هيئة تنمية البحث والتطوير والابتكار
Research Development and Innovation Authority

رؤية VISION 2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

Emerging Technologies Report

2023

An annual report issued by the Research, Development and Innovation Authority

Emerging Technologies Report

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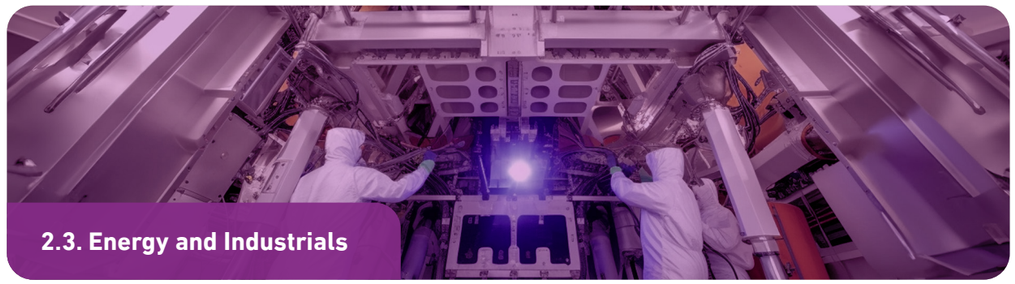

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Foreword

Dr. Mohammed Alotaibi

President of the Research, Development and Innovation Development Authority

Technology foresight is one of the important areas of effective strategic planning that enables to deal with a world in which competition between nations increases. Based on the role of the Research, Development and Innovation Development Authority (RDIA) in preparing national plans for the research, development and innovation (RDI) sector, developing the necessary strategies for their implementation, and conducting relevant studies and research, the Authority's National Observatory for Research, Development and Innovation (NORDI), presents the "Emerging Technologies Report (2023)".

NORDI presents this report, which includes the results of monitoring, surveying, analyzing and evaluating the most important technical signals during the year 1444 AH/1445 AH (2023 AD). The observatory's study and evaluation activities included the most important technology breakthroughs within the national priorities for research, development and innovation, which are: Health and Wellness, Sustainable Environment, Energy and Industrials, and Economies of the Future.

This report provides a monitoring of several recent technological breakthroughs based on signals and events that occurred recently in RDI sector. Each of these technological signals was selected according to an established scientific methodology that explores the latest scientific achievements, innovations and technical developments that may lead to future changes. Thus, the report provides the necessary insights to plan for the future and seize the initiative to seize promising opportunities and invest in these technologies, or prepare for them and ward off potential risks.

To include the views of all actors in the RDI ecosystem, it takes into account individual and collective opinions, and ensure that technical foresight is a participatory process. In its future reports on technical foresight, the NORDI plans to expand the scope of participation in preparing these reports, to include experts from all universities, research institutes and innovation centers in the Kingdom of Saudi Arabia.

RDIA looks forward to the content of the report meeting the expectations of decision-makers, and to contribute to policy-making and appropriate strategic decision-making with regard to RDI priorities in the Kingdom. We hope that this report will be a step on a path full of ambitions and achievements for the good of our beloved Kingdom and all of humanity.

In conclusion, in my name and in the name of all my colleagues, I extend my sincere thanks and gratitude to the Custodian of the Two Holy Mosques and His Highness the Crown Prince, Prime Minister and Chairman of the Supreme Committee for Research, Development and Innovation for the generous support and continued empowerment of the research, development and innovation system, wishing everyone success in serving this great nation.

Emerging Technologies Report 2023

1

Introduction

1.1. Technology Foresight

Technology foresight is a strategic process that involves anticipating and understanding future technological developments and their potential impacts on society, businesses, and the economy. This proactive approach aims to guide decision-making, policy formulation, and strategic planning by identifying emerging technologies and trends early on. By leveraging a combination of expert insights, trend analysis, scenario planning, and stakeholder engagement, technology foresight helps organizations and governments navigate uncertainty and capitalize on future opportunities.

The process of technology foresight typically begins with horizon scanning, which involves systematically exploring new technologies, scientific discoveries, and innovation trends across various domains. This is followed by trend analysis, where experts identify and analyze patterns, drivers, and barriers to technological advancement. Scenario planning then constructs plausible future scenarios based on different combinations of trends and uncertainties, helping stakeholders understand potential outcomes and prepare for various possibilities.

One of the key benefits of technology foresight is its ability to foster innovation and competitiveness. By identifying promising technologies and anticipating market needs, organizations can allocate resources more effectively, prioritize research and development efforts, and develop new products and services ahead of competitors. This proactive stance not only enhances competitiveness but also mitigates risks associated with disruptive technological changes.

In addition, technology foresight supports informed policy-making. Governments and regulatory bodies can use foresight insights to design policies that promote sustainable development, address societal challenges, and ensure ethical considerations in technology adoption. For instance, foresight activities can highlight the potential societal impacts of artificial intelligence, enabling the development of regulations that balance innovation with ethical considerations and public welfare.

Furthermore, technology foresight plays a crucial role in addressing global challenges such as climate change, healthcare, and energy security. By identifying and prioritizing emerging technologies that can contribute to sustainable solutions, foresight efforts can guide investments and collaborative efforts towards achieving long-term goals.

Technology foresight is an essential tool for strategic planning and decision-making in an increasingly complex and dynamic technological landscape. It empowers organizations and governments to anticipate change, innovate responsibly, and shape a better future.

1.2. Methodology

This section explains the methodology for monitoring technologies and outlines the process for evaluating and approving signals. The NORDI team members monitor technological signals from multiple perspectives to ensure neutrality. They present an initial list of signals to experts for their scientific evaluation before submitting them to the scientific committee for scrutiny and approval.

Monitoring Vessels and Channels

Given the wide range of technological signals, their diverse sources, and the multiple forms of their influence, a comprehensive methodology has been developed to capture as many relevant signals as possible. The monitoring team searches for signals across various channels, including scientific discoveries, technology trends, business trends, startups, government websites, economic and news websites. Fig. 1 shows examples of databases used to monitor tech signals.

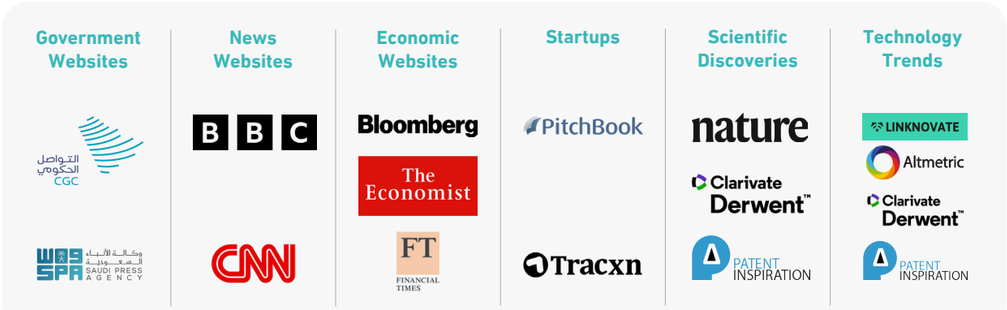


Fig.1.
Examples of monitoring vessels and channels used to monitor technical signals.

Monitoring Perspectives
Tech signals are monitored through four perspectives shown in Fig.2:

1. From top to down
2. From bottom to up
3. From inside the Kingdom to outside
4. From outside the Kingdom to inside

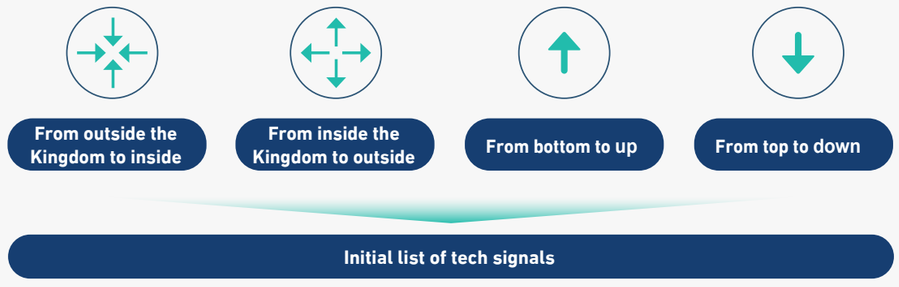


Fig.2.
Monitoring Perspectives of tech signals.

Evaluation and Approval of Tech Signals
After coming up with an initial list of tech signals through monitoring from the four perspectives, the signals are evaluated by three teams: the technical team, the economic team and the expert team, as in shown in Fig.3. The significance of the tech signals is evaluated according to six criteria:

1. The level of strategic impact (and the role of a technology in solving global challenges)
2. Degree of the need within the sector
3. The extent to which consumers are oriented towards a technology (market-pull)
4. The size of the economic impact and commercial benefit
5. Extent of technology readiness level
6. Degree of long-term impact

Fig.3.
Evaluation and approval of tech signals.

1.3. Synopsis of the Report

Based on the methodology stated above, this report includes an analysis of 30 tech signals resulting from a survey of more than 2800 technical signals covering national priorities for research, development and innovation based on the recommendation of the Scientific Committee of the NORDI. The full version of the report also provides detailed economic analysis of the selected technologies in terms of both the global markets and the Saudi market.

Dozens of experts in various scientific disciplines participated in preparing this report. The monitoring, scouting, examination and analysis of the tech signals was carried out by specialists from the technical team from the NORDI. The signals were also evaluated by members of the scientific committee from the employees of the King Abdulaziz City for Science and Technology (KACST). Fig.4. shows the stages of working on issuing this report.

Fig.4.
Stages of working on issuing this report.

Fig.5. shows the ranking of the selected tech signals according to relevance. The subsequent pages demonstrate an executive summary of the Emerging Technologies Report (2023).

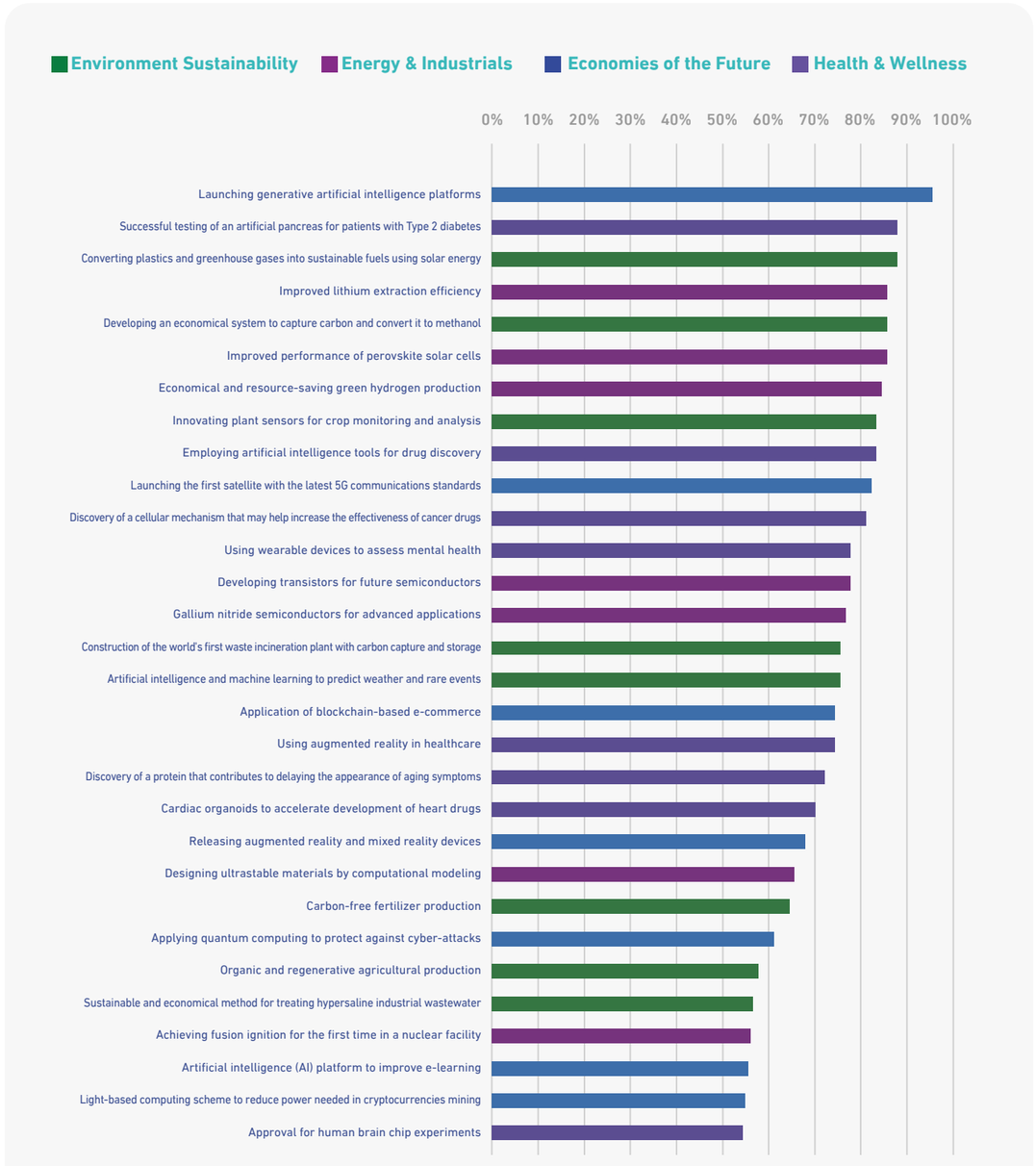


Fig.5.
Ranking of the selected tech signals according to relevance.

2

Tech Signals

erging Technologies Report 2023

2.1

Health and Wellness

2.1. Health and Wellness

Field

Diabetes Treatment

Diabetes is a global health issue affecting millions worldwide, with both Type 1 and Type 2 diabetes on the rise. The prevalence of diabetes varies across regions, influenced by genetic, lifestyle, and socioeconomic factors. Developing countries face rapidly increasing rates due to urbanization, sedentary lifestyles, and dietary changes. Access to healthcare, medication, and education about diabetes management remains uneven, leading to disparities in outcomes. International organizations, governments, and healthcare providers are working to improve prevention, diagnosis, and treatment. Public health initiatives focus on raising awareness, promoting healthy lifestyles, and enhancing access to care, aiming to curb the growing diabetes epidemic.

Type 2 diabetes results in elevated blood sugar levels, known as glucose. Typically, insulin regulates these levels, but in type 2 diabetes, insulin production is impaired. This condition can lead to severe complications over time, such as damage to the eyes, kidneys, nerves, and heart disease.

Tech Signal

01. Successful testing of an artificial pancreas for patients with Type 2 diabetes

Cambridge scientists have successfully trialed an artificial pancreas for Type 2 diabetes patients, showing it can significantly improve glucose control. Developed by the University of Cambridge, the device uses a glucose monitor, insulin pump, and a predictive app called CamAPS HX. In trials, the artificial pancreas doubled the time patients' glucose levels stayed within the target range and halved the time spent in high glucose levels compared to standard treatments.[1]

The research involved 26 patients who alternated between the artificial pancreas and standard insulin therapy. Results showed patients using the artificial pancreas spent 66% of their time in the target glucose range, compared to 32% with standard therapy. Time spent with high glucose levels was reduced from 67% to 33%, and average glucose levels dropped from 12.6mmol/L to 9.2mmol/L. Additionally, HbA1c levels, an indicator of long-term glucose control, decreased from 8.7% to 7.3%. The device proved safe, with no incidents of severe hypoglycemia.

The introduced device exhibit simplicity and effectiveness, noting its potential to address challenges in managing blood sugar levels and concerns over severe hypoglycemia. The findings were published in Nature Medicine. [2]

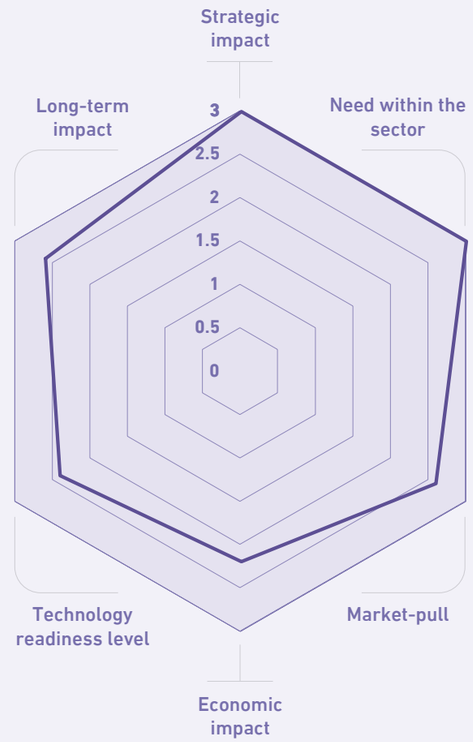
1 https://www.cam.ac.uk/research/news/artificial-pancreas-successfully-trialled-for-use-by-type-2-diabetes-patients

2 https://www.nature.com/articles/s41591-022-02144-z

3 www.precedenceresearch.com

Multi-factor evaluation of tech signal

Successful testing of an artificial pancreas for patients with type 2 diabetes



The global market size for type 2 diabetes treatments is estimated at

61.60$ billion by 2030

The compound annual growth rate (CAGR) during (2023 - 2032) is estimated at

8.2 % [3]

2.1. Health and Wellness

Field
Drug Development

Employing artificial intelligence (AI) tools in drug development is revolutionizing the pharmaceutical industry by enhancing efficiency, accuracy, and innovation. AI algorithms analyze vast datasets, identifying potential drug candidates and predicting their interactions with biological targets faster than traditional methods. This accelerates the initial stages of drug discovery, significantly reducing time and costs. AI can model complex biological systems, uncovering insights that guide the design of more effective and safer drugs.

Machine learning techniques optimize clinical trial designs, predict patient responses, and identify biomarkers, improving the success rates of new therapies. AI-driven platforms also facilitate personalized medicine by tailoring treatments to individual genetic profiles, enhancing patient outcomes. As AI continues to evolve, it integrates with other advanced technologies like quantum computing and CRISPR, further pushing the boundaries of drug development. By harnessing AI, the pharmaceutical industry aims to bring innovative treatments to market more swiftly, addressing unmet medical needs and improving global health.

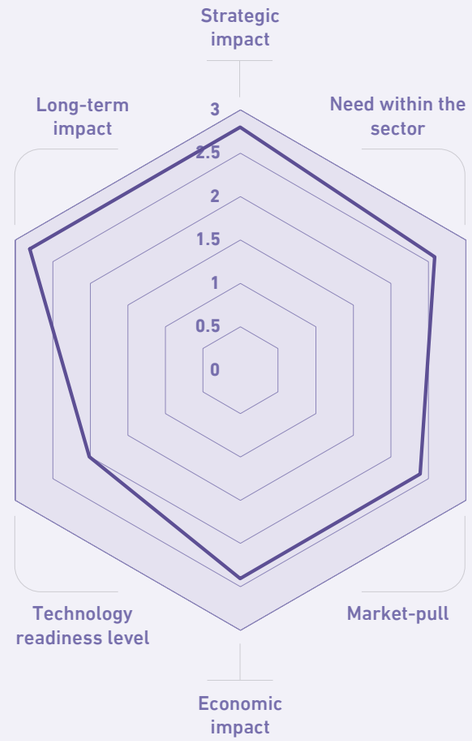
Tech Signal

02. Employing artificial intelligence tools for drug discovery

With platforms like DALL-E 2 and Midjourney popularizing diffusion generative models for creating surreal images, Massachusetts Institute of Technology (MIT)'s Jameel Clinic researchers see potential beyond art. They propose using these models, specifically a new molecular docking model called DiffDock, to accelerate drug development and minimize side effects. DiffDock, presented at the 11th International Conference on Learning Representations, offers a novel approach to computational drug design, moving away from traditional sampling and scoring methods.

DiffDock predicts multiple binding poses between drugs and proteins, enhancing accuracy in identifying binding sites, even with computationally generated protein structures. This capability, combined with AlphaFold's protein folding AI, can streamline drug target identification and reverse screening. Early tests show DiffDock's predictions within 2 angstroms are significantly more accurate than current models, which could revolutionize drug discovery. This new approach addresses Eroom's law, where drug development costs increase over time, by leveraging Moore's law of advancing computational power. 1

Multi-factor evaluation of tech signal
Employing artificial intelligence tools for drug discovery



The global market size for AI systems for drug discovery is estimated at

8.08$ billion by 2031

The compound annual growth rate (CAGR) during (2024 - 2031) is estimated at

21.5% 2

1 https://news.mit.edu/2023/speeding-drug-discovery-with-diffusion-generative-models-diffdock-0331

2 www.precedenceresearch.com

2.1. Health and Wellness

Field
Cancer Treatment

Cellular mechanisms play a key role in making cancer drugs more effective. One way they help is by increasing the amount of drug that stays inside the cancer cells. Normally, cancer cells have pumps that push drugs out, but by blocking these pumps, we can keep the drugs inside the cells longer, making them work better.

Another way is by targeting specific pathways that cancer cells use to grow and survive. For example, blocking certain signals that tell cancer cells to keep growing can make the cells more likely to die when treated with drugs.

Additionally, changing the environment around the tumor can help. For instance, altering factors like low oxygen levels and acidity in tumors can improve how well drugs are delivered and reduce resistance to treatment. Understanding these mechanisms can greatly enhance the effectiveness of cancer therapies.

Tech Signal

03. Discovery of a cellular mechanism that may help increase the effectiveness of cancer drugs

Researchers at Washington University School of Medicine have discovered a new signaling pathway that helps cells protect their DNA during replication, which could enhance cancer treatment effectiveness. 1

The team's study published in Molecular Cell identifies this pathway as crucial for cell survival during replication stress, often caused by radiation, toxic molecules, and cancer-causing genes. The pathway includes a series of molecular events that prevent excessive DNA damage when the DNA-duplicating machinery stalls. 2

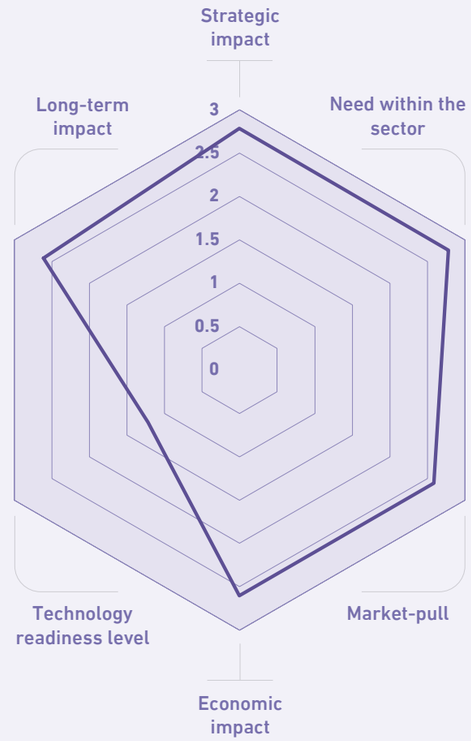
The key player is Exo1, a protein that normally fixes replication errors but can cause damage when replication stalls. A cascade of signals, starting with DNA fragments acting as alarms, eventually halts Exo1's activity, preventing further damage. Understanding this pathway, which involves eight proteins, opens potential for new cancer treatments by combining inhibitors of this pathway with existing chemotherapy drugs. These findings also have implications for autoimmune diseases, given the pathway's links to immunity and metabolism. 3

This newly identified pathway appears to be a key player in that cellular defense system. By disrupting this pathway, scientists hope to make cancer cells more susceptible to DNA-targeting drugs, ultimately leading to more potent cancer treatment.

1 https://medicine.wustl.edu/news/power-of-cancer-drugs-may-see-boost-by-targeting-newly-idd-pathway/
2 https://doi.org/10.1016/j.molcel.2022.12.034
3 https://scitechdaily.com/newly-identified-pathway-could-boost-the-power-of-cancer-drugs/
4 www.precedenceresearch.com

Multi-factor evaluation of tech signal

Discovery of a cellular mechanism that may help increase the effectiveness of cancer drugs



The global market size for cancer/oncology drugs is estimated at

289.2$ billion by 2030

The compound annual growth rate (CAGR) during (2023 - 2030) is estimated at

8.4% 4

2.1. Health and Wellness

Field
Mental Health

Mental health disorders are widespread, comprising 13% of the global disease burden, with one-quarter of the population experiencing psychological illness at some point. However, resources for evaluation are limited, according to researchers.

Geographic and socioeconomic disparities restrict access, and the necessity for in-person assessments or validated mental health surveys further exacerbates this issue. Understanding who is at psychological risk and tracking the effects of psychological interventions need improvement. Digital technology offers an opportunity to enhance access to mental health services for everyone.

Tech Signal

04. Using wearable devices to assess mental health

Researchers at the Icahn School of Medicine at Mount Sinai in New York found that applying machine learning models, a type of artificial intelligence (AI), to data passively collected from wearable devices can assess a patient's resilience and well-being. 1

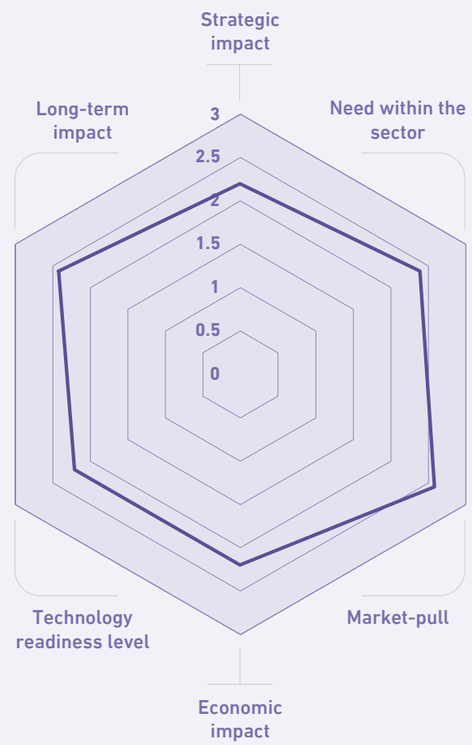
Their findings, published in the May 2nd issue of JAMIA Open, support using wearable devices like the Apple Watch® to monitor psychological states remotely without needing mental health questionnaires.

The study highlights that resilience, the ability to overcome adversity, is crucial for reducing stress, morbidity, and improving chronic disease management. The study explored the feasibility of assessing resilience through data from wearable devices like the Apple Watch. The findings indicated that wearable data could predict resilience and psychological well-being. Despite not being initially designed for this purpose, the study supports further investigation into using wearable data for psychological assessments. The degree of psychological resilience and other features of mental health were determined through measurements of physiological signals issued by smart watches. This data from study participants was used to derive and build machine learning models to predict the psychological state of individuals. It emphasized The potential to expand psychological care access and improve the algorithm's accuracy across diverse patient populations. Future research aims to use wearable data to study various physical and psychological disorders, leveraging AI for data analysis. 2

1 https://www.mountsinai.org/about/newsroom/2023/could-wearables-capture-well-being
2 https://academic.oup.com/jamiaopen/article/6/2/ooad029/7147662?login=true
3 www.grandviewresearch.com

Multi-factor evaluation of tech signal

Using wearable devices to assess mental health



The global market size for mental health applications is estimated at

16.9$ billion by 2030

The compound annual growth rate (CAGR) during (2023 - 2030) is estimated at

15.9% 3

2.1. Health and Wellness

Field
Digital Health

Augmented Reality (AR) is transforming healthcare by enhancing medical training, improving patient outcomes, and optimizing treatment processes. AR overlays digital information onto the real world, providing immersive experiences that facilitate complex medical procedures and education. Surgeons can use AR to visualize intricate anatomical structures in real-time during operations, improving precision and reducing risks. In medical training, AR simulations allow students and professionals to practice procedures in a controlled, risk-free environment, leading to better preparedness and skill development. AR also aids in patient care; for instance, it can help in explaining diagnoses and treatment plans, making medical information more accessible and understandable.

Additionally, AR applications assist in physical rehabilitation by creating interactive exercises that engage patients, promoting faster recovery. The integration of AR in telemedicine allows remote specialists to guide on-site practitioners through complex procedures, enhancing collaborative care. As AR technology advances, its potential to revolutionize healthcare continues to grow, promising more efficient, effective, and personalized medical solutions.

Tech Signal

05. Using augmented reality (AR) in healthcare

Founded in 2016 by physicians and engineers in New York City, Medivis is dedicated to advancing surgical care through the latest breakthroughs in augmented reality and artificial intelligence.

In June 2023, Medivis announced a $20 million 'Series A' funding round led by Thrive Capital, with participation from Initialized Capital, Mayo Clinic, and other notable investors. The funding will be used to scale engineering efforts, secure regulatory approvals, and commercialize their technology globally across various specialties such as neurosurgery, orthopedic surgery, interventional radiology, and reconstructive surgery.

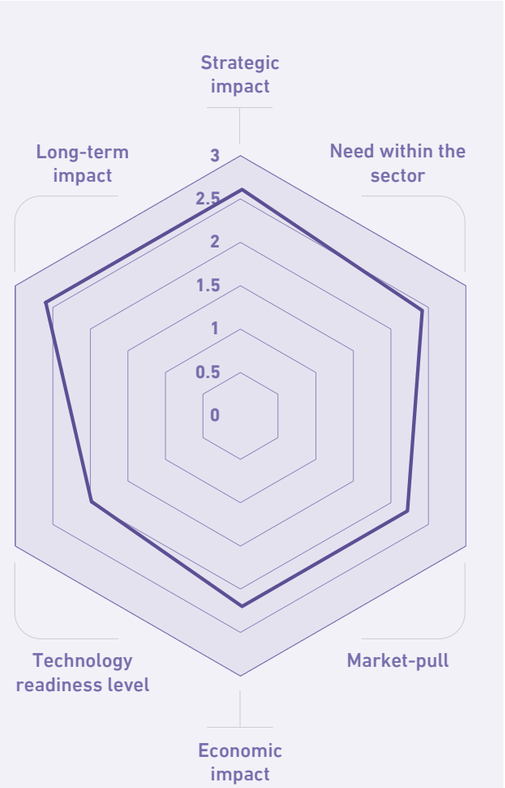
Medivis aims to introduce a new visual era in medicine through AR, providing clinicians with unprecedented visual guidance during procedures for safer patient care. It emphasizes the transformative potential of spatial computing in healthcare, improving both routine and complex medical interventions.

The company's technology employs augmented reality to see complex anatomical organs during operations and gives a more accurate understanding of the nature of the anatomy that doctors deal with, as augmented reality is expected to play a pivotal role in helping medical teams complete their routine as well as complex work. 1

1 https://www.medivis.com/press-release/medivis-raises-20m-series-a-to-advance-surgery-with-augmented-reality

2 www.researchandmarkets.com

Multi-factor evaluation of tech signal
Using augmented reality in healthcare



The global market size for augmented reality systems in healthcare is estimated at

9.14$ billion by 2028

The compound annual growth rate (CAGR) during (2023 - 2028) is estimated at

24.2% 2

2.1. Health and Wellness

Field
Anti-aging

Anti-aging research increasingly focuses on the role of proteins in cellular health and longevity. Proteins are crucial for maintaining various cellular functions, including DNA repair, metabolic processes, and cell signaling. As we age, the efficiency of these proteins often declines, leading to cellular damage and the onset of age-related diseases. Key proteins, such as those involved in mitochondrial function, play a vital role in energy production and cellular repair mechanisms.

Research has identified specific proteins, like CPEB4, that help sustain mitochondrial health by enhancing the biosynthesis of mitochondrial proteins. These proteins are crucial for preventing cellular senescence, where cells lose the ability to divide and contribute to tissue aging. By understanding and manipulating these proteins, scientists aim to develop therapeutic interventions to mitigate aging effects, improve health-span, and treat age-related conditions. The study of proteins in anti-aging research offers promising avenues for promoting longevity and enhancing overall well-being.

Tech Signal

06. Discovery of a protein that contributes to delaying the appearance of aging symptoms

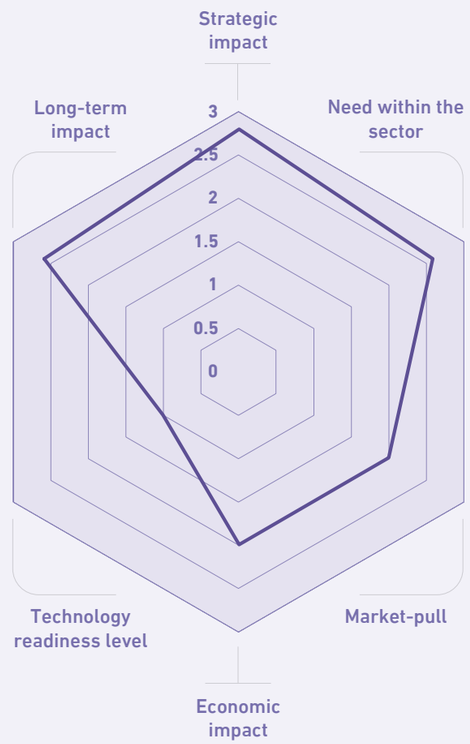
A research team from the Hong Kong University of Science and Technology (HKUST) has made a significant discovery involving the protein CPEB4, which could influence aging reversal strategies using adult skeletal muscle stem cells (MuSCs). Their study found that CPEB4 helps maintain mitochondrial metabolism by boosting the biosynthesis of mitochondrial proteins, thereby sustaining energy production in cells. The role of this protein has also been discovered in improving the functions of these cells and preventing the symptoms of aging in several other types of cells.

Aging typically leads to reduced mitochondrial function, contributing to cellular senescence and age-related defects. The team observed that CPEB4 levels decrease in aging tissues, particularly in skeletal muscle. Enhancing CPEB4 expression in aged MuSCs not only increased mitochondrial protein production and energy output but also protected against cellular aging. Transplanting these modified MuSCs into older mice resulted in improved muscle repair.

These findings suggest CPEB4's potential as a therapeutic target for mitochondrial diseases and for reversing cellular aging. 1 The findings were published in Developmental Cell. 2

Multi-factor evaluation of tech signal

Discovery of a protein that contributes to delaying the appearance of aging symptoms



The global market size for anti-aging therapeutics is estimated at

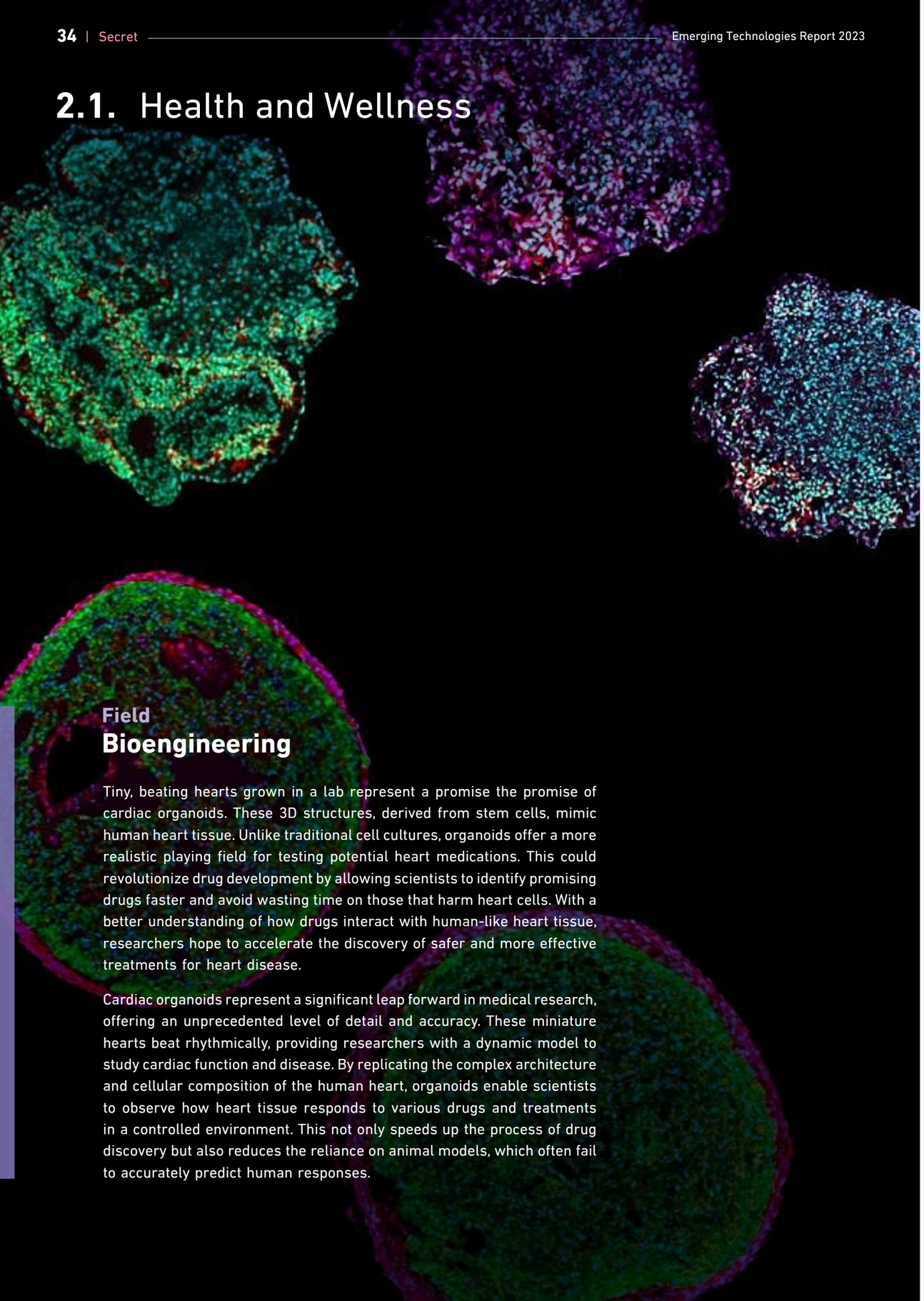
2.47$ billion by 2031

The compound annual growth rate (CAGR) during (2023 - 2031) is estimated at

17.5% 3

1 https://hkust.edu.hk/news/research-and-innovation/hkust-researchers-identify-protein-potential-therapeutic-target-age
2 https://www.cell.com/developmental-cell/fulltext/S1534-5807(23)00244-7
3 www.globenewswire.com

2.1. Health and Wellness



Field
Bioengineering

Tiny, beating hearts grown in a lab represent a promise the promise of cardiac organoids. These 3D structures, derived from stem cells, mimic human heart tissue. Unlike traditional cell cultures, organoids offer a more realistic playing field for testing potential heart medications. This could revolutionize drug development by allowing scientists to identify promising drugs faster and avoid wasting time on those that harm heart cells. With a better understanding of how drugs interact with human-like heart tissue, researchers hope to accelerate the discovery of safer and more effective treatments for heart disease.

Cardiac organoids represent a significant leap forward in medical research, offering an unprecedented level of detail and accuracy. These miniature hearts beat rhythmically, providing researchers with a dynamic model to study cardiac function and disease. By replicating the complex architecture and cellular composition of the human heart, organoids enable scientists to observe how heart tissue responds to various drugs and treatments in a controlled environment. This not only speeds up the process of drug discovery but also reduces the reliance on animal models, which often fail to accurately predict human responses.

Tech Signal

07. Cardiac organoids to accelerate development of heart drugs

Researchers at the Technical University of Munich (TUM) have created a «mini-heart» organoid using stem cells, allowing the study of early heart development and disease research. This advancement could provide insights into the formation of the human heart, which begins around three weeks after conception, a period when pregnancy is often undetected. Traditional animal studies have limited applicability to human heart development, making these organoids valuable. 1

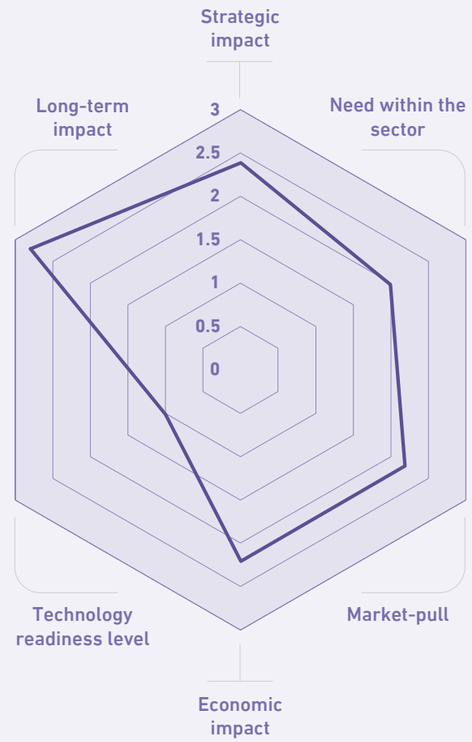
The research team developed this organoid using pluripotent stem cells, forming a sphere of 35,000 cells that mimic human heart signaling pathways. Published in Nature Biotechnology, their organoids include both cardiomyocytes and epicardium cells, essential for forming heart chambers and other cell types. 2

Notably, the team discovered new precursor cells in the epicardium, which may explain the fetal heart's self-repair ability, offering potential new treatments for heart conditions. Personalized organoids, created from patient stem cells, could emulate specific heart conditions like Noonan syndrome, facilitating drug testing and reducing animal experimentation.

TUM has patented the heart organoid creation process, which is part of broader organoid research at their Center for Organoid Systems, aiming to study various organs and diseases through interdisciplinary efforts.

1 https://www.tum.de/en/news-and-events/all-news/press-releases/details/mini-herzen-in-der-kulturschale
2 https://www.nature.com/articles/s41587-023-01718-7
3 https://finance.yahoo.com/

Multi-factor evaluation of tech signal
Cardiac organoids to accelerate development of heart drugs



The global market size for organoids is estimated at

12.80$ billion by 2030

The compound annual growth rate (CAGR) during (2022 - 2030) is estimated at

13.1% 3

2.1. Health and Wellness

Field
Brain-Computer Interfaces

Brain-computer interfaces (BCIs) represent a burgeoning technology with the potential to revolutionize human-computer interaction. BCIs function by establishing a direct communication channel between the brain and external devices. This is achieved through the use of sensors that capture and translate electrical signals generated by neural activity. These translated signals are then used to control external devices, such as computers, robotic limbs, or assistive technologies.

The potential applications of BCIs are vast, particularly within the medical field. BCI technology offers immense promise for individuals with paralysis or other neurological conditions that limit motor function. By enabling direct control of prosthetic limbs or computer interfaces through thought alone, BCIs have the potential to significantly improve quality of life and restore a degree of independence.

While BCI technology is still in its nascent stages, it presents a paradigm shift in how humans interact with the world around them. Future advancements in BCI research hold the potential to not only restore lost abilities but also redefine the boundaries of human-computer interaction.

Tech Signal

08. Approval for human brain chip experiments

Recently, the US Food and Drug Administration (FDA) approved Neuralink to conduct experiments with the developed electronic chip on the human brain. This technology may revolutionize human-computer interaction and open new possibilities in education, communications, healthcare and other sectors.

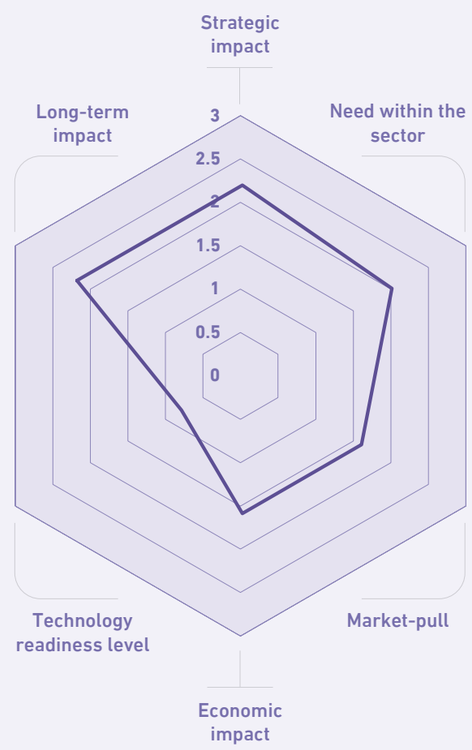
Neuralink aims to develop brain implants to treat conditions like obesity, autism, depression, and schizophrenia. While the FDA approved the use of Neuralink's brain implant and surgical robot for trials, details remain undisclosed, and recruitment for the trial has not yet begun.

Neuralink has faced scrutiny over allegations of rushed and flawed animal testing, resulting in unnecessary animal deaths. These concerns have led to a probe by the USDA's Office of Inspector General. The FDA's approval comes after addressing safety concerns, such as the device's lithium battery, wire migration within the brain, and safe extraction methods. Despite earlier predictions, human trials are only now starting after FDA concerns were addressed, highlighting the ongoing challenges in ensuring the safety and efficacy of Neuralink's technology. 1

1 https://www.reuters.com/science/elon-musks-neuralink-gets-us-fda-approval-human-clinical-study-brain-implants-2023-05-25/

2 www.marketresearchfuture.com

Multi-factor evaluation of tech signal
Approval for human brain chip experiments



The global market size for brain-computer interfaces (BCIs) is estimated at

6.05 $ billion by 2030

The compound annual growth rate (CAGR) during (2023 - 2030) is estimated at

15.5% 2

2.2

Sustainable Environment

2.2. Sustainable Environment

Field
Recycling

In recycling field, innovative advancements in solar energy are enabling the conversion of plastics and greenhouse gases into sustainable fuels, addressing environmental challenges and energy needs simultaneously. Researchers have developed solar-powered catalytic processes that break down plastic waste and capture greenhouse gases like carbon dioxide, converting them into valuable hydrocarbons and hydrogen. These products can be used as clean fuels, reducing reliance on fossil fuels and lowering carbon emissions.

The technology utilizes solar energy to drive chemical reactions, making the process environmentally friendly and sustainable. By converting plastic waste and greenhouse gases into useful fuels, this approach tackles two significant environmental issues: plastic pollution and greenhouse gas accumulation. This dual-benefit technology not only helps mitigate climate change but also contributes to the circular economy by transforming waste into resources. As research progresses, these solar-powered solutions could become pivotal in the transition to sustainable energy and waste management systems, promoting a cleaner and greener future.

Tech Signal

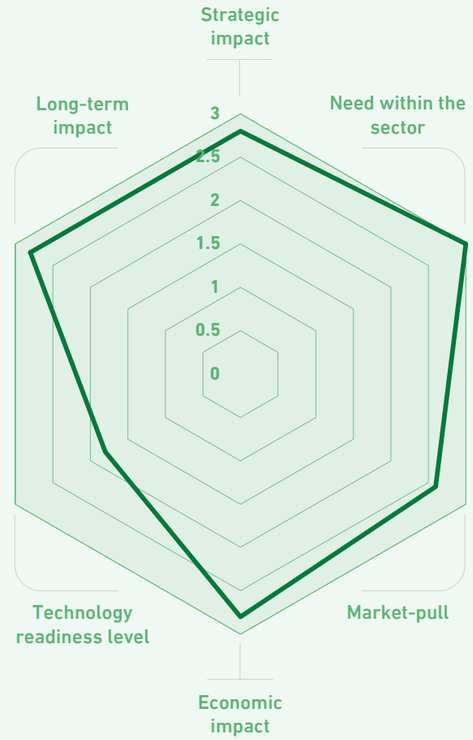
09. Converting plastics and greenhouse gases into sustainable fuels using solar energy

Researchers at the University of Cambridge have developed a solar-powered reactor that simultaneously converts carbon dioxide (CO2) and plastic waste into valuable chemical products. This innovative system, the first of its kind, transforms CO2 into syngas, a key ingredient for sustainable fuels, and plastic bottles into glycolic acid, used in cosmetics. The reactor's versatility allows for different end products by simply changing the catalyst. This breakthrough addresses both plastic pollution and greenhouse gas reduction, crucial for a sustainable circular economy.

The research team designed the reactor with two compartments: one for plastic and one for greenhouse gases. Using perovskite-based light absorbers and specific catalysts, the reactor efficiently converts waste into carbon-based fuels and glycolic acid under normal conditions. The system's high efficiency and tuneability mark a significant advancement over conventional methods. Future developments aim to produce more complex molecules, potentially leading to entirely solar-powered recycling plants. This research is supported by several European and UK funding bodies. 1 The results are reported in Nature Synthesis. 2

Multi-factor evaluation of tech signal

Converting plastics and greenhouse gases into sustainable fuels using solar energy



The global market size for waste recycling and treatment is estimated at

90$ billion by 2028

The compound annual growth rate (CAGR) during (2022 - 2028) is estimated at

4.8% 3

1 https://www.cam.ac.uk/research/news/solar-powered-system-converts-plastic-and-greenhouse-gases-into-sustainable-fuels
2 https://www.nature.com/articles/s44160-022-00196-0
3 www.marketresearchfuture.com

2.2. Sustainable Environment

Field
Carbon Capture

A novel approach to tackling climate change involves capturing carbon dioxide (CO2) and transforming it into methanol, a versatile clean fuel. This technology offers a double environmental benefit: removing greenhouse gas from the atmosphere while creating a sustainable fuel source. The captured CO2, often sourced from industrial emissions or directly from the air, undergoes a chemical reaction with hydrogen. This process, driven by catalysts, converts the CO2 into methanol. The key lies in using «green hydrogen,» produced from renewable sources like solar or wind power. This ensures the overall process is carbon-neutral or even carbon-negative, depending on the CO2 source. The resulting methanol can be used in various applications, including transportation fuels, blending with gasoline, or industrial processes. This technology holds promise for mitigating climate change by not only reducing atmospheric CO2 but also creating a cleaner fuel alternative.

Tech Signal

10. Developing an economical system to capture carbon and convert it to methanol

Scientists at the Department of Energy's Pacific Northwest National Laboratory (PNNL) have developed a cost-effective system to capture CO2 and convert it into methanol, a widely used chemical. This advancement aims to make carbon capture more affordable and widespread, addressing a key challenge in combating global warming. Methanol, used as fuel, solvent, and in various products, provides an incentive for large emitters to adopt this technology.

The new system, described in Advanced Energy Materials, integrates into power plants and industrial facilities, capturing CO2 before emission and converting it using a PNNL-developed solvent. This approach recycles CO2, akin to recycling materials like glass and plastics, reducing reliance on extracting new resources. The team envisions this technology not only cutting emissions but also spurring further development in carbon capture and creating a market for CO2-derived products. This milestone is crucial for broader efforts to prevent carbon emissions from entering the atmosphere.

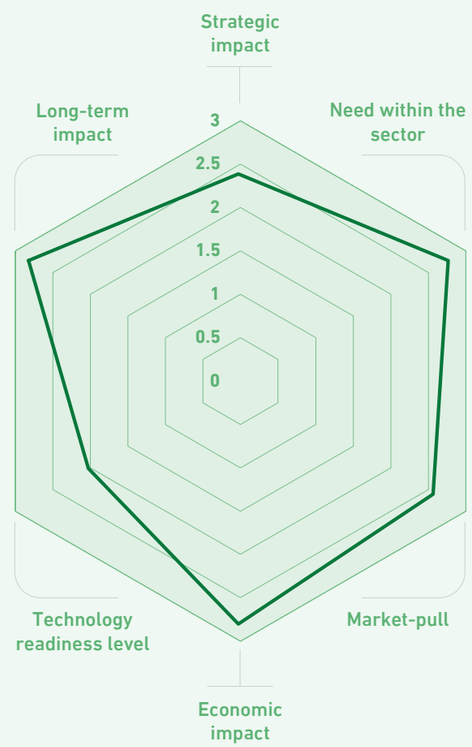
It is claimed that the system reduces the costs associated with carbon capture, with an efficiency of up to 90%. The system is designed to be used to capture carbon from the air or from emissions from coal- or gas-fired power plants or steel or cement plants. The captured carbon is converted into methanol. According to the team's estimates, this technology will reduce the cost of carbon capture to $39 per metric ton of carbon. This cost is approximately 75% lower than the cost using traditional carbon capture methods. 1

1 https://www.pnnl.gov/news-media/scientists-unveil-least-costly-carbon-capture-system-date

2 www.alliedmarketresearch.com

Multi-factor evaluation of tech signal

Developing an economical system to capture carbon and convert it to methanol



The global market size for carbon capture and use is estimated at

7.0$ billion by 2030

The compound annual growth rate (CAGR) during (2022 - 2030) is estimated at

13.8% 2

2.2. Sustainable Environment

Field
Crop Monitoring

In the realm of precision agriculture, plant sensors are emerging as game-changers for crop monitoring. These tiny devices, attached directly to plants or strategically placed within fields, act as the eyes and ears for farmers, offering real-time data on various aspects of plant health and their surrounding environment.

Imagine a sensor continuously monitoring soil moisture, alerting farmers when irrigation is needed to optimize water use and prevent crop stress. Similarly, sensors can track temperature, humidity, and light levels, crucial factors influencing plant growth. Early detection of these imbalances allows for targeted interventions, such as adjusting greenhouse settings or deploying shade covers.

Beyond environmental monitoring, some sensors delve deeper. By measuring electrical signals within the plant itself, they can detect signs of nutrient deficiencies or even identify the presence of disease at an early stage. This allows farmers to take preventive measures, minimizing crop loss and ensuring a healthier harvest.

Tech Signal

11. Innovating plant sensors for crop monitoring and analysis

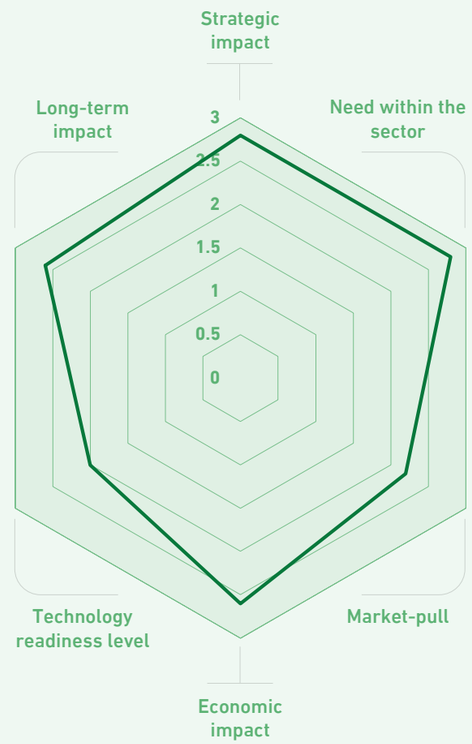
Both Grovera 1 and Phytech 2 have independently developed small needle sensors that are inserted into plant leaves or stems to measure changes in electrical resistance. The data is sent wirelessly to a laptop, where it is analyzed to form a perception of plant health. Farmers can thus monitor crops in real time and make precise interventions based on the specific requirements of plants, such as adjusting irrigation or fertilizer application in response to moisture levels or nutrient data.

The data collected by these sensors is often transmitted wirelessly, enabling farmers to monitor vast fields remotely through user-friendly dashboards or mobile apps. This empowers them to make informed decisions based on real-time insights, ultimately leading to increased crop yields, improved resource management, and a more sustainable agricultural approach.

1 https://growvera.com/
2 https://www.phytech.com/
3 www.verifiedmarketresearch.com

Multi-factor evaluation of tech signal

Innovating plant sensors for crop monitoring and analysis



The global market size for crop monitoring systems is estimated

8.17$ billion by 2030

The compound annual growth rate (CAGR) during (2023 - 2030) is estimated at

14.7% 3

2.2. Sustainable Environment

Field
Weather Forecasting

When it comes to predicting rare disasters, such as severe earthquakes, hurricanes or floods, computational modeling faces a difficult challenge. Statistically speaking, these events are so rare that there is not enough data to use in computer models to accurately predict when they will occur.

AI and machine learning are revolutionizing weather forecasting. Traditional methods rely on complex models, but AI excels at analyzing vast datasets – a perfect fit for weather's intricate multiple factors. By processing mountains of data from satellites, weather stations, and radar, AI can identify subtle patterns that escape human forecasters. This leads to more accurate predictions, especially for short-term weather.

The real power lies in predicting rare events. AI can unearth hidden connections within the data, potentially offering clues for flash floods, heatwaves, or tornadoes. While still under development, AI's ability to learn and adapt continuously holds immense promise for improved early warnings, allowing communities to prepare for these impactful but unpredictable weather phenomena.

Tech Signal

12. Artificial intelligence and machine learning to predict weather and rare events

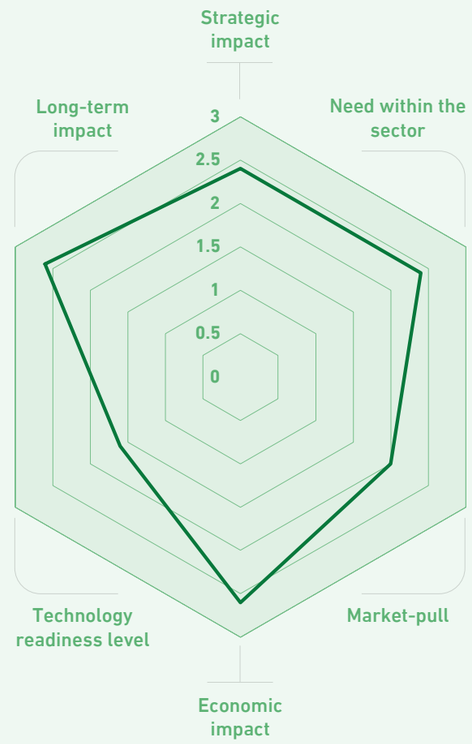
Using the concepts of artificial intelligence and machine learning, a research team from Brown University and the Massachusetts Institute of Technology (MIT) has come up with a framework that combines novel Bayesian experimental design (BED) training schemes with a set of deep neural operators (DNOs) to accurately predict rare events. The team explained that rare events like pandemics, environmental disasters, and earthquakes lack historical data, posing prediction challenges. 1

This study, that was published in Nature Computational Science, details how scientists combined statistical algorithms with a machine learning technique developed at Brown University. This approach, requiring less data, efficiently predicts rare events by focusing on data quality over quantity.

The researchers utilized active learning, a sequential sampling technique that identifies critical data points, to enhance the DeepOnet model—a dual-network deep neural operator. This model analyzes large datasets rapidly, but traditionally requires extensive data to function accurately. The study demonstrated that active learning could train DeepOnet to predict rare events using minimal data by identifying key precursors. The method was tested on predicting pandemic spikes, rogue waves, and ship stress, outperforming traditional models. The researchers believe this framework can improve forecasting accuracy and reduce costs for various rare event predictions. 2

1 https://www.brown.edu/news/2022-12-19/extreme-events
2 https://www.nature.com/articles/s43588-022-00376-0
3 www.globenewswire.com

Multi-factor evaluation of tech signal
Artificial intelligence and machine learning to predict weather and rare events



The global market size for predictive analytics is estimated at

55.5$ billion by 2032

The compound annual growth rate (CAGR) during (2023 - 2032) is estimated at

15.8% 3

2.2. Sustainable Environment

Field
Waste Treatment

Waste treatment involves processes to manage and dispose of waste materials. It includes recycling, composting, incineration, and landfilling to reduce environmental impact. Effective waste treatment minimizes pollution, conserves resources, and protects public health by ensuring safe disposal and potential recovery of valuable materials from waste streams.

Oxyfuel combustion uses pure oxygen instead of air for combustion, offering numerous benefits including easier CO2 capture. It adapts well to various fuel types, enabling efficient burning regardless of the waste's type or volume, which often contains large amounts of CO2. Carbon capture and storage (CCS) involves removing CO2 from emission sources like power plants, transporting it to storage sites, and depositing it underground to prevent atmospheric entry.

Tech Signal

13. Construction of the world's first waste incineration plant with carbon capture and storage

The Norwegian Technical Institute (SINTEF) is working on building the first experimental station in the world that combines the processes of oxygenic combustion of waste with carbon capture and storage through the (NETOX) project, which is expected to be operational during the year 2030. The project resulted from an alliance between the (SINTEF) Institute and the municipality of Ardal with the aim of Reducing carbon emissions resulting from burning waste. What is new in this technology is the combination of two previously known methods, namely oxygen combustion and carbon capture, where waste is burned using pure oxygen gas - instead of using air, which contains mostly nitrogen (about 78%) - which contributes significantly to carbon emissions resulting from burning waste. Reducing emissions, as it produces high-purity carbon dioxide that is easy to capture and store. 1

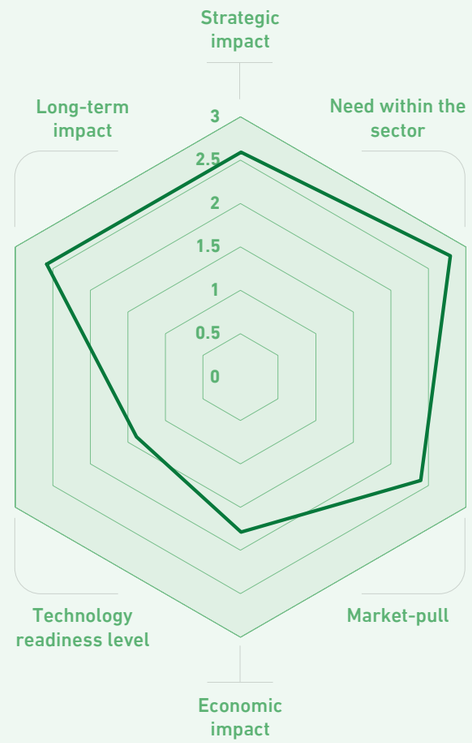
The advantages of oxyfuel combustion are significant. It generates fewer pollutants than conventional methods and simplifies CO2 capture due to the use of pure oxygen. Additionally, as emission costs rise, oxyfuel combustion becomes more profitable than emission reduction, encouraging companies and municipalities to invest in it as a viable emission reduction strategy.

1 https://innovationorigins.com/en/laio/worlds-first-waste-incineration-plant-with-carbon-capture-and-storage/

2 www.alliedmarketresearch.com

Multi-factor evaluation of tech signal

Construction of the world's first waste incineration plant with carbon capture and storage



The global market size for waste incinerator systems is estimated at

22.6$ billion by 2031

The compound annual growth rate (CAGR) during (2023 - 2031) is estimated at

4.2% 2

2.2. Sustainable Environment

Field
Fertilizer Production

Carbon-free fertilizer production aims to create fertilizers without emitting carbon dioxide (CO2) during the manufacturing process. Traditional fertilizer production, particularly the Haber-Bosch process for ammonia synthesis, is energy-intensive and relies heavily on fossil fuels, resulting in significant CO2 emissions. Transitioning to carbon-free methods involves adopting sustainable practices and alternative technologies.

One approach is using renewable energy sources, such as wind, solar, or hydropower, to power the production process. This eliminates the reliance on fossil fuels, thus reducing CO2 emissions. Additionally, green hydrogen, produced through the electrolysis of water using renewable energy, can replace natural gas in the Haber-Bosch process, further cutting carbon emissions.

Biological nitrogen fixation is another promising avenue. Certain bacteria and plants naturally convert atmospheric nitrogen into a form that plants can use, reducing the need for synthetic fertilizers. Genetic engineering and biotechnology can enhance this natural process, offering a sustainable alternative.

Tech Signal
14. Carbon-free fertilizer production

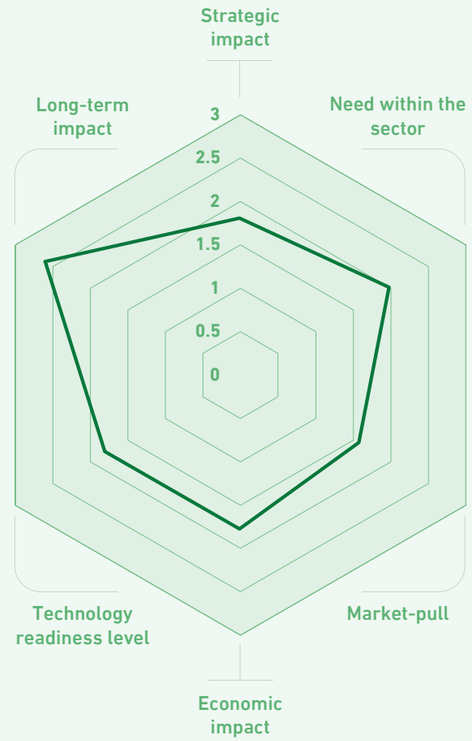
Developing carbon-free fertilizers is crucial for sustainable agriculture, addressing the dual challenges of feeding a growing population and combating climate change. By adopting these technologies, the agricultural sector can significantly reduce its carbon footprint while maintaining high productivity.

Researchers from the Federal Institute of Technology in Zurich (ETH Zurich) published a study on the production of nitrogen fertilizers free of carbon emissions to contribute to the sustainability and protection of the environment from pollution. Researchers have discovered the possibility of producing nitrogen fertilizers using water electrolysis, as it is believed that such a transformation will contribute to achieving food security. The researchers also sought to identify countries that may face risks in food production due to their dependence on nitrogen or natural gas, which may cause an increase in the price of demand for energy sources. 1

Innovations in precision agriculture can optimize fertilizer use, ensuring that plants receive the necessary nutrients without over-application. This reduces the overall demand for fertilizers and minimizes environmental impact. 2

1 https://iopscience.iop.org/article/10.1088/1748-9326/aca815
2 https://ethz.ch/en/news-and-events/eth-news/news/2022/12/producing-fertiliser-without-carbon-emissions.html
3 www.precedenceresearch.com

Multi-factor evaluation of tech signal
Carbon-free fertilizer production



The global market size for nitrogenous fertilizers is estimated at

92 $ billion by 2030

The compound annual growth rate (CAGR) during (2023 - 2030) is estimated at

5.3% 3

2.2. Sustainable Environment

Field
Organic and Regenerative Agriculture

Organic and regenerative agriculture are farming practices that prioritize environmental health, biodiversity, and sustainable food production. Organic agriculture avoids synthetic chemicals, fertilizers, and genetically modified organisms (GMOs), focusing instead on natural inputs and processes. This approach enhances soil fertility through composting, crop rotation, and the use of organic fertilizers, while controlling pests and diseases with natural predators, biological pesticides, and crop diversity.

Regenerative agriculture goes beyond sustainability, aiming to restore and enhance ecosystems. It incorporates organic principles but places a stronger emphasis on improving soil health, increasing biodiversity, and sequestering carbon. Key practices include no-till farming, cover cropping, agroforestry, and holistic planned grazing. These methods help build organic matter in the soil, improve water retention, and create resilient farming systems that can adapt to climate change.

Tech Signal

15. Organic and regenerative agricultural production

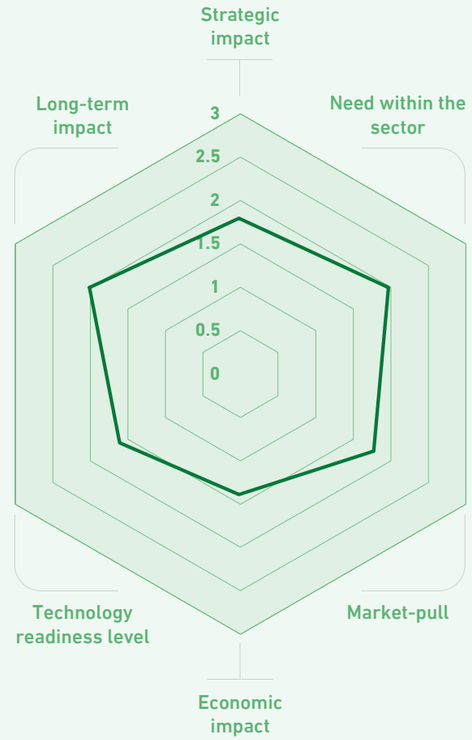
A joint research team from the British University of Lincoln, the Hellenic Mediterranean University, the Australian Southern Cross University, and the Norwegian University of Oslo published a scientific paper on the growing trend of renewable and innovative organic agriculture, instead of traditional organic agriculture, as chemicals manufactured from mineral fertilizers, pesticides, growth regulators, and animal food additives are not used in the regenerative agricultural system. Rather, it depends on agricultural cycles, organic fertilizers (animal, plant, and green), and biological resistance to pests to preserve microorganisms and provide nutrients to the plant. 1

Both organic and regenerative agriculture promote biodiversity by creating habitats for various plant and animal species. They also contribute to climate change mitigation by sequestering carbon in soils and reducing greenhouse gas emissions from farming operations. Moreover, these practices support the well-being of farmers and communities by reducing exposure to harmful chemicals and promoting healthier, more nutrient-rich food.

Adopting organic and regenerative agriculture can lead to more resilient and sustainable food systems, fostering a healthier planet and population while addressing pressing environmental challenges.

1 https://www.mdpi.com/2073-4395/13/5/1344
2 www.globenewswire.com

Multi-factor evaluation of tech signal
Organic and regenerative agricultural production



The global market size for regenerative agriculture is estimated at

21$ billion by 2029

The compound annual growth rate (CAGR) during (2023 - 2029) is estimated at

14.6% 2

2.2. Sustainable Environment

Field
Water Treatment

Hypersaline brines, leftover from desalination plants and other industries, pose a challenge. These super-salty solutions can harm ecosystems if dumped untreated.

Current methods like ocean discharge are being reconsidered due to environmental concerns. Brine management focuses on reducing the volume or extracting valuable resources.

One approach is minimizing liquid discharge (MLD) through techniques like membrane distillation. This separates water from the brine using a special membrane.

The ultimate goal is zero liquid discharge (ZLD), where all water is recovered. This often involves evaporation processes, which can be expensive.

Research is ongoing to develop more cost-effective ZLD techniques and to explore extracting valuable minerals from brines, turning waste into a potential resource.

Tech Signal

16. Sustainable and economical method for treating hypersaline industrial wastewater

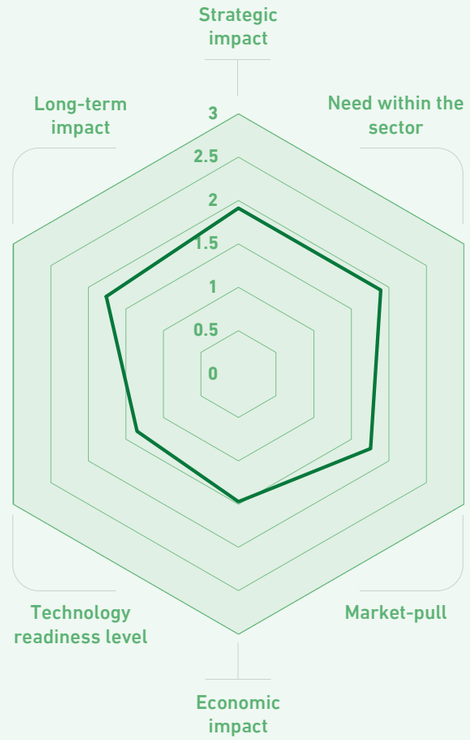
Vanderbilt researchers have developed an advanced method to improve the energy efficiency and cost-effectiveness of desalinating hypersaline industrial wastewater. Current methods like reverse osmosis, though effective for seawater, struggle with industrial brines from sectors such as mining and oil. Existing disposal methods, like deep geological injection and evaporation ponds, face increasing regulatory and environmental challenges. Zero liquid discharge (ZLD) and minimal liquid discharge (MLD) treatments, which aim to eliminate or reduce brine volume, rely on expensive mechanical vapor compression (MVC). 1

The new method, electrodialytic crystallization (EDC), described in Nature Water, offers a promising alternative by using an electric field to induce salt crystallization, avoiding costly evaporation. EDC's efficiency is hindered by electro-osmosis, where ions drag excess water through ion exchange membranes. Improved membrane design and optimized operation can enhance EDC's effectiveness. Preliminary analysis suggests that EDC, combined with reverse osmosis, could consume significantly less energy than MVC, making it a viable solution for industrial brine treatment. The study is supported by the National Alliance of Water Innovation.

1 https://news.vanderbilt.edu/2023/06/21/new-study-in-nature-water-demonstrates-a-vastly-more-sustainable-cost-effective-method-to-desalinate-industrial-wastewater/
2 https://www.nature.com/articles/s44221-023-00095-4
3 https://www.mdpi.com/2077-0375/10/9/221

Multi-factor evaluation of tech signal

Sustainable and economical method for treating hypersaline industrial wastewater



The global market size for predictive analytics is estimated at

458$ million by 2025

The compound annual growth rate (CAGR) during (2021 - 2025) is estimated at

5.6% 3

2.3

Energy and Industrials

2.3. Energy and Industrials

Field
Solar Cells

Perovskite solar cells (PVSCs) have garnered significant attention for their exceptional performance and potential to revolutionize the solar energy industry. One of their key advantages is high power conversion efficiency (PCE), which has rapidly increased from around 3% in the early 2000s to over 25% in recent years. This efficiency is comparable to traditional silicon-based solar cells but with potentially lower production costs.

The performance of PVSCs is attributed to their unique material properties, such as strong light absorption, long charge-carrier diffusion lengths, and tunable bandgaps. These characteristics enable efficient light harvesting and charge transport, crucial for high PCE. Additionally, PVSCs can be fabricated using solution-based processes, making them suitable for flexible and lightweight applications, including building-integrated photovoltaics and wearable devices.

However, challenges remain, particularly regarding the long-term stability and durability of PVSCs under environmental stress. Researchers are actively working on improving the material composition and protective encapsulation techniques to enhance their operational lifespan, paving the way for commercial viability and widespread adoption.

Tech Signal

17. Improved performance of perovskite solar cells

Researchers from City University of Hong Kong (CityU) have developed a novel multifunctional, non-volatile additive to enhance the efficiency and stability of perovskite solar cells (PVSCs) by improving perovskite film growth. This breakthrough facilitates the commercialization of PVSCs by enabling the production of high-quality films suitable for large-area solar panels. Led by Professor Alex Jen Kwan-yue, the team discovered that adding 4-guanidinobenzoic acid hydrochloride (GBAC) to the perovskite precursor forms a hydrogen-bond-bridged intermediate phase, which modulates crystallization and reduces defects in the film. Unlike volatile additives, GBAC remains in the film after annealing, serving as an effective defect passivation linker, reducing non-radiative recombination loss, and improving film quality. Experiments showed that GBAC significantly reduces defect density, boosting the power conversion efficiency of inverted (p-i-n) PVSCs to 24.8% (24.5% certified), with an overall energy loss reduced to 0.36 eV. This innovation represents a significant advancement in PVSC technology.[1] The findings were published in the scientific journal Nature Photonics.[2]

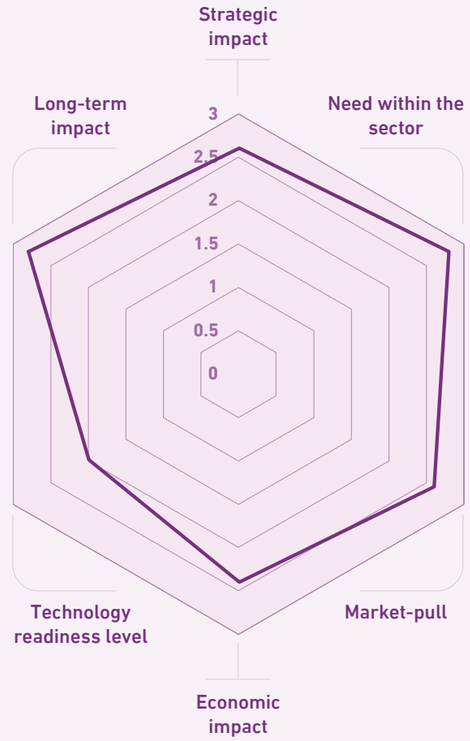
1 https://www.cityu.edu.hk/research/stories/2023/05/04/cityu-researchers-develop-additive-efficiently-improve-efficiency-and-stability-perovskite-solar-cells

2 https://www.nature.com/articles/s41566-023-01180-6

3 www.alliedmarketresearch.com

Multi-factor evaluation of tech signal

Improved performance of perovskite solar cells



The global market size for perovskite solar cells is estimated at

6.6$ billion by 2030

The compound annual growth rate (CAGR) during (2022 - 2030) is estimated at

32.4% [3]

2.3. Energy and Industrials

Field
Lithium Extraction

Improving lithium extraction efficiency is crucial for meeting the growing demand for lithium-ion batteries used in electric vehicles, portable electronics, and renewable energy storage. Traditional lithium extraction methods, such as evaporative brine extraction and hard rock mining, are resource-intensive, slow, and environmentally damaging. Thus, enhancing extraction efficiency while minimizing environmental impact is a significant focus for researchers and industry.

One promising approach is direct lithium extraction (DLE) technology, which involves using advanced materials and chemical processes to selectively extract lithium from brines or other sources. DLE can significantly reduce water usage and environmental footprint compared to traditional evaporation methods. For instance, ion-exchange resins, solvent extraction, and electrochemical methods are being developed to selectively target and isolate lithium ions from complex brine mixtures.

Tech Signal
18. Improved lithium extraction efficiency

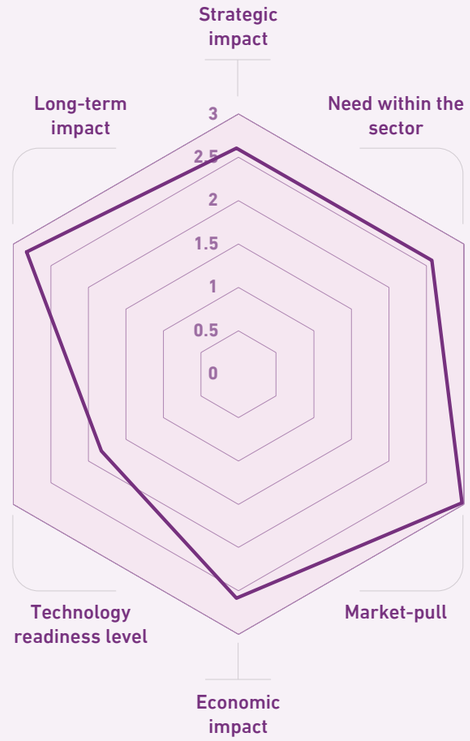
The team of oil and gas industry experts at Volt Lithium, a Canadian company, has presented a new lithium extraction technology; The team's primary goal was to create an efficient company for extracting lithium from brine solutions across the concentration spectrum. By leveraging fluid movement experience gained from the oil and gas industry, a technology was developed that demonstrated high recovery rates during testing at the lithium facility, where recovery rates of up to 90% were achieved from brines and from lithium recoveries at highly saline concentrations in oil fields of up to 34 mg per liter, and still maintain commercial economics, an achievement that has yet to be reported by other lithium producers. 1

Nanotechnology also offers innovative solutions. Nanomaterials with high surface area and specific affinity for lithium can improve extraction rates and selectivity. Additionally, advancements in membrane technology allow for more efficient separation processes, reducing energy consumption and improving yield.

1 https://finance.yahoo.com/news/volt-lithium-corp-announces-successful-123300512.html

2 www.grandviewresearch.com

Multi-factor evaluation of tech signal
Improved lithium extraction efficiency



The global market size for lithium is estimated

19$ billion by 2030

The compound annual growth rate (CAGR) during (2022 - 2030) is estimated at

12.3% 2

2.3. Energy and Industrials

Field

Hydrogen Production

Economical and resource-saving green hydrogen production focuses on creating hydrogen using renewable energy sources while minimizing costs and resource consumption. This involves utilizing technologies like water electrolysis powered by wind, solar, or hydropower to split water into hydrogen and oxygen without emitting carbon dioxide. Key advancements in this field include the development of efficient electrolyzers, such as anion exchange membrane (AEM) and proton exchange membrane (PEM) systems, which offer high efficiency and adaptability.

To further reduce costs, researchers are exploring the use of abundant, low-cost materials for catalysts, like nickel and manganese, instead of expensive precious metals. Innovations in direct lithium extraction and improved membrane technologies also contribute to lowering energy consumption and operational expenses. Additionally, integrating green hydrogen production with other renewable energy projects can optimize resource use and reduce overall costs, paving the way for sustainable, large-scale hydrogen production essential for a clean energy future.

Tech Signal

19. Economical and resource-saving green hydrogen production

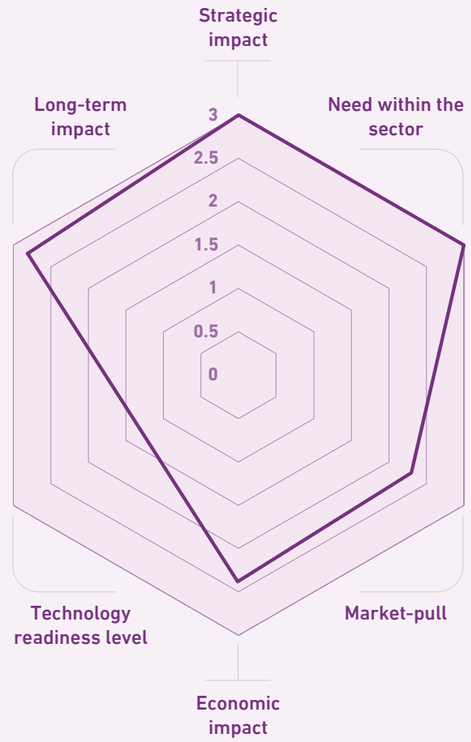
As part of the HighHy project, researchers from Germany and New Zealand are enhancing the efficiency of AEM electrolysis to produce green hydrogen using manganese and nickel. AEM electrolysis combines the benefits of alkaline and PEM electrolysis, but has faced challenges due to slow oxygen evolution reactions (OER) with non-precious metals, leading to high energy requirements. The HighHy project aims to develop effective OER catalysts and efficient AEM electrolyzers by exploring a nickel-manganese compound. This compound is cost-effective, readily available, and chemically active. Researchers are testing various synthesis methods, compositions, and structures to optimize the catalysts, focusing on improving electrochemical activity and optimizing electrode contact and electrolyte flow. The goal is to reduce energy consumption for oxygen generation, making AEM electrolysis industrially viable. With potential efficiency around 80%, AEM electrolysis offers lower material costs, greater flexibility, and high hydrogen purity, presenting a promising and cost-effective alternative to traditional electrolysis methods. 1

1 https://hydrogentechworld.com/scientists-develop-nickel-manganese-catalyst-compound-for-aem-electrolysis

2 www.globenewswire.com

Multi-factor evaluation of tech signal

Economical and resource-saving green hydrogen production



The global market size for green hydrogen is estimated at

7.3$ billion by 2027

The compound annual growth rate (CAGR) during (2023 - 2027) is estimated at

61.0% 2

2.3. Energy and Industrials

Field
Transistors and Semiconductors

The development of transistors for future semiconductors is essential as we approach the physical limits of silicon-based technology. Researchers are focusing on creating reconfigurable transistors using advanced materials and innovative designs. One promising approach involves ferroelectric materials, which can change their polarization under an electric field and retain this state even when powered off. This property allows transistors to perform multiple functions, enhancing efficiency and versatility.

Additionally, the integration of III-V materials offers significant potential for high-frequency applications and energy-efficient components, crucial for next-generation technologies like 6G networks, IoT, and quantum computing. These advancements aim to overcome the limitations of Moore's Law by enabling smaller, faster, and more energy-efficient transistors. Neuromorphic circuits, inspired by the human brain's structure, are also being developed to support artificial intelligence. These innovations are crucial for maintaining progress in computational power and addressing the growing demand for more efficient and powerful electronic devices.

Tech Signal

20. Developing transistors for future semiconductors

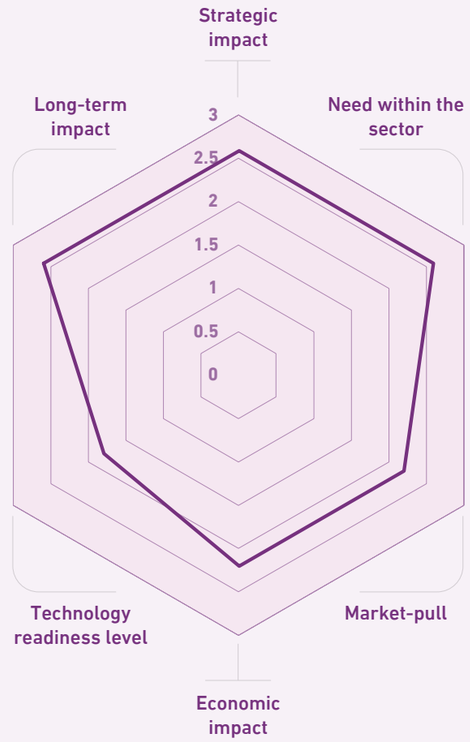
As standard transistors approach the limit of their small size, having more functions on the same number of modules becomes increasingly important in enabling the development of small energy-efficient circuits for improved memory and more efficient computing devices.

Researchers at Lund University in Sweden have shown how to create new transistors that are configurable and controllable at a new, finer level. They have developed reconfigurable transistors using ferroelectric materials, enabling precise control and multiple functionalities in semiconductors. This innovation is crucial as standard silicon transistors approach their miniaturization limits, posing challenges in improving computational power and energy efficiency. By integrating ferroelectric grains that alter polarization with an electric field, these transistors can retain their configuration even when the power is off, enhancing performance and energy efficiency. The new transistors, called ferro-TFET, operate at low voltages and can modulate input signals, beneficial for future applications like wireless communication, IoT, and quantum computers. This research supports the development of neuromorphic circuits, which mimic the human brain's structure for AI. 1

1 https://www.lth.se/article/cutting-edge-transistors-for-semiconductors-of-the-future/

2 www.globenewswire.com

Multi-factor evaluation of tech signal
Developing transistors for future semiconductors



The global market size for transistors is estimated at

26.83$ billion by 2030

The compound annual growth rate (CAGR) during (2023 - 2030) is estimated at

10.0% 2

2.3. Energy and Industrials

Field
Semiconductors

Gallium nitride (GaN) semiconductors are revolutionizing the electronics industry with their superior performance and efficiency compared to traditional silicon-based semiconductors. GaN's wide bandgap enables devices to operate at higher voltages, frequencies, and temperatures, making them ideal for a variety of high-power and high-frequency applications. These properties allow GaN semiconductors to significantly enhance the performance of power electronics, radio frequency (RF) amplifiers, and optoelectronic devices.

In power electronics, GaN transistors and diodes offer faster switching speeds, higher efficiency, and reduced energy losses. This translates to more compact and efficient power supplies, inverters, and converters, which are critical for applications in electric vehicles, renewable energy systems, and consumer electronics. The ability to operate at higher frequencies also reduces the size of passive components like inductors and capacitors, further shrinking the overall system footprint.

Tech Signal

21. Gallium nitride semiconductors for advanced applications

Odyssey Semiconductor Technologies Inc. in Ithaca, New York, announced the development of high-voltage vertical power switching components based on gallium nitride (GaN) process technology. The importance of gallium nitride (GaN) semiconductors is that they offer better commercial advantages over silicon carbide (SiC) and have high performance levels with low cost that may not be achieved by competing technologies.

With industry-leading innovation, Odyssey's approach to vertical GaN will offer even greater commercial advantages over silicon than silicon carbide or lateral GaN. Vertical GaN offers a 10x advantage over silicon carbide (SiC) at performance enabling smaller and lighter power systems and cost levels unattainable by the competing technologies. 1

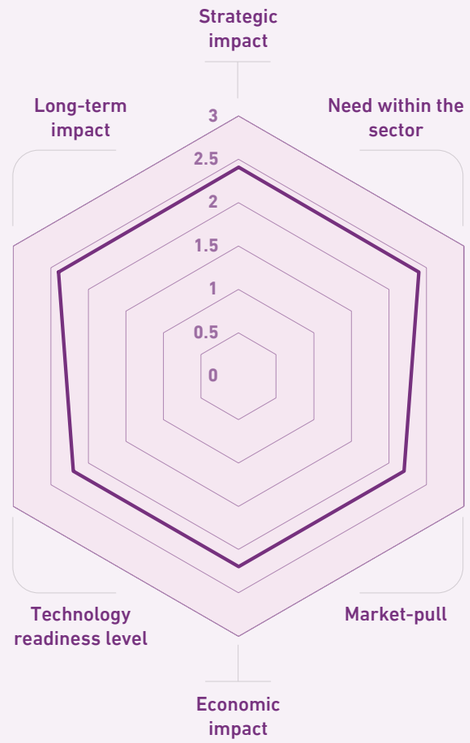
GaN's high electron mobility and thermal conductivity make it a preferred material for RF applications, including 5G base stations, satellite communications, and radar systems. These devices benefit from GaN's ability to handle high power densities and deliver robust performance in demanding environments.

In optoelectronics, GaN is the foundational material for blue and ultraviolet LEDs, lasers, and photodetectors, driving advancements in lighting, displays, and medical devices.

As technology advances, GaN semiconductors are expected to play an increasingly crucial role, enabling more efficient, powerful, and miniaturized electronic systems, thereby supporting the ongoing evolution of modern technology.

1 - 2 https://investors.odysseysemi.com/news/press-releases/detail/48/odyssey-semiconductor-technologies-delivers-vertical-gan

Multi-factor evaluation of tech signal
Gallium nitride semiconductors for advanced applications



Together, the 650-volt and 1200-volt power device market is expected to exceed

5$ billion by 2027

The compound annual growth rate (CAGR) during (2024 - 2027) is estimated at

40% 2

2.3. Energy and Industrials

Field
Metal-Organic Frameworks (MOFs)

Metal-organic frameworks (MOFs) are a class of porous materials constructed from metal ions or clusters coordinated to organic ligands. This structure creates a highly ordered, three-dimensional framework with vast surface area and tunable porosity, making MOFs highly versatile for various applications.

One significant application of MOFs is in gas storage and separation. Their high surface area and adjustable pore sizes enable the efficient capture and storage of gases like hydrogen, methane, and carbon dioxide. This makes them promising for carbon capture and storage (CCS) technologies, as well as for hydrogen storage in fuel cells.

MOFs are also utilized in catalysis. Their customizable nature allows for the creation of active sites tailored to specific chemical reactions, improving efficiency and selectivity. This is particularly beneficial in petrochemical refining, pharmaceutical production, and environmental remediation.

In the realm of drug delivery, MOFs offer advantages due to their biocompatibility and ability to encapsulate and release drugs in a controlled manner. This targeted delivery can enhance the efficacy of treatments and reduce side effects.

Tech Signal

22. Designing ultrastable materials by computational modeling

MIT researchers have developed and built new environmentally friendly materials that are energy efficient and less expensive by using computer modeling rather than traditional trial-and-error methods. Among these materials: metal-organic frameworks (MOFs) or metal-organic frameworks. By taking advantage of previous conventional experimental data and building and training computer models, it is possible to predict and determine features related to the stability of MOFs, which has allowed access to many promising materials that are stable in different conditions, and are expected to be used in many practical applications such as capturing greenhouse gases.

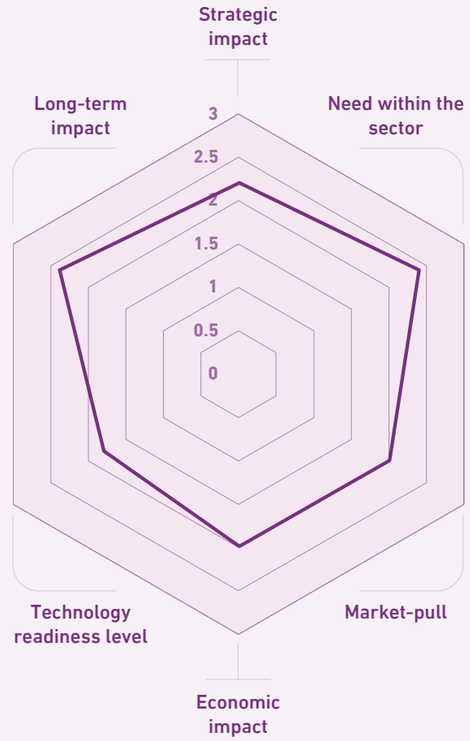
Using their computational model, the researchers have identified about 10,000 possible MOF structures that they classify as “ultrastable,” making them good candidates for applications such as converting methane gas to methanol. 1

Additionally, MOFs are being explored for use in sensors. Their porous nature and tunable properties enable the detection of various chemicals and environmental pollutants at low concentrations, making them valuable for environmental monitoring and industrial safety.

1 https://news.mit.edu/2023/scientists-computational-modeling-design-ultrastable-materials-0404

2 www.gminsights.com

Multi-factor evaluation of tech signal
Designing ultrastable materials by computational modeling



The global market size for metal–organic frameworks (MOFs) is estimated at

26.83$ billion by 2032

The compound annual growth rate (CAGR) during (2023 - 2032) is estimated at

13.0% 2

2.3. Energy and Industrials

Field
Nuclear Fusion

Fusion energy, derived from the process where light nuclei combine to form a heavier nucleus, releasing immense energy, promises a clean, virtually limitless energy source. Unlike traditional nuclear power, which relies on fission, fusion produces minimal radioactive waste and no greenhouse gas emissions. Fusion nuclear energy is clean energy; it produces large amounts of energy without emitting harmful carbon gases associated with the combustion of fossil fuels, in addition to reducing waste. It is safer energy than nuclear fission energy.

Fusion energy's potential lies in its ability to provide sustainable power without the environmental drawbacks of fossil fuels or the long-lived radioactive waste of fission. Advances in laser technology and inertial confinement fusion have brought us closer to harnessing this power, paving the way for a future where fusion energy could play a crucial role in addressing global energy needs and combating climate change.

Tech Signal

23. Achieving fusion ignition for the first time in a nuclear facility

The U.S. Department of Energy (DOE) and the National Nuclear Security Administration (NNSA) announced a breakthrough in fusion ignition at Lawrence Livermore National Laboratory (LLNL). On December 5, LLNL's National Ignition Facility (NIF) achieved the first controlled fusion experiment that produced more energy than the laser energy used to drive it. This significant milestone will enhance national defense and support clean energy advancements. The achievement aligns with President Biden's goal of a net-zero carbon economy and supports NNSA's Stockpile Stewardship Program.

This development involves using a laser system to create conditions similar to those in stars and nuclear weapons, paving the way for potential clean fusion energy. The project required collaboration across various institutions, including Los Alamos National Laboratory, Sandia National Laboratories, and several universities. With this success, researchers will focus on optimizing and commercializing fusion energy, aiming to provide a sustainable, clean energy source for the future. This breakthrough underscores the importance of continued investment in cutting-edge scientific research to address complex global challenges. 1

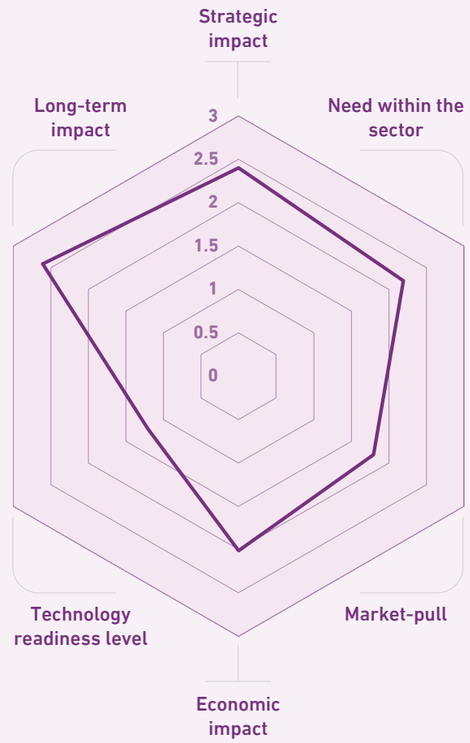
Fusion ignition is a milestone in nuclear fusion research where a controlled fusion reaction produces more energy than is consumed to initiate it. Achieving fusion ignition marks a significant breakthrough toward realizing fusion energy as a viable power source.

1 https://www.energy.gov/articles/doe-national-laboratory-makes-history-achieving-fusion-ignition

2 www.altenergymag.com

Multi-factor evaluation of tech signal

Achieving fusion ignition for the first time in a nuclear facility



The global market size for fusion energy is estimated at

843$ billion by 2040

The compound annual growth rate (CAGR) during (2031 - 2040) is estimated at

6.1% 2

2.4

Economies of the Future

2.4. Economies of the Future

Field
Generative Artificial Intelligence

Generative Artificial Intelligence (Generative AI) is a subset of AI focused on creating new content, such as text, images, audio, and videos, by learning patterns from existing data. Unlike traditional AI models that simply analyze data, generative AI models use deep learning techniques to generate human-like content. This technology underpins various applications, from chatbots and virtual assistants to content creation tools and synthetic media generation.

Generative AI is revolutionizing industries by automating creative processes, enhancing productivity, and enabling personalized user experiences. In healthcare, it aids in synthesizing medical data for research. In entertainment, it creates realistic visual effects and virtual characters. Despite its potential, generative AI also raises ethical concerns, including the risk of generating deepfakes and biased content. As this technology evolves, ensuring responsible use and addressing ethical challenges will be crucial for its integration into society. New Generative AI platforms are introduced every day. Examples include GPT-4o and Gemini

Tech Signal

24. Launching generative artificial intelligence platforms

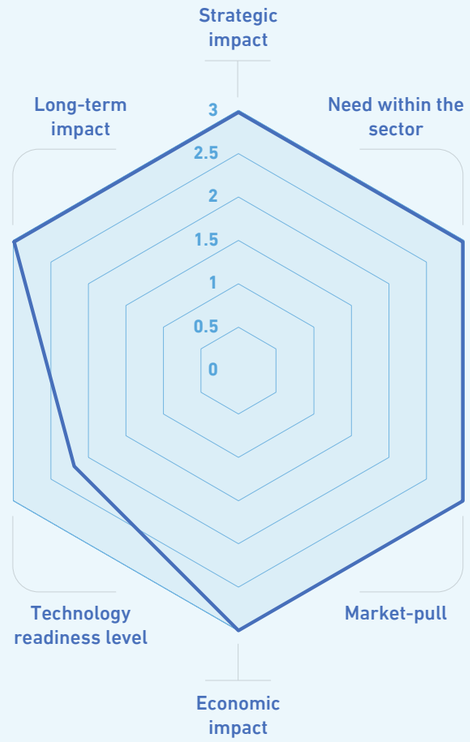
GPT-4o («o» for «omni») represents a significant advancement in natural human-computer interaction, capable of accepting a variety of inputs including text, audio, images, and videos, and generating outputs in text, audio, and image formats. It can process audio inputs remarkably quickly, with response times as low as 232 milliseconds and an average of 320 milliseconds, akin to human conversational response times. This model matches GPT-4 Turbo in English text and coding performance, excels in non-English text, and offers faster processing at half the cost in the API. GPT-4o notably outperforms current models in vision and audio comprehension. 1

Gemini by Google, unveiled in December 2023, is their most powerful AI model yet. Developed by DeepMind, it signifies a leap forward in AI capabilities. Three versions exist: Ultra for complex tasks, Pro for versatile use, and Nano for efficient on-device smartphone AI.

Previously known as Bard, Gemini represents a rebranding and upgrade. Bard's capabilities formed the foundation for Gemini, but Gemini boasts advancements in multimodality, handling text, code, images, and even audio seamlessly. This «Gemini era» for Google emphasizes responsible AI development while pushing boundaries. 2

1 https://openai.com/index/hello-gpt-4o/
2 https://gemini.google.com/
3 www.marketsandmarkets.com

Multi-factor evaluation of tech signal
Launching generative artificial intelligence platforms



The global market size for generative AI is estimated at

51.8$ billion by 2028

The compound annual growth rate (CAGR) during (2024 - 2028) is estimated at

35.6% 3

2.4. Economies of the Future

Field
Satellites

Satellites equipped with the latest fifth-generation (5G) communication standards are revolutionizing the way we connect and interact globally. These advanced satellites are designed to enhance the speed, reliability, and efficiency of data transmission, addressing the growing demand for high-speed internet and seamless connectivity. With 5G technology, satellite communications are no longer limited to remote or underserved areas; they are becoming integral to mainstream connectivity solutions.

One of the key advantages of 5G satellites is their ability to support ultra-low latency, which is crucial for applications requiring real-time data transmission, such as autonomous vehicles, telemedicine, and online gaming. These satellites operate in higher frequency bands, including millimeter waves, which provide significantly higher bandwidth and data rates compared to previous generations. This allows for faster download and upload speeds, improved video streaming quality, and enhanced user experiences.

Moreover, 5G satellites play a pivotal role in bridging the digital divide by providing high-speed internet access to rural and remote areas where terrestrial networks are not feasible. They also enhance network resilience by serving as backup communication channels during natural disasters or network outages.

Tech Signal

25. Launching the first satellite with the latest 5G communications standards

The Spanish startup, Sateliot, is pioneering the operation of a Low-Earth Orbit (LEO) nanosatellite constellation with 5G-IoT standard coverage. In April 2023, they launched the first satellite under the 3GPP 5G NB-IoT NTN Release 17 standard.

This standard marks a significant shift in the telecom industry. Traditionally, non-terrestrial networks (NTNs) operated by established satellite providers use proprietary technology, limiting connectivity to devices from the same company, thereby increasing costs and reducing accessibility. Sateliot's innovation allows all operators to connect seamlessly and affordably to its satellite network when coverage is needed.

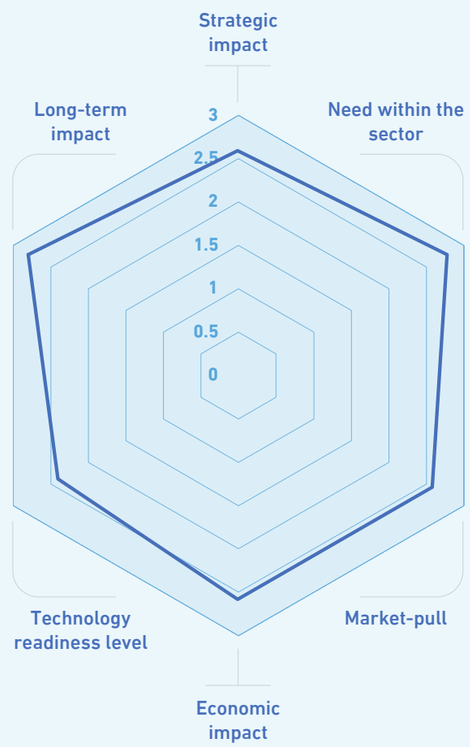
As a result, any NB-IoT device can easily connect to both satellite and cellular networks, enabling widespread adoption of IoT even in remote locations.

Sateliot is a key contributor to the 3GPP standard, alongside Qualcomm, Apple, Sony, and Samsung, with the goal of democratizing satellite connectivity. Their vision is to ensure that «anything, anywhere» can be connected for as little as $1 per month. 1 - 2

As the integration of 5G technology with satellite communications continues to advance, it promises to unlock new possibilities in IoT (Internet of Things), smart cities, and global connectivity, driving innovation and economic growth on a global scale.

1 https://www.gsma.com/get-involved/gsma-membership/gsma_resources/sateliot-to-launch-first-ever-satellite-under-5g-standard-to-democratize-iot/
2 https://sateliot.space/en/
3 www.statista.com

Multi-factor evaluation of tech signal
Launching the first satellite with the latest 5G communications standards



The global market size for 5G-enabled satellites is estimated at

22.7$ billion by 2032

The compound annual growth rate (CAGR) during (2023 - 2032) is estimated at

28.6% 3

2.4. Economies of the Future

Field
Blockchain / E-commerce

Blockchain-based e-commerce is transforming the digital marketplace by addressing many of the challenges associated with traditional e-commerce systems. One of the key applications of blockchain in e-commerce is enhancing transaction security and transparency. Blockchain's decentralized ledger system records every transaction in a way that is immutable and verifiable, significantly reducing the risk of fraud, chargebacks, and payment disputes. This ensures that both buyers and sellers have a secure and trustworthy environment for conducting business.

Another critical application is supply chain transparency. Blockchain allows for the tracking of products from their origin to the end consumer. This transparency not only builds consumer trust by verifying the authenticity and source of products but also helps in identifying and eliminating counterfeit goods. Additionally, it enables more efficient inventory management and logistics, as all stakeholders have access to real-time data.

Smart contracts, another application of blockchain, automate and enforce contractual agreements without the need for intermediaries. This reduces administrative costs and speeds up transaction processes. For example, a smart contract can automatically release payment to a seller once a product is delivered and confirmed by the buyer, ensuring prompt and fair transactions.

Tech Signal
26. Application of blockchain-based e-commerce

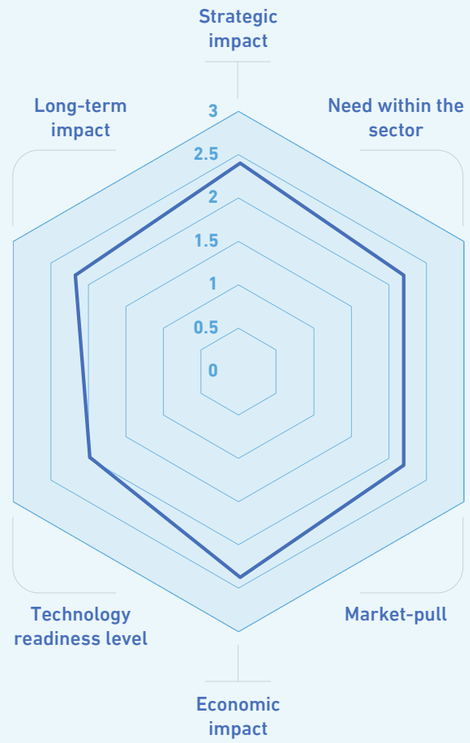
In a review paper published in Electronics, applications and challenges of blockchain-based e-commerce are demonstrated. E-commerce platforms provide businesses of all sizes the opportunity to sell their products and enhance their brand visibility to a wider audience. As technology advances, the e-commerce industry is continually evolving with new methods for buying and selling goods and services. Despite its growth, traditional e-commerce systems face challenges such as payment disputes, chargebacks, fraud, and lack of transparency.

Blockchain technology has the potential to revolutionize e-commerce by making transactions more efficient and secure. By creating a decentralized network, blockchain can securely store and share digital assets, allowing buyers to access detailed product information, including origin and source, and reducing the risk of fraud. Although blockchain's application in e-commerce is still in its infancy, this review paper explores the research on blockchain-based e-commerce, emphasizing its applicability and challenges as documented in literature from 2017 to 2022. 1

Furthermore, blockchain facilitates microtransactions and cross-border payments with lower fees and faster processing times compared to traditional banking systems. This is particularly beneficial for small businesses and consumers in developing countries, enabling greater participation in the global e-commerce market.

1 https://doi.org/10.3390/electronics12081889
2 www.arabianbusiness.com

Multi-factor evaluation of tech signal
Application of blockchain-based e-commerce



The global market size for blockchain is estimated at

40$ billion by 2025

The compound annual growth rate (CAGR) during (2023 - 2025) is estimated at

58.6% 2

2.4. Economies of the Future

Field
Augmented Reality and Mixed Reality

Augmented reality (AR) and mixed reality (MR) glasses are at the forefront of immersive technology, blending the digital and physical worlds in innovative ways. AR glasses overlay digital information onto the real world, enhancing the user›s perception of their environment. This technology is widely used in various fields, including gaming, education, healthcare, and retail. For instance, in retail, AR glasses allow customers to visualize products in their real-world context before making a purchase, enhancing the shopping experience and reducing return rates.

Mixed Reality (MR) glasses take this a step further by not only overlaying digital content but also integrating it with the physical world, allowing for interaction in real-time. MR glasses can create a seamless blend of virtual and real environments, where digital objects can interact with physical ones. This capability is particularly valuable in fields like architecture, engineering, and design, where professionals can manipulate and assess virtual models within a real-world context.

Tech Signal
27. Releasing augmented reality and mixed reality devices

In June 2023, Apple announced its revolutionary product, which is the first-of-its-kind mixed reality (MR) glasses called Vision Pro. The glasses feature the option of using augmented reality (AR) and virtual reality (VR) in addition to mixed reality technologies. This announcement represented an encouragement for developers to develop applications that take advantage of this device's content display technologies, making it easier for the user to see virtual content with his surrounding environment. 1

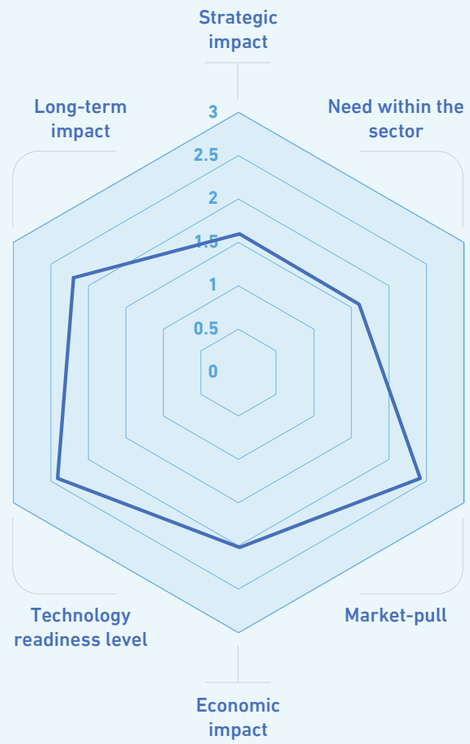
On the other hand, a research team from MIT was able to develop integrated augmented reality glasses that enable the wearer to recognize and locate objects and objects hidden from the eye's field of vision, either because they are inside boxes or under other objects.

The system utilizes radio frequency (RF) signals, which can pass through common materials like cardboard boxes, plastic containers, or wooden dividers, to find hidden items that have been labeled with RFID tags, which reflect signals sent by an RF antenna. 2

The potential of AR and MR glasses extends to remote collaboration, where users in different locations can interact with shared virtual objects as if they were in the same space. This technology is set to transform how we work, learn, and interact, making the boundary between the virtual and real worlds increasingly fluid.

1 https://www.apple.com/bw/newsroom/2024/06/apple-vision-pro-arrives-in-new-countries-and-regions-beginning-june-28/
2 https://news.mit.edu/2023/augmented-reality-headset-enables-users-see-hidden-objects-0227
3 www.marketsandmarkets.com

Multi-factor evaluation of tech signal
Releasing augmented reality and mixed reality devices



The global market size for augmented reality is estimated at

88.4$ billion by 2026

The compound annual growth rate (CAGR) during (2023 - 2026) is estimated at

31.5% 3

2.4. Economies of the Future

Field
Quantum Computing/Cybersecurity

Applying quantum computing to protect against cyber-attacks represents a paradigm shift in cybersecurity. Quantum computing leverages the principles of quantum mechanics to perform complex calculations at unprecedented speeds, enabling the development of new cryptographic methods that are virtually unbreakable by classical computers.

One of the primary applications of quantum computing in cybersecurity is the enhancement of encryption techniques. Quantum key distribution (QKD) is a revolutionary method that uses quantum mechanics to securely exchange encryption keys between parties. Any attempt to intercept or tamper with the keys disrupts the quantum state, alerting both parties to the presence of an eavesdropper. This ensures that communication remains confidential and secure from potential cyber-attacks.

Additionally, quantum computing can significantly improve the detection of cyber threats. Quantum algorithms can analyze vast amounts of data much faster than classical algorithms, identifying patterns and anomalies indicative of cyber-attacks in real-time. This capability enables organizations to respond to threats more quickly and effectively, minimizing potential damage.

Moreover, quantum computers can simulate and predict sophisticated attack vectors, allowing cybersecurity professionals to develop more robust defense mechanisms. By understanding how potential attacks might unfold, organizations can preemptively strengthen their systems against emerging threats.

Tech Signal

28. Applying quantum computing to protect against cyber-attacks

A research team from the University of Melbourne has demonstrated the effectiveness of machine learning algorithms for data-driven tasks like image classification and feature detection. However, it is shown that their susceptibility to adversarial examples—input samples modified to deceive the algorithm—poses a significant challenge. The combination of machine learning with quantum computing has the potential to create tools that not only improve accuracy and computational efficiency but also enhance robustness against adversarial attacks. Recent research has utilized quantum mechanical phenomena to defend against such attacks, accelerating the development of the field of quantum adversarial machine learning (QAML) and potentially providing a new quantum advantage. Despite promising initial results, there are still obstacles to creating robust, real-world QAML tools. This review explores recent advancements in QAML, highlights key challenges, and suggests future research directions that could pave the way for practical QAML solutions as quantum computing hardware advances and noise levels decrease. 1

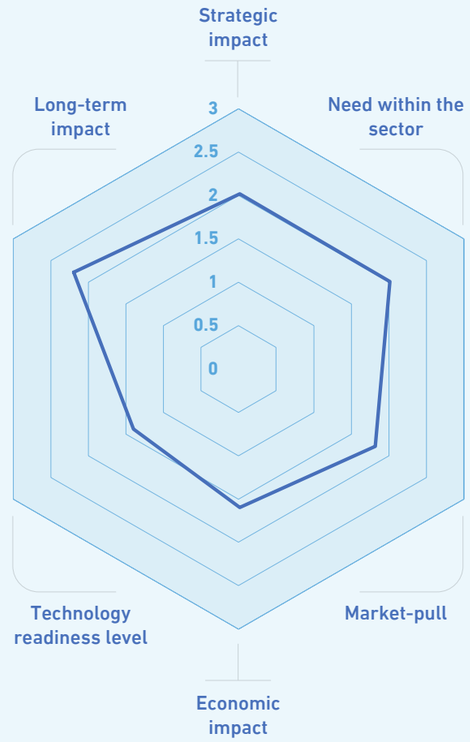
Despite its promise, the integration of quantum computing into cybersecurity is still in its early stages, with ongoing research and development needed to overcome technical challenges. However, as quantum technology matures, its application in protecting against cyber-attacks holds the potential to revolutionize the field, offering unparalleled security in an increasingly digital world.

1 https://pursuit.unimelb.edu.au/articles/using-quantum-computing-to-protect-ai-from-attack

2 www.mordorintelligence.com

Multi-factor evaluation of tech signal

Applying quantum computing to protect against cyber-attacks



The global market size for cybersecurity is estimated at

314$ billion by 2028

The compound annual growth rate (CAGR) during (2024 - 2028) is estimated at

11.44% 2

2.4. Economies of the Future

Field

Artificial Intelligence

Artificial Intelligence (AI) platforms are revolutionizing e-learning by providing personalized, efficient, and engaging educational experiences. These platforms utilize AI algorithms to analyze student data, such as learning habits, strengths, and weaknesses, to create customized learning paths. This personalized approach ensures that each student receives the right level of challenge and support, enhancing their learning outcomes.

One of the key benefits of AI in e-learning is adaptive learning technology. AI platforms can dynamically adjust the content and difficulty based on a student's performance, ensuring that learners remain engaged and motivated. This technology helps in identifying knowledge gaps and provides targeted resources to address them, making the learning process more effective.

AI-powered chatbots and virtual tutors offer instant assistance and feedback, simulating one-on-one interactions with a teacher. These tools are available 24/ 7, providing students with continuous support and making learning more accessible. Additionally, AI can automate administrative tasks such as grading and tracking progress, allowing educators to focus more on teaching and less on paperwork.

Tech Signal

29. Artificial intelligence (AI) platform to improve e-learning

A team from the Autonomous University of Madrid (Universidad Autónoma de Madrid) has built a platform based on artificial intelligence for the purpose of improving distance e-learning. The prototype of the platform provides tools for teachers that enable them to monitor students and ensure their presence in lessons and exams remotely. In addition, the platform analyzes students' 24 /7 behavior using different data issued by their devices in order to identify a specific list of events, such as lack of concentration and the level of psychological stress of the student, which allows the teacher to deal with the student better than the traditional method of e-learning in which these indicators are not available. 1

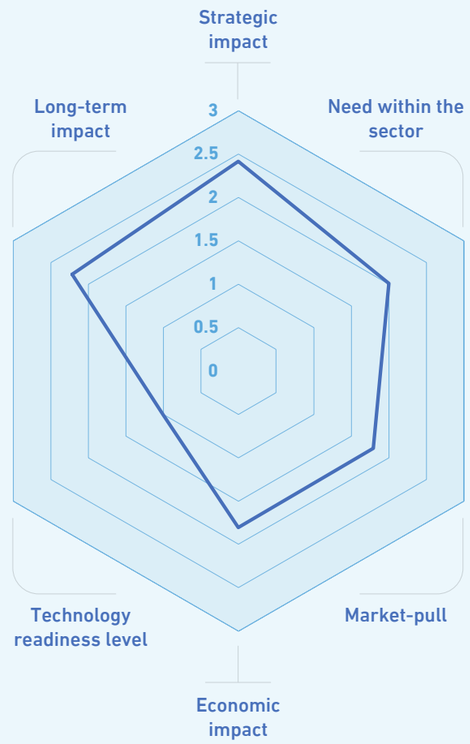
Moreover, AI platforms enhance the interactivity of e-learning through gamification and immersive technologies like virtual and augmented reality. These features make learning more engaging and enjoyable, helping to maintain student interest and improve retention rates.

1 https://techxplore.com/news/2022-12-ai-based-platform-personalize-e-learning.html

2 www.grandviewresearch.com

Multi-factor evaluation of tech signal

Artificial intelligence (AI) platform to improve e-learning



The global market size for AI in education is estimated at

29$ billion by 2030

The compound annual growth rate (CAGR) during (2022 - 2030) is estimated at

36.0% 2

2.4. Economies of the Future

Field
Optical Computing

Light-based computing, also known as photonic computing, leverages the properties of light to perform computations, offering a promising alternative to traditional electronic computing. In the context of cryptocurrency mining, light-based computing schemes present a revolutionary approach to significantly reduce the power consumption associated with the process.

Cryptocurrency mining is inherently energy-intensive due to the need for substantial computational power to solve cryptographic puzzles. Traditional electronic computers rely on electrical signals, which generate heat and consume large amounts of electricity. Conversely, photonic computing uses photons instead of electrons, enabling faster data transmission with lower energy dissipation.

The core advantage of light-based computing lies in its efficiency. Photons, being faster than electrons, can transfer data at the speed of light with minimal resistance, leading to reduced power loss. Additionally, photonic circuits can operate at lower temperatures, further decreasing the cooling requirements, which are a significant part of the energy expenditure in mining operations.

Tech Signal

30. Light-based computing scheme to reduce power needed in cryptocurrencies mining

Researchers from Stanford University have introduced a new light-based computing scheme that employs a photonic integrated circuit to decrease the energy consumption required for cryptocurrency and blockchain applications. Mining cryptocurrencies such as Bitcoin, which involves verifying transactions and adding new cryptocurrency to the blockchain, currently uses up to 1% of the world's energy. This energy usage is anticipated to rise as cryptocurrency and blockchain applications become more widely adopted.

Cryptocurrencies are digital forms of currency generated through encryption algorithms. These alternative currencies depend on a blockchain, a type of digital ledger that records information, such as transactions, in a manner that is highly resistant to alteration or hacking. 1

Moreover, the parallel processing capabilities of light-based systems allow for more efficient handling of complex calculations involved in cryptocurrency mining. This parallelism, combined with the inherent speed of light, can potentially accelerate the mining process, making it more sustainable.

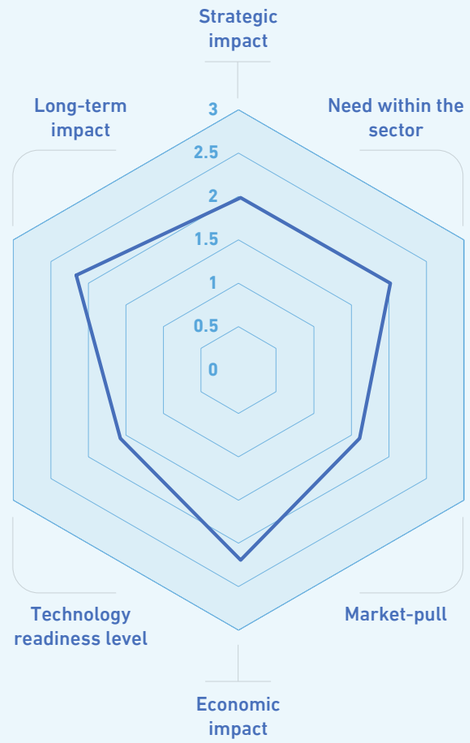
Adopting light-based computing for cryptocurrency mining could thus lead to a substantial reduction in power consumption, contributing to a more environmentally friendly and cost-effective mining process. As the technology matures, it may revolutionize the industry, aligning it with global sustainability goals.

1 https://www.optica.org/about/newsroom/news_releases/2023/april/light-based_computing_scheme_reduces_power_needed/

2 www.precedenceresearch.com

Multi-factor evaluation of tech signal

Light-based computing scheme to reduce power needed in cryptocurrencies mining



The global market size for AI in education is estimated at

7.0$ billion by 2032

The compound annual growth rate (CAGR) during (2023 - 2032) is estimated at

12.9% 2

3. CONCLUSION

The landscape of emerging technologies in 2023 is marked by rapid advancements and groundbreaking innovations that are poised to reshape industries and societies. This report has explored several key areas where technological progress is making significant strides: artificial intelligence (AI), quantum computing, biotechnology, and renewable energy, among others.

In health sector, this report covers signals in drug development, diabetes and cancer treatment, mental health, digital health, bioengineering and brain-computer interfaces (BCIs). For instance, biotechnology is a domain experiencing rapid evolution, with innovations in gene editing, personalized medicine, and synthetic biology. Emerging techniques are enabling precise modifications to genetic material, offering potential cures for genetic disorders and advancements in agricultural productivity. Personalized medicine is tailoring treatments to individual genetic profiles, improving efficacy and reducing side effects. Meanwhile, synthetic biology is opening new frontiers in bioengineering, creating novel organisms and materials with wide-ranging applications.

In sustainable environment sector, innovations include: recycling, carbon capture, crop monitoring, weather forecasting, waste treatment, fertilizer production, regenerative agriculture and water treatment. Technologies like carbon capture and storage (CCS) and green hydrogen production are reducing carbon footprints, while advancements in waste treatment are promoting sustainable ecosystem. These technologies not only aim to mitigate environmental impact but also pave the way for a more sustainable and resilient future.

In energy and industrials, breakthroughs include the fields of: solar cells, lithium extraction, transistors, semiconductors, metal-organic frameworks (MOFs), hydrogen production and nuclear fusion. For instance, renewable energy technologies are critical in the global effort to combat climate change and transition to sustainable energy sources. Advances in solar, fusion, and battery storage technologies are making renewable energy more efficient and effective, driving widespread adoption and integration into power grids worldwide. These innovations are crucial for reducing greenhouse gas emissions and achieving international climate goals.

In economies of the future, AI continues to revolutionize various sectors, from healthcare and finance to manufacturing and entertainment. The integration of AI-driven solutions is enhancing efficiency, accuracy, and decision-making processes, fostering an era where machine learning and automation are integral to daily operations. Quantum computing, still in its nascent stages, holds the promise of unprecedented computational power, capable of solving complex problems that are currently beyond the reach of classical computers. As research and development in this field progress, the potential applications in cybersecurity, material science, and large-scale data analysis could be transformative.

As we move forward, it is essential to address the ethical, social, and regulatory challenges posed by these emerging technologies. Ensuring equitable access, safeguarding privacy, and mitigating potential risks will be pivotal in harnessing the full potential of these advancements for the betterment of humanity. The trajectory of technological progress in 2023 sets a promising foundation for continued innovation and promising opportunities for the Kingdom of Saudi Arabia in the years to come.

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