general intelligence). As such, the advent and further development of AI will pose a fundamental challenge to existing global and national political, economic, and social structures, creating the urgent need for new frameworks to control the development and roll-out of AI.

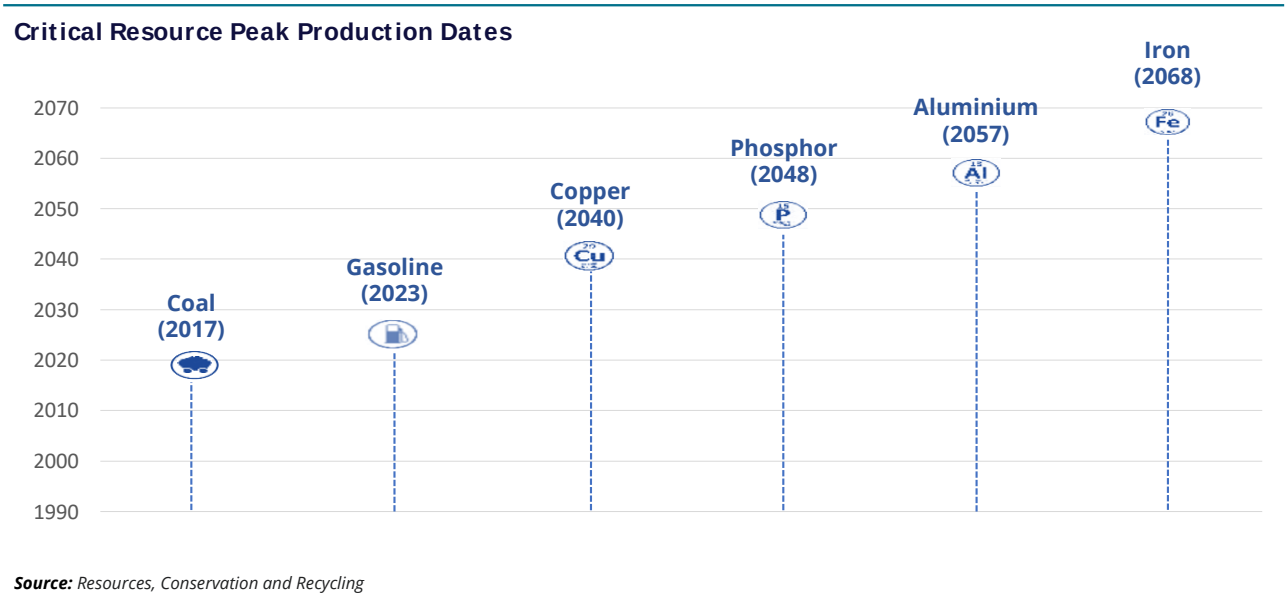
The Long-term Sustainability Transition

Following centuries of industrial-led growth, the resulting world system delivered the breakthroughs that define today's world and increasingly pushed against planetary boundaries, creating the need for the world to move to a more sustainable model of development. The new model will also need to cater for an additional two billion people by 2050, as well as bringing to prosperity the two-thirds of the world that live in the Global South, and the low income households in developed countries The transition to a more sustainable and inclusive model represents a pivotal shift in how societies, economies, and the environment interact, seeking to balance economic growth and social development with the preservation of planetary resources.

Past shifts in civilizations were facilitated by systemic energy and resources transitions unlocking more powerful and functionally superior energy sources that powered ever greater waves of economic development … looking ahead, this spells the end of fossil fuels given they are finite and cannot be the basis of building a future for 10 billion people with aspirations to move beyond the limits of the planet.

The majority of economic growth in history has involved reshaping, processing or consuming natural resources by using energy. Humankind's successive exploitation of coal, oil, and gas (each at accelerating rates of adoption) over the past two centuries has driven unprecedented productivity growth, economic development, and wealth creation, but has also led the world to a point where critical natural resources are being depleted at a rate that will see their production peak and decline in the coming years.

Figure 7: Global Resource Tipping Points Expected[23]



Source: *Resources, Conservation and Recycling*

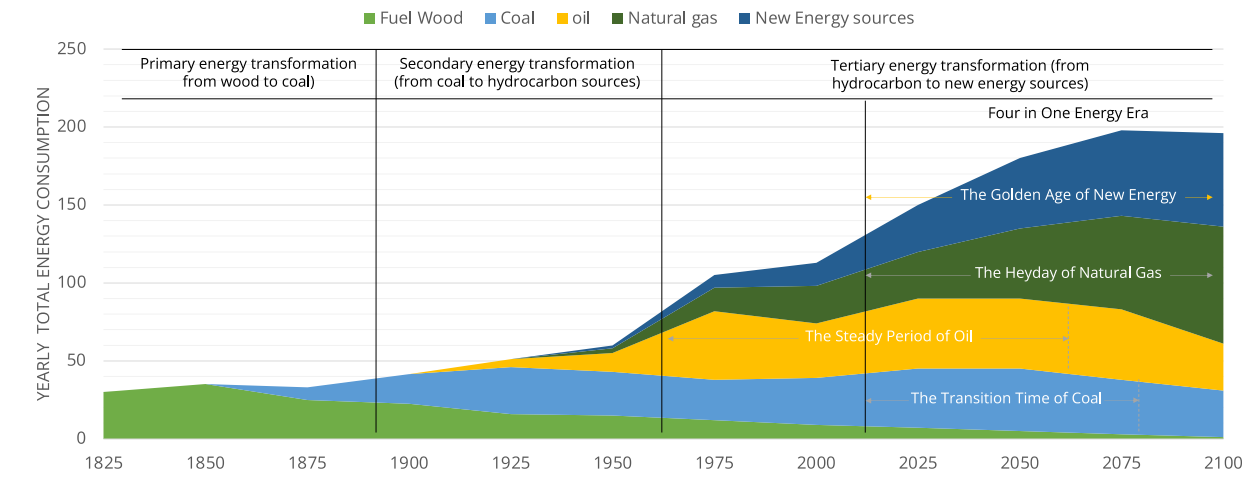
Resource depletion also requires replenishing, and/or finding alternatives for resources like water, fishing stocks and timber, as well as agricultural land, which in many places around the world are being consumed at unsustainable rates. Current projections of water usage,

exacerbated by pollution and demographic trends, mean that up to half of the world's population could be living in areas facing water scarcity by as early as 2025, with up to 700 million people facing displacement due to water scarcity by the end of the decade.

The required global sustainability transition will require the world to develop alternatives for nearly all the world's natural resources, whether they are finite or renewable.

Central to this shift is a systemic energy transition, away from fossil fuels that are not only finite, but also unsustainable in terms of their planetary impact as the key driver of anthropogenic climate change.[24] Past energy transformations have involved unlocking more powerful and functionally superior (i.e. denser, more economic, easier to transport) energy sources that have powered ever greater waves of economic development.

Figure 8: Global Energy Transitions[25]



Source: *Vaclav Smil (2017), Energy Transitions: Global and National Perspectives.*

The energy transformation currently underway will need to transition the world's needs to a new source that is not only functionally superior, and more affordable, but also practically infinite in supply and with a minimal ecological footprint.

Finally, the sustainability transition also encompasses the preservation of biodiversity, reducing pollution, fighting environmental degradation, and managing future human-nature interactions, counteracting the decades if not centuries of environmental damage that current global patterns of industrialization and development have resulted in.

Stepping back, the decline of the current liberal international order is being defined by powerful forces. This order has governed the relationships between states for over half a century, setting the rules of engagement for global economic, political, security and even humanitarian action for over 50 years, based on principles of political and economic liberalism, collaboration through multilateral institutions, the primacy of human rights, capitalism, liberal democracy and coordinated action. The current order's rules and institutions have been challenged by shifting geopolitical power, artificial intelligence, and sustainability, given they were created generations ago under very different circumstances and for different purposes. While today's national and multilateral institutions are striving to provide the leadership to address these pressing issues facing the world, they are struggling to do so and have joined the call for the renewal of the world system to one that can cope with the disorder and impose and enforce new rules on the world.[26]

The world today is in the transition to an era-defining civilizational shift which will see innovations that will redefine almost everything we experience today over the decades to come.

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It is increasingly evident that the world today is in the transition to an era-defining civilizational shift which will see innovations that will redefine almost everything we experience today over the decades to come.

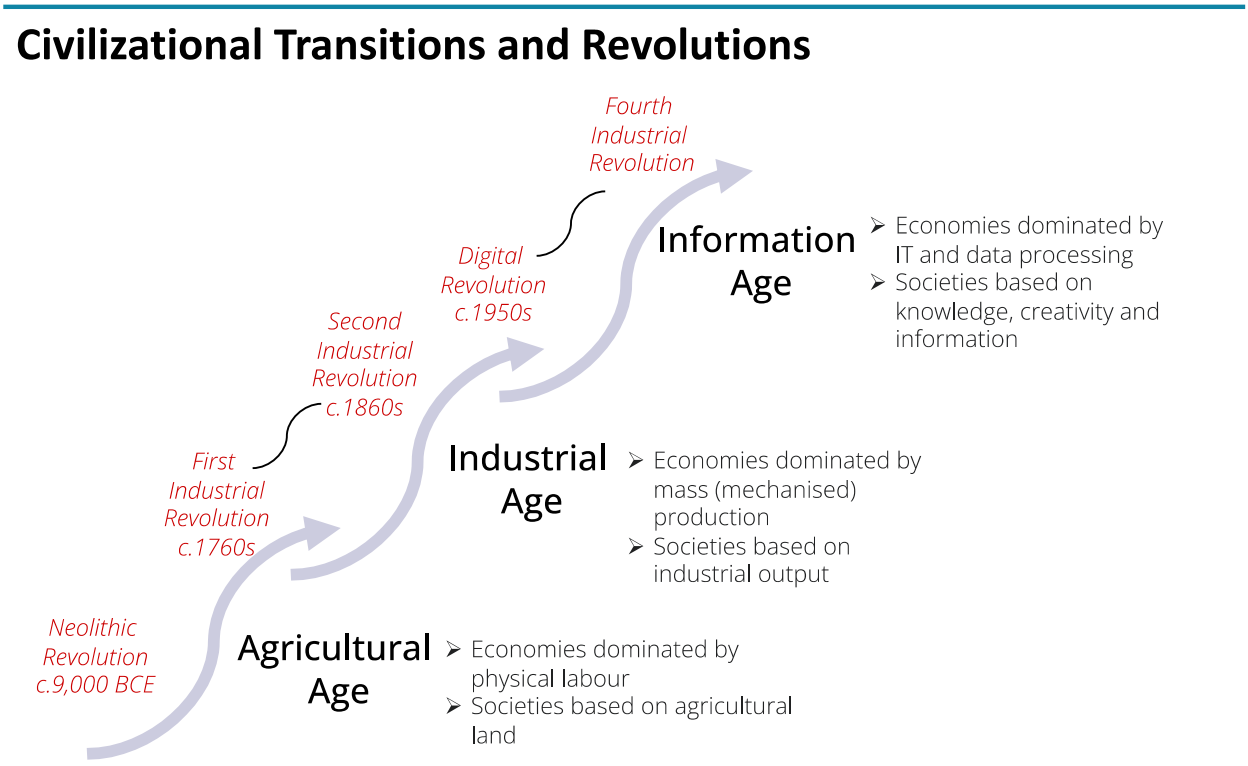
2. A World in Transition Between Civilizations

We are in the midst of a civilizational transition.

Global civilization-level transitions in human history have been few and far between. For over 95% of human history, people lived and died in small nomadic hunter-gatherer groups and with a limited material culture that most anthropologists believe lacked the social complexity to be deemed a civilization at all.[27] Since c.10,000 BCE however, several transitions, or revolutions, have fundamentally transformed human society to create modern civilization.

The first major transition, triggered the creation of permanent settlements, leading to states, centralized administrations and political structures and the invention of writing, in what is now known as the Agricultural Age. The second major transition beginning in the late 18th century with the First Industrial Revolution, ushered in the Industrial Age, characterized by mechanization and industrial production based on exploitation of a widening range of fossil fuels, led to waves of unprecedented economic and population growth, as well as colonization and power struggles across the world, laying the seeds of today' power structure and multilateral institutions. The latest transition, triggered by the Digital Revolution[28] starting in the mid-20th century, has seen the development and widespread adoption of digital technology in the Information Age,[29] with information increasingly replacing manufacturing as the key driver of economic value and leading to the emergence of post-industrial societies and economies, while leaving behind former colonies, largely across the Global South, in relative poverty.[30]

Figure 9: The Transition to the Next Stage of the Information Age[31]



Source: Technology as a Force for Good

Every previous shift in civilizations has involved massive changes across geopolitics, spawned new forms of government, created new economic and trading systems, led to altered settlement and migration patterns, transformed modes of social organization, livelihoods, and culture, and innovated and implemented new technologies, such that the world following a shift would be all but unrecognizable to the people living before it.

Within the space of a century, the Industrial Revolution saw rural agricultural societies with hereditary autocracies of kingdoms and empires overseen on horseback replaced by urban industrial nation-states, with railways, cars, air travel and ocean liners and managers overseeing thousands of workers in factories.

The world today finds itself at a similar inflection point as in the 19th century with the technologies of the Information Age having reached a tipping point, ready to create a future radically different to the present across almost every dimension, in a process that will include a series of mass social, political, economic, and technological upheavals.

Starting in Europe, this civilization conquered the world, built long range weapons, put man on the moon and crisscrossed the world with telecommunication networks, and after two world wars created multilateral institutions with the noble aim of promoting the peaceful co-existence of all. The UN SDGs are a product of this enlightenment.

The world today finds itself at a similar inflection point as it was in the 19th century with the technological progress of the Information Age having reached a tipping point ready to create a future radically different to the present across almost every dimension, in a process that will include a series of mass social, political, economic, and technological upheavals.

In fact, the current multi-dimensional threats facing the world referred to as a polycrisis, the systemic issues such as climate change, and the long-term transformations of a changing power structure of blocs, AI and sustainability are all aspects of this civilizational transition. Using an oceanic analogy, the events of the polycrisis are like waves, erratic and potentially with significant destructive capacity. The systemic challenges on the other hand are more like tides, ebbing and flowing with greater force but also with greater predictability. And the long-term transformations are similar to deep currents that shape the ocean itself and the life within. When these converge as they are now, the world faces a tsunami that changes everything. The existence of these structures is of course not unique to the current transition but has been a feature throughout historical one as well.

Figure 10: The Structure of Civilizational Transitions[32]

Level of Interaction	The Transition to Industrial Civilization (19th Century)	The Transition to the Information Civilization (21st Century)
Short-Term Events and Crises *(Waves)*	▪ Riots (Chartists, Luddites) ▪ Famines (Great Irish Famine) ▪ Revolutions (1848)	▪ Wars (Ukraine, Gaza) ▪ Economic shocks ▪ Pandemics
Systemic Changes and Challenges (Tides)	▪ Urbanization ▪ Population growth ▪ Economic industrialization	▪ Global migration ▪ Inequality ▪ State instability
Long-Term Impacts and Transformations (Currents)	▪ Colonization and globalization ▪ The rise of Western hegemony ▪ Fossil fuels and anthropogenic climate change	▪ Multipolarity ▪ Digitization and AI ▪ The global energy transition

Source: Force for Good

Of course, the waves, tides and currents all impact one another thanks to human agency. Short-term events drive decisions and responses that have long-term impacts, and long-term goals have short term effects, leading to a complex feedback loop shaping trajectory of the global transition underway.

Moving to a Sustainable, Secure, and Superior Future

While the transition to the world's next civilization is already underway, the events of recent years and the outlook ahead indicate that it will be a rocky one. Navigating this transition effectively require the world to address a series of interrelated challenges unfolding on different timescales of which security and sustainability are ever-present and testing world systems. First, it will require addressing the security risks and disruptions created by the various crises taking place in

the world today, be they economic, political, or social. Second, it will require addressing the world's sustainability challenges relating to people, prosperity, the planet, and peace, defined by the 17 SDGs which provide a blueprint for the global levelling up that needs to occur to address these challenges by 2030.

Neither of these two goals can be reached in isolation. Security without long-term sustainability will be fleeting, and without sufficient security the world cannot make the investments and decisions required to deliver sustainability. Together however, secure sustainability enables the world to manage a transition to the future that minimizes disruptions and shares the inevitable transitions costs in an equitable way.

If the world can achieve sufficient secure sustainability, the world's future has the potential to be a bright one. Enabled by technology, this future can be functionally superior to the present in a number of fundamental ways, including a world of:

- Post-scarcity economics, in which the production costs of essential goods approach zero due to automation and advanced manufacturing techniques;
- Net-zero resource consumption such that finite natural resources are not depleted, thanks to sustainable practices and breakthroughs in material sciences delivering planetary sustainability;
- A functionally superior energy source for the world that is ubiquitous, clean, efficient, and at near zero cost;
- Individual-to-individual transaction systems for the delivery and distribution of value as part of far more equitable societies and systems of finance, trade, and economics, locally and internationally, and
- Human security for all defining core shared values and needs and operationalized for the multi-faceted delivery of solutions to the individual.

The path to such a future can be created by a series of technological breakthroughs. Any shift in civilizations is ultimately driven by the growth of knowledge, delivering the science and technology that delivers a changed world and changed societies and individuals. Over the course of the 20th century alone we have split the atom, decoded DNA as the language of life, and built machines that outperform the human brain by several orders of magnitude along specific dimensions. But populists are now undermining trust in science for political gain and thereby threatening all human progress, and we have also honed our ability to make war during the past century, killing nearly 200 million people since 1900 with increasingly lethal and innovative armaments, and secured the means to wipe out all human life on the planet many times over.[33]

Enabled by technology, this future can be functionally superior to the present in several fundamental ways, including a world of post-scarcity economics, net zero resource consumption, a functionally superior energy source, and human security for all.

Technology is clearly a critical driver of change, but its ability to deliver progress depends entirely on how it is used. With the world today facing unprecedented disruptions and standing on the cusp of radical change, the question of how we will use the technologies that are becoming embedded ever deeper into our economies, our societies, and our minds and bodies is a critical one.

The Risks of Transition

In the transition between the Industrial Age and the Information Age, and with the world's population rising dramatically from 6.2 billion in 2000 to c.10 billion by 2050,[34] the critical resources underpinning economies are increasingly competed for, expensive to extract and more dangerous for the economy. Yet, given demand is what drives economies in both rich economies and developing ones, the cycle of extraction can only be broken if either individuals who are consumers and citizens can be convinced to stop measuring their progress in terms of consumption or breakthroughs can be made that allow this consumption to continue in a less destructive manner. In the absence of either, a highly competitive scenario emerges in which rich nations and individuals mostly horde the assets, and poorer ones rise up against their loss. The consequences are felt in politics, society, economics, and individual relationships and include citizens replacing governments that fail to deliver with ones that can or merely promise they can, mass migration to places that offer the opportunity to live the better life and the use of trade as a weapon of protection and the breakdown of relationships.

> *The essence of the transition challenge is that progress is defined as mass consumerism and all the world's political, social and economic systems, backed by militaries, are designed to deliver that ... participants in this system is ready to let go of that and the Global South aspires to join it ... this creates fierce competition and hoarding of resources, and this path can only be traversed safely if the fundamental values of consumerism change or if technology delivers the means to satisfy this exponentially growing consumerism economically and without destroying the planet*

The world is in such a transition at this point, some of the features of this include:

1. Competition for natural resources. The danger is not that the world runs out of natural resources, but that there will not be enough, it will not be delivered quickly enough, cost-effectively enough, and cleanly enough to satisfy demands. The intense competition for these resources will damage geopolitical relationships and lead to instability.
2. Competition for political power. Given that the industrial era has built prosperity through consumption, political power goes to those that can feed this now basic requirement. As this need cannot be satisfied in a world facing increasing scarcity, governments are more likely to pursue what are essentially zero-sum strategies such as protection of their own assets (for example, land, jobs, social security) and increasing resource extraction from

across the world, or when they know they cannot deliver, resort to diversions, populist solutions that distract citizens from the path of decline they are on (such as 'culture wars' that pit citizens against each other, proxy wars, and actual wars).

3. Competition for solutions. In the absence of relinquishing consumerism, the only viable solution is one of scientific and technological breakthroughs that allow consumption to continue and expand without adverse ecological consequences. This will need to replace the industrial generation of natural resources and energy sources in particular, but also the activities that built it including jobs, entertainment, and trade.

The key determinants of how long, steep and fast the decline in security and sustainability will be depends on many factors, but of these one of the most fundamental is how quickly science and technology can fill the gaps that replace the old model with new solutions, recognizing that the longer it takes the greater the risk that more and more of the planet and the world's societies are irretrievably destroyed. The path to the future era involves crisis and requires great leadership and unprecedented risk-taking investments in solutions.

In summary

- The world is facing an unprecedented series of interrelated political, social, economic, and environmental disruptions that threaten global peace and prosperity.
- These disruptions are ultimately surface phenomena of deeper and long-term transitions underway, including the emergence of a multi-polar world, the sustainability and energy transition, and the increasing embeddedness of digital technology and now AI across industries, societies, and all aspect of human activity.
- The long-term transitions are the drivers of a global civilizational shift to the Information Age, which holds the promise of a superior future for the world in terms of peace, prosperity, and human flourishing.
- However, the disruptions the world is facing point to potentially significant transition risks that must be managed for this future to be realised.
- Technology has perhaps the most critical role to play in allowing the world to make a secure sustainable transition.

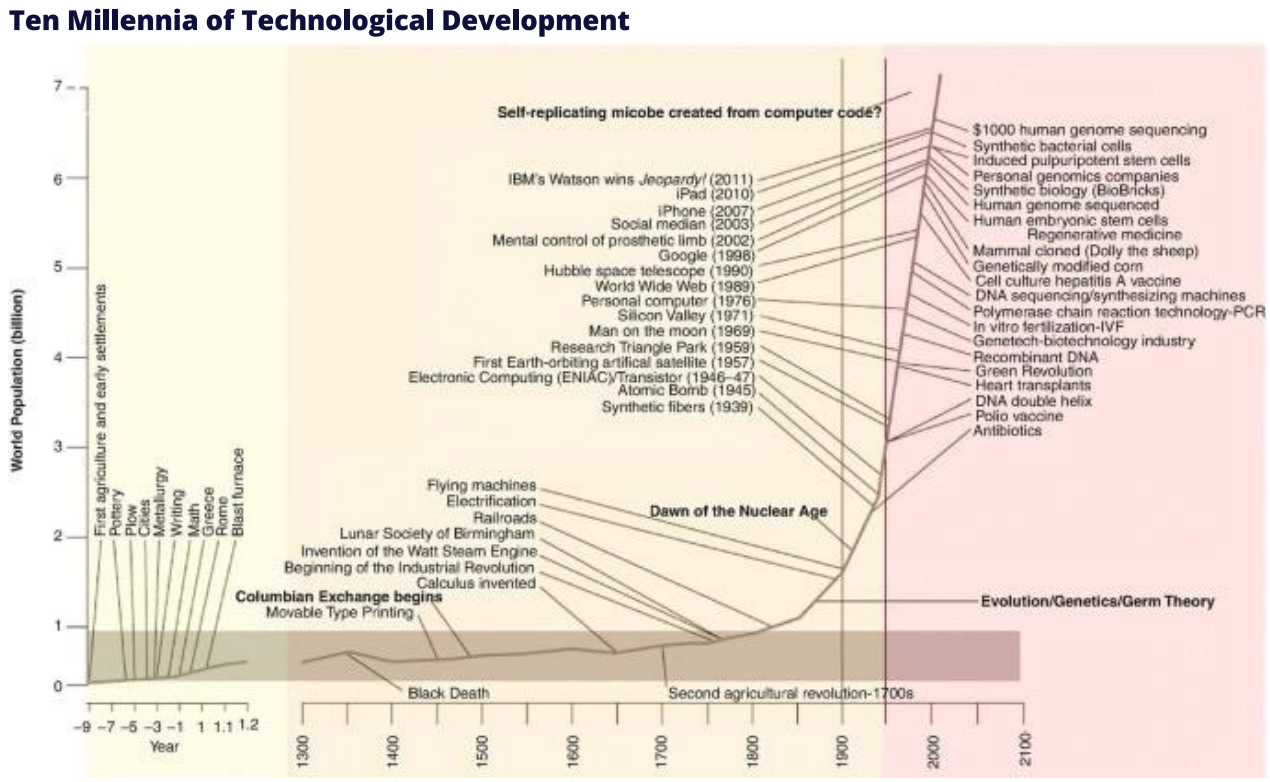
III. Technology as the Critical Change Agent

Technology has a been a key driver of progress throughout human history, and its role in delivering a secure, sustainable, and superior future for the world is a critical one. Technology is one of the most important factors determining whether, and how, the world will achieve the SDGs, and access to technology has been recognized as core dimension of human security in its own right. Most importantly technology, particularly digital technology, is one of the primary engines of the civilizational shift underway. Among digital technologies, artificial intelligence is perhaps the most fundamental disruptor, with the potential to transform industries, societies and even the global order. Further, AI's impact will only grow as progress in computing capacity continues to accelerate, and how the world engages with this technology will be key to unlocking its potential benefits.

1. Technology and the Civilizational Shift Underway

Technology is a, if not the, key catalyst for the civilizational shift underway today.[35] Throughout history, technology has been instrumental in shaping revolutions in human culture, societies, and politics.[36] The growth of knowledge has underpinned nearly all human progress, with leaps in scientific understanding driving innovative and transformative technologies and applications. Many social scientists have identified technology as the primary factor driving the development of all human civilization,[37] and the modern world is inseparable from the technologies that have both created it and continue to suffuse it.

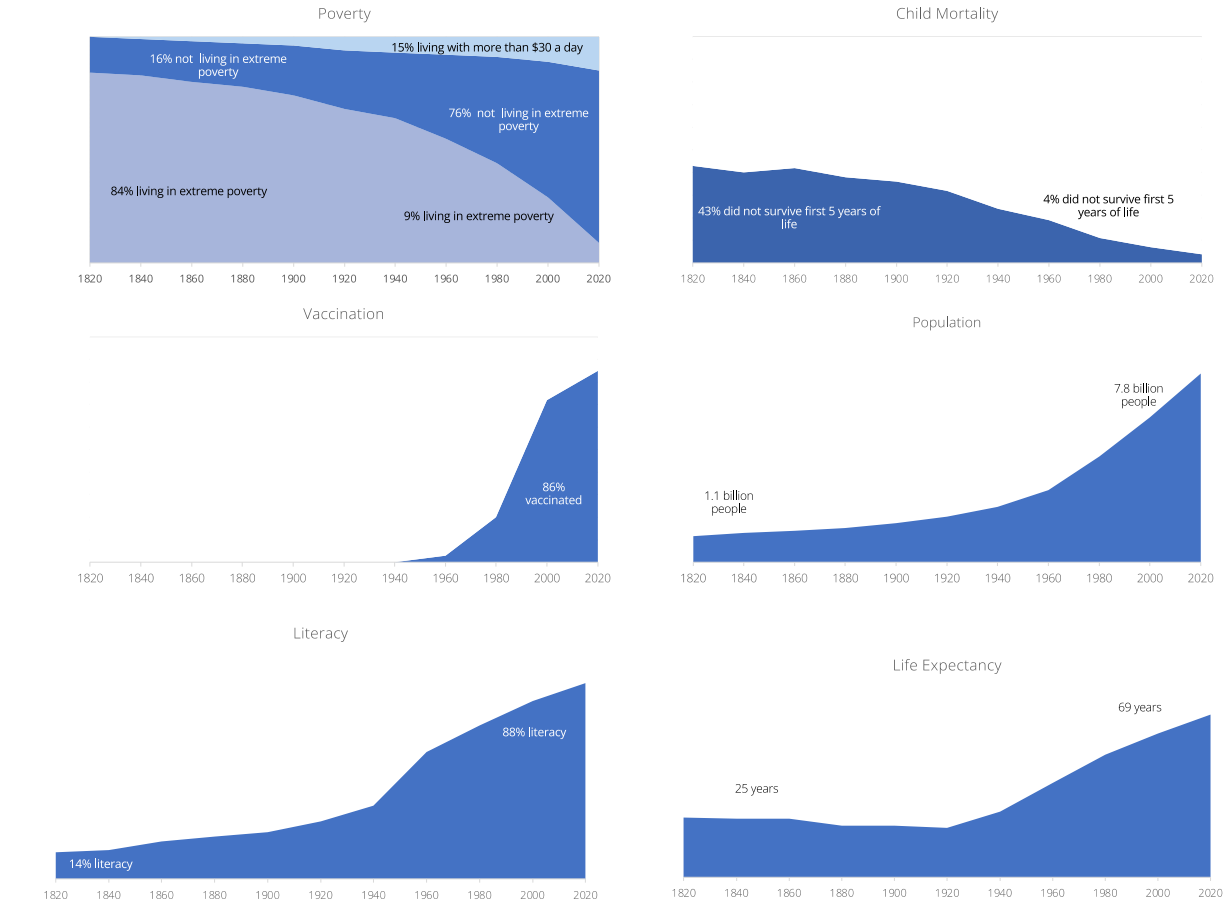
Figure 11: Technological Progress Creating the Modern World[38]



Source: *Adapted from Milken Institute, University of Chicago*

The progress that these technologies have cumulatively enabled for human flourishing in terms of its impact on economies and markets, healthcare and medicine, energy and resource availability, and the diffusion of knowledge and know-how in the past two centuries alone has been staggering.[39] Technology has helped drive productivity growth and prosperity, raising incomes and dramatically reducing poverty. It has also driven unprecedented advances in healthcare and medicine, leading to a sharp reduction in childhood mortality and increases in life expectancy. It has also enabled humans to extract and use their natural resources more effectively, driving the growth of agricultural production and consequently global population growth. Finally, it has allowed humans to spread knowledge more easily, enabling the rapid increase in literacy. Thanks to technology, the world looks almost unrecognizable, and that too for the better, to the world that existed two centuries ago.

Figure 12: Two Centuries of Global Progress[40]



Sources: *World Bank, UNESCO, WHO, OECD*

The term technology is utilized in this report in its broadest sense, namely 'the application of scientific knowledge and methods to the practical aims of human life. As such, it encompasses not just tools but techniques and systems, too. These technologies are used with resources in processes and organizations to create value.

Many of the most valuable technological innovations in history have been those that have focused on resources and energy, allowing the world to leverage a greater range of materials and to greater effect, or to harness more powerful or more functional sources of energy. In fact, all major leaps in global progress historically have been underpinned by material science and energy breakthroughs, like the mass exploitation of fossil fuels in the 18th and 19th centuries or the use of electricity in the 19th and 20th centuries. The biggest leaps in progress today in contrast are being driven by advances in information processing,

The biggest leaps in progress today are being driven by advances in information processing, rather than natural resources, which makes sense given a more functional and sustainable energy is probably not one that can be dug out of the ground, it needs to be created in a laboratory with the application of advanced mathematics and physics.

rather than material and energy in the form of natural resources, which makes sense given that a more functional and sustainable form of energy is probably not one that can be dug out of the ground, it needs to be created in a laboratory with the application of advanced mathematics and physics.

The tools, techniques, systems and organizational processes that deliver 'technology' have changed dramatically with the advent of the internet and are set to make a further leap in speed and complexity on the back of advanced computing technologies - including AI, blockchain, distributed and parallel processing, IoT, quantum computing and online global systems - that interlink everything in real time in global network, and then will transform even more radically if, as many scientists believe, this network becomes "intelligent and self-aware".

2. Technology's Role in a Sustainable, Secure, and Superior Future

The world's transition to the future is inextricably linked to technology and innovation, and whether such a future is indeed sustainable, secure, or superior to the status quo depends very much on technologies available and how the world deploys them. [41]

Technology's role in delivering sustainability

The SDGs, a critical marker of the world's long term sustainability transition, were adopted by all 193 UN member states in 2015 and represent a shared blueprint to achieve peace and prosperity for people and the planet by 2030. As such their achievement underpins further sustainable and equitable growth. However, at their halfway mark in 2023, the world is far off track in achieving these goals. Insufficient action, underinvestment, and the impacts of environmental, economic, and security shocks on an insufficiently resilient world are pushing the goals further out of reach, with none of the 17 SDG currently on track.[42] At current rates of development, rather than eradicating poverty and illiteracy by 2030, the world will still be home to over half a billion people living in extreme poverty, and to almost 400 million young people unable to read and write.

The good news is that the SDGs require no fundamental technological breakthroughs to be achieved by 2030. The bad news is they require cooperation, collaboration, and the global application of local solutions at a time of increasing global rivalry and conflict.

As a result of chronic underfunding, inflation and reduced FDI and ODA, the total funding need for the SDGs continues to grow such that annual spending levels on sustainable development estimated at US$4.5 trillion are failing to impact the total SDG funding need, which remains unchanged from last year at up to US$175 trillion, with one year less now available to achieve the goals.[43] (See Research Process and Methodology for details.)

The good news is that they require no fundamental technological breakthroughs to be achieved by 2030. The bad news is they require cooperation, collaboration, and the global application of local solutions at a time of increasing global rivalry and conflict. The most powerful stakeholders that need to act in the short term to close this gap are governments, private sector corporations, and individuals. The 2023 Capital as a Force for Good Report identifies six solution areas that emerge from a detailed analysis of the 169 targets underlying the SDGs and what it takes for them to be met.[44] The solution areas compromise policy, technology, public sector activities, infrastructure, private industry, and financial services, with any given target addressed by an SDG-specific mix of these solution areas.

Figure 13: Summary of Global Stakeholders in Capital[45]

Global Stakeholder	Liquid Assets Owned, Controlled, or Administered
Individuals (Households)	US$255 trillion (owned)
Governments	US$185 trillion (owned)
Private Sector Corporations	US$57 trillion (controlled)
Finance Industry	US$387 trillion (fiduciary-managed)

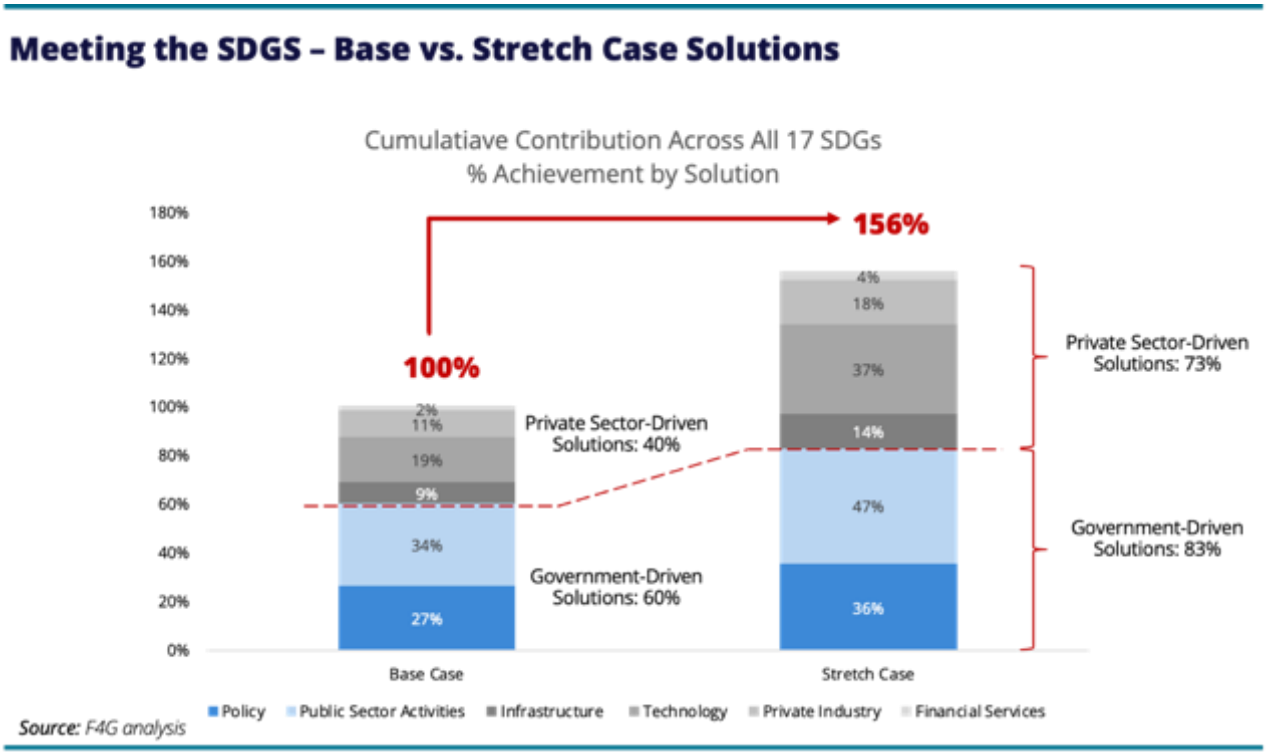
Source: Capital as a Force for Good

The 2023 Capital as a Force for Good Report examined each SDG target and its underlying indicators to determine the potential solutions mix for a given goal, resulting in a percentage breakdown by solution area for the achievement of every SDG target. The results from this work are as follows (please see the Research Process and Methodology section of this report for details):

1. Policy provides solutions for 27% (Base) to 36% (Stretch Case) of the goals.
2. Public Sector Activities can solve nearly 34% (Base) to 47% (Stretch Case) of the goals.
3. Technology (Digital) solves for 19% (Base) to 37% (Stretch Case) of the goals.
4. Infrastructure solves for 9% (Base) to 14% (Stretch Case) of the goals.
5. Private Industry solves for 11% (Base) to 18% (Stretch Case) of the goals.
6. Financial Services directly solves for 2% (Base) to 4% (Stretch Case) of the goals, while the finance industry indirectly funds up to 73% of the solutions for the goals in the stretch case.

Technology, much like capital, cuts across all these solution areas, as a core enabler of any process that is designed to further the goals. Given increasing global digitization, things like computing, communication, and connectivity technologies increase the efficiency, decision making and delivery capabilities of all the stakeholders delivering the goals, including policy makers, the public sector, the private sector, and the financial services industry, among others.

Figure 14: Solutions for Meeting and Exceeding the SDGs[46]



But technology, and what is broadly termed the 'tech sector', also plays a critical role in achieving a range of specific SDGs directly. Not only do several SDG targets explicitly call for the use of digital technologies, the UN's most recent work estimates that digital tech can directly *impact* about 70% of the 169 SDG targets.[47] In aggregate, digital technology has the potential to *solve* for up to 37% of the goals, assuming that best-in-class innovations are fully deployed for each goal.

Beyond digital technologies, meeting the SDGs will require the mass deployment of technologies addressing global health, education, financial inclusion, employment, sustainability, energy, and governance challenges, among others. While new inventions clearly have a role to play, in practice most of the heavy lifting in meeting the SDGs will need to be done by the scaling of existing technologies. The scale of the SDGs and the short time frame for their achievement calls for technologies that are proven, robust, flexible, scalable, and low cost, and can be deployed rapidly in a manner that maximizes inclusion of the world at large, especially the two thirds of the world that the industrial revolution failed to adequately include in the progress it delivered, and who might well be even further left behind as we transition to the next technology inspired era.

Beyond digital technologies, meeting the SDGs will require the mass deployment of technologies addressing global health, education, financial inclusion, employment, sustainability, energy, and governance challenges, among others. While new inventions clearly have a role to play, in practice most of the heavy lifting in meeting the SDGs will need to be done by existing technologies.

Technology's Role in Underwriting Human Security

The social, political, economic, and technological upheavals accompanying the transition from one world system to its eventual successor are fueling rising levels of disorder and risk, which in turn is giving rise to an increasing number of global security challenges. With security directly linked to survival, matters of 'security' are always a top priority for national leaders, particularly over the short term, at the expense of virtually any other priority.

Security broadly consists of protection from harm and resilience to its effects, but it can be defined on many levels, international, regional, state, community, and the individual. These reflect the relationship and interrelationship between peoples. As a result, human security should be viewed as a complement to national and international security, and aimed at safeguarding human rights and bolstering the other security at the individual, community, and regional levels through non-violent means to contribute to enhanced stability and development.

Human security as defined by the United Nations has historically included seven dimensions, including food security, environmental security, technology access, personal safety, community security, economic security, healthcare access, and political security.[48] Technology has a critical role to play across all these dimensions as an enabler, force multiplier, and as a direct contributor with targeted solutions. Given the power of technology as a tool to advance human security in all its dimensions, 'access to technology' has recently been added as the eighth pillar of human security in its own right.[49]

Figure 15: Technology and Human Security[50]

Food Security. Technology aids in producing nutritious food more efficiently with less waste, water, and land, and is accessible to all people. From growing to distributing food, innovative tech can bring the necessary dietary needs to all communities.

Access to Healthcare. Innovation that improves patient care and health outcomes. Technologies include health products/services that empower individuals to have more control over their health as well as access to health care in remote settings.

Economic Security. Innovation that creates a pipeline for new companies, ideas, and job opportunities. These technologies enable entrepreneurs to start a business, run a business and offer opportunities for meaningful work at a fair wage.

Environmental Protection. Technology creates a path to a more sustainable future. Innovation helps to reduce our environmental footprint and better harness climate-friendly energy resources while introducing novel approaches to limiting waste.

Personal Safety & Mobility. Focused on technologies that keeps individuals, their finances, data, and privacy safe. In addition, this includes solutions for individuals to move freely about. This includes innovation such as blockchain-enabled tech, technologies that limit risk for personal wellbeing and accessible modes of transportation.

Community Security. Technology enables access to information, education and provides services that keep communities safe. These technologies provide better emergency services for citizens or deployment of wireless broadband in remote areas.

Political Freedom. Innovation empowers governments and citizens to connect and share information freely and fairly. Constituencies equipped with tools that strengthen self-determination can prosper peacefully.

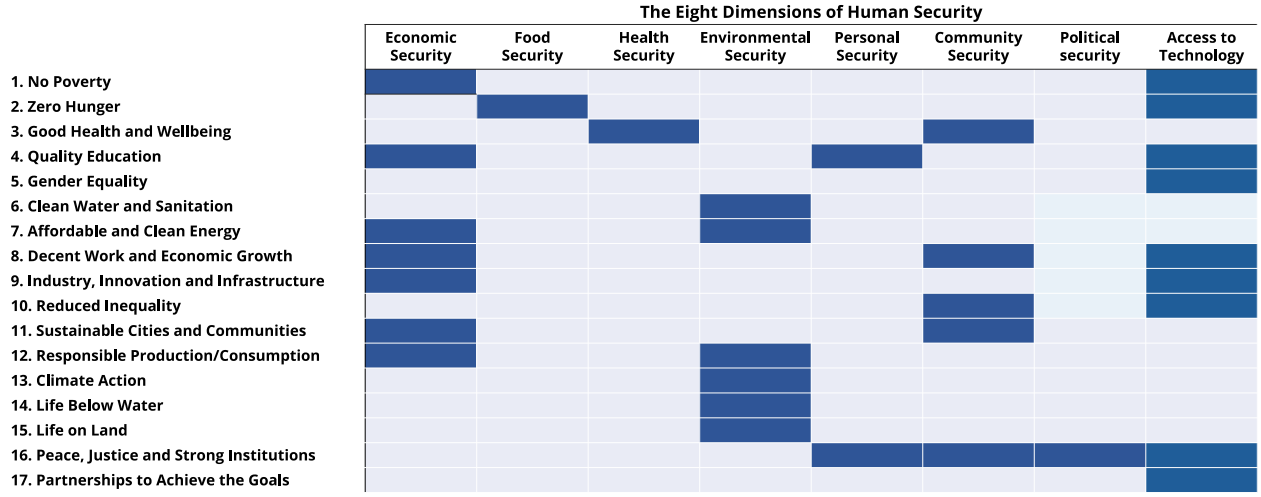
Access to Technology. As one of the most powerful tools enhancing the human experience today, technology at its core helps us do more with less. Having access supports communities worldwide in the sharing of vital information related to combating disease, ensuring sustainable food practices, energy efficiency, access to clean water, and so much more.

Source: Human Security for All (HS4A) campaign

Given technology's impact on human security is closely tied to its impact on sustainability, unsurprising given both ultimately serve to underpin human flourishing, the 17 SDGs, are closely intertwined with the eight pillars of human security. as laid out below.

Figure 16: Human Security and the SDGs[51]

Sustainable Development Goals and The Eight Dimensions of Human Security



Source: *Force for Good*

Following decades of relative stability, individual security is declining rapidly. Since 2020 alone, 43 countries have seen a significant increase in the risk posed to human security as measured by the Human Security Index, negatively impacting the economic, environmental, and social prospects of a significant number of people across the world. This deterioration is being driven by challenges at the level of national politics as well as international security. Powerful states have been swept by populist leaders stoking and playing to people's fears at home, increasingly retrenching from international commitments, and reducing international collaboration. The resulting rising geopolitical disorder is leading to a refocus on the more traditional state and international level definition of security, meaning security and defense. The key aspects of this are:

- Physical Security – Weapons Can Destroy or Defend. Conventional and nuclear arms are seen by leading nations as integral to the global security order but are of course also tools of mass killings and destruction. Total global military expenditure grew faster than global GDP in 2022, increasing by US$80 billion to exceed US$2.2 trillion,[52] while state-based conflict related deaths reached a 28 year high of 237,000.[53]
- Cybersecurity – Technology to Undermine the Physical Order. Cybertechnologies are asymmetric in their ability to cause large scale harm relative to the level of investment required to build them, leading to a 'democratization of destruction' in which less powerful countries can represent massive global security threats. Countries like Iran and Vietnam are ranked among the top ten global cyber-powers based on intent and capability,[54] despite neither country being among the world's 30 largest economies or military spenders.[55]
- Information Security - Technology to Impact Integrity of the State. Digital Information and communications have a critical impact on public opinion, decision making, spreading critical information and fake news with equal speed. Information security is becoming increasingly central to national security, with digital technology being used in nearly 90% of identified cases of national election interference.[56]
- Energy Security – (Lack of) Technology Sharing to Drive the Energy Transition. Other than for the dozen or so major countries that are net exporters of (mainly fossil fuel) energy, long-term energy security will require the mass deployment of renewable technologies. Based on current projections however, the share of fossil fuels in the global energy mix will remain just above 60% in 2050 implying the need for accelerated investments.[57]
- Economic Security – Technology to Destroy and Replace Technology. Economic security is closely tied to a state's command of the resources required to achieve national goals, including the flourishing of its citizens and all other aspects of security in the long run too. Digital technology – in the form of IT spending, e-commerce, and the output of digital industries, among others – is an increasing driver of global economic growth and is expected to reach US$23 trillion (or c.21% of global GDP) by 2025.[58]

Given the fact that technology is inextricably linked to each of these security risks, countries around the world are increasingly recognizing that innovation and access to technology are central to national security.[59] The resulting competition is a key impetus not just for the scaling of existing commercial technologies but also for innovations across emerging, technologies that are only beginning to impact the world but have the potential to fundamentally transform it over the longer run. Among these, AI stands out as perhaps the most critical one, cutting across and impacting all the elements of global security laid out above as a potential source of both progress and risk by enabling more effective destruction and defense as well as greater economic progress and inequity in

The estimate of total potential economic benefit of AI is currently estimated at up to US$26 trillion annually, (a potential gross increase of global GDP of 25%) … however, AI and the automation it enables is also estimated to place nearly 30% of jobs across OECD countries at risk.

that. In terms of economic impact for example, the total potential economic benefit of AI is currently estimated at up to US$26 trillion annually, (or a potential gross increase of global GDP of 25%).[60] However, AI and the automation it enables is also estimated to place nearly 30% of jobs across OECD countries at risk, implying potentially costly and long term labor and economic dislocations that will eat into AI's benefits, and have profound political effects. AI's impact across the other dimensions of security promises to be on a similar scale, making the technology a strategic national priority for every country in the world.

Technology's Role in Creating a Superior Future

Perhaps most self-evidently, technology creates the future. While global security is needed to create the stability required for long-term sustainability, and sustainability is needed to level up the world and enable a just transition for the world, technology's biggest impact will be to drive this transition and to determine the shape the world to come. For this world to be a superior one, it will need to be more peaceful, more prosperous, and more equitable than the present. This will require overcoming some of the greatest challenges that humanity faces today, be they economic, environmental, geopolitical, or societal.

Every human endeavor is set to be re-shaped by technology in creating this future. Such a future would be radically different from today in terms of how people live, societies work, politics operates, economies are structured, industries create value, and how states function. The features of a superior future based on our current world, and predicated on the direction of technological innovation include:

- Digital Technology. The blurring of the boundaries between the physical, digital, and biological spheres creates new possibilities to address major global issues in the physical world, and new opportunities for everything affecting life.
- Energy. New energy sources replace carbon, with fusion and its derivatives being the most likely near-term prospect for commercialization, providing an abundant, clean, and near-free energy source.
- Virtualization. The metaverse creates a shift in the human paradigm itself through the widespread adoption of virtual, augmented, and mixed reality platforms, with global economic and social activity increasingly also occupying digital spaces.
- Materials. Breakthroughs in material sciences replace the need for the extraction of finite natural resources with sustainable and cost-effective synthetic alternatives.
- Industry. Increasing automation, material breakthroughs and abundant near-free energy allows for nearly limitless scaling that drives down the marginal costs of production towards zero.
- Finance. The adoption of a pervasive distributed form of capitalism that drives mass inclusion, while renewing and reinventing global trade dramatically reduces the need for centralized control and financial intermediation.

- People. People empowered by technology are provided access to opportunities regardless of time, space, geography, demography, gender, race, or income levels.
- Space. The leveraging of space becomes far more possible with a new energy source providing access to new resources, and new territories to live in, driving massive innovations of their own along the way.

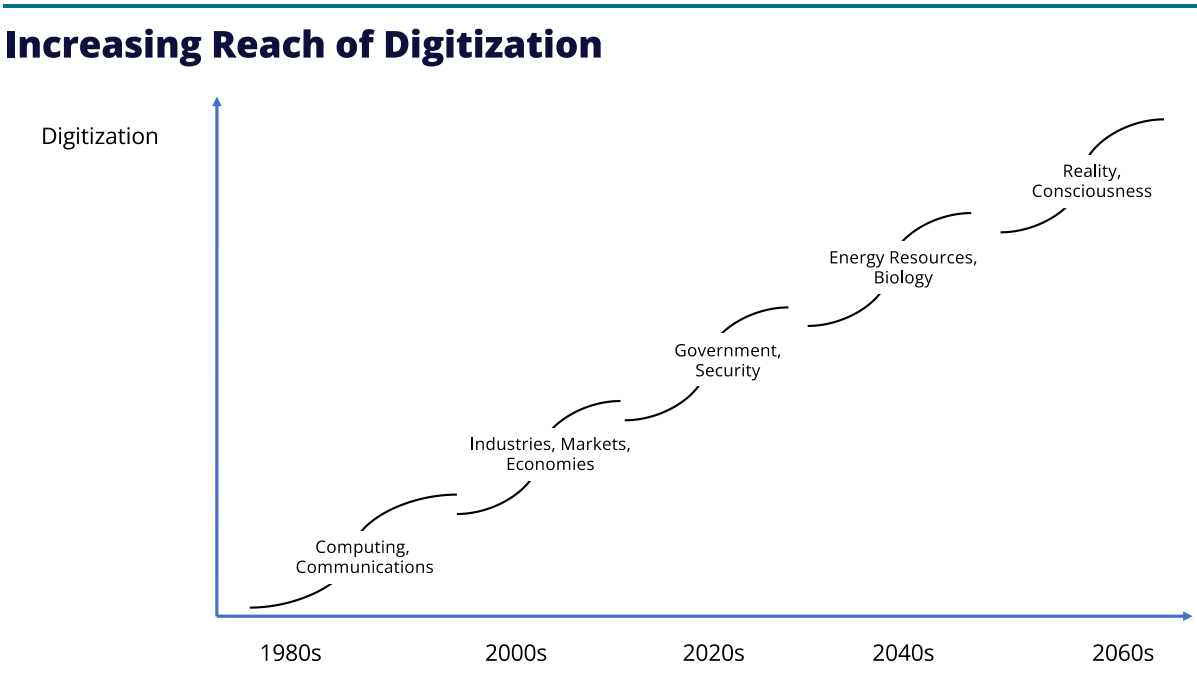
Underpinning the developments laid out above are a series of future technological breakthroughs based on quantum leaps in scientific understanding from today's levels. These leaps will require significant research and innovation in artificial intelligence, computing, and data sciences, alongside energy, material sciences, engineering, and life sciences.

3. Digital Intelligence and AI at the core for the future

Digital Technology and Early AI Drivers of Progress

While all forms of technology have the potential to drive human progress, digital technology has an outsized role to play in the shift to the next civilization currently underway. Digital technology, being the electronic tools, systems, devices, and resources that generate, store or process data, is increasingly augmenting, transforming, and then becoming integral and embedded across all aspects of the economy and society. The advances and breakthroughs being made today in areas like electric vehicle design or precision medicine are only possible due to the application of advanced digital technologies.

Figure 17: Digital Everything[61]



Source: *Force for Good*

Having transformed the way the world thinks about and delivers health, finance, education, entertainment, and commerce (among others) over the past twenty years, digital technologies are now transforming material sciences, energy, manufacturing, construction, and biology, a trend line that would ultimately culminate in a world where digital and physical reality achieve parity, a possibility that would become more likely should digital entities realize conscious awareness.

Digital progress has seen exponential growth; computing power, speed and cost-efficiency has been doubling every 24 months since the 1960s[62] while data storage improvements have exceeded these growth rates by 800%.[63] This massive increase in capabilities has enabled increasingly rapid advances in AI, whose impact on the world promises to be several orders of magnitude greater than that which digitization has had to date, enabling, disrupting and redefining our virtual and physical reality. While digitization on its own enables communication, increases access to information, and drives productivity, AI increases the number of intelligent agents capable of pursuing goals in the world, imbuing machines with the ability to interpret information, make decisions and take actions, augmenting and in many cases potentially replacing human decision making. Critically, AI also accelerates scientific research, aiding in complex simulations, data analysis, and modelling, advancing our scientific understanding and allowing for more and faster breakthroughs across all areas of technology innovation.

In creating a superior future, AI increases the number of intelligent agents capable of pursuing goals in the world, imbuing machines with the ability to interpret information, make decisions and take actions, augmenting and in many cases potentially replacing human decision making.

Artificial Intelligence Set to Transform the World

The past and potential future evolution of AI and its key inflection points – its transition from a tool used by humans to a self-learning technology that is smarter than humans and capable of driving their behavior – can be described as a series of incarnations.

Incarnation 1: Tool (2000-2012)

The early development of AI was largely focused around harnessing the explosion of various new forms of structured and unstructured data to build large datasets, and the development of algorithms that could analyze those datasets using reasoning and logic to address defined problem statements. Over the decade, these algorithms evolved from doing descriptive and diagnostic data analysis towards predictive and prescriptive analytics which enabled a range of consumer and enterprise use cases.

Perhaps the most notable application of this was Google's search algorithms which effectively retrieved information from an indexed library of billions of pages of web content and presented results and answers to queries to its users. The algorithm was so effective that it led to Google dominating the search market with the number of searches growing over 100x from 9.2 billion in

2000 to 1.0 trillion by 2010 and estimated to have further grown to over 2.0 trillion searches annually currently.[64]

Incarnation 2: Human Mimic (2012-2022)

The progress being made by AI systems has been accelerating rapidly. For many decades, computing costs and power limitations set an effective ceiling on AI technology, which was largely based on 'symbolic AI', using predefined rules and symbolic representations to mimic logical reasoning, and relying heavily on human-defined structures and knowledge. In contrast, the 1990s saw the rise of machine learning, which uses statistical methods to enable machines to improve at tasks with experience, primarily through pattern recognition and inference from data, without explicitly programmed instructions.

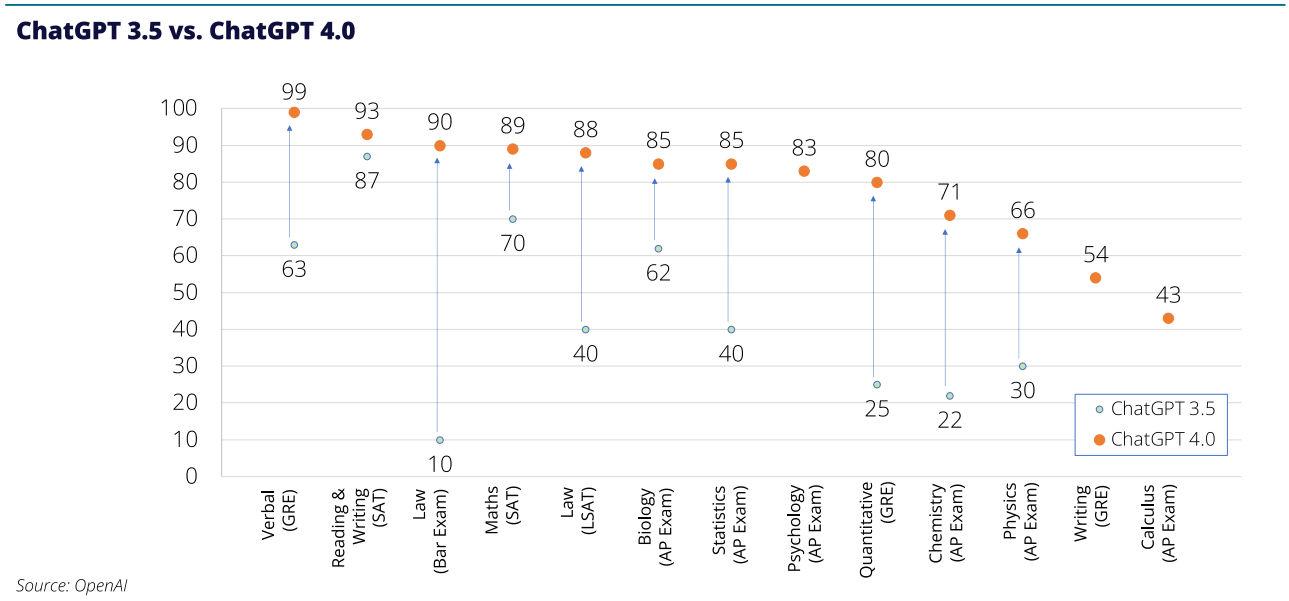
The past decade on the other hand, has seen the rapid development and advancement of 'deep learning' models based on artificial neural networks inspired by the human brain which used multiple 'layers' to extract progressively better-quality output from raw data.[65] These models were applied to a range of use-cases including natural language processing, speech recognition, computer vision, and machine translation to produce results comparable to human performance.

This in turn has given rise to generative AI, specifically large language models ("LLMs"), which leverage 'Transformer' architecture - a neural network design that that uses advanced techniques to understand and generate text - and have become the preferred model for natural language processing. These LLMs can perform a wide range of natural language processing tasks including generating human-like text, answering questions (including discerning the intent behind a question), translating, and summarizing text, and determining the sentiment or emotions in a particular piece of text.

Incarnation 3: Student-Teacher (2023)

Recent versions of OpenAI's ChatGPT, the most widely used LLM globally, can be trained for multiple complex tasks and industrial applications, including specialized knowledge, currently the domain of human experts. For example, the self-learning capabilities of generative AI is seeing LLMs rapidly evolve from sub to superhuman performance across a range of academic and professional arenas, While OpenAI's GPT3.5 model, launched in November 2022 still scored near the bottom of the student cohort across most tests, GPT4.0 which was introduced only five months later already ranks in the top quintile across most exams.

Figure 18: GPT Performance on Professional and Academic Exams (Percentile Rank)[66]

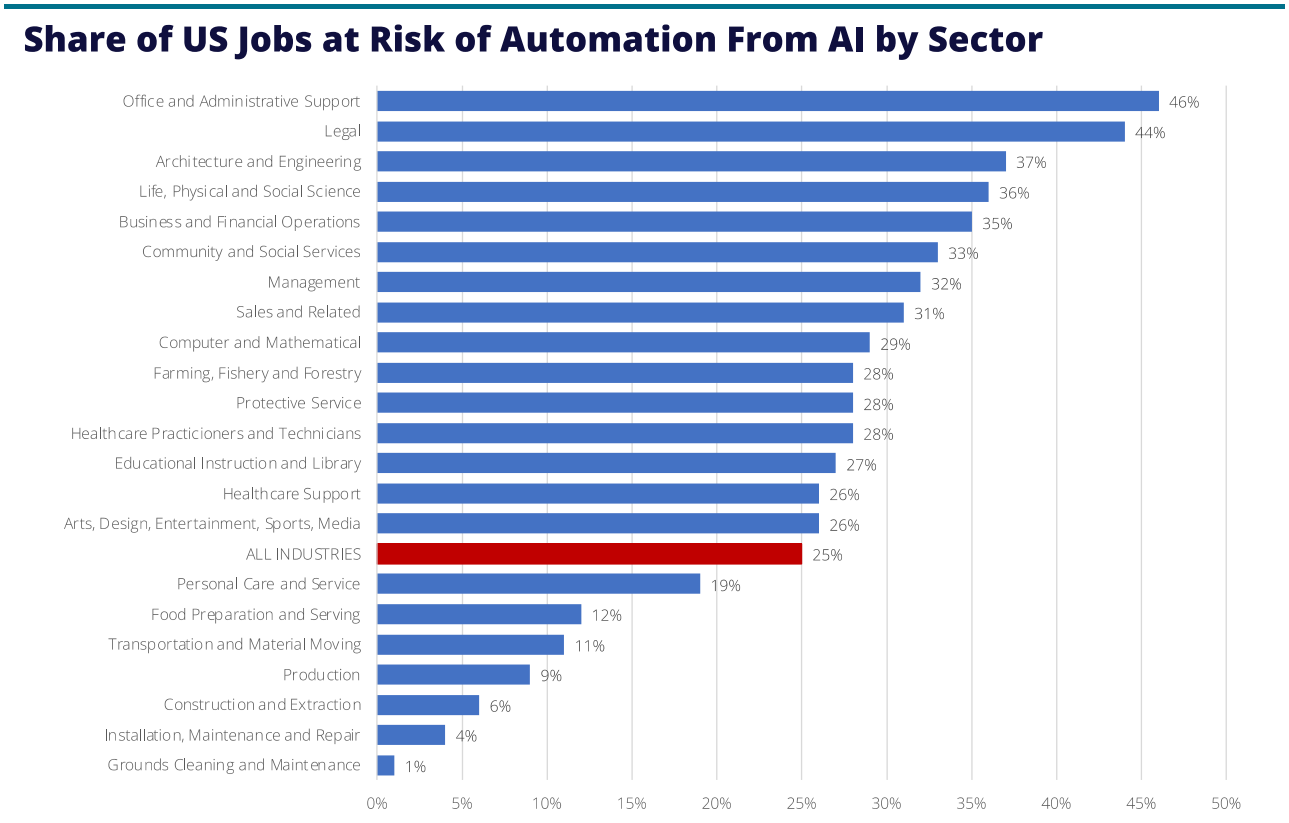


Source: OpenAI

Incarnation 4: Polymath (2024 -?)

Generative AI's capacity to outperform humans across a wide variety of disciplines alongside its ability to seamlessly communicate with machines creates the potential for it to replace humans across a staggering range of tasks. As many as two-thirds of human occupations are exposed to some degree of automation by AI for some or all their workloads[67].

Figure 19: AI and Job Displacement[68]



Source: Goldman Sachs Research

Administrative and professional jobs are the most exposed initially, but physical tasks will be increasingly automated as well as AI increasingly combines with robotics. Recent estimates suggest that up to one third of all jobs currently being done the industrialized world can be automation by AI.

While this automation is expected to boost productivity by as much as 1.5% annually over a ten-year period, (like the boost provided by earlier transformative technologies like the electric motor and personal computer[69]), it is estimated that it could displace 300 million workers around the world as well.[70]

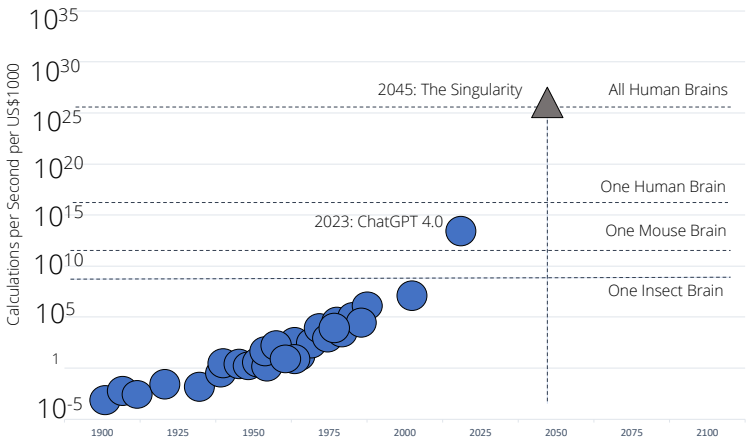
Incarnation 5: Superior

The impact that AI has will only continue to grow as AI systems continue to grow in capabilities and computing capacity. As AI learns to complete more and more human tasks and becomes more and more intelligent, the prospect of AI reaching the point where it becomes smarter than humans and achieves 'Artificial General Intelligence' (AGI) becomes a reality. In this paradigm, AI is an autonomous system that can accomplish any task that humans can perform, better than humans.

A survey of 356 AI experts indicated that more than half of them believe that the year in which "there is a 50% chance that human-level artificial intelligence exists" will be 2060 or sooner, and a quarter of them believe that it could be before 2040[71]. And the recent developments in generative AI suggest that this possibility remains very much on track and may even have accelerated, with some experts predicting that AGI may now be achieved within the next decade[72].

Figure 20: The Exponential Growth of Computing Power[73]

Approaching the 'Singularity'



Source: *Ray Kurzweil, Kurzweil Technologies Inc.*

The progression of AI once machine intelligence surpasses human intelligence (a point sometimes referred to as the 'Singularity') is inherently difficult to imagine or predict.

Today, almost every major digital system used by humans is networked, and these systems are carrying an increasing share of the world's content, including the internet, communications, social

media, entertainment and political information, and running an increasing share of the world's critical processes, including financial transactions, education, healthcare, production management, corporate functions, government functions, international trade, environmental monitoring, and defense and security intelligence. AI already taps into many of these systems and their data to perform. An AI that has increasing awareness of its presence and purpose in each of these systems would effectively be an artificial superintelligence with the potential to transfer goals from one system to another, and potentially setting its own goals which may not align with those of its designers. This so-called 'alignment problem' gives rise to the need for control over the development of AI which is a task that has only just begun and who's feasibility depends on human interested parties being aligned on their common security concerns, a difficult task indeed.

Using AI to Drive SDG Performance, an Overview

While the various incarnations of AI play out, and the world works through how to manage these, AI is likely the smartest tool to drive the SDGs and close the gap in their achievement.

As a tool with near universal applicability, AI's potential impact on both security and sustainability over the near term is far reaching. In terms of security, the benefits are immediate: AI can analyze vast amounts of data to predict potential conflicts, natural disasters, or other security threats, enabling preventive measures to be taken for planning and coordination of effective responses, for example, by optimizing the distribution of humanitarian aid, or by analyzing damage to coordinate relief efforts more effectively. Further technologies like facial recognition, and automated data analysis can enhance the ability to monitor high-risk areas for potential threats, helping to prevent crimes or terrorist activities. Finally, AI can help in detecting and responding to cyber-attacks as these become more sophisticated, protecting critical infrastructure and sensitive data.

In terms of sustainability AI can act as a critical enabler of 79% of the 169 targets underlying the SDGs, driving societal, economic, and environmental outcomes in near equal measure.[74] Importantly AI has the potential to positively impact all 17 of the SDGs in multiple ways, as illustrated in the table below, which itself was produced using a generative AI model.

Figure 21: AI and the SDGs[75]

SDG	AI Impact Potential
	▪ Predictive analytics to identify regions at risk of poverty. ▪ AI-driven agricultural technologies to increase crop yields for small farmers. ▪ Automating and improving the efficiency of aid distribution.
	▪ Precision agriculture for optimizing food production and reducing waste. ▪ AI in supply chain management to reduce food spoilage. ▪ Development of AI-based nutritional planning tools.
	▪ AI in diagnostics to improve disease detection and treatment. ▪ Personalized medicine for tailored healthcare solutions. ▪ AI-driven research in drug discovery and epidemic tracking.
	▪ Adaptive learning platforms for personalized education. ▪ AI tools for language translation to overcome education barriers. ▪ Analysing educational data to improve teaching methods.
	▪ AI algorithms to identify and reduce gender biases in hiring. ▪ AI-driven platforms to support women entrepreneurs. ▪ Analysing data to better understand and address gender disparities.
	▪ AI for monitoring and predicting water quality issues. ▪ Optimization of water distribution systems in urban areas. ▪ AI in wastewater treatment processes for better efficiency.
	▪ AI in optimizing renewable energy sources. ▪ Predictive maintenance for energy infrastructure. ▪ Enhancing energy efficiency in buildings and industries.
	▪ AI-driven job market analytics for skill development. ▪ Automation to increase productivity and create new job opportunities. ▪ AI tools for small businesses to access markets and finance.
	▪ AI in predictive maintenance for industrial machinery. ▪ Facilitating research and development through AI-driven insights. ▪ Enhancing logistics and supply chain efficiencies.
	▪ AI in financial services to provide credit access to the underserved. ▪ AI-driven educational tools for marginalized communities. ▪ Enhancing accessibility technologies for people with disabilities.
	▪ AI in urban planning for sustainable and efficient cities. ▪ AI-driven traffic management and public transport optimization. ▪ Enhancing public safety through smart surveillance systems.
	▪ AI in supply chains to promote ethical sourcing and reduce waste. ▪ AI tools for lifecycle assessment of products. ▪ Automation in recycling processes.
	▪ AI in climate modeling and forecasting. ▪ AI-driven solutions for carbon footprint reduction. ▪ Enhancing the efficiency of climate change mitigation strategies.
	▪ AI for monitoring and protecting ocean biodiversity. ▪ Predictive analytics for sustainable fishing practices. ▪ AI in studying and mitigating the effects of ocean acidification.
	▪ AI in wildlife tracking and habitat protection. ▪ Predictive tools for forest fire prevention. ▪ AI-driven land-use planning for sustainable development.
	▪ AI in crime prediction and prevention. ▪ Enhancing legal research and access to justice through AI tools. ▪ AI-driven systems for monitoring and preventing corruption.
	▪ AI to analyze and optimize international aid. ▪ Facilitating cross-border collaboration through AI-driven platforms. ▪ Enhancing global data sharing and analysis for informed decision-making.

Source: OpenAI

Conclusion: Secure AI is a Requirement for its Use in Realizing a Secure, Sustainable and Superior Future

The overlapping and sometimes competing use-cases for AI across sustainability, security and the creation of a superior future are complex. In the long run these three objectives are of course more or less perfectly aligned: an unsecure or unsustainable future cannot be a superior one, just like an unsustainable world cannot be secure, and vice versa. However, in the short term there will likely be many trade-offs to be made, between a technology's use for good or for harm, between its benefit and its costs, and in terms of the prioritization between sustainability, security, and a superior future in the face of global resource and capacity constraints.

In creating a superior future, AI increases the number of intelligent agents capable of pursuing goals in the world, imbuing machines with the ability to interpret information, make decisions and take actions, augmenting and in many cases potentially replacing human decision making.

There is a growing tension between the power of technology to do good, its uneven distribution across countries making it an uneven arbiter of benefits, its power to be used as a weapon, and the potential for its negative consequences to dislocate societies and the world order with it.

Given its immense potential power, the future that AI creates can range from utopian to dystopian. Its double-edged nature is evident in dichotomies such as:

- Its productivity benefits come with employment dislocations that risk increasing inequality.
- In terms of sustainability, it is estimated to enable 134 targets across all the goals as stated above, but it is also estimated to inhibit 59 targets.
- AI can enhance digital security, but it can also enable mass surveillance and the erosion of personal privacy, and so in the hands of authoritarian regimes, it can be a tool for social control and repression.
- AI can generate, process, and deliver critical information to aid performance but it can also generate fake news, misinformation and deep fakes that undermine social cohesion and political participation.
- And while it can enhance human security it can also be used to power autonomous weapon systems with unrivalled killing potential.

The enormous potential and risk of technology and AI necessitates the development of robust technology safety and governance measures, ensuring that these technologies are developed and deployed responsibly, with consideration for their economic, societal, and environmental impact as well as individual rights. Furthermore, AI safety and governance are vital for the sustainable and beneficial integration of AI across society and industries.

Each of these considerations calls for a global alignment to create appropriate policies and regulation, and there are an increasing number of national and international initiatives that are

looking to create global governance regimes around key digital technologies and their use. However, major countries today remain at various stages of evolving their approach to AI regulation, and many have differing views of how best to do it. Major efforts include the following:

Figure 22: Global AI Governance Efforts – A Snapshot[76]

Regulation	Regulatory Body/Country	Status	Summary
Artificial Intelligence Act	European Union	Active	The AI Act is a comprehensive legal framework that will regulate the development, deployment, and use of AI systems in the European Union based on their level of risk to human health, safety, and fundamental rights
Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence	United States	Active	The Executive Order on AI directs various agencies to develop guidelines and standards for high-risk AI systems such as facial recognition, healthcare algorithms and autonomous weapons
Artificial Intelligence and Data Act	Canada	Proposed	The Artificial Intelligence and Data Act establishes a comprehensive EU framework for regulating high-risk AI systems, prioritizing safety, fairness, mandating rigorous risk assessments and human for potentially harmful AI applications.
Next Generation Artificial Intelligence Development Plan	China	Active	Algorithmic recommendation systems management, including provisions on content management, tagging or labelling, transparency, data protection and fair practices. "Deep synthesis" technology regulation, in particular to combat deep fakes
Global AI Governance Initiative	China-led	Active	The Global AI Governance Initiative proposes collaborative international efforts to foster responsible AI development. It emphasizes adherence to human values, open-source knowledge sharing, and agile governance frameworks.
AI Principles and a Code of Conduct	G7 group of countries	Active	The AI Principles and Code of Conduct advocates for risk-based assessments, user rights, and robust safety measures to promote transparency, environmental sustainability, and continuous improvement of AI.
The Global Partnership on Artificial Intelligence (GPAI)	Transnational organization under OECD	Active	Promotion of international cooperation and coordination on responsible AI development and usage
UNICRI Centre for AI and Robotics	United Nations	Active	UNICRI's Centre for AI and Robotics promotes responsible AI for a safer future through education, research, and collaboration, ensuring its benefits contribute to a just and equitable world.

If politicians can work with other stakeholders to define the control and limits of this powerful technology in a comprehensive global agreement with far greater safeguards than the most

destructive technologies known to man, nuclear weapons, technologists, and users from all walks of life can play their role in ensuring that humankind can actually deliver secure sustainability and a just transition to the future while avoiding the pitfalls. This is clearly a challenging ask and likely given the power that AI provides in terms of power, conquest, and wealth creation, among other human goals, it will require a global agreement of the level of the Non-Proliferation Treaty.

In summary

- Technology is the key catalyst for progress, the key driver of civilizational change throughout human history, and the transition to the future is inextricably linked to technological innovation, both for solving short term challenges and for building a superior world, in the longer-term
- Technology, particularly digital technology, has been recognized as a critical enabler to achieving the UN SDGs, and a core pillar of human security.
- The creation of a superior future for the world depends on the achievement of a series of innovation breakthroughs across AI, computing, and data sciences, but also energy, material sciences and life sciences.
- AI has a critical role to play throughout this transition and beyond, and given its potential for unprecedented progress and destruction, requires a global agreement on how best to manage it.
- If an appropriate charter and safeguards can be agreed between all nations for all peoples, AI opens the way to supporting humankind in addressing the major challenges and unlocking the major opportunities ahead.

IV. Key Technologies for a Sustainable, Secure, and Superior Future

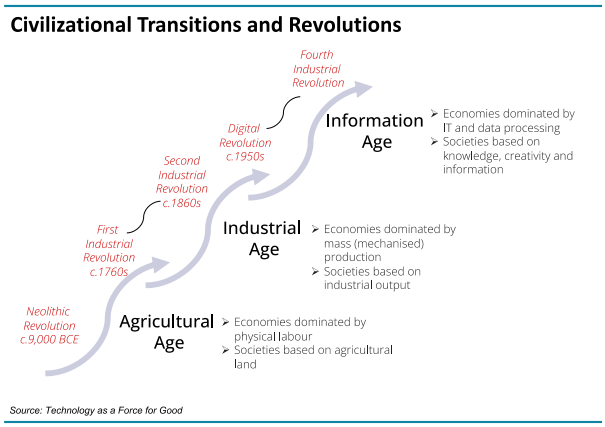
The transition to the future is being driven by the Fourth Industrial Revolution and its fusion of technologies that blur the lines between the physical, digital, and biological spheres. This revolution in turn is being built by 19 core technologies, described in the 2023 Technology as a Force for Good report. These digital and digitally enabled technologies span IT, industrials, energy, virtualization, materials and resources, space (and aeronautics) and health, and are the building blocks for both a superior future and for the secure and sustainable transition to it. With the world seemingly on the verge of critical breakthroughs across many of these technologies, global tech leaders' engagement with these building blocks continues to increase, with the world's largest and most innovative companies positioning to be the future leaders across one or more of these 19 core technologies.

1. The Fourth Industrial Revolution and its Building Blocks

We are in the midst of a transition which through scientific and technological breakthroughs will create a whole new civilization. The growth of human knowledge, which lies at the core of all technology and innovation, is a continuous process, as is the progress it delivers. However, this progress is not uniform in nature. Steady growth is punctuated by periods of rapid change, in which a series of interrelated technological breakthroughs disrupt prevailing paradigms, driving accelerated growth, and fundamentally transforming societies. If these breakthroughs, or

revolutions, are big enough they can drive a global civilizational shift that creates a new era for the world.

The last such shift was initially triggered as part of the advent of the Industrial Age c.250 years ago, its first part was the First Industrial Revolution commencing in the late 18th century in Britain, which rapidly transitioned Northern European states from agrarian economies to industrialized ones. This era was defined by the introduction of machinery and the steam engine. The use of coal as a primary energy source replaced traditional methods like wind, water, and animal power, signifying a major shift in energy utilization. This not only revolutionized manufacturing but also transformed transportation with the development of the steam locomotive and steamship. It was followed by a Second Industrial Revolution spanning the late 19th to early 20th centuries. This second revolution drove profound social, political, and economic change for the world, ushering in the next phase of the Industrial Age and spreading it across the globe. It was characterized by the emergence of new technologies in electricity, in the form of electrical lighting and power, mass manufacturing with the assembly line, as well as communications innovations such as the telephone and telegraph, and the internal combustion engine, facilitating the development of automobiles and airplanes, significantly altering the dynamics of transportation and urbanization. This advanced the European economies and enabled them to create colonies across the world.



The transition from the Industrial Age to The Information Age, began in the 1950s in what is sometimes referred to as The Third Industrial Revolution, or the Digital Revolution, which marks the initial transition from the Industrial Age to the Information Age, with information technology replacing manufacturing as the primary driver of economic value. This revolution was marked by the transition from analogue electronic and mechanical devices to digital technology. The computer was at the forefront of this transformation, and digital technologies have since reshaped every aspect of modern life, from healthcare to education, and from commerce to personal interactions.

Today, the world is in the next phase of the Information Age, (sometimes misleadingly referred to as the Fourth Industrial Revolution), one in which the full economic, social, and environmental impact of information technology will unfold. This revolution is being driven by a set of technologies that is blurring the boundaries between the physical, digital, and biological spheres. Critically the Fourth Industrial Revolution is being shaped by the integration of digital intelligence into physical (and biological) systems.

The technologies rising in this Age are already reshaping industries, economies, and societies. Moreover, it has the potential to deliver sustainability, security, and a superior future for the

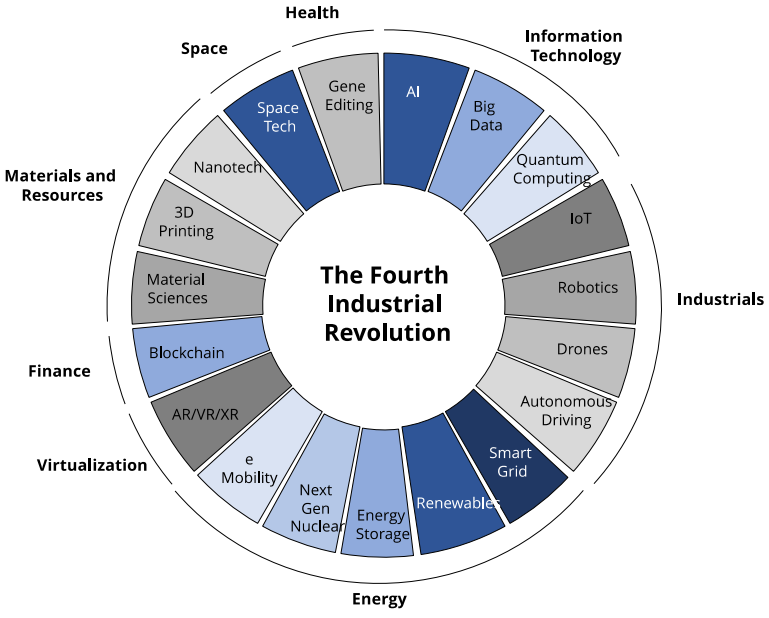
world. It promises increased productivity, improved health outcomes, and enhanced quality of life, but also raises questions regarding privacy, security, job displacement, and the ethical implications of emerging technologies that will need to be addressed.

The 2023 Technology as a Force for Good Report identified 19 'disruptive' technologies at the core of the Fourth Industrial Revolution, these 19 technologies emerged from a detailed analysis of the world's 100 leading digital technology companies, which collectively generate annual revenues of US$3.7 trillion, representing by some estimates over two thirds of the global tech industry. Many of these companies are driving the innovation and technologies which are blurring of boundaries between industries. An analysis of their strategies, research programs and initiatives, partnerships, investments and product and service roadmaps revealed an emphasis on 19 distinct technologies across IT, industrials, energy, virtualization, materials and resources, space (and aeronautics) and health, which together represent the building blocks of the future. These include the following:

19 'disruptive' technologies are being heavily competed for in a bid to drive the innovations which are blurring the boundaries between industries and create a superior future

Figure 23: Core Technologies of The Fourth Industrial Revolution[77]

The 19 Core Technologies of the Information Age



Source: *Force for Good*

These building blocks can loosely be grouped as belonging to a series of traditional industry sectors like industrials, energy, IT, and others, but given the integrated nature of the change underway their impact is much wider than impacting a single industry. Further, these blocks interact with one other and are often deployed in innovative combinations. For example, one of nanotech's biggest current use cases is the manufacturing of solar panels, and data analytics is

essential to consumer industries, and AI is integral to the management of smart grids. Together these 19 core technologies are the building blocks for the delivery of sustainability, security, and a superior future, and the major technology solutions focused on these areas draw heavily on mix of these 19 technologies.

2. Core Technologies Driving Security, Sustainability, and A Superior Future

The 19 core technologies potential impact on sustainability and human security in the near term varies significantly but have a positive contribution to make. In practice, sustainability and security priorities overlap significantly, covering food security, human health, energy security, mobility, and environmental security. While the issues of education and financial inclusion are primarily regarded a matter of sustainability, security also includes community security, covering cultures, values, and the protection of minorities, as well as political security, concerned with protection of human rights and the well-being of all people.

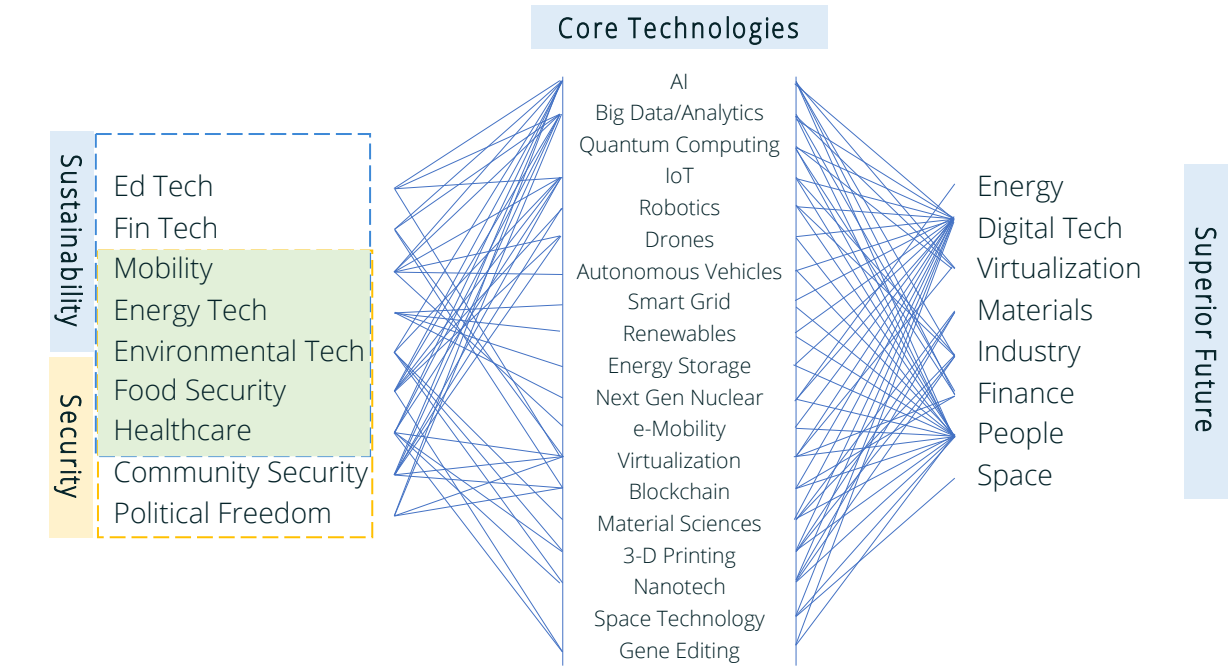
Today, we appear to be at a pivotal moment in history given the world is on the brink of breakthroughs in AI, quantum computing, nanotech, genetics, and fusion, each of which individually have radical transformative potential ... collectively, these breakthroughs can fundamentally reshape the world.

Unsurprisingly, the 19 core technologies also have a more fundamental, longer-term role to play the world, being critical elements required to create a superior future. As stated earlier, a superior future will involve radical changes across eight core aspects, including digital technology, energy usage, virtualization (and reality), materials science advances, industrial transformation, decentralized finance, empowered people, and the accessing of space.

Today, we appear to be at a pivotal moment in history given the world is on the brink of breakthroughs in AI, quantum computing, nanotech, genetics, and fusion, each of which individually have radical transformative potential. Collectively, these breakthroughs can fundamentally reshape the world,

The chart below captures the 19 core technologies and their role in delivering secure sustainability on the one hand, and a superior future on the other hand.

Figure 24: Delivering Secure Sustainability and a Superior Future[78]



Source: *Force for Good*

3. Breakthroughs and Innovations Underway

Importantly, the leaders and innovators driving these 19 core technologies include both tech and non-tech companies, with the latter's origins lying in engineering, manufacturing, industrials, medicine, and energy. The nature of the breakthroughs and innovations being pursued (and achieved) by these leaders varies and includes everything from fundamental scientific innovations that will take years if not decades to commercialize (for example the build out of nuclear fusion reactors), to scaled investments that are already driving mass adoption (for example, in electric vehicles and eMobility solutions).

Identifying the most innovative breakthroughs therefore requires a technology-by-technology view, assessing the respective technology leaders' R&D, business development, investments, products and services, M&A, and strategic activities against each of the 19 core technologies' potential impact on secure sustainability and a superior future. The picture that emerges from a selection of the innovations and innovators for each of the 19 technologies is one of a world on the cusp of major breakthroughs to a new age.

1. Artificial Intelligence

Impact on Secure Sustainability:

- Smarter and automated decision-making
- Optimized resource use
- Data driven insights
- Productivity convergence for developing countries

Impact on Superior Future:

- Automation of complex tasks
- Enhanced research and development
- Complex problem solving
- Optimized resource management

Key Breakthrough: OpenAI's Generative AI Revolution

OpenAI's ChatGPT models are the first generative AI models available to the public and are already being used in a range of commercial applications including customer service, software coding, content creation, education, and training, amongst others.

Other Breakthrough Areas: NVIDIA is developing advanced chips to increase their processing power for AI application, and MistralAI is developing a fully open source LLM, which is expected to further democratize access to key AI tools globally.

2. Big Data Analytics

Impact on Secure Sustainability:

- Pattern and trend identification
- Advanced threat detection
- Enhanced decision-making and resource management

Impact on Superior Future:

- Transformation of decision making
- Real time predictions
- Mass personalization

Key Breakthrough: Edge Computing from Amazon, Microsoft, Alphabet, Intel, Oracle, and Tech Industry Giants

Tech industry leaders have shifted towards edge computing platforms that enable data to be stored and processed closer to where it is generated, allowing big data to be processed at higher speeds and volumes, thus enabling real-time analytics.

Other Breakthrough Areas: Augmented analytics, by companies like Tableau, SAS Institute and TIBCO, leverage AI and machine learning to improve data preparation, insight generation and insight explanation to make big data analytics accessible to non-technically trained professionals.

3. Quantum Computing

Impact on Secure Sustainability:

- Complex problem solving and modelling
- Enhanced encryption

Impact on Superior Future:

- New life-saving treatments and therapies unlocked through quantum modeling of chemical reactions
- Material science breakthroughs through quantum modeling

Key Breakthrough: IBM Achieving Quantum Supremacy

IBM's 127-qubit Eagle quantum computer has recently achieved quantum supremacy, outperforming a supercomputer to solve a complex practical math problem.

Other Breakthrough Areas: Google's QuantumAI advances of quantum error correction, essential for building large-scale quantum computers, or Microsoft's Azure Quantum program's breakthroughs in building scalable topological qubits.

4. Internet of Things

Impact on Secure Sustainability:

- Enhanced surveillance and monitoring
- Systems integration and automation
- Improved industrial efficiency and minimization of waste
- Optimization of energy usage in industrial and residential applications

Impact on Superior Future:

- Complete industrial automation with the ability for industrial plants to 'speak to each other'

Key Breakthrough: Emerson's PlantWeb Digital Ecosystem

Emerson's IoT ecosystem integrates sensors and data analytics into industrial assets and production systems, in order to automate plant workflows.

Other Breakthrough Areas: Bosch's smart city Efflink platform, linking networks of buildings together for urban management, and mobility; Software AG's IoT edge platform, reducing computing time and cost for IoT applications.

5. Robotics

Impact on Secure Sustainability:

- Human replacement in physical and hazardous work
- Disaster response
- Law enforcement

Impact on Superior Future:

- Automation of complex physical human tasks when combined with AI

Key Breakthrough: Boston Dynamics' Humanoid Robot Program

Boston Dynamic's Atlas, a humanoid robotics platform, is driving advances in whole-body mobility and bimanual manipulation to create a robot with near universal commercial utility.

Other Breakthrough Areas: Intuitive's da Vinci surgical robot system is pioneering minimally invasive robot-assisted surgeries, while automated mobile robots by companies like KUKA are integrating material transport and assembly processes.

6. Drones

Impact on Secure Sustainability:

- Surveillance and monitoring to improve efficiency and reduce waste
- Search and rescue
- Precision agriculture to monitor and manage crops
- Unmanned warfare

Impact on Superior Future:

- Improving traffic flows and congestion through traffic monitoring
- Autonomous air transport

Key Breakthrough: Amazon's Prime Air Delivery Service

Amazon's drone delivery system currently undergoing testing aims to achieve a target 30-minute journey time from warehouse to customer.

Other Breakthrough Areas: Altitude Angel's drone corridor, a 70-mile-long corridor for commercial UAVs connecting two UK cities with network of ground-based beacons, and agricultural drones from DJI and Parrot enabling precision agriculture.

7. Autonomous Vehicles

Impact on Secure Sustainability:

- Increased transportation efficiency, lower traffic congestion and lower emissions through shared mobility
- Improved road safety through reduction in human errors
- Automation of industrial transport systems

Impact on Superior Future:

- Reimagination of urban landscapes and transport infrastructure

Key Breakthrough: Waymo One's Autonomous Ride Hailing

Waymo has launched the first fully autonomous driving ride hailing service in the world in selected US cities, increasing reliability and passenger safety.

Other Breakthrough Areas: Cruise Origin's completely driverless Robotaxi platform, or Tesla's Level 4 autonomous driving software, already installed in 400,000 passenger cars.

8. Smart Grid

Impact on Secure Sustainability:

- Enhanced energy efficiency
- Improved power supply reliability
- Renewable energy and EV charging integration

Impact on Superior Future:

- Complete decentralization of energy generation

Key Breakthrough: Itron's Advanced Metering Infrastructure 2.0

Itron's AMI 2.0 platform ties smart-meters into an edge-computing network with real-time data, enabling decarbonization and grid resiliency.

Other Breakthrough Areas: Microgrids, for example by Schneider Electric, powered by renewables or STMicroelectronic's Demand Response Management solutions driving grid efficiency

9. Renewables

Impact on Secure Sustainability:

- Reduced greenhouse gas emissions
- Natural resource sustainability
- National/regional energy security

Impact on Superior Future:

- Critical contributor to global net zero

Key Breakthrough: Linde's Electrolyzers for Green Hydrogen

Linde has built the world's largest 24-megawatt proton exchange membrane (PEM) electrolyzer capable of producing zero-carbon green hydrogen.

Other Breakthrough Areas: Turbine-less wind power by Aeromine generating electricity from airflow, and solar powered windows by Ubiquitous Technologies that allow visible light to pass through it while absorbing ultraviolet and infrared light into electricity.

10. Energy Storage

Impact on Secure Sustainability:

- Renewable energy integration
- Grid stability
- Reducing carbon emissions

Impact on Superior Future:

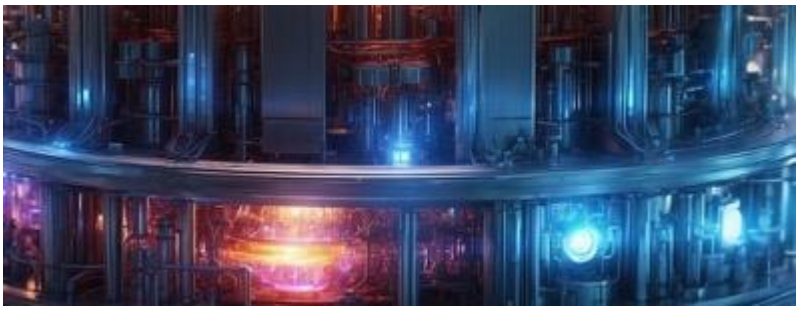
- The end of fossil fuels

Key Breakthrough: CATL's Condensed Battery Technology

CATL has announced a new "condensed" battery with 500 Wh/kg, doubling energy density vs. traditional batteries to make electric aviation feasible.

Other Breakthrough Areas: Structural supercapacitors, combining structural support with energy storage, enhance the power capacity of electronic devices and vehicles without increasing their weight, Northvolt's sodium-iron batteries, offer safer, more cost-effective, and sustainable storage than conventional batteries.

11. Next Generation Nuclear

Impact on Secure Sustainability: • Lower carbon emissions and acceleration of Net Zero emissions • Energy security for all Impact on Superior Future: • Clean, abundant, and functionally superior energy source	Key Breakthrough: Net Energy Gain in Fusion Reaction Achieved  Lawrence Livermore National Laboratory has achieved net energy gain in a fusion ignition, producing 2.6 megajoules of energy from 2.1 megajoules of energy used to power the laser igniter, a critical breakthrough for commercial fusion technology. Other Breakthrough Areas: Private fusion companies working with governments on fusion plant design, including Commonwealth Fusion Systems and Tokamak Energy

12. eMobility

Impact on Secure Sustainability: • Electrification of transport enables decarbonization • Zero tailpipe emissions Impact on Superior Future: • Shared and sustainable mobility replaces owned vehicles	Key Breakthrough: Decentralized Charging Networks  With increased adoption of electric vehicles across countries, startups such as Voltpost and EVIO have developed charging solutions to convert lampposts and conventional electric sockets into smart EV charging stations, removing a critical impediment to faster EV adoption. Other Breakthrough Areas: Startups like GO Sharing in the Netherlands and AltMobility in India are offering eMobility-as-a-Service platforms for shared on-demand sustainable transportation for both retail users and commercial fleets.

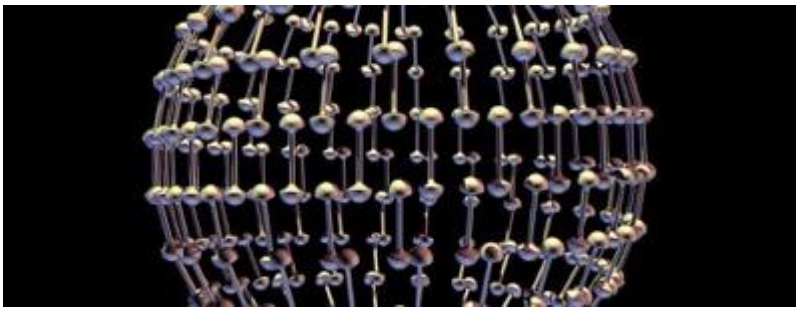
13. Virtualization (VR, ER, AR, XR, MR)

Impact on Secure Sustainability: • Tele-health • Virtual education • Remote work and collaboration Impact on Superior Future: • Blurring physical and digital boundaries • Enhanced learning and training • Innovative entertainment and social interactions • Personalized services	Key Breakthrough: Meta's Metaverse  Meta has invested US$50 billion in the Metaverse, a virtual reality solution offering seamless virtual spaces for work, education, and entertainment. Other Breakthrough Areas: Apple's Vision OS Spatial computing operating system for application development, or Microsoft's MR platforms offering immersive mixed reality enterprise services

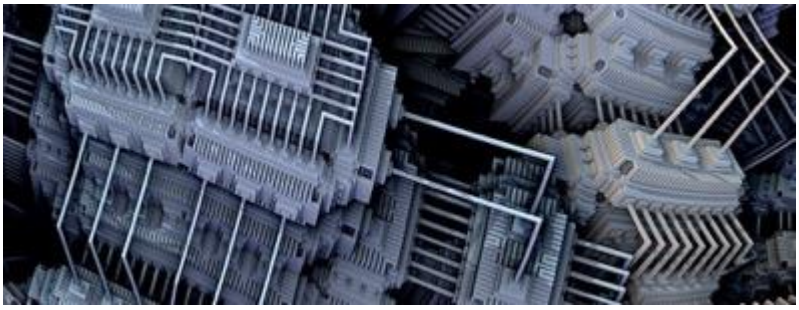
14. Blockchain

Impact on Secure Sustainability: • Increased digital privacy • Secure transactions • Speed and cost effectiveness Impact on Superior Future: • Democratization and decentralization of finance and commerce • No intermediaries or central control	Key Breakthrough: Ethereum 2.0  Ethereum 2.0 is a scalable global platform for developing blockchain-related projects, incorporating a native token to pay transaction fees. Other Breakthrough Areas: Ripple's decentralized finance transaction platform, or Linux's Hyperledger Fabric, an open-source blockchain framework designed for enterprise use cases.

15. Material Sciences

Impact on Secure Sustainability: • Synthetic alternatives to natural resources with improved efficiency • Superconductors to enable frictionless bearings, magnetic levitation, electric cars and other technologies Impact on Superior Future: • Self-healing materials • Programmable matter (with the ability to process information and change its own properties) • Metal foam to enable space colonies and floating cities	Key Breakthrough: CubicPV's Perovskite Solar Cell  CubicPV's photovoltaic cells using perovskite produce at least 20% more energy (and potentially up to double) vs. the prevailing silicon technology. Other Breakthrough Areas: Graphenea, a leading producer of graphene, a carbon based flexible and transparent conductor, or emerging lab based technologies like synthetic metamaterials.

16. 3D Printing

Impact on Secure Sustainability: • Creation of complex structures • Customization and precision in product design • Reduced waste and increased efficiency Impact on Superior Future: • Organ printing • Infrastructure • Personalization and customization of goods	Key Breakthrough: Replique's Metal 3D Printing  Replique's 3D printing platforms across multiple materials manufacture on-site spare parts for industrial processes. Other Breakthrough Areas: Stryker's orthopedic printing for artificial joints and implants , or ICON's 3D construction printing technology.

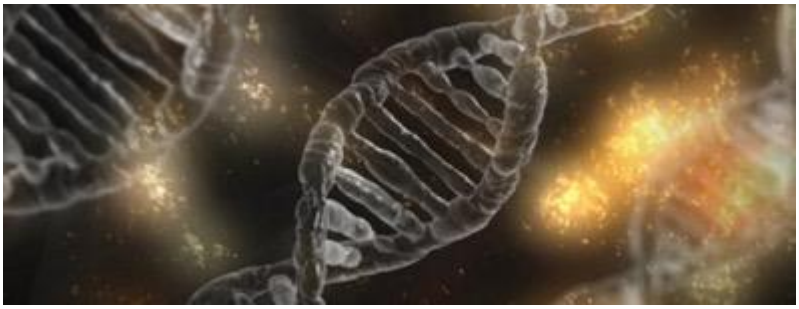
17. Nanotech

Impact on Secure Sustainability: • Targeted drug delivery • Advanced diagnostics • Component miniaturization Impact on Superior Future: • Stronger and lighter materials • Biosensor systems that enable complex and customized diagnostics and human-machine interactions	Key Breakthrough: DNA Nanoturbines  Researchers in Germany have developed a self-configuring nanoscale device capable of transforming energy from electrical or salt gradients into practical mechanical work. Other Breakthrough Areas: Nanotech drug delivery systems: offers precision targeting specific cells or tissues, or nano-scale materials for higher-density data storage, or self-healing nanostructured materials in aerospace or electronics.

18. Space Technology

Impact on Secure Sustainability: • Access to affordable internet connectivity for all, including in remote areas • Accelerated materials science breakthroughs Impact on Superior Future: • Space-based (Zero-G) manufacturing and R&D • Development of interplanetary civilization	Key Breakthrough: SpaceX's Starlink Satellite Internet  SpaceX's Starlink service provides global high speed internet services with a network of over 5,500 mass-produced small satellites in low Earth orbit. Other Breakthrough Areas: Crewed missions to sub-orbital space by private companies, including Virgin Galactic, or Blue Origin's communications and energy solutions for space exploration.

19. Gene Editing

Impact on Secure Sustainability: • Medical breakthroughs curing diseases • Agricultural optimization • Environmental engineering Impact on Superior Future: • Transhuman augmentation	Breakthrough: First FDA Approved Genome-Edited Cell Therapy  Vertex Pharmaceuticals and CRISPR Therapeutics have received FDA approval for the world's first gene edited therapy, treating otherwise incurable sickle cell disease. Other Breakthroughs: Intellia Therapeutics' gene editing pipeline focused on amyloidosis and angioedema.

4. Tech Industry Leaders Driving and Competing for a Superior Future

Digital technology is the common thread that connects the 19 core technologies of the future, and 'Big Tech' and other tech sector leaders have unsurprisingly sought to engage with all of them to varying degrees. Last year's report examined the 19 core technologies through the lens of the 100 leading (digital) tech companies, mapping of their initiatives (solutions, products, R&D, and partnerships) across these key segments of future tech.

The 'tech industry' as commonly defined encompasses companies focused on the research, development, and distribution of IT related goods and services, including software and services, hardware and equipment, semiconductors, internet and e-commerce, and IT services, among others. The 100 leading global tech companies represent a significant portion of the worldwide market for digital technologies, generating an estimated two thirds of the total industry revenues and representing nearly 25% of the total global equity market capitalization across *all* industry sectors. These tech sector leaders include the following:

Figure 25: Tech Sector Leaders

Amazon.com, Inc.
Apple Inc.
Alphabet Inc.
Samsung Electronics Co., Ltd.
Microsoft Corporation
JD.com, Inc.
Alibaba Group Holding Limited
Meta Platforms, Inc.
Dell Technologies Inc.
Tencent Holdings Limited
Sony Group Corporation
Intel Corporation
HP Inc.
IBM Corporation
TSMC Limited
Xiaomi Corporation
Cisco Systems, Inc.
QUALCOMM Incorporated
Oracle Corporation
SK Hynix Inc.
Schneider Electric S.E.
SAP SE
Micron Technology, Inc.
Netflix, Inc.
Meituan
Broadcom
NVIDIA Corporation
Salesforce, Inc.
Applied Materials, Inc.
PayPal Holdings, Inc.
Nokia Oyj
ASML Holding N.V.
Baidu, Inc.
Coupang, Inc.
Texas Instruments Incorporated
MediaTek Inc.
Block, Inc.
Uber Technologies, Inc.
Lam Research Corporation
Tokyo Electron Limited
Automatic Data Processing, Inc.
Advanced Micro Devices, Inc.
TE Connectivity Ltd.
Fiserv, Inc.
Adobe Inc.
Murata Manufacturing Co., Ltd.
Pinduoduo Inc.
Nintendo Co., Ltd.
Infineon Technologies AG
Fidelity National, Inc.
Cadence Design Systems, Inc.
NetEase, Inc.
Vmware, Inc.
Kuaishou Technology
STMicroelectronics N.V.
Intuit Inc.
Analog Devices, Inc.
NXP Semiconductors N.V.
Booking Holdings Inc.
eBay Inc.
Sea Limited
KLA Corporation
Activision Blizzard, Inc.
Global Payments Inc.
MercadoLibre, Inc.
Electronic Arts Inc.
Microchip Technology Incorporated
Adyen N.V.
ON Semiconductor Corporation
GLOBALFOUNDRIES Inc.
Keyence Corporation
Equinix, Inc.
Airbnb, Inc.
ServiceNow, Inc.
Roper Technologies, Inc.
Dassault Systèmes SE
Palo Alto Networks, Inc.
Arista Networks, Inc
Keysight Technologies, Inc.
Workday, Inc.
Constellation Software Inc.
JD Health International Inc.
Shopify Inc.
Marvell Technology, Inc.
Autodesk, Inc.
Synopsys, Inc.
Zoom Video, Inc.
Foxconn Technology Co., Ltd.
Robinhood
OpenAI
Twitter/X Corp
ByteDance
Stripe, Inc.
Canva
Databricks
Revolut
Unity
Atlassian Corporation
Chime

Breadth and Depth of Engagement

The level of the 100 tech industry leaders' current engagement with the 19 core technologies varies significantly. Larger companies, and 'Big Tech' in particular, are key players across a wider range of technologies, especially so since many of the core technologies require scale for successful development. Areas like AI and big data analytics for example are 100% digital in nature and more or less core to the business of nearly every one of the 100 largest tech companies, while gene editing and nanotechnology are highly specialized fields that require significant engineering and specific domain expertise. The charts below capture the investments,

products and partnerships launched by the world's 100 largest tech companies in each of the 19 core technology areas.

Figure 26: Tech Leaders Engagement Across the 19 Core Technologies[79]

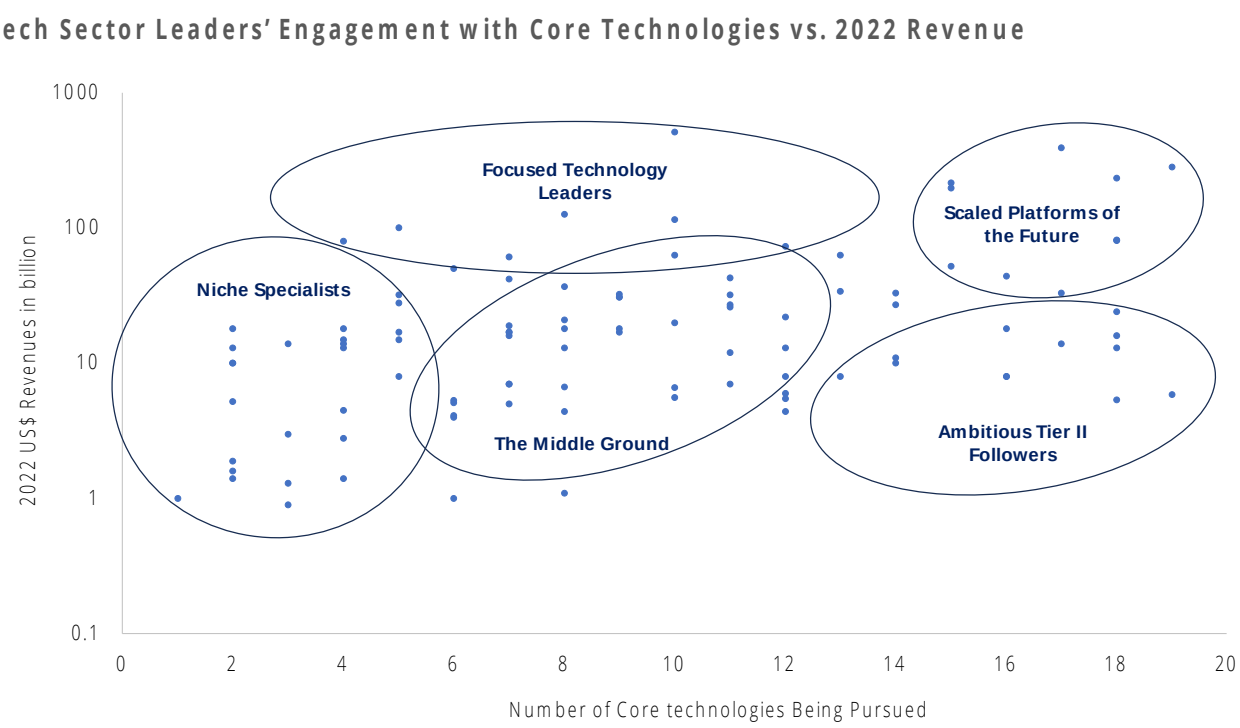
There are a number of insights emerging from this analysis:

- **Universal Engagement with Core Technologies.** All tech sector leaders are positioning themselves across one or more of these 19 technologies.
- **AI and Big Data are Critical Areas of Focus.** AI has emerged as a near universal area of engagement for tech sector leaders, followed closely by big data, with 98% and 87% of leaders pursuing initiatives there, respectively, reflecting both their status as critical general-purpose applications that can be deployed across every industry sector, as well as their adjacency to tech companies' own core businesses and capabilities.
- **Significant Focus on Industrial Technologies.** Approximately half of tech sector leaders engage with one or more digital industrial technology, led by IoT (62%), but with significant engagement in autonomous driving (45%) and drones (40%), reflecting the increasing digitalization of industrials.
- **Energy Increasing as Attractive Target.** Over half of tech sector leaders are pursuing opportunities related to renewables (60%) and smart grid technologies (59%) with slightly less than half engaging in e-mobility (47%) and energy storage (40%), reflecting the expected future growth of the renewables sector in the context of the energy transition underway.
- **Virtualization and Blockchain Increasingly Seen as Core Technologies.** Significant engagement with virtualization (63%) and blockchain (48%) reflects these technologies' growing role across a widening range of applications and industries.
- **High Potential Future Technologies Currently Targets of Specialists.** Technologies such as next generation nuclear (fusion) (13%), gene editing (17%), and nanotech (27%) are potentially as disruptive (and valuable) as AI, but are currently at much earlier stages of development, as well as being highly complex fields of science. While IT plays a critical role in these technologies, it is also a highly specialized one far removed from most tech sector leaders' core businesses and are targeted by specialists in collaboration with industry domain experts.

Evident Emerging Strategic Positions in Competing for the Future

Measuring tech sector leaders' total engagement (across R&D investments, partnerships, and products) with the 19 core technologies relative to own levels of scale provides the following picture.

Figure 27: Tech Sector Leaders' Core Technology Engagement vs 2022 Revenues[80]



Source: Technology as a Force for Good

The analysis reveals increasing engagement with the core technologies largely uncoupled from the underlying company size. In particular

- The median 2022 revenues generated by the 100 tech sector leaders was US$15 billion, and median number of core technologies engaged with was 8.5.
- Engagement with the 18 technologies is somewhat correlated with company size, with larger companies engaging across a wider range of technologies. However, there is significant variance in the technology engagement levels across the spectrum of company size.
- Nearly ten companies engaged with 18 or more of the technologies overall, while only one company engaged with just a single technology and less than ten companies with two or fewer.

The last year has seen a shift in the evident approach to positioning across these core technologies. The analysis reveals increasing engagement with the core technologies largely uncoupled from the underlying company size. The strategies and positions emerging area as follows:

- **Scaled Platforms of the Future.** The largest companies have mostly chosen to establish a presence across 15 or more of the core technologies, including six companies with revenues over US$150 billion.
- **Ambitious Tier II Followers.** This group, representing smaller but still multi-billion dollar enterprises engaging in more than 12 technologies, has broadened to include earlier

stage companies, including one company in the lowest quintile of revenue generation, implying that members of their tier believe they can be successful taking positions in multiple sub-components of the each of these core technologies or aim to scale on a broad front to achieve the position of the Scaled Platforms.

- **Focused Technology Leaders**. Several of the world's largest tech companies appear to be continuing to take a more concentrated approach to the technologies of the future, focusing their efforts on technologies across a limited number of segments, with two companies in the highest quintile of revenue generation engaged with five or fewer of the 19 technologists.
- **Niche Specialization**. Over one quarter of tech sector leaders are engaging focused on five or fewer core technologies. These companies are mainly niche specialists, focusing on one or two disruptive technologies beyond core IT (enabled by AI and/or big data).
- **The Middle Ground**. These companies, representing more than a third of the group, have diversified initiatives across six to up to a dozen disruptive technologies, implying a focus on several segments beyond core IT. While this strategy is likely not competitive against the Scaled Platforms or the Niche Specialization players if fully played out, it may well be a steppingstone to one of these and may well make sense in the period before there is clarity on the developmental roadmap for disruptive technologies.

In summary

- The civilizational shift underway is being driven by the transition to the Information Era which is not only blurring the boundaries between technology and other industry sectors, but between digital, physical, and biological systems as well.
- The building blocks of the Fourth Industrial Revolution are 19 core technologies, which play distinct fundamental roles in underpinning both secure sustainability in the short term and a superior future in the longer term.
- The 19 core technologies are areas of increasing interest and engagement by global tech sector leaders, who are increasingly competing with one another to drive breakthroughs across these areas that will position them as leaders of the future as well.
- Engagement with information processing technologies like AI and Big Data is near universal, with 98% and 87% the 100 global tech sector leaders pursuing initiatives there, but industrial, energy and financial technologies are also attracting the attention and investment of half or more of these companies.
- Tech sector leaders are also increasing their engagement with earlier stage specialist areas of technology like gene-editing, nanotech, and nuclear fusion, albeit from much lower levels, given the fundamental transformative impact these technologies may have.

I. Technology's Strategic Role in Geopolitical Power

Given the disruptive potential and the transformative power of the 19 core technologies, it is no surprise that they are increasingly emerging as fields of geopolitical competition between countries and power blocs. Innovation and access to superior technology throughout history has determined the dominant states of the times. The 19 core technologies therefore sit alongside a state's core assets – its people, land, energy resources, capital, and economic output – in determining their emerging power position in the 21st century. The world's major power blocs, as well as regional powers, are therefore positioning themselves across these technologies, leveraging their innovation capacity, their domestic economies, and their capital to build leadership positions in the technologies of the future.

1. Technology and Geopolitical Power

While the continued development of the core technologies critical for the future depends heavily on the research, development and investment activities of the tech sector, and their industrial adoption, these technologies redefine the world we live in. As such, the exploitation of these technologies is a matter of grand strategy and politics. The power that these technologies confer is political, military, economic and social and as such impacts billions of people and are therefore its deployment is far too important to be left to individual businesses to decide or self-regulate, no matter how well intentioned they may be. Just as technology for constructing and breaking codes were a matter for states in Second World War, the core technologies that determine the future are a matter for the state too. Likewise, today, governments will play a leading role in strategic technological development and deployment, working hand in hand with the private sector and other stakeholders.

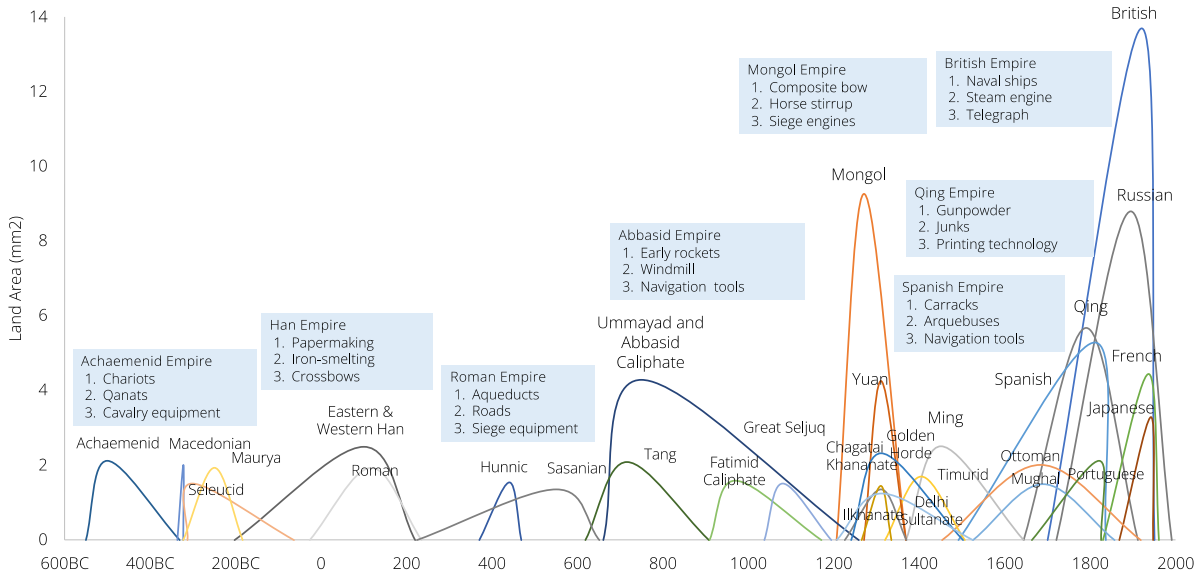
Looking back over history at the relationship between power and technology, it is clear that technology has been a strategic resource for states throughout history, by being a powerful adjunct to the state's ability to leverage its core assets. In the Agricultural Age these included land and people. In the Industrial Age the list of core assets expanded to include manufacturing capacity (as a measure of economic output) and access to energy, and in the Information Age these assets grew further and included intellectual property and computing power. Technology provides states with the power to generate economic value, political capital at home, conquest abroad over peoples and markets. Given this power, technology breakthroughs have often been guarded jealously by their innovators, seeking to gain an advantage over their rivals. This has made technology a weapon of the state in its global positioning. While merchants may have opened markets, states, often reluctantly, took control at the point at which it became a strategic asset for the power of the nation.[81] Sufficiently powerful innovative technologies will likely fall into the same camp.

Technology provides states with the power to generate economic value, political capital at home, conquest abroad over peoples and trade, making technology a weapon of the state.

The link between technology leadership and geopolitical power is ancient. Throughout history successive empires have risen on the back of new innovations and technologies whose exploitation has underpinned their success and rapid growth. The mastery of a succession of disruptive technologies including the production of steel, lateen rigging on ships, and gunpowder among others, conferred advantages to states on an increasingly global scale and helped shape and re-shape the geopolitical order of the world. And as the rate of technological innovation has accelerated, the life spans of empires have shortened, with their technological advantages being more quickly eroded.

Figure 28: Empires and Technology[82]

Rise and Fall of Major Empires – and the Technologies that Drove Them



Source: Greater Pacific Capital, Research, 2020; Data Sources: East-West Orientation of Historical Empires, Turhin, Adams and Hall (2006); Expansion and Contraction of Large Polities: Context for Russia; The Rise and the Fall of the Japanese Empire, David James; Cambridge University

In a world of accelerating innovation and progress, technology has unsurprisingly become an increasingly critical area of focus for geopolitics, with leading global countries both competing and cooperating with one another to ensure future access to the core technologies that will drive security, sustainability, and a superior future. Against the backdrop of an increasingly multi-polar world, America's growing great power competition with China has increasingly encapsulated technology rivalry. Both the EU and India recognize the importance of technology as a core pillar of security, with the EU a mature investor in the field. In addition, there are a number of regional powers with increasingly global aspirations and the ambition to compete head on with major power blocs in some areas. These regional powers include Russia, Saudi Arabia, Japan, and the UK, some with geopolitical aspirations and some with economic ones strongly rooted in technology and innovation.

The positioning of these regional and global powers varies significantly across the 19 core technologies, with each bloc having unique assets and conditions that provide it with advantages (and disadvantages) across the lifecycle of each technology, ranging from fundamental innovation capacity to the existence of a large domestic market to support the creation of industry leaders.

Figure 29: Core Technologies and Geopolitics[83]

	USA	China	EU	India	Russia	Saudi	Japan	U.K.
Artificial Intelligence								
Market Size *(all US$ billion)*	87	29	45	4	1.7	1.2	2.4	21
Patent Applications *(as of 2023)*	36,830	12,219	5,534	3,422	<122	<122	122	461
Funding *(all US$ billion)*	335	92	58	19	0.1	1	2.7	23.5
Big Data								
Market Size	101	80	40	2.2	2-4	0.2	11.8	5-10
Patent Applications	3,993	74	330	275	<3	<3	<3	73
Funding	34	4.3	2.2	1.4	<0.7	<0.7	<0.7	1.5
Quantum Computing								
Market Size	0.3	0.1	0.1	NA	NA	NA	145	80
Patent Applications	15,484	904	2,310	240	<34	<34	48	188
Funding	2.3	0.1	1.7	0.05	<0.05	<0.05	0.06	1.2
IoT								
Market Size	172	147	297	27	17.4	10	31.7	26
Patent Applications	47,720	9,701	6,535	2,616	<32	<32	<32	412
Funding	72	8	11	1	0.3	0.3	0.3	4
Robotics								
Market Size	7.7	6.4	11.3	0.8	0.3	0.1	2.7	1.3
Patent Applications	33,833	29,344	7,164	1675	<183	<183	1185	553
Funding	8.2	4.1	1.3	0.1	0.1	0.1	0.5	0.2
Drones								
Market Size	1.3	1.4	0.6	0	0	0	0.1	0.1
Patent Applications	15,124	181	2,294	650	<60	<60	90	215
Funding	9.7	1.8	1.4	0.2	0.2	0.2	0.2	0.3
Autonomous Driving								
Market Size	8	3	5.1	0.4	0.2	0.1	0.9	1
Patent Applications	26,145	1,773	4,380	691	<54	<54	189	541
Funding	36.6	6.7	3.4	0	0	0	0.4	1.5
Smart Grid								
Market Size	8.7	13	NA	0.5	NA	NA	NA	NA
Patent Applications	15,255	1,118	2,707	565	<6	<6	6	196
Total Funding	10.3	0.4	2.25	0.2	0.01	<0.01	0.04	4.25
Renewables								
Market Size	186	238	300	52	12	0.04	35	31
Patent Applications	7,384	1,579	1,616	1,031	<100	<100	<100	317
Funding	114	85	266	14	NA	NA	26	31
Energy Storage								
Market Size	60	45	92	3.1	2.07	NA	11.3	13.9
Patent Applications	77,571	35,365	15,500	2,777	<343	<343	421	1,606
Funding	29	19	26	1.2	0.1	<0.1	0.17	3.8
Next Gen Nuclear (Fusion)								
Market Size	50	-	53.8	1-1.5	0.5-1	NA	NA	80.7
Patent Applications	9,525	958	1,358	248	46	<46	109	121
Funding	4.5	<0.01	0.1	<0.01	<0.01	<0.01	0.1	0.2
e-Mobility								
Market Size	70	292	145	5.6	NA	NA	6.9	19
Patent Applications	76,038	22,204	17,633	2,875	<215	<215	1394	1531
Funding	57	43	18.5	5	0	0	0.2	3.5
Virtualization								
Market Size	8.8	5.0	8.0	0.6	0.4	0.1	1.8	1.6
Patent Applications	28,026	1,945	4,870	830	<49	<49	128	389
Funding	7	0.6	0.6	0.2	0.1	0.1	0.1	0.8
Blockchain								
Market Size	6.2	4	1.1	0.9	NA	NA	1.7	1
Patent Applications	5716	593	614	409	<11	<11	<11	84
Funding	41	8.2	9	1.2	0	0	0.7	7.6
Material Science								
Market Size	22	17.5	17	5.5	NA	2.6	NA	NA
Patent Applications	30,867	10,231	4,439	1,610	<207	<207	294	245
Funding	9.5	1	0.95	0.15	<0.15	<0.15	0.8	0.75
3D Printing								
Market Size	4.3	1.5	6.8	0.25	0.2	0.1	0.6	0.5
Patent Applications	36,680	1,337	5,100	677	<113	<113	<113	636
Funding	8.4	0.8	1.7	0.03	<0.03	0.03	0.03	0.4
Nanotechnology								
Market Size	23.3	5-10	17	<0.15	NA	NA	3-5	04-Jun
Patent Applications	1,889	279	278	287	30	<18	25-Jan	19
Funding	19.6	1.9	2	<0.15	<0.15	<0.15	0.15	2.5
Space Technology								
Market Size	111	141	98	8.1	0.11	0.4	2.5	20.65
Patent Applications	126,203	52,240	20,370	4,022	<265	<265	265	1,813
Funding	20.5	1.45	1.15	0.2	<0.2	<0.2	0.35	0.4
Gene Editing								
Market Size	3.00	1.4	1.5	<0.01	NA	0.27	0.5	<0.01
Patent Applications	27,996	12,477	5,575	1,092	284	<284	1,332	<284
Funding	97.1	11	8.8	1	<0.01	<0.02	0.01	0.02

Source: Statista

Note: The analysis above is indicative of the future potential positioning of countries with regards to the 19 core technologies. It inherently assumes that national interests are reflected in national spend rather than exploring the changing nature of international trade. This latter dimension has two pertinent elements, the first being the current international competitive positioning of a country's companies, so for example, while the EU is the largest global market for renewable energy, China's manufacturers dominate the renewable energy equipment market, producing 80% of the world's solar panels and 60% of its wind turbines.[84] The second being the opposing trend whereby, while market share in international markets matters the longer-term sustainability of such positions is being eroded in a world of increased geopolitical competition, in which technology is seen as critical to security, and the rationale of the friend and near-shoring of critical resources like energy and technology trumps simple economic calculations.

In addition to the technological positions of nations, a number of broader macro non-technological capabilities are also essential to determining a state's geopolitical positioning. These comprise the core assets of a state — people, land, economic output, energy resources, capital, and intellectual property –which are the core platform upon which technological power can be leveraged. Considering the positions of the regional and global powers with regards to both the 19 core technologies *and* the distribution of critical strategic assets results in the picture below.

Figure 30: Global Assets and Geopolitics[85]

	USA	China	EU	India	Russia	Saudi Arabia	Japan	U.K.
Share of Global Resource in %								
Market Capitalization	31%	15%	14%	3%	0%	3%	5%	11%
GDP	26%	17%	18%	4%	2%	1%	5%	3%
Wealth	31%	19%	23%	3%	1%	1%	5%	3%
Defence Spend	40%	13%	19%	4%	4%	3%	2%	3%
Trade	11%	14%	13%	3%	2%	1%	3%	3%
Population	4%	18%	9%	18%	2%	0%	2%	1%
Arable Land	11%	9%	11%	11%	9%	0%	0%	0%
CO_2 Emissions	13%	33%	7%	7%	5%	2%	3%	1%
Energy Consumption	15%	26%	12%	7%	6%	2%	3%	1%
Government Debt as % of GDP	121%	77%	83%	83%	20%	23%	261%	102%
Global GDP Rank								
2023	**1st**	**3rd**	**2nd**	**5th**	**9th***	**15th***	**4th**	**6th**
2050	**2nd**	**1st**	**3rd**	**4th**	**8th***	**12th***	**6th**	**7th**

Sources: World Federation of Exchanges, SIPRI, Bloomberg, MSCI, IMF World Economic Outlook, WTO Stats (WITS), Worldometer, World Population Review, European Commission, Enerdata World Energy & Climate Statistics Yearbook 2023

This analysis 80provides several important insights on the nature of power and how technology plays a critical role in its exercise in the future.

1. US Overall Leadership Position. The US still leads the world in almost every meaningful way across most critical assets, and in some assets, for example defense spending and corporate value commands a bigger global share, 40% and 43% respectively, than the next two power blocs combined.
2. China Overtaking EU to Challenge US. Population aside, China appears to be level with the EU across many dimensions, with a similar share of global GDP (17% vs 18%), trade (14% vs

13%), market cap (15% vs 14%) and wealth (19% vs 23%). However, its political system allowing it to mobilize these resources and assets in a much faster and comprehensive way, and its medium-term growth is set for it to overtake the EU across most metrics soon.

3. India at Nascent Stage, Showing Significant Potential. India across many of the macro dimensions lags the other power blocs, with resources on par with regional powers across many assets including market cap (3% - equal to Saudi Arabia), GDP (4% - trailing Japan), defense spending (3% - on par with Russia) and trade (3% - equal to the UK). However, its population and its high growth are drivers that can see it rapidly grow to the level of the other blocs, overtaking the EU by the middle of the century.
4. US Financial Strength is Market Based, Political Issues Exist for the Approval of Large Strategic Spends. The US's huge market capitalization adds weight to the private sector while high levels of public debt stand in the way of the state, which coupled with a deep political divide and politicization and resistance to the energy and sustainability transition may hinder its leadership (noting that it's Inflation Reduction Act committed $783 billion for energy security and climate change).[86]
5. Full Range Technology Remains an American Game. The US remains the clear leader in deploying capital into 18 of the 19 of the core technologies and across total patent applications in each of them, thanks to it being home to the world's largest technology market overall, and home to the majority of the sector's global leaders.
6. China's Leadership in a Few Core Technologies Makes it a Powerful Player. China's advantage across selected areas of tech (e.g. e—mobility, drones, etc.) stems from its scaled domestic market in key products, the serving of which has created a series of tech leaders with scaled and low-cost manufacturing capabilities. Further, China's strong position in EVs (with the world's largest market) and renewables (the 2nd largest market globally) in particular means that it has a critical role to play in the in the global energy transition.
7. India's Technology Capabilities Are Rising Quickly. Similar to its position in non-tech related critical assets India's (low) investment levels and (small) market size across the 19 technologies reflects its historical status as a developing country. The country's rapid growth is however enabling significant research and investment that will position India as a tech leader of the future.
8. EU Scale and Regulatory Leadership Make it a Rule-Setter for Technology. The EU is big technology adopter, rather than an innovator, and its market size far outstrips its share of global investment in the key technologies, giving it potential power as a regulator of how innovation is used, rather than how it is created.
9. Regional Players with Point Leadership Across Technologies. In most cases other countries' efforts across the critical technologies pale in significance relative to the four power blocs, given their small research bases and domestic markets, as well as their more limited funding capacity. For the most case, other countries are competitive in one or two specific

technologies but lack broad based tech capabilities to proactively shape the future. Examples include:

- Russia continues to fall further behind as a global power based on the metrics, with its population projected to decline by 18% by 2050, but while lacking the financial and human resources to compete head-on across all technologies, is investing heavily into AI, big data, and cyber capabilities, which provide asymmetric power projection potential even at lower investment levels relative to global leaders.
- Saudi Arabia is deploying its significant reserves of petrodollars to invest in future energy sources such as green hydrogen, while continuing to harvest oil and gas energy, (while also being a large investor in the global technology sector through its sovereign wealth fund).
- Japan continues (for the time being) to maintain a major role in robotics, in which it has traditionally led the world, given the country's focus on manufacturing and the constraints of its labor market due to its declining population.
- The UK is a major center for technologies including blockchain and AI, as well as a significant investor in these areas, with the potential to play more broadly given its heavily financialized and services-based economy.

10. US Leadership of Emerging Technologies Requires Sustained R&D Investments, Challenged by its Reserves. The US remains well positioned for building superior future technologies, it leads in AI and quantum computing, and has a track record in fundamental breakthroughs in these areas but will need to maintain a strong focus in basic research to sustain its leadership position over the long term which required massive funding, pointing to its finances being a relative issue.
11. China's R&D Efforts Closing the Gap. China in the past decade has significantly stepped up its basic research across a range of technologies and has overtaken the EU in patent filings across electric vehicles, AI, IoT, battery technologies and gene editing, among others, but still lags well behind the US in all cases.
12. India Making Fundamental Research Push. India is also investing heavily in R&D and now ranks among the top five countries in terms of research output for 19 out of 44 technologies across materials and manufacturing, AI and computing, energy, quantum, biotech, sensors, space, robotics, and transportation.[87]

In summary

- Technology is a critical source of the power of states and as such it will not be left to corporations in the transition to a whole new power structure as the world shifts towards the Information Age.

- The 19 core technologies are targets of increasing geopolitical competition between major countries and power blocs, given that technological superiority is a key source of geopolitical power.
- The US is best placed to lead the world into the Information Age given its continued global leadership in key geopolitical assets (including wealth, economic output, and military power), as well as across the 19 core technologies as a whole.
- Rising US public debt makes it reliant on its capital markets, and a sharply divided political system to approve spend, in contrast to both China and the EU, with India at a far lower level of financial capacity at this stage.
- China has effectively drawn level with the EU across key (non-tech) strategic assets and has overtaken it in terms of R&D across the most critical technology, but still lags the US across most dimensions.
- The EU's most critical asset is the size of its common market, which positions it as a powerful rule-setter for the global terms of trade and as a regulator of how the technologies of the future will be used.
- India still lags the three major power blocs across nearly all dimensions of power, reflecting its ongoing transformation from a developing to middle income country. However, its sustained long term economic growth is creating opportunities for it to increasingly compete across key technologies in the future.

V. Urgent High Impact Solutions for the UN SDGs

The long-term transition to a superior future requires the shorter-term delivery of global security and sustainability, as encapsulated by the SDGs. Given the scale of the issues and the approaching deadline for the goals, this will likely require the deployment and scaling of a series of mature technology solutions, rather than relying on breakthroughs in emerging technologies. There are a number of such technology solutions that can have a material impact on the goals, given global deployment with local adaptation as required. In the absence of top-down blueprint for the goals, global stakeholders will need to identify and prioritize the highest potential technology solutions as candidates for execution.

1. High Impact Tech Solutions Required

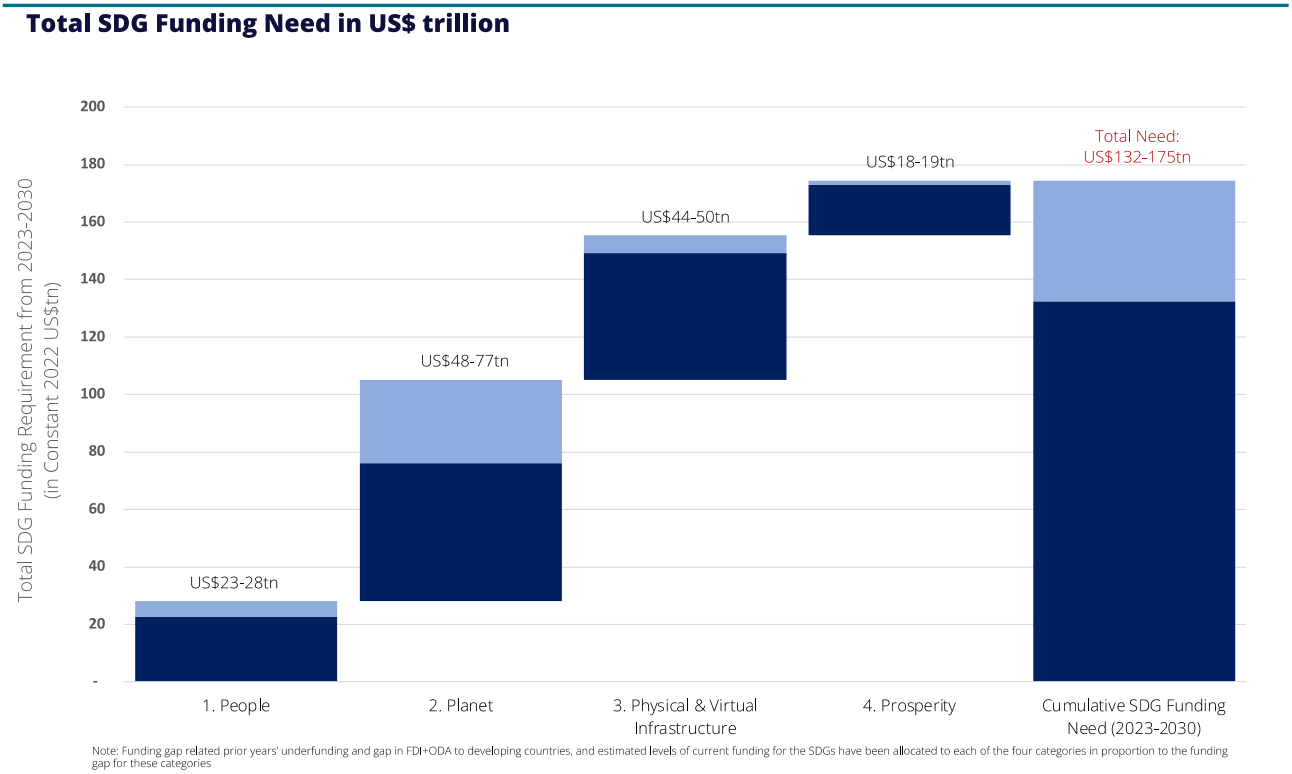
Multiple Stakeholders Developing Targeted Solutions to Address the SDGs

Given the 19 core technologies long term impact potential, they have emerged as increasingly fierce areas of competition for both global tech leaders and the countries that host them, with the winners in key technologies shaping a superior future for the world. However, as stated above, this long-term transition requires the delivery of global scale security and sustainability in the near term, with the SDGs and their 2030 target date representing the best framework for what this means for the world.

The Capital as a Force for Good report found that in the absence of extensive collaboration between countries, the SDGs require funding of US$132-175 trillion and have a shortfall of

US$103-137 trillion, representing 40% of the world's gross financial assets of US$440 trillion, or c.20% of the global GDP of US$100 trillion annually through 2030.[88]

Figure 31: Total SDG Funding Requirement[89]



With less than seven years left, time is running out to meet the goals, and none of the 17 SDGs are currently on track to be met. Moreover, given the lack of cohesion between governments amid increasing geopolitical rivalry, and the lack of alignment between the Global North and the Global South, between rich and poor within countries, and between the public and private sectors means that it is highly unlikely that a global multi-stakeholder plan to address the goals, much less one than is sufficiently radical to actually achieve them, will actually emerge.

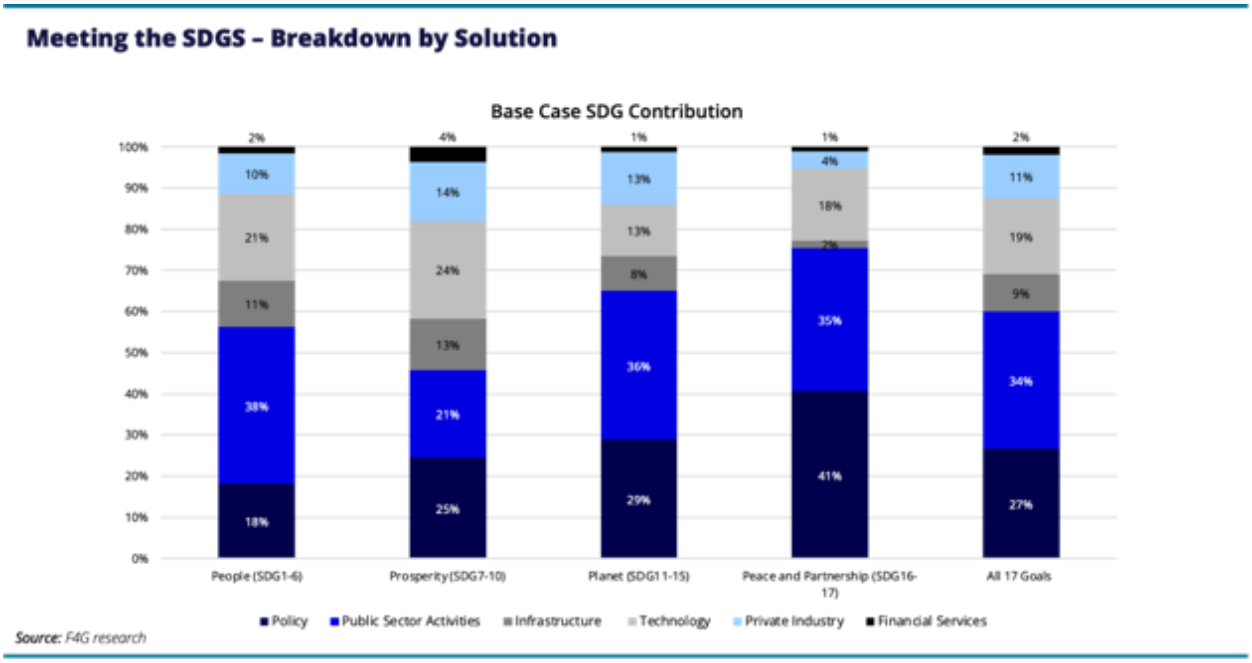
Moreover, given the lack of cohesion between governments amid increasing geopolitical rivalry, and the lack of alignment between nations, the success of the SDGs will depend on the world identifying, scaling, and executing viable initiatives globally, at speed, without building and securing alignment on a comprehensive global action plan … and there are many such solutions waiting deployment.

Therefore, the success of the SDGs will depend on the world identifying, scaling, and executing viable initiatives globally, at speed, without building and securing alignment on a comprehensive global action plan. Luckily, many such initiatives exist and have been developed and implemented by innovative and entrepreneurial organizations, be they financial institutions, private sector corporations, NGOs, international organizations, or national governments.

The existence of such solutions makes the challenge for the world to meet the goals a potentially feasible one, focused on scaling and rolling out existing solutions globally. These solution areas

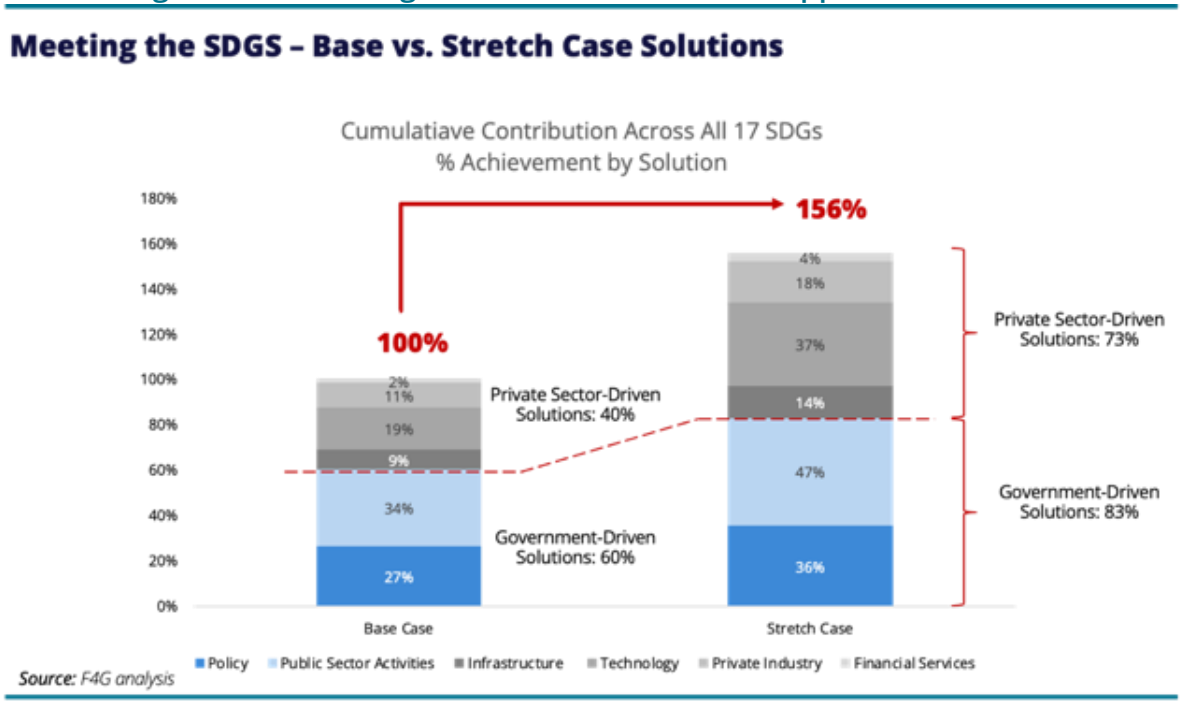
span a range of policy, technology, public sector activities, infrastructure, private industry, and financial services-related initiatives. Deployed together, and at scale, the right mix of solutions across these six areas can fully deliver the SDGs, as illustrated in the chart below.

Figure 32: Breakdown of Solutions to Deliver the SDGS[90]



Moreover, if each solution area were to deliver to its maximum, the world can exceed the targets set by the SDGs by more than 50%, creating a better, more sustainable, and secure world than originally targeted for by 2030. However, unlocking the maximum potential of each solution area as this Stretch Case implies, will require changing current regulatory policy, technology, and financing practices in a way that if well implemented may well be transformative for the world, leveraging best practices from around the world at scale.

Figure 33: Exceeding the SDGs with Maximum Application of Solutions[91]



In any case, digital technologies have a critical role to play in meeting the SDGs, capable of delivering c.20% of the total SDG need in the Base Case and nearly 40% in the Stretch Case.

Technology, specifically information technology, is a fundamental enabler across all the goals (much like capital), enabling critical information processing, automation, communication, and knowledge sharing for the dissemination of best practices and coordinated action. However, beyond this fundamental impact, specific technology solutions can drive critical progress on individual SDGs, with targeted innovation creating products services and solutions to deliver outcomes related to specific goals.

Ten Tech Solutions with Global Impact Potential

Digital technology solutions can contribute to nearly 150 of the 169 SDG targets, impacting all 17 goals. The base case of technology's potential contribution to the goals, delivering universal and affordable broadband connectivity, can be almost doubled to 37% through the scaled deployment of best-in-class innovations for each goal, with the highest impact potential across SDG4 (Quality Education), SDG8 (Decent Work), SDG16 (Peace Justice and Strong Institutions), and SDG2 (Zero Hunger).

There are of course countless specific digital technology solutions (digital or otherwise) from around the world that have the potential to impact global security and/or progress the SDGs at scale.

This report highlights ten such technology-based solutions which illustrates how the SDGs and secure sustainability for the world might be achieved over the short-term. They have been selected from a range of solutions that have been developed and deployed by stakeholders across a large number of countries, industries, markets, themes, and issues against specific criteria, namely:

- *Relevance*, the ability to directly address an SDG or indirectly address an SDG via addressing an issue;
- *Scalability*, being scalable, transferable across boundaries, and potentially replicable by others;
- *Materiality*, the current or potential scale of the initiative as an indication of its potential in making a material quantifiable impact on one or more SDGs, and
- *Timing*, sufficient execution is possible within the 2030 timeline.

While each of the 19 core technologies can make significant contributions to the SDGs in theory, in practice many of them fail to meet the criteria above, many being at too early a stage to currently make material impact on the goals by 2030. Quantum computing and fusion technology are potentially transformative for the world but still may be more than a decade away from commercial mass deployment. Other technologies like renewables and big data analytics on the other hand are already at the stage of mass deployment globally and can play a major role in meeting the goals. Given the cost and logistical constraints imposed by the SDGs however, much of the heavy lifting of meeting the goals will likely need to be done by a more basic set of

technologies that drive communications, computing, and automation, and by scalable engineering technologies, and the ten solutions highlighted in this report reflect these needs and constraints. It is important to note of course that the ten solutions do not represent an exclusive list, and that many others meet the selection of criteria above.

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The ten selected solutions illustrate the breadth of the issues that technology can rapidly solve, and broadly fall into four 88categories:

1. Universal Enabling Solutions. General purpose digital technologies that can be applied flexibly across a large number, or even all the SDGs, enhancing the ability of a broad set of stakeholders to deliver against the goals.
2. Digital Solutions. IT-based digital technologies applied to specific challenges, with purpose-built platforms and applications designed to maximize impact on defined goals.
3. Tech-Enabled Solutions. Solutions to specific challenges developed and delivered outside of the traditional tech industry, but (largely) designed and powered by digital technology.
4. Scaled Industrial Solutions. Industrial and infrastructure -based solutions to specific challenges, driven by scale and process optimization with IT playing an enabling role.

Moreover, these ten solutions are being driven by a diverse set of global stakeholders, including private sector corporations (both collaboratively and competitively), national governments and transnational organizations like the UN. A summary of the ten solutions is provided below.

Figure 34: Ten Tech Solutions for Global Scaling

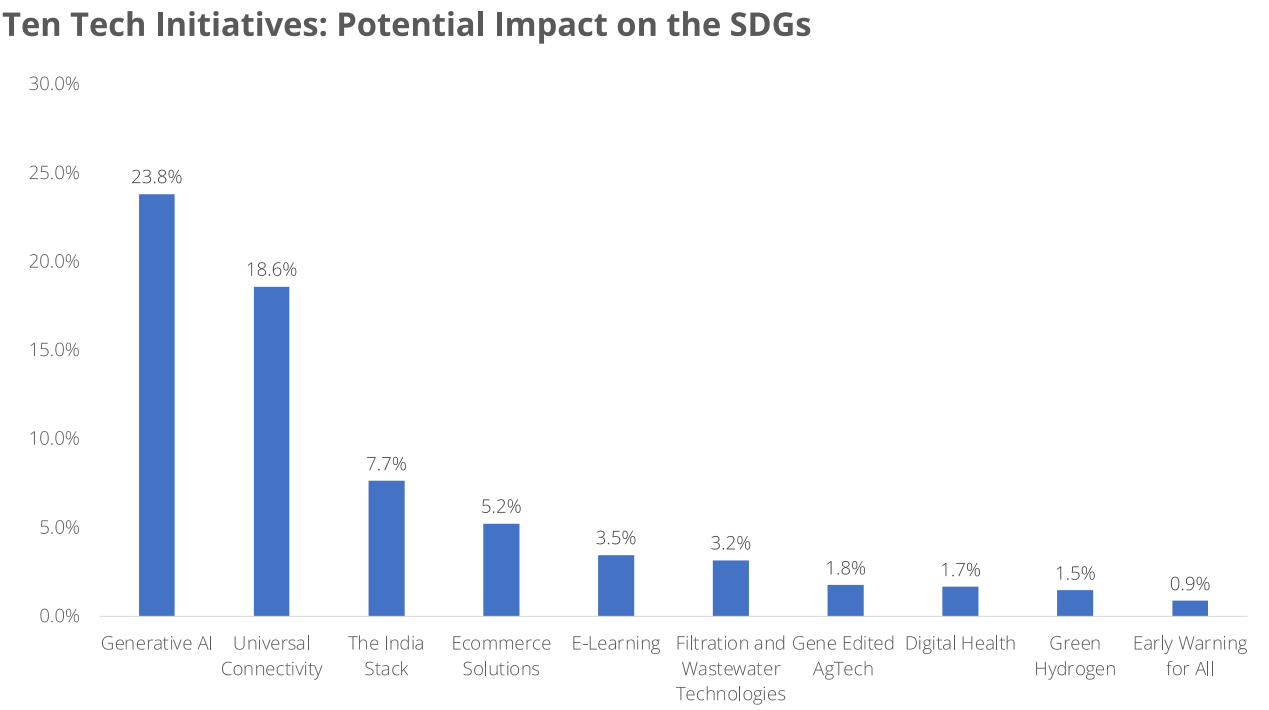
	Description	Sponsoring Organization(s)	Key SDGs Impacted
Universal Enabling Solutions	**Global Internet Connectivity.** A global initiative led by to connect every school in the world to the internet by 2030, offering a gateway to universal connectivity	UNICEF, ITU	
	Generative AI. Generative AI's ability to learn, adapt, and create offers new ways to solve complex problems, enhance human creativity, and improve decision making across all the goals	Private sector tech companies	
Digital Solutions	**The India Stack.** A unique digital infrastructure for the delivery of mass financial inclusion for all, serving as a platform for broader social inclusion,.	Government of India	
	Ecommerce Platforms. B2B and B2C e-commerce platforms are engines to drive economic participation for small businesses, enabling both local and international trade, particularly in emerging markets	Private sector tech companies	
	Digital and Telehealth. World's largest telehealth and virtual medicine platform including primary care, mental health, and chronic condition management, as well as mobile health	Teladoc Health	

	Description	Sponsoring Organization(s)	Key SDGs Impacted
	E-Learning Platforms. National digital learning platforms to overcome barriers to education and to improve overall learning outcomes	National governments	
Tech- Enabled Solutions	**Gene Edited AgTech.** Targeted gene editing technologies based on CRISPR/Cas9 can revolutionize global food systems with enhanced nutrition, improved food safety, greater resistance to disease, and better climate resilience	Private sector companies	
	Early Warning for All (EW4A). Global initiative for every person on earth to be covered by multi-hazard early warning systems	United Nations	
Scaled industry Solutions	**Green Hydrogen Solutions.** Green hydrogens a zero-carbon alternative to fossil fuels in key industrial processes and commercial logistics, filling a critical niche in the energy transition alongside renewables and electrification	Private sector companies, national governments	
	Filtration and Wastewater Treatment Technologies. Innovative technologies are improving the efficiency, reducing the cost, and driving the scalability of water filtration and wastewater treatment technologies around the world	Private sector tech companies	

Significant SDG Contribution Potential

The most critical common feature among the highlighted solutions is their growth potential. Each of these solutions can be scaled globally to deliver significant impact against the SDGs. Assuming that each solution was to be deployed globally as preferred ways to solve the problems they were designed to address, these ten programs could drive significant progress against the goals, ranging from nearly 20% for the most impactful universal enabling solutions to highly targeted solutions addressing important issues such as disasters, transition energies for climate targets, and inclusive healthcare. Importantly, the ten identified solutions do not represent an exhaustive or exclusive list, and there are many more initiatives which could have an equally fundamental impact on the SDGs. Some of these will no doubt overlap with the highlighted solutions while others will be completely discrete, focused on specific challenges that the ten selected solutions leave unaddressed. Some examples from the research underpinning this study include solutions as varied as automation, robotics and sensor solutions, circular economy technologies, internet of things (IoT) applications, digital platforms for sustainable consumption, carbon capture and storage, crowdfunding, and crowdsourcing platforms, to name a few.

Figure 35: Headline Contribution to the SDG Targets[92]



Source: Technology as a Force for Good

The chart above represents each solution's direct[93] impact potential on 169 SDG targets, without considering the impact of double counting or overlaps. For example. Reaping the full benefits of AI as a Universal Enabling Solution presupposes universal internet connectivity, as do the other Digital Solutions on the list. Further, the analysis also excludes the potential inhibiting impact that solutions could play, as well as questions of cost or feasibility with regards to scaling these initiatives as the preferred solution for their specific goals.

The three initiatives with the highest direct impact potential Are:

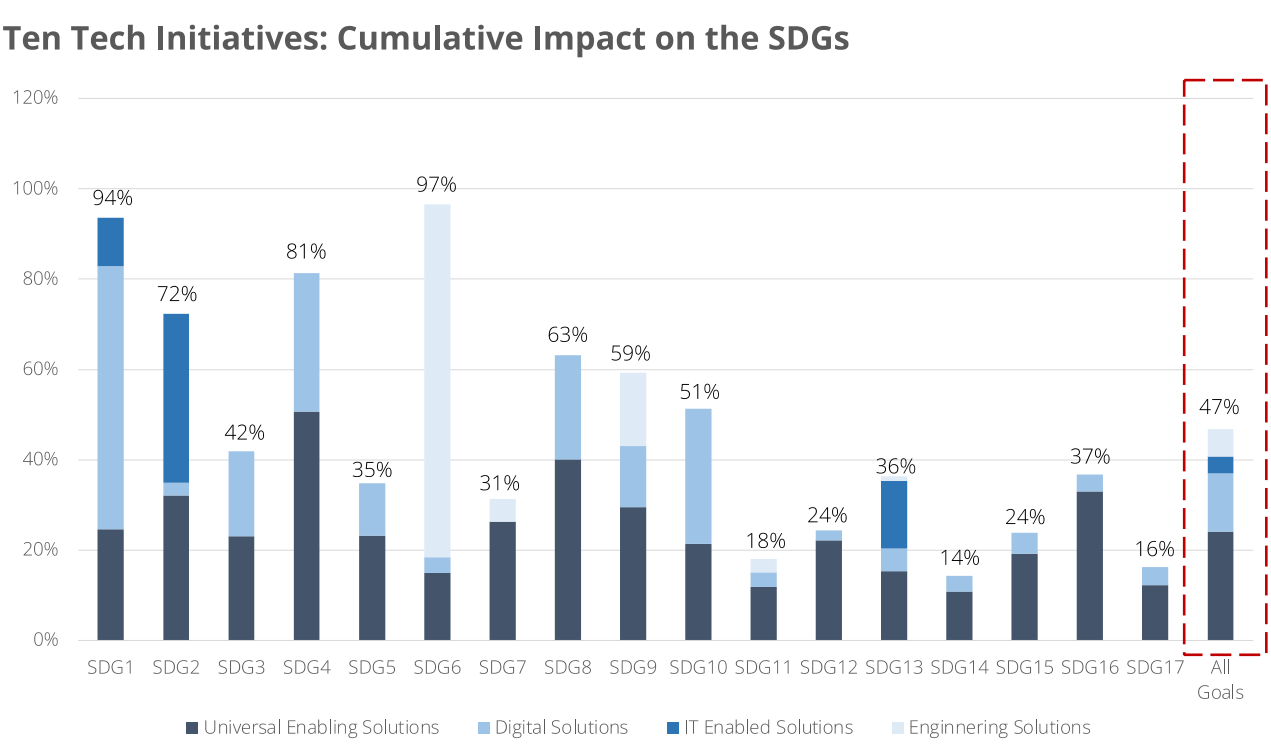
- Generative AI (24%), which will radically improve decision making across almost all the goals, generating new insights, incorporating more information to deliver better outcomes, and automating processes at speed and scale to support targeted actions, building on the benefits generated by universal internet connectivity. Given the speed of advances being made it generative AI, its potential impact on the SDGs is continuing to evolve and will likely grow significantly as it is applied to specific goals in a targeted fashion.
- Universal Internet Connectivity (19%), which serves as a support structure for all 17 SDGs, enabling critical information processing, automation, communication, and knowledge sharing for the dissemination of best practices and coordinated action. [94] With connectivity and access, stakeholders can drive inclusion, raise productivity, and increase equality of opportunity, positively contributing to over 150 of the goals' 169 targets.[95]
- The 'India Stack' (8%), initially designed to facilitate online banking and digital payments, has evolved into a broad-based digital infrastructure platform driving the digitization of society

and the economy, enabling applications in financial services, healthcare, education and training, public services, transportation, commerce, among other things. Its impact on the goals is accordingly broad-based and fundamental.

Unsurprisingly, the three most impactful solutions are 'Universal Enablers' that have broad applicability and can facilitate the delivery of multiple SDGs, as well as being flexible enough to be applied to specific goals in a targeted fashion for additional impact. Interestingly, two of the three solutions (Universal Internet Connectivity and the India Stack) are not dependent on any cutting-edge technological innovation, integrating mature and widely available technologies into programs designed for cost-effectiveness and scale. Unsurprisingly, these solutions have been developed and are being championed by the UN and a national government, respectively, illustrating once again that the critical role of the public sector in delivering the SDGs, as well as the need for 'frugal', rather than (just) cutting-edge innovation.

Were they to be applied in combination with each other, the potential cumulative SDG impact of the ten solutions would be transformational. If each solution were fully funded, and deployed globally, they could cumulatively drive progress against all 17 of the goals to solve for c.47% of the SDGs in total, (net of any overlap between the initiatives). The table below shows the cumulative potential impact on the goals.

Figure 36: Cumulative SDG Impact Potential - Ten Tech Initiatives[96]



Source: Technology as a Force for Good

Key Observations:

- Cumulatively these ten solutions, globally scaled and fully executed, can solve for nearly half (c.47%) of the SDGs, net of any overlap between solutions.
- Universal Enabling Solutions like generative AI and universal connectivity have a fundamental role to play in driving all 17 SDGs.
- Universal Enabling Solutions are particularly impactful on people and prosperity related goals, (e.g. SDG4 and SDG8) as well as on government-related targets (SDG16), given the underlying digital transformation of the global economy, society, and governments underway.
- Some goals like SDG 4 (Education) and SDG 6 (Clean Water) by their nature require targeted technology solutions, both digital and industrial, given these goals' targeted scopes
- Other goals are harder to address with digital or highly targeted 'point' technology solutions given the physical constraints involved (for example, planet-related goals like SDG14 (Life under Water) or SDG15 (Life on Land) in particular and will require applying a broad range of technologies in connection with policy, behavioural change, business practises and processes, among others.

Stepping back, for these ten, or any other set of technology solutions to address 47% of the SDGs, in practice they would be required to be deployed globally under a wide range of conditions and in countries at very different stages of economic, infrastructure and technological development.
This also presupposes that every country has the baseline of development required to adopt, deploy, and utilise the ten solutions, which requires the ability to efficiently formulate and enforce the necessary policy regimes, the execution resources (including human capital) and capabilities implement solutions, and the capital required to pay for their setup and operation.

Secondly, the expansion and worldwide implementation of these initiatives will necessitate substantial local customization, along with the allocation of resources, the sharing of best practices, and essential capital investment to guarantee their effective execution in various locations.

Thirdly, the potential of any initiative for worldwide scaling depends on its universal applicability (namely, the extent to which it is needed and can be effectively deployed across various countries and regions) and its implementation feasibility (that is, its complexity or simplicity, associated costs, and the risks involved in execution).

Finally, the distribution and nature of the ten highlighted tech solutions provides the beginnings of a framework for identifying, selecting, and prioritizing further solutions in pursuit of the SDGs, with prospectively technologies being ranked in the three orders of priority, namely:

1. First Priority Solutions: Universal enabling technologies with the potential to drive incremental progress against all the goals.
2. Second Priority Solutions: Targeted technology solutions ready for mass scaling that can make a substantial impact on a single SDG, or a major subset of a goal's targets., and
3. Third Priority Solutions: Niche technologies for specific targets deployed as part of a broader solution set (for example., specially designed sensors for wildlife tracking aiding conservation efforts.)

Without addressing the first priority solutions, the transition will be highly uneven and inequitable and therefore risk stability and the broader transition itself.

2. Ten Tech Solutions to Drive the SDG

Connectivity for All

Delivering Global Internet Connectivity to Close the Digital Divide

Giga is a global initiative led by UNICEF and the ITU to connect every school in the world to the internet by 2030, offering a gateway to universal connectivity

Key Highlights

- The program currently has three categories of activity, including mapping, to identify the schools in an area, financing, to provide financial resources to the schools, and helping to establish connectivity
- In terms of mapping, Giga as of 2022 has mapped 2.1m school locations in 136 countries (or c.25% of all schools globally)
- In terms of funding, Giga has mobilized US$5 billion to accelerate the delivery of critical infrastructure and close the digital divide.
- In terms of connecting, Giga has connected over 2m student in 5,561 schools across 20 countries to date, and is targeting a further 20,000 schools for 2023

➢ The Giga platform has the potential to be a major springboard for the delivery of universal internet connectivity and providing a potential access point to reach the 1/3 of the global population still unconnected

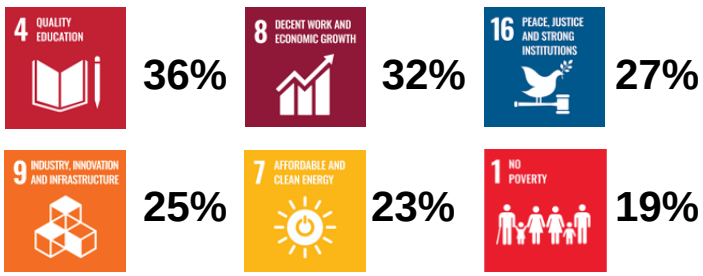
Universal Internet Connectivity: The Case for Global Scaling

34% of the global population (or 2.7 billion people) still not connected to the internet. (ITU)

1.3 billion children missing out on information, opportunities and choices due to lack of connectivity (ITU)

0.45% of annual global GDP required to fund universal connectivity (IMF)

Potential Contributions to Key SDGs in % (selected)



Generative AI

Generating innovative solutions and facilitating evidence- based decision-making

Generative AI's ability to learn, adapt, and create offers new ways to solve complex problems, enhance human creativity, and streamline processes across various domains.

Key Highlights

- Revolutionizing Problem-Solving: Generative AI can tackle complex issues that have long been challenging for humans, offering innovative solutions in areas like climate change, healthcare, and logistics.
- Enhancing Creativity and Innovation: By providing new tools and perspectives, this technology can significantly boost human creativity, leading to novel inventions, artworks, and designs.
- Accelerating Research and Development: Generative AI can rapidly analyze data and generate hypotheses, speeding up research processes in fields ranging from science to market analysis.

➢ Generative AI is a critical technology that will serve as a fundamental enabler of all 17 SDGs, supporting, augmenting and potentially replacing human problem solving and decision making for targeted actions against the goals

Generative AI: The Case for Global Scaling

US$7 trillion uplift in global GDP from generative AI over a ten-year period (Goldman Sachs)

US$1.3 trillion of spending on generative AI expected by 2032 reshaping global tech spending (Bloomberg Intelligence)

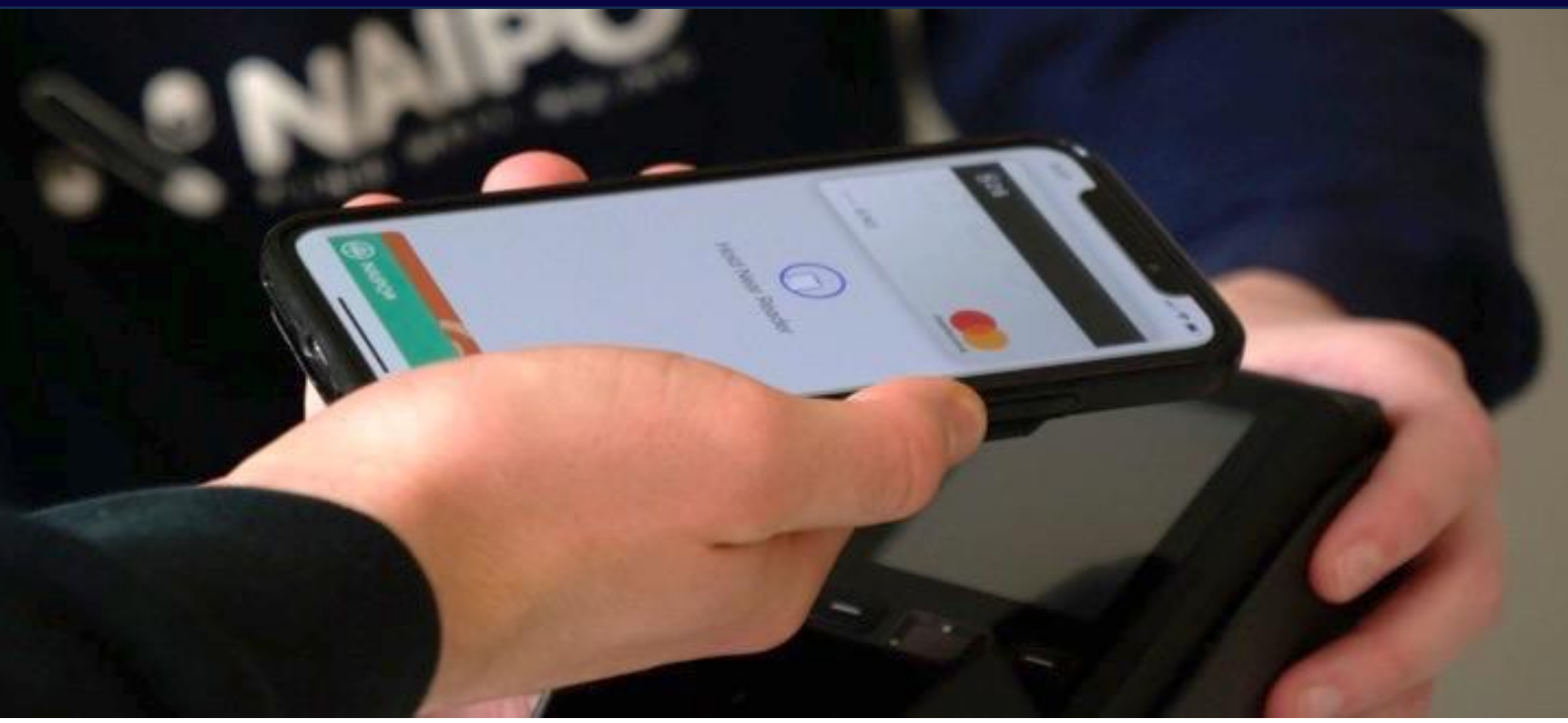
33% of new drug and material science discoveries will be driven by generative AI by 2025 (Gartner)

Potential Contributions to Key SDGs in %

SDG impact delivered through (digital) Technology solutions, enabling communications, information and data process, access to information and specialist applications

The India Stack

Digital Infrastructure Providing Digital Identity and Payment Solutions for Financial Inclusion



A unique digital infrastructure for the delivery of mass financial inclusion for all, serving as a platform for broader social inclusion, a free to individual payment systems enabling peer-to-peer transaction, other digital services to people and businesses.

Key Highlights

- Aadhaar, a crucial component of India Stack, provides a digital identity to every citizen based on biometric and demographic data.. 67 Billion digital identity verifications have been done to date.
- The India stack has enabled payment solutions which has significantly contributed to financial inclusion and has enabled people to access banking services, make digital payments, and participate in the formal economy. A total of real-time mobile payments worth INR 14.05 trillion have been made
- Its government-led approach, emphasis on digital identity, and cross-sector applicability set it apart from traditional technology initiatives, making it a unique and transformative development in India's digital landscape.
  - ➢ Transfer of India Stack technologies for adoption and integration into national banking systems to drive global financial inclusion

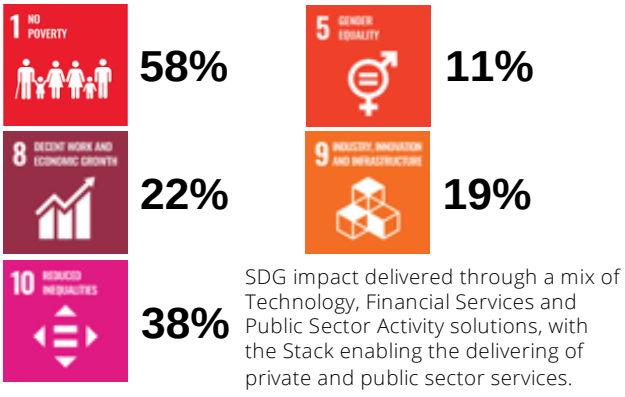
The India Stack: The Case for Scaling

450 million people in India financially included with digital bank accounts (Government of India)

1.4 billion adults globally without banks accounts (The World Bank)

2.6 billion adults not digitally financially included (The World Bank)

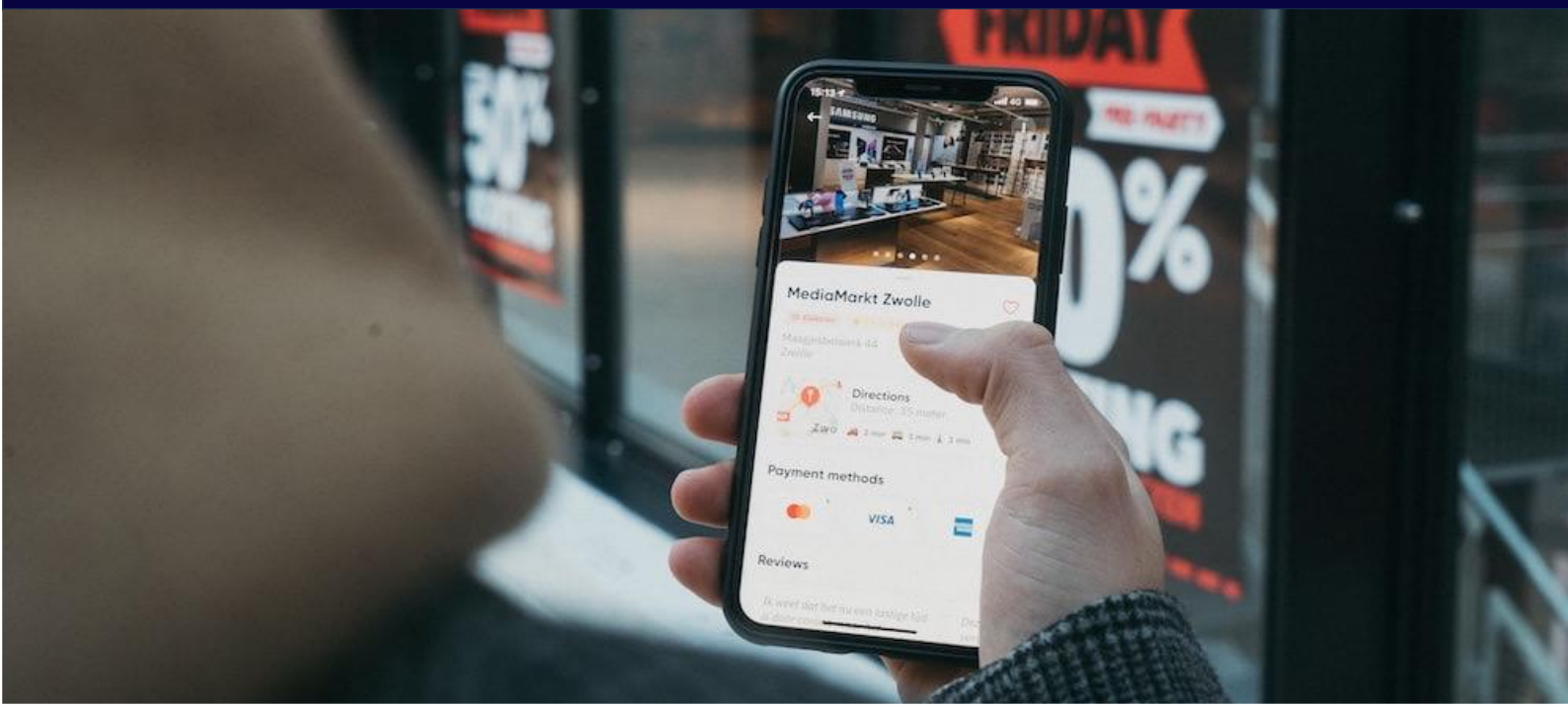
Potential Contributions to Key SDGs in %



SDG impact delivered through a mix of Technology, Financial Services and Public Sector Activity solutions, with the Stack enabling the delivering of private and public sector services.

E-Commerce Platforms

Delivering digital trade and entrepreneurship across developing countries



B2B and B2C e-commerce platforms have the potential to drive economic participation for small businesses, enabling both local and international trade and entrepreneurship

Key Highlights

- Global e-commerce platforms [like Amazon and Alibaba], as well as regional competitors are increasingly penetrating developing markets, providing internationalization opportunities for small to medium sized businesses (SMEs)
- B2B platforms in particular allow MSMEs to sell products and services to professional buyers and consumers across the world, and build a name for themselves beyond their geographical borders
- E-commerce platforms are enabling the emergence of rural production centres across developing countries from microenterprises serving long-distance customers
- Digital commerce more broadly can positively impact ten of the 17 SDGs

➢ E-commerce platforms in developing markets are driving digital inclusion and bottom-up economic growth for small businesses and micro-entrepreneurs

Ecommerce Platforms: The Case for Global Scaling

70% of global GDP generated by (M)SMEs (ILO)

50-80% of employment in developing countries generated (M)SMEs, the vast majority of which do not have proprietary ecommerce capabilities (Accenture)

28% of global retail sales occurring online, increasing to 41% by 2027 (BCG)

Potential Contributions to Key SDGs in %

32%

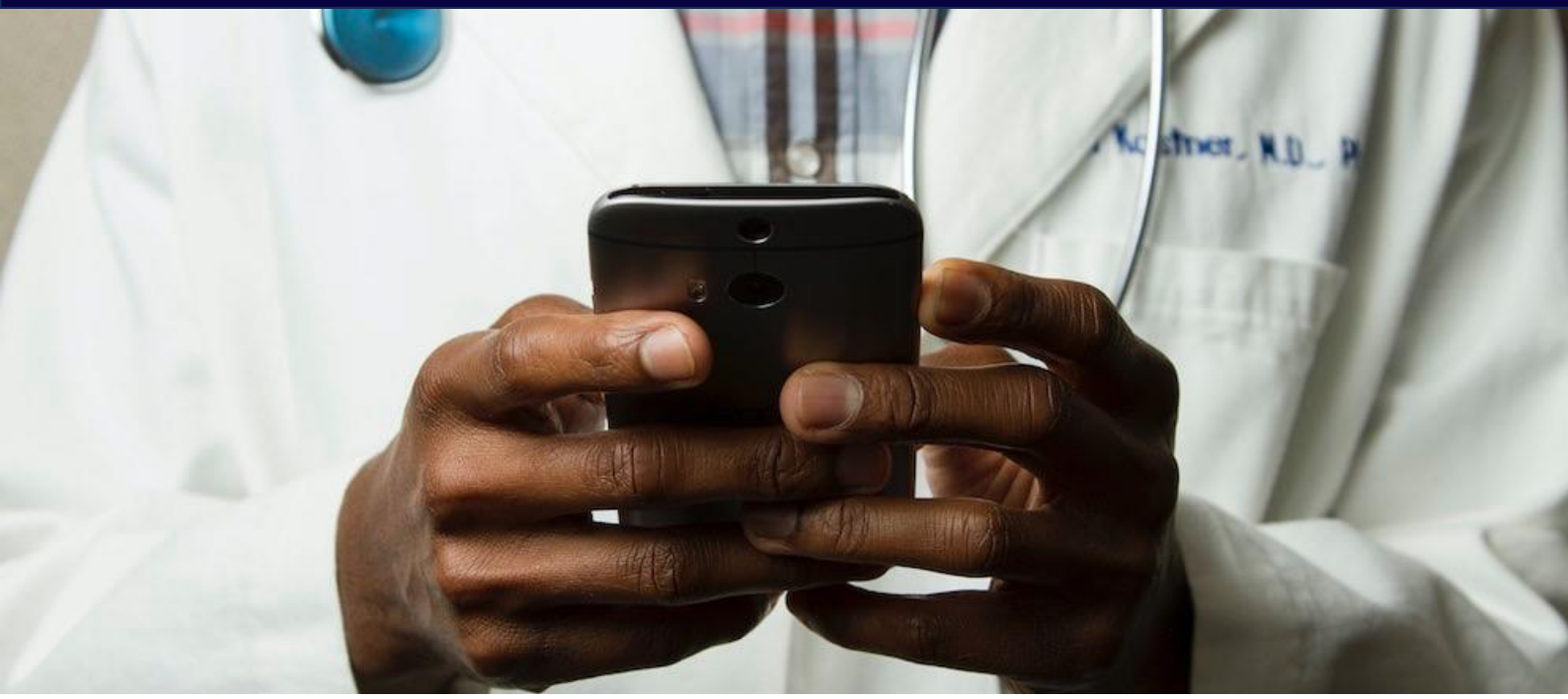
6%

SDG impact delivered (digital) technology, digitizing consumers and MSMEs and driving entrepreneurship and trade, as well as through Public Sector Solutions, creating efficient markets for public procurement and spending

Digital and TeleHealth

Delivering whole-person virtual healthcare

Teladoc



World's telehealth and virtual medicine platform including primary care, mental health, and chronic condition management, as well as mobile health

Key Highlights

- Leading global digital health company delivering virtual care platform connecting 80m patients and 30,000 healthcare providers.
- Offers telehealth solutions to patients, physicians and hospitals, extending the virtual reach of healthcare providers and improving the quality of care.
- Comprehensive solutions covering primary care, emergency care, chronic condition management and mental health.
- Offers personalised care plans for patients with mobile device solutions, monitoring, and care provider integration
- Delivers care in 130 countries and in more than 30 languages, partnering with local hospitals and healthcare systems

➢ Digital health tools can significantly close the gap in the provision of quality healthcare, overcoming geographic barriers, infrastructure challenges and issues with the local quality of care

Digital and Telehealth: The Case for Scaling

50 million virtual physician visits delivered annually by Teladoc, c.5% of total US market (Teladoc annual report)

10 million additional healthcare workers needed globally by 2030 with shortages in 132 countries (WHO)

c. 23% of women in Sub-Saharan Africa face barriers in accessing healthcare due to the distance of the nearest healthcare facility (NIH)

Potential Contributions to Key SDGs in %

28%

SDG impact delivered through Technology solutions, providing digital platforms for the delivery of public and private sector services

e-Learning Platforms

Delivering Digital Education Outcomes Globally

National digital learning platforms used by governments around the world to overcome barriers to education and to improve overall learning outcomes

Key Highlights

- Digital learning platforms can close education gaps through remote and personalised learning, teaching digital literacy and supporting and training teachers
- c.500 national digital learning platforms in the world today across 180 countries, but many lack best in class features including
  - On- and offline functionality
  - Enhanced accessibility
  - Mobile enablement
  - Interactivity
  - Learning management functions and online resources
- UNICEF and UNESCO have launched the Gateways to Public Digital Learning program to strengthen national platforms, by identifying and sharing best practices, and setting norms and standards for platform development

➢ Fit for purpose e-learning platforms have a critical role to play in delivering inclusive, high-quality education globally, while also addressing the growing digital divide

E-Learning: The Case for Scaling

244 million children currently out of school (UN)

70% of children aged 10 in low- and middle-income countries unable to read and understand a simple text (UN)

69 million teachers are needed to reach universal basic education by 2030 (UN)

Potential Contributions to Key SDGs in %

59%

SDG impact delivered through Technology solutions, providing digital platforms for the delivery of public and private sector services

Gene Edited AgTech

Creating functional cures for previously untreatable diseases

Targeted gene editing technologies based on CRISPR/Cas9 have the potential to revolutionize global food systems with enhanced nutrition, improved food safety, greater resistance to disease, and better climate resilience

Key Highlights

- Currently, over 500 products are being developed worldwide using CRISPR and are at different stages of development
- Enriched Nutrition. Development of agricultural products enhanced with targeted vitamins and amino-acids to increase nutrition and deliver additional health benefits
- Improved Yields. Technologies increasing grain sizes have delivered maize and rice crops offering 10% and 8% yield increases, respectively
- Crop Resistance. Multiple applications including targeting susceptibility for specific diseases and creating more drought and temperature resilient crops
- Improving Regulatory Support. The European Commission has tabled a 2023 proposal to widen the EU's strict GMO regulations to allow (mutagenesis and cisgenesis) gene-edited agricultural products

➢ Gene edited agricultural products have a potentially critical role to play in feeding the soon to be ten billion people in a world facing increasing environmental constraints and challenges

Gene Edited AgTech: The Case for Global Scaling

238 million people in 48 countries facing acute food insecurity in 2022, up 10% annually (Reliefweb)

60% increase in global food production required by 2050 to feed the global population (FAO)

90% of the world's soil at risk of degradation by 2050. (UNDRR)

Potential Contributions to Key SDGs in %

38%

SDG impact delivered through technology solutions, underpinning sustainable food production, providing productivity increases, nutrition benefits, and supporting genetic diversity

Early Warning for All (EW4A)

Multi-hazard Early Warning Systems Covering Every Person on Earth

Initiative to create early warning systems (MHEWS) with global coverage including disaster risk knowledge, hazard detection, monitoring, and forecasting, warning dissemination and communication, and response preparedness

Key Highlights

- Multi-agency UN initiative involving the International Telecommunications Union, the World Meteorological Organization and the United Nations Office for Disaster Risk Reduction, in partnership with the International Federation of Red Cross and Red Crescent Societies (UN)
- MHEWS are integrated systems addressing varying hazards in contexts where hazardous events may occur alone, simultaneously, cascading or cumulatively over time, considering potential interrelated effects
- Multi-technology and effort integrating monitoring and modelling systems (sensors, ICT and AI), warning and communication systems (telecom and mobile), and knowledge management systems (Internet, IT)

  ➢ Multi-hazard early warning systems are critical to minimizing harm to people assets and livelihoods in the world's most vulnerable places, underpinning sustainable development efforts and adapting for inevitable climate change

Multi-Hazard Early Warning Systems: The Case for Global Scaling

300,000 disasters related deaths across 135 countries between 2015-2021 (UN)

1.05 billion people in 145 impacted by natural disasters between 2015-2021 (UN)

US$330 billion average annual economic losses from disasters, representing 1% of impacted countries' GDP (UN)

Potential Contributions to Key SDGs in %

11%

13%

SDG impact delivered through technology, policy and public spending solutions, creating human and asset resistance to and resilience against disasters

Green Hydrogen

A Critical Technology of the Long-term Energy Transition and Global Carbon Neutrality

Green hydrogen solutions, (produced by electrolysis powered by renewables), are a zero-carbon alternative to fossil fuels in key industrial processes and commercial logistics, filling a critical niche in the energy transition alongside renewables and electrification

Key Highlights

- Energy Storage. Hydrogen and hydrogen-based fuels are high potential technologies for storing energy from renewables, with the potential to transport energy over long distances
- Transportation and Logistics. Hydrogen fuel cells are functionally superior to lithium-ion batteries in terms of energy density, range and recharge speeds, making (green) hydrogen an attractive zero-carbon alternative to battery electric vehicles for long range logistics and commercial vehicle fleets
- Industrial Decarbonization. Hydrogen is one of the limited options for major decarbonizing industrial sectors, such as iron and steel, cement, and chemicals, which require chemical transformations that are not amenable to decarbonization by other clean energy sources.
- Increasing Policy Focus. Major countries are increasing green hydrogen's role their energy strategies, with the EU' targeting green hydrogen to account for up to 20% of the energy supply in 2050 and China seeking to increase green hydrogen production to 100 GW by 2030, 12x the level of *global* production in 2022

➢ Green hydrogen has a potentially critical role to play in the global energy transition, filling in gaps where electricity cannot easily or economically replace fossil fuels across logistics, industrials and energy storage

Hydrogen Strategies: The Case for Scaling

85 gigatons, CO2 emissions reduction potential of green hydrogen by 2050 (>2x global annual CO2 output) (Deloitte)

6x growth in global hydrogen energy production to 2050 (Deloitte)

US$1.2 trillion in green hydrogen investment needed by 2030 to meet global climate targets (IEA)

Potential Contributions to Key SDGs in %

16%

3%

SDG impact delivered through private sector and infrastructure solutions, providing sustainable and decarbonized energy, infrastructure, and industrial development

Filtration and Water Treatment Technologies

Advanced technologies improving physical, biological and chemical water filtration and treatment systems globally

Innovative technologies are improving the efficiency, reducing the cost, and driving the scalability of water filtration and wastewater treatment technologies around the world

Key Highlights

- Modularly constructed omni-processors combine an incinerator, and power plant using thermal hydrolysis and a water filtration system to treat faecal and wastewater sludge while generating electricity
- Aquaporins, or water channels, are organic proteins that filter and purify water twice as fast as other existing water-treatment systems, and almost double the water recovery rate as well, treating highly polluted industrial wastewater in the oil and gas, food and beverage, dairy farming, and textile industries
- Nanotechnology including carbon nanotubes (CNTs) and graphene coated membranes can remove nearly any organic, inorganic and biological compounds from water more efficiently than conventional filtration methods

➢ Advanced water purification and treatment technologies are critical to underpinning health and sustainable development, particularly in least developed and other vulnerable countries

Water Filtration and Treatment: The Case for Global Scaling

1.7 billion people use drinking water sources contaminated with faeces (WHO)

40% deficit in the global water supply projected by 2030 . (UN)

US$260 billion is lost globally each year due to lack of basic water and sanitation (water.org)

Potential Contributions to Key SDGs in %

51%

SDG impact delivered through technology, infrastructure and public spending solutions, delivering safe drinking water and access to sanitation, and improving water quality, et al.

Conclusion

Of course, the world's requirement for sustainability does not end in 2030, or with the achievement of the SDGs, which are merely a stepping stone from which further progress can be made for the world. As stated above many of the 19 core technologies are unlikely to have an impact on 2030 Agenda given their stage of development and the need for further innovation breakthroughs. However, over the longer-term their sustainability impact is potentially transformative for the world. Potential examples worth considering include the following:

1. Fusion Energy, delivering near zero-cost, universal, clean, and highly scalable energy across the world;
2. Artificial General Intelligence (AGI), offering universal problem-solving capabilities to help efficiently address nearly every global issue;
3. Advanced Nanotech in Medicine, Material and Environmental Sciences, reshaping our bodies and physical environmental in a dynamic and targeted fashion;
4. 3D Printed Organs and advanced human performance re-engineering, underpinning significant extensions in human life- and health-spans;
5. Synthetic Biology, engineering living systems to solve environmental, economic, and social challenges;
6. Brain-Computer Interfaces (BCI), offering cognitive enhancement and integrating the benefits of AI for individuals;
7. Space Elevators, providing a platform for the scaled and cost effective scientific economic exploitation of space, and
8. Light-based (Optical) Computing, significantly increasing globally available computing power and speed using less space and energy, underpinning further digital enablement and value creation.

In summary

- Addressing the world's near-term security and sustainability challenges will require substantially meeting the SDGs, which will require the deployment and scaling of a series of solutions that leverage established technologies.
- These solutions will need to include both enabling technologies that can underpin the delivery of all the goals, as well as targeted digital and industrial technology solutions that can make a significant impact on specific goals.
- The ten solutions highlighted in this report collectively have the potential to solve for nearly 50% of the SDGs' delivery with global deployment and scaling.

VI. Conclusion: Shaping the Future

Technology is the catalyst for a civilizational shift in the world. As such, competition for technology leadership has become a matter of national security. However, in the absence of raising the Global South, the continued progress of the rich nations of the Global North is at risk. The SDGs can be solved with existing solutions and deliver a more equitable platform from which technology can build a far superior future. In the transition to a new civilization built on information and a new generation of technologies, the world is about to enter a whole new era that has the potential to deliver peace, prosperity, and freedom to all. The tech industry has a critical role to play in building this superior future.

The Rising Wave of the Future

Irrespective of the seemingly cascading set of disruptions that continue to distract global leaders from long-term planning, the momentum pushing the world into a future defined by new technologies is inexorable. This future is today being shaped by a series of core technologies of which a few are critical to decisively shifting the world from the now fossil fuel-limited present to a more unbounded future. These defining technologies change the underlying energy and resource base of the world and use AI and digital technologies to transform every aspect of human activity. The current status of research and innovation in these areas indicates that these breakthroughs are at least a decade away, though.

The Transition

In the intervening period, the world is passing through a state of transition. With war already raging in Europe and in the Middle East, if there is a third conflict in Asia, this could lead to a worldwide conflict that severely delays the transition and potentially changes its nature. Every transition bears its own challenges and the transitions between civilizations are no exception, with the scale of risks commensurate with the scale of the transition itself. The one the world faces today is a historic one and would be the third such one in human history, following the Agricultural and the Industrial Ages.

Until the breakthroughs that underwrite a world of plenty are made, the global paradigm will continue to be one of competition and hoarding of scarce resources. This gap between civilizations therefore is a dangerous one, where the unintended consequences of short-term actions can have real long terms costs for the world.

Managing the Transition

A secure transition requires unity to tackle common issues, which is scarce in previous transitions and periods of rapid technological change. While this provides the best chance of reacting to the inevitable environmental, economic, social, and political shocks that will continue to rock the world, the urgent focus should be on levelling up the world such that the known risks are minimized. This is best achieved by pursuing the SDGs, delivering security and sustainability, and creating a baseline of global development, such that the benefits of the major future technological breakthroughs can be widely shared in an inclusive and equitable fashion.

Alternative Paths

There has been a longstanding philosophical difference between those advocating for retrenchment to save the planet and those advocating for bold spending and innovation to overcome all issues. While the likely path is a middle road, there is no agreement yet on what this may look like, and the IPCC points to five scenarios ranging from going green to fully exploiting fossil fuels to generate maximum economic value in a bid to solve any issues that arise, with three middle paths that fail to deliver sustainable development. The world is on a combination of these middle paths and currently headed to a sub-optimal outcome for future generations.

While, in the face of existential threats like climate change and unsustainable resource consumption, there is ultimately no alternative but to find a path that safeguards the ecosystem, the Industrial Era's legacy is an unyielding demand for consumption-based growth and so the delivery of sustainable development is also a requirement. History has shown that retrenchment (also known as degrowth) - consuming and producing less to conserve resource and live within planetary bounds - has been rejected by polities the world over (at least when speaking about voluntary retrenchment) and today is no different. And science, in the form of the Second Law of Thermodynamics has shown that simply standing still, which in economics is the less severe zero-

growth option, is harder than it looks, particularly in the face of populism and today's socially connected world.

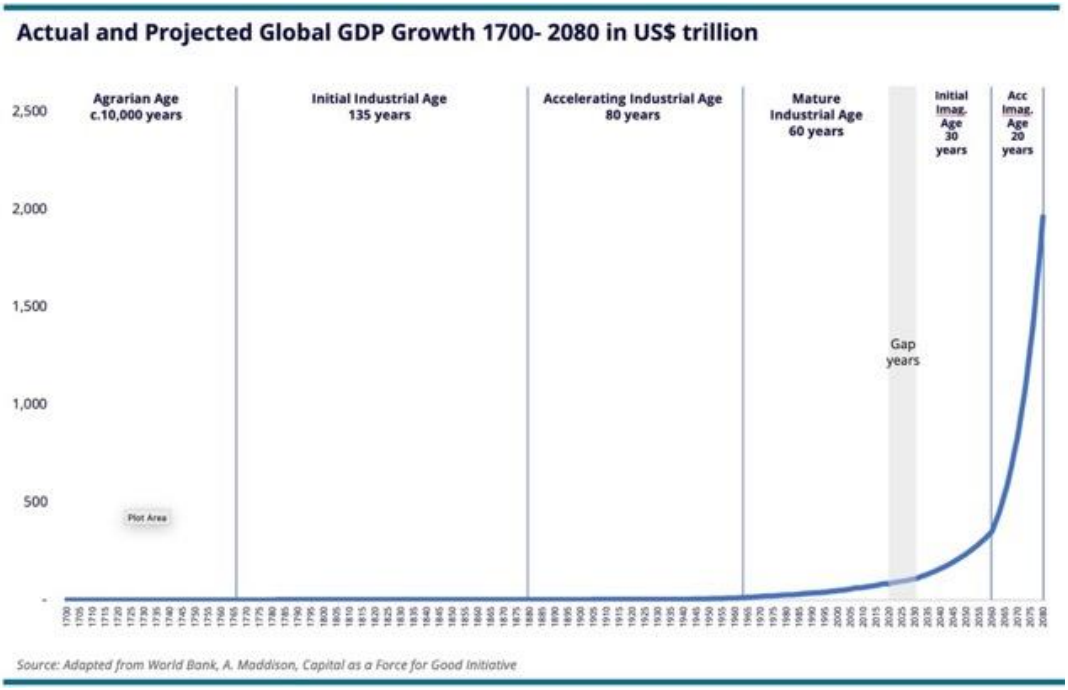
An Implicit or Explicit Deal Between the Global South and North

The likely course of action therefore involves a sustainable path of progress, requiring mobilizing the will, capital, and resources to making sure the global platform is secure, delivering an equitable world where the SDGs are met in the short-term. This requires a bargain that delivers peace and prosperity in the Global South, in exchange for limiting mass migration to the Global North, whose impact has strained political and social systems there. This bargain would allow for the world to have the stability required to pursue the breakthroughs that change the world's paradigm and create a step change in human progress.

The Superior Future

The advent of a clean abundant highly economic energy source, AI as a supportive technology for advancing every sphere of human activity backed by quantum computing, nanotech, and breakthroughs in genetics allows for the creation of a whole new civilization. The impact of these breakthroughs will not unfold in a linear fashion of course, but will accumulate over time, growing exponentially as innovations are scaled and integrated globally, and as more and more breakthroughs interact with each other in a positive feedback loop. For example, the initial breakthroughs of the Industrial Age, such as the steam engine and machine manufacturing, lifted global growth marginally above pre-industrial levels but also paved the way for further innovations like electrification and the production line, which in turn led to global growth accelerating further.

Figure 37: Global GDP Growth 1700-2080[97]



The prospect for a world that underwrites secure sustainability globally while continuing to invest in the future is a bright one, minimizing the risks and duration of the gap years that define transition period on the one hand, and benefiting from unprecedented and accelerating growth over the long term on the other hand. By some estimate the world could more than triple global GDP by 2060, reaching US$350 trillion, implying an average share of global wealth for the world's then ten billion people, roughly equal to that enjoyed by South Koreans today.[98] Thereafter however global growth has the potential to accelerate further, transforming the world in ways which are almost unimaginable.

From Today to the Future

Successfully pursuing this dual-track strategy of near-term secure sustainable development and long-term innovation breakthroughs to create a superior future is the only viable strategy for humankind at this juncture. However, in the transition between eras the temptation to fight for the past is overwhelming and today's wars over land in Europe and the Middle East, and the destruction that go with it demonstrate vividly how much we are still stuck in the values of the Industrial era's age of conquest. To succeed, the world's leaders would need to overcome competition in favor of cooperation and sharing, which seems simple but also intractable. As a measure of the will to move to the future, the world will need to demonstrate it can urgently address the global conflicts that are costing an untold number of lives, destroying billions of dollars, and weakening the global community's ability to communicate and collaborate with each other. This would also potentially lay the ground for technology, and in particular AI, being enshrined in a charter for use in creating peace, prosperity, and freedom rather than better weapons.

The world has the technologies to create a sustainable future that levels up the world, and capital will follow the deployment given the world's top corporations possess these technologies and the solutions that they spawn. If this happens, the values of the world will be transformed and the race to deploy the technologies that further raise the world will be a shared one between all the peoples of the world. That future is clearly within grasp.

APPENDIX

1. Full List of Companies Featured in this Report

Amazon.com, Inc.
Apple Inc.
Alphabet Inc.
Samsung Electronics Co., Ltd.
Microsoft Corporation
JD.com, Inc.
Alibaba Group Holding Limited
Meta Platforms, Inc.
Dell Technologies Inc.
Tencent Holdings Limited
Sony Group Corporation
Intel Corporation
HP Inc.
IBM Corporation
TSMC Limited
Xiaomi Corporation
Cisco Systems, Inc.
QUALCOMM Incorporated
Oracle Corporation
SK Hynix Inc.
Schneider Electric S.E.
SAP SE
Micron Technology, Inc.
Netflix, Inc.
Meituan
Broadcom
NVIDIA Corporation
Salesforce, Inc.
Applied Materials, Inc.
PayPal Holdings, Inc.
Nokia Oyj
ASML Holding N.V.
Baidu, Inc.
Coupang, Inc.
Texas Instruments Incorporated
MediaTek Inc.
Block, Inc.
Uber Technologies, Inc.
Lam Research Corporation
Tokyo Electron Limited
Automatic Data Processing, Inc.
Advanced Micro Devices, Inc.
TE Connectivity Ltd.
Fiserv, Inc.
Adobe Inc.
Murata Manufacturing Co., Ltd.
Pinduoduo Inc.
Nintendo Co., Ltd.
Infineon Technologies AG
Fidelity National, Inc.
Cadence Design Systems, Inc.
NetEase, Inc.
VMware, Inc.
Kuaishou Technology
STMicroelectronics N.V.
Intuit Inc.
Analog Devices, Inc.
NXP Semiconductors N.V.
Booking Holdings Inc.
eBay Inc.
Sea Limited
KLA Corporation
Activision Blizzard, Inc.
Global Payments Inc.
MercadoLibre, Inc.
Electronic Arts Inc.
Microchip Technology Incorporated
Adyen N.V.
ON Semiconductor Corporation
GLOBALFOUNDRIES Inc.
Keyence Corporation
Equinix, Inc.
Airbnb, Inc.
ServiceNow, Inc.
Roper Technologies, Inc.
Dassault Systèmes SE
Palo Alto Networks, Inc.
Arista Networks, Inc
Keysight Technologies, Inc.
Workday, Inc.
Constellation Software Inc.
JD Health International Inc.
Shopify Inc.
Marvell Technology, Inc.
Autodesk, Inc.
Synopsys, Inc.
Zoom Video, Inc.
Foxconn Technology Co., Ltd.
Robinhood
OpenAI
Twitter/X Corp
ByteDance
Stripe, Inc.
Canva
Databricks
Revolut
Unity
Atlassian Corporation
Chime

This year's list of 100 companies varies slightly from the one analyzed in the 2023 Technology as a Force for Good report. Several privately held companies were added to the list given the growing scale these companies are building and their increasing leadership in critical areas of tech. Additions include scaled companies like Stripe and ByteDance that are generating annual revenues in excess of US$10 and $100 billion dollars, respectively, and smaller companies like OpenAI holding commanding market shares in critical technologies like LLMs among others. These additions were balanced with several removals from the list, specifically of companies that can/should more accurately be classified as belonging to other industry sectors, like Tesla (an automotive company, at least for the time being), IQVIA (a clinical research organization) and Wolters Kluiwer (an information services publishing company). The table below summarizes the changes to the 2023 list of 100 tech industry leaders.

Figure 38: Changes vs the 2023 List of 100 Tech Industry Leaders

Additions	Deletions
OpenAI	Tesla
Twitter/X Corp	IQVIA
ByteDance	Wolters Kluiwer
Canva	Fortinet, Inc.
Databricks	CoStar Group, Inc.
Revolut	Veeva Systems Inc.
Unity	CrowdStrike Holdings, Inc.
Robinhood	Enphase Energy, Inc.
Chime	Snowflake Inc.
Venmo	Checkout.com

2. 2. Report Leadership and Execution

Project Leadership

Ketan Patel, Chairman, Force for Good, Chair of the Advisory Council, Force for Good, CEO and Founder, Greater Pacific Capital

The Force for Good Advisory Council

Helen Alderson, Independent Board Member; Trustee ODI

Edward Braham, Chairman, M&G plc.

Chantal Line Carpentier, Development Economist, United Nations Conference on Trade and Development (UNCTAD) New York office of the Secretary-General

Nitin Desai, Former Under-Secretary-General for Economic and Social Affairs of the United Nations

Garry Jacobs, President and CEO of the World Academy of Art & Science

Anja Kaspersen, Senior Fellow Carnegie Council; former Director of the UN Office for Disarmament Affairs

Jonathan F. Miller, Former CEO of Digital Media at News Corp, Former chairman and CEO of America Online

Nicky Newton King, former Chief Executive Officer, Johannesburg Stock Exchange; former Director, World Federation of Exchanges.

Sir Alan Parker, Chairman and founder, Brunswick Group

Usha Rao-Monari, Former Under-Secretary General, UN Development Programme; Senior Adviser, Blackstone's Infrastructure Group; Director, Sustainable Business Advisory Group at the International Finance Corporation, World Bank Group

Report Authorship

This report was prepared by **Ketan Patel,** and **Christian Hansmeyer,** with review, feedback, and insights from the Advisory Council.

Data Gathering and Analysis

Christian Hansmeyer, Report lead, **Nandan Desai,** Review lead, **Aditya Ajit,** Analytics and research, **Ushma Shah,** Analytics and research, **Lesley Whittle,** Project administration

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RESEARCH PROCESS AND METHODOLOGY

1. SDG Solution Areas Analysis

Research Objective: The SDG solution areas analysis illustrates how the 17 UN Sustainable Development Goals can be met by the coordinated actions of global stakeholders, using currently available resources, and leveraging established tools and solutions.

Research Process:

1. Core information set. The core document examined to establish the potential solutions to address the SDGs was at the level of the 169 SDG targets established in the indicators, namely the 2030 Agenda for Sustainable Development.
2. Determination of potential solutions, initiatives, and resources to address SDGs. The analysis included a detailed review of the literature and research on each of the 17 SDGs, as well as discussions with subject matter experts, analysis of the existing landscape of efforts to meet the goals to identify and map the tools and resources and resources available to meet a given goal, as well as the key stakeholders involved in their achievement. Key stakeholders considered included governments, the private sector, households (both as individuals and collectively as civil society), and the finance industry (consisting of both public and private sector actors). The core resources available to stakeholders included:
    1. Capital. Financial resources funding the sustainable development (investing and operating) activities of all stakeholders.
    2. Natural Resources. Land, raw materials, and natural resources, both in the context of exploitation and conservation.
    3. Human Resources. The choices and actions of individuals, acting as consumers, professionals, voters, and as members of society.
    4. Intellectual Property. Knowledge, ideas, and innovation, as well as the technological breakthroughs that they deliver.
3. Synthesis into six solutions. The resulting list of potential solutions was categorized into six distinct overarching solution areas grouping together various subsets of initiatives tools and resources. These solution areas' applicability to a given goal varies from target to target. These six solutions included:
    1. Policy. Public policy initiatives, consisting of legislation, regulation, national strategies, bilateral and multi-lateral treaties, enabling actions for public sector activities, and the provision of incentives to the private sector;
    2. Public Sector Activities. Government execution actions including the deployment and operation of public systems and organizational infrastructure, the provision of public services, public financing and direct transfers, and policy enforcement actions;

3. Technology. Information and communications technology, including the provision of IT and telecom services information processing and data analytics, and the deployment of digital goods and services;
4. Infrastructure. The basic physical structures and facilities needed for the operation of society, including public services infrastructure, the built-up environment, and the infrastructure designed for resilience and protection;
5. Financial Services. The provision of financial services to households and micro- small- and medium-enterprises with direct impact on SDG targets, delivering financial inclusion, increasing prosperity, and financial resilience, and
6. Private Sector. Solutions delivered by private sector business activities, including through organizational change, the development of new business opportunities, and partnerships with public sector.

4. Base Case estimates for achieving SDG targets. The analysis further considered each SDG target, its underlying indicator(s), and the literature on the specific solutions, to determine each solution's potential contribution to meeting the target, resulting in a percentage estimate. The base case percentage estimate of each solution's contribution to a specific target assumed that solutions would be based on well-established activities and models, leveraging currently available resources, with solutions scaled and transposed as required. The aggregate percentages of all the Base Case solutions for a given target add up to 100%, indicating that the mix of solutions determined have the potential to fully achieve the SDGs.
5. Stretch Case estimates for the SDGs. A second estimate determined a 'Stretch Case' of solutions' contribution to the SDGs. This stretch case percentage estimate of each solution's contribution to a specific target considered a wider set of tools and solution-sets. In addition to the activities and models considered in the Base Case estimates, the Stretch Case also considered more targeted solutions and initiatives that might require significant local adaptation to be scaled globally. The aggregate percentages of all the Stretch Case solutions for a given target can exceed 100%, indicating that if all solutions were executed to Stretch Case levels the target for achieving the SDGs could be exceeded, leading to an achievement above the original 100% target.

Process, Assumptions, Requirements and Limitations:

1. Unweighted Targets. The contribution of each solution to the SDGs in both the Base and Stretch Cases is determined by calculating its average contribution across all 169 SDG targets. This average is not weighted to specific targets or goals (each of which contains between five and 19 targets).
2. Technology Solution. Technology contributes to 87% of the targets, making an at least c.5% contribution to their achievement reflecting technology's enabling role, providing critical information processing, automation, communication, and knowledge sharing for the dissemination of best practices and coordinated action. The Base Case estimate assumes the achievability of universal connectivity and the global deployment of existing mass-market IT solutions. The Stretch Case considers the potential impact of advanced digital technologies

including Web 3.0, cloud ecosystems, and artificial intelligence, among others, deployed at scale.

3. Policy Solutions. Policy solutions based on laws and regulations are assumed to also require an element of accompanying public sector activity in the form of enforcement actions. Policy solutions based on incentives are assumed to require some level of private sector solutions as well (unless the underlying SDG target is specifically focused on providing incentives, rather than on delivering outcomes). The Base Case estimate focuses on the scaled deployment of enabling legislation and regulation for the SDGS. The Stretch Case estimate assumes a more supportive enabling environmental and greater use of incentives.
4. Public Sector Activity Solutions. The Base Case estimate focuses on the essential government services and activities needed to achieve the SDG's underlying targets. The Stretch Case estimate assumes the removal of significant capital constraints in least developed and developing countries. Significant enhancements to funding public sector activities has proven to be a barrier to success thus far, however the implementation of policy (encompassing laws, regulations, and governance) makes the public sector activity funding more feasible and enhancing the base case activities makes the stretch case more feasible.
5. Infrastructure Solutions. Infrastructure solutions includes the physical element of IT, telecoms, and other digital infrastructure but does not consider the development or deployment of software or the dataflows the infrastructure carries. The Base Case estimate is based on the global scaling of existing mass infrastructure solutions and technologies. The Stretch Case estimate assumes the global adoption of 'state of the art' infrastructure technologies, including building information modelling, smart infrastructure, and advanced materials, among others.
6. Financial Services Solutions. Financial Services solutions are defined as opportunities where the delivery of financial service products to households and MSMEs *directly* contributes to a target's achievement. The Base Case estimate is based on the provision of basic financial services required to achieve a given target. The Stretch Case estimate assumes providing target populations with a full suite of financial solutions across banking, insurance, and asset/wealth management to enable broader prosperity.
7. Private Sector Solutions. The Base Case estimate is based on a 'business as usual' scenario in which private sector corporations continue to play their existing commercial roles and pursue opportunities in keeping with existing strategies and business models. The Stretch Case estimate assumes private sector corporations make long term investments, reposition their businesses for the future, incorporate new business models (as required) and expand their strategic focus.

Interdependencies, Outcomes, Scope, and Limitations:

1. First, Second and Third Order Outcomes. Each target was evaluated in isolation, with only the first order impact of a given solution on that target considered. Second and third order impacts on other target, which are potentially substantial given the interdependency of the goals, have not been considered.

2. Policy Affects Feasibility of Other Solution Areas. The implementation of policy (encompassing laws, regulations, and governance) makes a country a stronger candidate for private sector participation.
3. Relationship between Base and Stretch Cases. Achieving the base case makes the stretch case more feasible by enhancing the attractiveness of countries.
4. Order of Magnitude. The analysis in this report can only be considered to provide an order of magnitude of the potential impact of solutions to each of the SDGs, at the level of the SDG targets, and serves to demonstrate that the SDGs can be feasibly achieved both technically and financially.

Multi-stakeholder Process Required. Translating the analysis into precise numbers requires the process to be conducted with multiple stakeholders with potential implementation roles, alongside subject-matter experts on the nature of the problem, including UN member states, for each of the 17 goals. Such an analysis would also determine (i) the integration of the various solutions required to meet a given target, (iii) the practical feasibility of scaling and transposing existing solutions globally, (iv) and the capital required to scale and deploy these solutions.

2. Calculating the Cost of the SDGs

A Simple Framework to Target, Fund, and Measure the SDGS, Recap

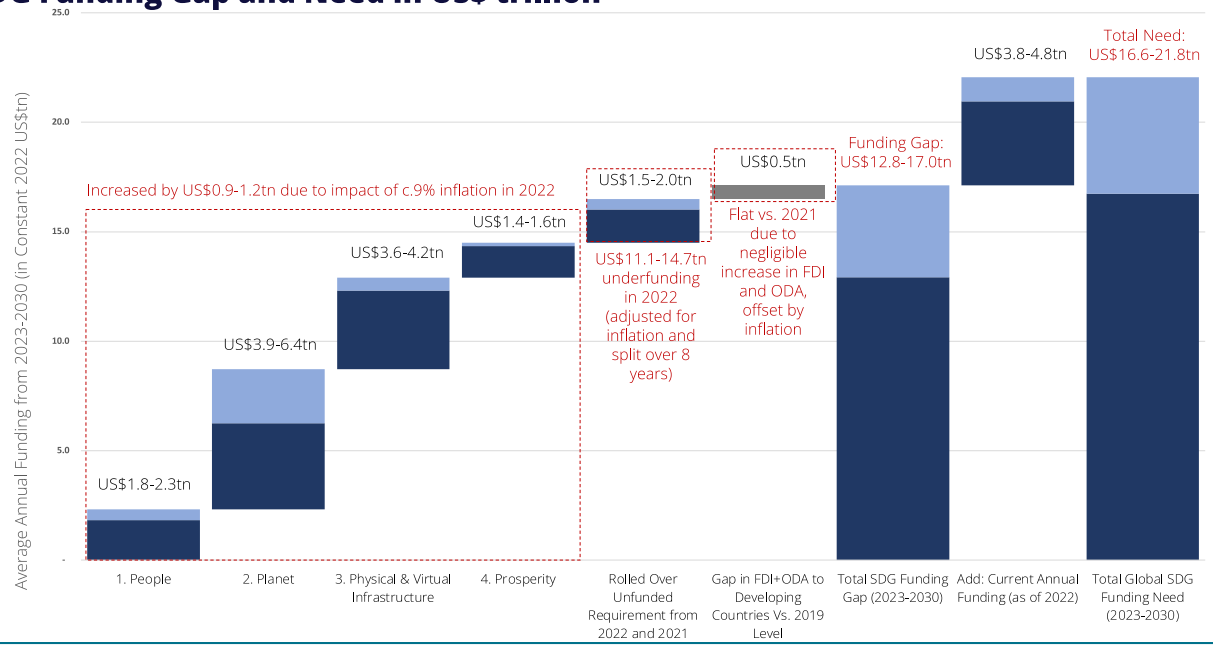
A similar simple and practical approach is required for all the SDGs. The 2021 Capital as a Force for Good report grouped the 17 SDGs into four interrelated, interconnected, and interconnected categories, with one important enabling category:

I. People. Addressing basic human needs including access to quality education and healthcare, and ending world hunger;
II. Planet. Saving the planet by addressing climate change, biodiversity loss, and addressing plastics;
III. Platforms Enabling human activity by building the necessary infrastructure, and affordable housing;
IV. Prosperity. Creating shared prosperity through financial inclusion for small businesses, women, and underserved populations, and providing social security, and
V. Peace and Partnership. Delivering peace and partnerships to enable stakeholders to work together with the aim of meeting the SDGs.

Last year's analysis[99] estimated a gap of c.US$11.3-14.9 trillion annually across the first four categories, largely in developing countries, and a total requirement of US$15-19.6 trillion per annum to meet the SDGs by 2030. The build-up to this average annual funding gap and total requirement, as presented in last year's report, is summarized in the chart below:

Figure 39: Previous Year's Estimate of Total SDG Financing Cost and Gap[100]

SDG Funding Gap and Need in US$ trillion



It is noteworthy that Peace and Partnership, are crucial to the SDGs overall success, and are not included in the financing estimates. While governments and policy makers often play the leading role in addressing peace and facilitating partnership, their success or failure (from a financier's perspective) results in financiers supporting or withholding investments in states that do not meet their criteria. This adverse impact on countries with low governance, which often have the most acute SDG funding needs, is set to grow as a side-effect of the adoption of ESG by financial institutions and businesses.

Revised Assessment of the Funding Need and the Gap

The 2023 funding gap has been revisited to reflect several factors.

I. **High Inflation.** Inflation globally increased to 8.7% in 2022 (vs. 4.7% in 2021), with c.7% inflation in advanced economies and c.10% inflation across emerging markets, on average[101], driven by the war in Ukraine, an increase in food and energy prices, and continued supply chain bottlenecks. Inflation erodes the value of increases in SDG funding and compounds the overall requirement across all categories and increased the annual SDG funding gap by US$1.0-1.4 trillion in 2022.

II. **Chronic Underfunding.** Total funding for the SDGs is estimated to have increased by only 5.4-5.9% to US$3.8-4.9 trillion in 2022, given the sharp slowdown in GDP growth globally in 2022 vs. 2021 when the world was recovering from the pandemic-induced lockdowns[102]. This means that c.US$11-15 trillion of the total SDG funding need in 2022 was not funded, which compounds on top of the 2021 underfunding, and gets further compounded by inflation. With each year of severe underfunding for the SDGs, the overall funding gap for the remaining years is quickly compounding to an unachievable quantum.

III. **Foreign Investment and Aid to Developing Countries Still Well Below Pre-Pandemic Levels.** Foreign direct investment (FDI) and official development assistance (ODA) to developing countries declined by c.US$0.7 trillion in 2020 due to the pandemic as countries turned their resources inward[103]. While there was a partial recovery in 2021 with US$0.2 trillion increase in FDI and ODA to developing countries, momentum reversed in 2022 with FDI

and ODA to developing countries increasing by only US$63 billion or 6% vs. 2021[104]. As a result, after accounting for inflation, overall FDI and ODA to developing countries remains c.US$0.6 trillion below pre-pandemic (2019) levels.

Taking the above factors into account, the revised estimate suggests that the total annual funding required to meet the SDGs has increased to c.US$16.6-21.8 trillion (in constant 2021 US dollars), a c. 10% increase vs. last year's estimate. The total funding gap at US$103 137 trillion has stayed largely constant relative to last year's US$102-135 trillion, with one year less for this gap to be closed. The key components of this increase are broken down in the table below.

Figure 40: Total SDG Funding Gap, 2023 Revised Estimate (vs. 2022 Estimate)[105]

Constant 2022 US$ trillion, except where noted	Low	High	Notes
Last Year's Estimate of Annual SDG Funding Gap (2021 US$)	11.3	14.9	2022 Capital as a Force for Good Report
Add: Increase in Rolled Over Underfunded Requirement (from 2021 and 2022)	0.6	0.9	US$11.2-14.8 trillion unfunded requirement from 2022 (added to 2021 unfunded requirement)
Add: Impact of Inflation (Adjustment from 2021 to 2022 Constant US$)	1.0	1.2	Based on global consumer price inflation of 8.7% in 2022
Less: Increase in FDI and ODA to Developing Countries in 2022	(0.1)	(0.1)	c.US$53 billion additional FDI and ODA for developing countries in 2022 vs. 2021
Revised Estimate of Annual SDG Funding Gap	12.8	17.0	
% Increase in Last Year	13%	14%	
Add: Estimated Current SDG Funding Annually (as of 2021)	3.8	4.8	2021 SDG funding estimate increased at the rate of nominal GDP growth
Revised Estimate of Total Annual SDG Funding Requirement	16.6	21.8	
% Increase in Last Year	10%	11%	

Notes: The total supply of SDG funding is inherently difficult to estimate given the absence of any publicly available estimates which aggregate public investments by member states, investments by the private sector, and cross-border flows of development assistance and direct investment by developed countries in developing countries specifically against the SDGs. The analysis above assumes that the supply of financing for the SDGs increased at the rate of nominal GDP growth in 2022 (factoring in both the economic recovery and inflation) to reach US$3.8-4.8 trillion in 2022. This appears to be a safe assumption considering the following factors:

After record stimulus levels in 2020 and 2021, developed and developing economies were fundamentally fiscally constrained in increasing public expenditure on the SDGs to the extent of the growth in their total output[106].

SDG achievement gaps still point to persistent gaps in developing countries, indicating that, even with the record levels of funding seen in 2021, this has been altogether insufficient[107].

While there was a 19% in new sustainable debt issuances in 2022 (from US$1.1 trillion in 2021 to US$0.9 trillion in 2022[108]), funding for the SDGs is significantly broader and encompasses public spending and private investment. An analysis of the SDG financing initiatives of the 25 large financial institutions (which together accounted for c.80% of the total US$3 trillion of sustainable financing by 125 finance industry leaders analyzed in the 2022 Capital as a Force for Good report), suggests that despite the slowdown in sustainable debt issuances, overall sustainable financing by the finance industry increased by c.4% in 2022, which is consistent with the 3.2-3.7% increase assumed in the analysis above[109].

Taken together, the total funding requirement to achieve the SDGs is estimated at US$16.6-21.8 trillion annually between 2022 and 2030, or US$132-175 trillion in total over eight years, only a quarter of which is currently being funded and mostly in developed nations.

Please refer to the 2021 Capital as a Force for Good report for further details about the methodology used to arrive at the original funding gap estimates.

VII. DISCLAIMER, REFERENCES AND NOTES

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References

The terms country and economy as used in this Report also refer, as appropriate, to territories or areas; the designations employed and the presentation of the material do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city, or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. In addition, the designations of country groups are intended solely for statistical or analytical convenience and do not necessarily express a judgment about the stage of development reached by a particular country or area in the development process. The major country groupings used in this Report follow the classification of the United Nations Statistical Office:

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The following symbols have been used in the tables:

• A slash (/) between dates representing years, e.g., 2010/11, indicates a financial year.

• Use of a dash (–) between dates representing years, e.g., 2010–2011, signifies the full

period involved, including the beginning and end years.

• Reference to “dollars” ($) means United States dollars, unless otherwise indicated.

Annual rates of growth or change, unless otherwise stated, refer to annual compound rates. Details and percentages in tables do not necessarily add to totals because of rounding.

End Notes, Sources

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