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Leveraging frontier technologies and innovation to advance regional integration for sustainable and inclusive growth

Issues paper

I. Introduction

1. In 2015, the global community adopted the 2030 Agenda for Sustainable Development, pledging to ensure prosperous lives for all. That same year, the African Union launched Agenda 2063: The Africa We Want, envisioning shared prosperity, unity and integration.

2. Meeting these goals and aspirations has been challenging. An estimated 29.3 per cent of employed Africans in 2024 still lived on less than \$2.15 per day despite having a job. In 2025, about 23.2 per cent of young Africans are not studying, working or receiving training. Beyond these labour market difficulties, Africans also face limited access to systems that can protect them from poverty and vulnerability. In 2023, only 19.1 per cent of Africans were covered by at least one form of social protection. Meanwhile, the annual average output per worker on the continent is to grow by just 1.3 per cent in 2025, which is half the average for low-income countries.¹ Furthermore, one third of the African population do not possess legal identification or documentation, meaning that their contribution to or participation in the continent’s development may remain largely unaccounted for. The slow pace of progress towards these goals and aspirations underscores the urgency to rethink growth strategies, placing innovation, regional synergies and inclusion at the centre of the continent’s development agenda.

3. In the light of the challenges described above, the aim of the present paper is to explore how harnessing frontier technologies and innovation can transform the continent’s development trajectory. The paper provides a definition of frontier technologies, an assessment of the continent’s readiness to leverage them and an examination of their impact on businesses and the

* E/ECA/CPRTIIT/4/1.

¹ International Labour Organization, ILOSTAT database. Available at <https://ilostat.ilo.org/data/> (accessed on 22 September 2025).



attainment of the Sustainable Development Goals. It also contains a discussion of the mutually reinforcing relationship between frontier technologies and regional integration and includes recommendations on strategic pathways for their adoption. The paper concludes with a list of key questions for consideration by the Committee.

II. Understanding frontier technologies

4. There is no universally agreed definition of frontier technologies. In part, frontier technologies “encompass an array of new materials, products, applications, processes and business models [that] are interdependent, interconnected and mutually reinforcing”.² For instance, artificial intelligence, which refers to computer systems and machines that simulate human capabilities such as learning, comprehension, problem solving, decision-making and creativity, is not one technology but encompasses various new devices, hardware, software, applications and uses. Similarly, genetic engineering, which refers to manipulating genetic codes of an organism to change its traits, is not one technology or method. The same applies to advanced battery technologies that power the wireless world. These batteries, including lead-acid batteries, flow batteries, nickel-cadmium or lithium-ion batteries and batteries using various metal-air chemistries, are diverse and have a visible impact.³

5. Frontier technologies are important drivers of innovation, entrepreneurship and industrial development, and thus have a significant impact on the economy, society and the environment. For instance, electricity, semiconductors and the Internet have enabled new and innovative solutions, business models and industries with wide societal impact, which is likely to continue given the recent developments in digital technology, biotechnology, nanotechnology and renewable energy technologies.

6. Frontier technologies offer challenges and opportunities worldwide. They are often built on the basis of existing technologies, which creates path dependence.⁴ For example, artificial intelligence is being built on existing digital technologies (chips, data centres, software and public digital infrastructure) and is benefiting from existing data sets (e.g. from media, healthcare, academic, entertainment, scientific and government databases). Developed countries have easier access to the necessary skills and experience, infrastructure and markets, including firms actively investing in artificial intelligence, while developing countries may lack these resources.

7. That being said, frontier technologies also evolve rapidly, with unclear market standards and practices, allowing developed and developing countries to learn simultaneously. Egypt, the United Arab Emirates and Viet Nam stand out as examples of developing countries that are investing in the adoption, development and application of artificial intelligence. In some cases, developing countries can choose to leapfrog by investing in the latest technology, while more advanced countries may have to upgrade existing systems.⁵

² *World Economic and Social Survey 2018: Frontier Technologies for Sustainable Development* (United Nations publication, 2018).

³ Daniele Rotolo, Diana Hicks and Ben R. Martin, “What is an emerging technology?”, *Research Policy*, vol. 44, No. 10 (December 2015).

⁴ Path dependence refers to how past choices about the way in which technologies are developed, regulated or used strongly shape their future direction, making it difficult to switch to different approaches later.

⁵ Khuong M. Vu and Simplice Asongu, “Backwardness advantage and economic growth in the information age: a cross-country empirical study”, *Technological Forecasting and Social Change*, vol. 159 (October 2020).

8. Lastly, frontier technologies present numerous technological and market niches that developing countries can exploit to bypass existing challenges. The mobile revolution, for instance, enabled developing countries to design unique business models that cut down defaults (e.g. prepaid services), pass most investment costs to the private sector and expand services (e.g. mobile banking).

III. Leveraging frontier technologies in African business

9. African businesses are increasingly harnessing frontier technologies to solve chronic challenges, compete globally and shape new markets. These innovators vary from mobility start-ups and companies developing digital platforms for agriculture, to industries powered by artificial intelligence and financial technology unicorns,⁶ signalling a rising tide of technology-driven growth. Their impact is tangible: empowered businesses and consumers, tighter market links and enhanced productivity.

A. Intelligent transport

10. African businesses are reshaping transport using frontier technologies to boost efficiency, cut costs and reduce emissions. In Rwanda, Ampersand operates over 4,000 electric motorbike taxis with smart battery-swap stations. Riders complete more than 14,700 swaps daily, travelling up to 200 km on 35–40 per cent lower operating costs and offering fares to passengers that are 10–20 per cent cheaper than those for fuel bikes. Ampersand commands 13 per cent of the motorbike taxi market in Kigali, supported by national policies aimed at promoting electric vehicles.⁷ Likewise, such logistics platforms as Lori Systems and Kobo360 in Kenya and Nigeria use artificial intelligence to optimize freight routes.⁸

B. Agriculture technology on the rise

11. Throughout the continent, agriculture, which has long been constrained by limited access to finance and low mechanization, is being reimaged through frontier technologies. In Kenya, Apollo Agriculture is transforming smallholder farming with a one-stop shop that provides credit, insurance and agronomy-related advice through a single platform. By combining machine learning, satellite imagery and mobile finance, Apollo Agriculture de-risks farm lending and boosts productivity. Its artificial intelligence engine builds personalized credit profiles, predicts optimal input use and planting times and adjusts loan terms based on weather and harvest data. Serving over 5,000 field agents and 1,000 agri-retailers, Apollo Agriculture helps farmers to achieve 2.5 times the national average yield, thereby enhancing food security and economic growth.⁹

⁶ Unicorns refer to start-ups that have reached a market capitalization of more than \$1 billion.

⁷ Remeredzai Joseph Kuhudzai, “Ampersand leads the charge as electric motorcycle market share surges in Kigali, Rwanda”, CleanTechnica, 1 May 2025.

⁸ AU Startups, “African day special: the AU-Startups top 54 African tech companies facilitating cross border trade in Africa”, 27 May 2023.

⁹ Chan Zuckerberg Initiative, “Apollo agriculture raises \$40 million to expand platform to help small-scale farmers improve their yields”, 22 March 2022.

12. Hello Tractor operates in 16 African countries using the Internet of things and a mobile application to provide pay-as-you-go tractor services. It has connected over 1 million farmers and helped them to cultivate over 690,000 acres, allowing them to plant up to 40 times more efficiently than through manual labour, boosting yields and income.¹⁰

C. Smarter, safer and more transparent mining practices

13. Frontier technologies are improving productivity, transparency and safety in African mining. In Rwanda, blockchain is being used to trace tantalum from its extraction in the mine to its export, verifying that its origin is conflict-free and boosting investor confidence. This model could also be applied to other high-value minerals. In South Africa, mining firms are using artificial intelligence and robotics to optimize extraction, improve maintenance and reduce accidents, cutting workplace injuries by 40 per cent in deep mines.¹¹

D. Advances in manufacturing

14. African manufacturers are gradually adopting automation and digital systems to raise productivity. For instance, A to Z Textile Mills in the United Republic of Tanzania – one of the largest garment firms in East Africa – partnered with the Centre of Excellence for Information and Communications Technology in East Africa to digitalize its warehouse and inventory management systems. By introducing mobile barcode scanning and real-time tracking, the firm improved its production cycle, forecasting and responsiveness to demand.¹²

E. Financial technology and digital services

15. Perhaps the most celebrated success in African frontier technology development is in financial services, where African firms lead the world in mobile money and financial technology innovation. Building on the mobile money revolution pioneered by the M-Pesa money transfer service launched in Kenya, a new generation of African financial technology start-ups is expanding rapidly. Flutterwave, founded in Nigeria in 2016, has grown into a pan-African leader in payment solutions, serving over 1 million businesses and 2 million individuals across 12 African countries and globally. Processing over 500,000 transactions daily in over 30 currencies, Flutterwave is powering cross-border e-commerce.¹³ The developmental impact is evident: deeper financial inclusion, smarter products and bold new revenue opportunities across Africa.

IV. Achieving the Sustainable Development Goals through the adoption of frontier technologies

16. Africa, like other regions, faces severe climate, health and energy challenges and is exploring innovative ways to tackle these issues through the adoption of frontier technologies. Throughout the continent, a quiet but transformative shift is taking place, in which innovative solutions are being leveraged to address urgent needs while advancing the implementation of the 2030 Agenda and Agenda 2063.

¹⁰ United Nations, Special Advocate of the Secretary-General for Inclusive Finance for Development, “Hello Tractor is revolutionizing farming and fueling economic empowerment through digital financing for smallholders in Kenya”, 7 November 2023.

¹¹ AfricaLive, “Where South Africa can lead: AI and robotics”, 20 February 2025.

¹² East African Community/German Agency for International Cooperation, “EAC digital pioneers: enhancing production through automation of industry processes” (n.d.).

¹³ See <https://flutterwave.com/ng/>.

A. Environmental application of the Internet of things and blockchain

17. In Kenya, platforms powered by artificial intelligence, such as M-Situ,¹⁴ are being piloted to monitor forest ecosystems using sensors embedded in the Internet of things, offering early warning signals for deforestation and environmental risks. In addition, farmers in Kenya are benefiting from the Kuzi artificial intelligence tool,¹⁵ which uses satellite data and machine learning to generate pest and weather forecasts, helping to safeguard food security in the face of climate uncertainty.

18. South Africa is applying blockchain technology to reshape the continent's carbon market in order to simplify certification, reduce costs and effectively channel climate finance to local communities.¹⁶ It is also using sensors embedded in the Internet of things to maintain consistent temperatures in cold storage facilities and ensure that perishable goods are safe during transit and storage periods.

B. Grid modernization

19. Similar stories of harnessing frontier technologies for reliable and sustainable energy, such as smart mini-grids and solar grids, are emerging across the continent. While mini-grids themselves are not new, their evolution into smart systems that run mainly on renewable energy, use digital technology and mobile-based services and benefit from improved power storage marks a frontier shift in energy access. With close to 600 million Africans lacking reliable access to electricity, representing nearly half the continent's population and more than 80 per cent of the global electricity access gap,¹⁷ frontier technologies play a major role in bridging this divide and attaining the Sustainable Development Goals. For example, in Kenya, innovative mini-grids powered by solar energy are deployed in such regions as Turkana to enhance access to clean energy.¹⁸ In Nigeria, such companies as Husk Power Systems are decentralizing energy solutions using smart solar mini-grids to generate and store power in batteries.¹⁹

C. Healthcare and drone technology

20. Drone technology is being used to improve healthcare in Rwanda through the delivery of essential medical products in remote areas.²⁰ Ghana and Nigeria are also using drone technology for delivery services. Moreover, South Africa, partnering with Egypt, Kenya, Nigeria, Senegal and Tunisia, is establishing messenger RNA vaccine facilities to localize pharmaceutical production and strengthen health systems.²¹ Scaling up the application of these innovative technologies can support the achievement of the Goals in the areas of climate, access to affordable healthcare and clean energy.

¹⁴ See <https://m-situ.com/>.

¹⁵ See www.selinawamucii.com/kuzi/.

¹⁶ See <https://climera.co.za/>.

¹⁷ United Nations, United Nations Sustainable Development Group, "Decoding Africa's energy journey: three key numbers", 27 January 2025.

¹⁸ Kelvin Kipng'etich, "Kenya: the rise of green mini-grids – how community-based solar projects are electrifying Kenya's last mile", Capital Business, 12 May 2025.

¹⁹ See <https://huskpowersystems.com/>.

²⁰ Modestus Amaechi and others, "From A to O-positive: blood delivery via drones in Rwanda", Reach Alliance, April 2021.

²¹ African Development Bank, "Six African countries to receive initial transfer of mRNA vaccine technology", 23 February 2022.

V. Harnessing mutual reinforcement between frontier technologies and regional integration

A. How regional integration relies on frontier technologies

21. The African Continental Free Trade Area represents a monumental undertaking to integrate the continent's economies and establish a single market for goods and services. The strategic adoption and deployment of frontier technologies could contribute significantly to the successful operationalization and functioning of the Area. For instance, efficient and interoperable payment systems, such as the Pan-African Payment and Settlement System, can enhance the security, cost-effectiveness and speed of cross-border payments.²² Furthermore, such technologies as blockchain can support trade facilitation by expediting and streamlining the conformity assessment and certification processes in relation to the underlying technical regulations and standards, thereby reducing bureaucratic delays and boosting overall trade efficiency under the Area.²³

22. However, African countries need to significantly invest in digital infrastructure to power the frontier technologies. Despite the pivotal role of Internet connectivity for most of these technologies, mobile broadband penetration on the continent was only 51.5 per cent in 2024, while fixed broadband penetration was only 0.9 per cent. The affordability of broadband Internet services also remains a major hurdle. As of 2023, the cost of mobile broadband data in Africa was 4.5 per cent of gross national income per capita, considerably higher than the global average of 1.3 per cent. Fixed broadband was even more expensive, averaging 14.8 per cent of gross national income per capita, far exceeding the world average of 2.7 per cent.²⁴

23. Most frontier technologies require robust data centres to process large volumes of information efficiently. Proximity to data centres also translates to higher service performance due to lower latency and reduced international bandwidth costs. However, only 2 per cent of the 5,064 global colocation data centres are in Africa. Moreover, the continent's cloud infrastructure system is dominated by cloud service providers based in the United States of America, despite the risks associated with massive overreliance on few global service providers.²⁵

24. An enabling regulatory environment is equally crucial for the development and adoption of frontier technologies, as it fosters trust, ensures security and enhances efficiency. However, regulatory fragmentation poses a significant challenge, increasing compliance costs and hindering the scalability of technologies across borders. For instance, only 16 countries have ratified the African Union Convention on Cyber Security and Personal Data Protection, highlighting a persistent continental gap in the legal compliance of data governance systems.²⁶

25. This underscores the imperative to accelerate the implementation of regional and continental frameworks, such as the Digital Transformation Strategy for Africa 2020–2030, the 10 principles of good digital identity

²² AfricaNenda, Economic Commission for Africa (ECA) and World Bank, *The State of Inclusive Instant Payment Systems in Africa: SIIPS 2024* (October 2024).

²³ African Union Development Agency, "Exploring blockchain-enabled technologies to strengthen Africa's continental-wide trade systems", blog, 11 July 2022.

²⁴ International Telecommunication Union, ITU DataHub. Available at <https://datahub.itu.int/> (accessed on 30 June 2025).

²⁵ ECA, *Digital Infrastructure in Africa* (Addis Ababa, 2023).

²⁶ See <https://au.int/en/treaties/african-union-convention-cyber-security-and-personal-data-protection>.

systems,²⁷ and the Protocol to the Agreement Establishing the African Continental Free Trade Area on Digital Trade and its related annexes. These instruments are aimed at harmonizing regulatory standards across the continent and driving the development of robust digital infrastructure and systems, thereby creating a more integrated and efficient system for frontier technologies. Their effective implementation will be critical to advancing regional integration through the Area.

26. Now that the Area is operational, the conversation is evolving, with growing emphasis on ways to accelerate its implementation and transition to the next phase of continental integration. In an era in which digital trade is a powerful vehicle for growth, innovation and inclusion, frontier technologies are catalysts for deeper integration.

27. In a 2025 report entitled *Delivering on the African Economic Community: Towards an African Continental Customs Union and African Continental Common Market*, the Economic Commission for Africa (ECA) and partners advanced this discussion to the next phase, applying the ambitious framework for a continental free trade area to a deeper regional integration initiative involving the formation of an African continental customs union and an African continental common market. These ambitious new goals will hinge upon not just political will and institutional capabilities but also the strategic deployment of frontier technologies.

28. In the report, ECA recommended the adoption of a common tariff nomenclature and common customs management regulations to provide a standardized system for the classification of goods and for clearing procedures. In parallel, the customs revenue-sharing formula establishes a fair mechanism for distributing the financial benefits of common trade policies among members. Because these instruments are politically sensitive, leveraging artificial intelligence and blockchain technologies is critical. Artificial intelligence can, for instance, be used to analyse real-time trade flows, detect anomalies and forecast revenue contributions, thereby ensuring that the customs revenue-sharing formula is implemented on the basis of accurate and transparent data. Combined with blockchain for immutable record-keeping, artificial intelligence helps to design interoperable customs systems with greater fairness, traceability and security.

29. An important element in establishing an African continental customs union is the creation of a common external tariff, which will require harmonized trade and customs procedures, seamless data-sharing and integrated trade facilitation systems, and will be instrumental in reducing trade and business transaction costs and helping to detect and eliminate non-tariff barriers between African countries and countries that are outside the customs union. In the report, ECA outlined the requirements for developing and implementing a common external tariff, including robust administrative capabilities for monitoring, collecting and analysing data, systems to monitor and evaluate the redistribution of tariff revenues, significant technical expertise to handle the complexities of harmonizing tariffs across countries and learning systems to enable policymakers and institutions to improve implementation. Smart contracts offer an efficient means of administering these requirements, playing a vital role in automating compliance within the common external tariff framework, making them less prone to human error.

B. How frontier technologies depend on regional cooperation

30. The relationship between regional integration and frontier technologies is mutually supportive. Just like frontier technologies can support the

²⁷ See www.uneca.org/dite-for-africa/principles-of-digital-id.

advancement of regional integration, scaling up frontier technologies also demands regional cooperation. Because the success of these technologies depends on large-scale use, interoperability and shared infrastructure, there may be a need for deliberate cooperation and coordinated interventions beyond national confines. For example, by aligning policies, pooling resources and harmonizing standards among one another, countries can reduce deployment costs, enable cross-border compatibility and create large, integrated markets that are attractive to investors and innovators.

31. There are early signs that regional cooperation is delivering results on this front. For instance, under the Programme for Infrastructure Development in Africa, 17 countries are now digitally connected by means of optical fibre; regional information and communications technology capacity has reached 9 terabytes, exceeding the 2020 target of 6 terabytes; and broadband penetration has surpassed 25 per cent. In addition, 30 million more people now have access to electricity through projects supported by the Programme.²⁸ While these may not be frontier technologies themselves, they are essential enablers, laying the foundation for the successful deployment and scaling up of advanced technologies across the continent.

VI. Adoption of frontier technologies

32. There is no single solution for accelerating the adoption and use of frontier technologies because there are multiple significant barriers, such as the lack of required skills; the high cost of research and development, technology and its support infrastructure; the uncertainties of success; regulatory barriers; and low general acceptance by users. African countries may put in place a number of measures to accelerate the uptake of frontier technologies, including building a talent base, investing in research, development and innovation, investing in infrastructure and creating markets.

A. Human capital development

33. All technology functions optimally with a well-trained and skilled workforce and a population capable of designing, developing, deploying, using, maintaining and upgrading the technology. Education and training can play an important role. Current estimates suggest that only 13 per cent of African children can read and understand a simple story by the age of 10, about 15 per cent of all students in upper secondary are enrolled in technical and vocational training, and the gross enrolment rate in tertiary education is 9 per cent (compared with 42 per cent globally).²⁹

34. Efforts are urgently needed to equip the population, especially young people and women, with the technological, entrepreneurial, creativity-based and problem-solving skills required to use, design and produce knowledge products.³⁰ The “Education 5.0” initiative in Zimbabwe and the competency-based curriculum in Kenya are examples of such efforts. The Alliance for Entrepreneurial Universities in Africa is equally empowering millions of students with problem-solving and entrepreneurial skills, irrespective of their field of study.

²⁸ African Union Development Agency, *Programme for Infrastructure Development in Africa (PIDA): First 10-Year Implementation Report – A Decade of Transforming Africa’s Infrastructure* (Johannesburg, South Africa, June 2023).

²⁹ United Nations Educational, Scientific and Cultural Organization, “UNESCO forum on higher education in Africa: a driver for sustainable development”, concept note prepared for the forum held on 10 and 11 December 2024. Available at www.unesco.org/en/higher-education/2024-africa-forum.

³⁰ World Economic Forum, “Catalysing education 4.0: investing in the future of learning for a human-centric recovery”, May 2022.

35. Regional centres of excellence are addressing critical technical skills gaps beyond borders. In Ghana, the nuclear certification laboratory trains professionals from across West Africa, while the Institute for Water and Energy Sciences of the Pan-African University provides specialized graduate education.³¹ Technical institutions are working with industry partners to align curricula with emerging workforce needs, ensuring that graduates possess relevant skills for the evolving energy landscape.

B. Investing in research and development

36. Frontier technologies demand significant investment in research and development to invent new and significantly improved products and processes to remain competitive. Expenditure on research and development in Africa was estimated to be \$36.1 billion (in purchasing power parity) in 2023, representing about 1.3 per cent of the global \$2.75 trillion.³² Most research and development in Africa is conducted by the public sector rather than by industry as is the case in advanced countries.

37. First, Africa needs to grow its research and development base by increasing funding, creating centres of excellence in frontier technologies development and adaptation, and improving the policy environment for commercializing, seeding and attracting technology start-ups. For instance, Governments can encourage appropriate research and development and deployment of small modular reactors, which represent a new generation of nuclear technology and are particularly well suited to African energy needs. With capacities under 300 MWe per unit, these compact facilities can serve decentralized or off-grid applications and are cheaper than conventional nuclear plants.³³ Their modular design enables incremental capacity expansion.

38. Second, Africa needs to build strategic research and development alliances with willing advanced countries given the widening base of global research and development.³⁴ The research programme developed as a partnership between the Kenya Medical Research Institute, the Wellcome Trust and the University of Oxford in 1989 is an example. The programme has grown from 12 staff members to over 800 researchers and support staff, and has built state-of-the-art laboratories, clinical trials and training facilities. In 2024, the programme attracted 26.2 million pounds in grant income, published 246 peer-reviewed articles and hosted 175 trainees and 73 graduates.³⁵ Such a long-term alliance helps to expand national and regional research and development capacity in biotechnology.

C. Infrastructure development for frontier technologies

39. Accelerating uptake will require investment in domestic and regional infrastructure, such as: data centres, high-performance computing, cloud computing and fifth-generation mobile network deployments, which are needed to drive the adoption of digital technologies; science, technology and industrial parks for commercializing technologies; and charging stations for the large-scale adoption of electric vehicles. However, much of this infrastructure depends heavily on traditional infrastructure, such as transport, energy and

³¹ Tracey Honney, “US and Ghana launch nuclear training hub”, Nuclear Engineering International, 7 August 2024.

³² Davide Bonaglia, Lorena Rivera León and Sacha Wunsch-Vincent, “End of year edition: against all odds, global R&D has grown close to USD 3 trillion in 2023”, World Intellectual Property Organization, 18 December 2024.

³³ Joanne Liou, “What are small modular reactors (SMRs)?”, International Atomic Energy Agency, 13 September 2023.

³⁴ Melissa Flagg, “Global R&D and a new era of alliances”, Center for Security and Emerging Technology, June 2020.

³⁵ See <https://kemri-wellcome.org/>.

communication infrastructure. For instance, efficient postal services are critical to facilitate electronic commerce.³⁶

40. Governments should play an important role in developing national and regional infrastructure. In addition, public-private partnerships could drive investment in the infrastructure required to scale up the adoption of frontier technology. For example, the Hyphen hydrogen project, with a total project capital investment of over \$10 billion, is funded by two private investors and the Government of Namibia. By 2027, the project is expected to generate 1 million metric tons of green ammonia for export annually and to create 15,000 jobs.³⁷ The high investment cost covers, among other things, the construction of a solar farm to power the plant, pipelines to transport hydrogen and the modernization of port facilities. Such partnerships will be needed to meet the high cost of infrastructure development.

D. Creating markets for frontier technologies

41. Governments play an essential role in driving private sector development and creating a competitive market for frontier technologies. For instance, in a bid to add 1 GW of solar electricity to the national grid by the end of 2025, Zambia reduced the approval time for solar energy projects from six months to 48 hours, eliminated import duties, passed directives to establish feed-in tariffs (a guaranteed payment at a fixed, pre-agreed price for producers of renewable electricity), launched the net metering programme to allow homes and businesses with rooftop photovoltaic systems to receive credit for any excess energy sent back to the grid, and established standards for solar products, among other measures. This has attracted 29 developers to sign power purchase agreements with the national utility company.³⁸ In addition, several banks have launched financial products for individuals and institutions, and the number of training programmes for technicians, as well as the number of wholesalers and retailers, has grown, giving rise to a competitive solar market.

42. Similarly, Ethiopia reduced duties on imported electric vehicles and banned the import of fuel-powered cars for personal use, driving the uptake of electric vehicles, which has led to a rise in the number of service providers to meet the market demand. The continent's electric vehicle market is experiencing remarkable growth, with a current market size of \$17.4 billion in 2025, projected to reach \$28.3 billion by 2030.³⁹

E. Timing of adoption of frontier technologies

43. There is no perfect time to adopt any technology. However, the cost of adopting frontier technology escalates as the technology matures. For instance, the average cost of training a frontier artificial intelligence model has doubled every year since 2016 and is expected to average \$1 billion by 2027.⁴⁰ Similarly, the costs of developing a state-of-the-art hyperscale data centre may reach \$1 billion or more by 2030, especially considering the expanding use of artificial intelligence. Therefore, countries seeking to enter these markets late may be priced out, face increased competition and will lack the experience that the early adopters have gained.

³⁶ Universal Postal Union, *Development of Physical Postal Services to Better Reflect E-Commerce Customer Needs in Both the "Below 2 kg" and "Above 2 kg"* (Berne, Switzerland, 2023).

³⁷ See <https://hyphenafrika.com>.

³⁸ ZESCO Limited, "ZESCO signs PPAs for 332MWp solar projects under micro-generator scheme, presidential solar initiative, and developer-initiated IPPs", press release, 18 February 2025.

³⁹ Thabo Nkosi, "The growth of EV sales in Africa: latest figures", EV24.africa, 6 May 2025.

⁴⁰ Nestor Maslej and others, *Artificial Intelligence Index Report 2024* (2024).

44. However, the cost to the user and risks of failure fall as technologies mature. For instance, the cost for sequencing a human genome has fallen from about \$100 million in 2001 to about \$500–\$600 in 2023.⁴¹ That of clean energy has dropped significantly over the past decade: by 90 per cent for solar photovoltaic systems and batteries and by 70 per cent for onshore wind technology,⁴² driven by advances in technologies and industrial production. Therefore, there are advantages and disadvantages to being an early adopter or latecomer, depending on whether countries want to be engaged in production and export or the use of largely imported frontier technologies.

VII. Conclusion

45. Africa stands at a decisive crossroads. The convergence and mutually reinforcing nature of frontier technologies and regional integration offers an unprecedented opportunity to reshape the continent's development trajectory in a manner that is faster, smarter and more inclusive. However, this window will not remain open forever. The continent must move from fragmented pilots to coordinated efforts to scale up; from vision statements to actionable measures to invest in skills, infrastructure and institutions. Seizing the moment means building the environments in which innovation thrives, markets connect and integration accelerates. If Africa chooses to be proactive and bold, some of today's constraints, such as limited legacy infrastructure, energy deficits or informal economies, could be reframed as opportunities to adopt innovative solutions and build differently from more advanced economies, delivering on the promises of the 2030 Agenda and Agenda 2063 through home-grown, technology-powered transformation.

46. Drawing from the issues raised in the present paper, the following questions are proposed for consideration by the Committee:

- (a) Improving readiness to adopt frontier technologies:
 - (i) What priority actions are needed to strengthen the foundational enablers of frontier technology adoption, in particular the quantity, quality and affordability of information and communications technology infrastructure and digital connectivity?
 - (ii) How can countries accelerate the development of talent, institutions and systems to absorb, adapt and scale up frontier technologies?
- (b) Leveraging frontier technologies in African business:
 - (i) What policy, regulatory and system support is needed to scale up businesses involved in frontier technologies across Africa and strengthen their competitiveness in regional and global markets?
 - (ii) How can countries expand access to innovation finance, technical support and market entry opportunities for start-ups, businesses led by women and young people and small and medium-sized enterprises in high technology and digitally enabled sectors?

⁴¹ World Intellectual Property Organization, "Measuring genome sequencing costs and its health impact", 19 March 2025.

⁴² Hannah Ritchie, "Solar panel prices have fallen by around 20% every time global capacity doubled", Our World in Data, 12 June 2024.

(c) Achieving the Sustainable Development Goals through the adoption of frontier technologies:

(i) What specific policy instruments can be used to scale up the deployment of frontier technologies in priority areas of the Goals, such as energy, health, agriculture and education?

(ii) What delivery models can Governments or partners use to ensure that frontier technologies do not only benefit urban elites or large firms but also reach underserved groups, such as rural communities, women and young people?

(d) Harnessing mutual reinforcement between frontier technology and regional integration:

(i) In which critical areas of implementation of the Agreement Establishing the African Continental Free Trade Area can frontier technologies help to overcome persistent bottlenecks or accelerate progress?

(ii) In what ways can frontier technologies be leveraged to accelerate the operationalization and proper functioning of the African Continental Free Trade Area and to facilitate the transition to even deeper forms of economic integration in Africa?

(iii) How can existing regional cooperation frameworks be better leveraged to harmonize standards, scale up digital infrastructure and regulate emerging technologies?

(e) Timing of frontier technology adoption and acceleration of uptake:

(i) What differentiated policy and investment strategies are needed for countries at varying levels of readiness and absorptive capacity?

(ii) What bold public-private strategies can unlock the infrastructure, talent and market systems needed to accelerate frontier technology uptake across the continent?
