Mapping Saudi Arabia's Deep Tech Ecosystem

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hello tomorrow

Building a deep tech hub in Saudi Arabia:
unleashing the potential by 2030

The recent pandemic and energy crisis have underscored the necessity for a profound global economic and environmental transformation. Consequently, governments and industries are sending clear signals to accelerate the adoption of deep technologies (deep tech) worldwide for measurable impact and resilience. To align with this trend, Saudi Arabia is ambitiously striving to become a leading deep tech hub in-line with the country's Vision 2030 objectives.

Saudi Arabia's Ministry of Communications and Information Technology (MCIT) and King Abdullah University of Science and Technology (KAUST), in collaboration with Hello Tomorrow, are partnering to support the country in realising this ambitious goal.

What is the report's approach?

To outline actionable strategic recommendations, the adopted approach revolves around three pivotal steps:

1. Analyse the current state of the deep tech ecosystem in Saudi Arabia by delving into multiple facets encompassing the local deep tech startup scene, investment landscape, research and development infrastructure, talent pool as well as policies and regulations.
2. Explore key emerging technology trends that are shaping deep tech's future and assess associated challenges in scaling those opportunities.
3. Highlight Saudi Arabia's industrial initiaves in line with emerging deept tech trends

What is deep tech?

Deep tech startups are dedicated to addressing global challenges and distinguished by the utilisation of cutting-edge scientific research and engineering. Their business value relies on intellectual property, leading to extended and capital-intensive development cycles. They also depend on scientific and technical talent pools and confront significant market risks.

In order to differentiate deep tech companies and select them for the mapping, a rigorous analysis and ranking based on the following criteria was performed:

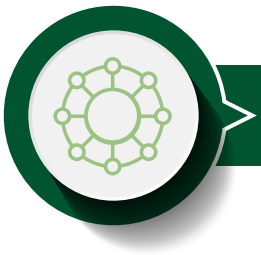
- Science-based innovation
- R&D capital requirements
- Hardware components
- Economic and environmental impact
- Uniqueness of the solution
- Multiple technologies leveraged
- Proprietary know-how and intellectual property

Ecosystem Mapping

5 key pillars have been identified to analyse the Saudi deep tech ecosystem through a holistic approach

To provide a comprehensive analysis of the Saudi deep tech ecosystem, a holistic approach based on five key pillars presented and defined below has been developed.

These equally important topics, although related to each other, have been addressed in parallel to draw specific and actionable conclusions for all ecosystem actors from both the public and private sector (government, academia, investors, corporations, startups, networks, etc.)

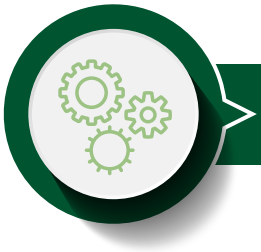


Deep tech ecosystem

Driven by Saudi Vision 2030, Saudi Arabia is undergoing significant transformations to align with its ambitious development goals of **becoming a global deep tech hub**. This chapter presents an overview of the current state of the Saudi deep tech ecosystem.

Investment

Deep tech startups often don't follow the established funding progression of other types of young tech enterprises. To establish and scale up, deep tech entrepreneurs today need to tap into a variety of private and public funding sources. This chapter is dedicated to examining the **investment trends and venture capital landscape** in Saudi Arabia.



Infrastructure & ecosystem enablers

In order to find investors, clients, mentors, or talent, entrepreneurs need to navigate well-connected ecosystems. In the “Research & growth infrastructure" chapter, we delve into the **deep tech capabilities available for key stakeholders** (entrepreneurs, researchers,...) in the country. This section examines the current state of **global scientific research, technology transfer, IP generation**, and support for deep tech entrepreneurs, including **entrepreneurship programs, incubators, and accelerators**.

Talent

The competition for technical and business talent in the deep tech industry is intense. In this chapter, we provide an overview of the **current talent pool in the country**, as well as recent **initiatives and programs** aimed at supporting local talents and attracting international talent.

Policy, regulations & government incentives

This chapter is dedicated to showcasing the recent **regulatory developments** in Saudi Arabia's deep tech ecosystem, highlighting the government's intervention to encourage entrepreneurship and bring more flexibility to the legal framework. Existing **government-based initiatives and policies** that will impact the deep tech ecosystem are further explored, as new regulations are progressively shaping the space.

1. DEEP TECH ECOSYSTEM
Exploring the Saudi deep tech startup scene:
Propelling the rapid development of a growing ecosystem

The deep tech startup ecosystem is still in its infancy and is relatively modest in size when compared to the overall startup landscape, suggesting a promising but evolving sector with significant room for expansion.

With over 1,000 startups identified in Saudi Arabia, the thriving ecosystem is leveraging the widespread adoption of technology and the country's accelerated economic growth, as well as its increasing openness to the global market, to enhance a fertile environment for entrepreneurial ventures.
The ambitious Vision 2030 goals of diversifying Saudi Arabia's digital economy are propelling the rapid development of an emergent deep tech ecosystem. 43+ deep tech startups have been identified using a rigorous assessment methodology to ensure that only ventures that are Saudi-born and working with emerging, potentially ground-breaking and science-based technologies were selected. Key initiatives will be showcased in this report, which highlight the potential for exponential growth if the necessary actors and enablers are implemented.

1,000
Startups identified in Saudi Arabia, including

43+
High growth potential deep tech startups

Half of all deep tech startups built in Saudi Arabia are working on AI and IoT technologies.

Half of Saudi Arabia's deep tech startups are focusing on AI and IoT technologies, with 25% of them specialising in Industry 4.0 (IoT, robotics and industrial automation) and another 25% dedicated to Artificial Intelligence and computing. From a sectoral perspective, there is a significant representation of the food and agriculture sector, with several startups showcasing a diverse range of technologies, including sustainable products (bioplastics, biofuels and wastewater recycling) and solutions for vertical farming.

50%
Of deep tech startups built in Saudi Arabia are working on AI and IoT technologies

The health and energy sectors also show strong opportunities for growth and innovation, especially in long-duration battery and storage systems or in innovative drugs and treatments.

The deep tech startups that have originated in Saudi Arabia are currently in their early stages of development, but the ecosystem is already attracting mature international companies.

Saudi deep tech startups already raised more than $100M since 2020[1]

Most advanced deep tech startups are starting to grow at the international level, such as Iyris, who already developed partnerships in the US, or Lucidya and Quantum Solutions which have a presence outside of the Kingdom.

Moreover, the dynamism of Saudi Arabia's ecosystem has already attracted mature deep tech companies such as the quantum computing pioneer Pasqal or the green construction company Mighty Buildings, which have both opened offices in the country.

1. Tracxn

2. INVESTMENT
Financing deep tech: Bridging the gap in deep tech investments amidst Saudi Arabia's startup funding boom

2022 was a record-breaking year for global startup investments in Saudi Arabia.

As well as a slight increase in the total number of deals between 2021 and 2022 (144 vs. 149, a 3.4% increase), the volume of those deals has skyrocketed, with total startup funds soaring by 72% from $575M in 2021 to $987M in 2022 (combined total of all startups in the country).[1]

$987M
Raised by all Saudi Arabian startups in 2022

This is fuelled by a rapidly expanding funding ecosystem, ranking in MENA's top three for funding and deals.

The number of active investors in Saudi Arabia has consistently increased since 2018, with a significant 43% rise[1]. This growth has propelled Saudi Arabia into the top three countries in the MENA region for both funding and deal volume, with 23%[1] of all deals in the MENA region in 2022 taking place in KSA.

104
Active startup investors registered in KSA in 2023, a 41% increase from 2018

This expansion is highly dependent on public funds, as the government is committed to nurturing tech startups and scaleups.

The tech scene enjoys strong public support in Saudi Arabia, with public entities like the Public Investment Fund (PIF) and Saudi Venture Capital (SVC) leading investment rounds in scaleups and driving ecosystem growth through massive investments in funds.

SVC, a government-owned investment fund with a capital of $1.5B, has already invested in 31 funds, 16 institutional investors, five angel groups, and six accelerators & startup studios[2], demonstrating the government's commitment to fostering the development of a startup ecosystem in the country.

Deep tech is being primarly supported by top universities and industrials.

In 2022, deep tech startups have raised less money than other technology-focused startups, which is mainly due to their early development stages. Moreover, the deep tech investment ecosystem leverages various actors, such as universities who are looking to transfer their research into commercial opportunities and corporates who invest in deep tech to solve their own industrial challenges.
Indeed, as of today, KAUST and Waed Ventures (Saudi Aramco's venture arm) are the first deep tech investors in the country.

Traditional investors in web and digital technologies can develop connections with such deep tech actors to gain more knowledge and awareness about deep tech opportunities.

1. Saudi Arabia Venture Capital Report, MAGNiTT, 2022 – MCIT and Hello Tomorrow analysis
2. SVC website – portfolio

3. INFRASTRUCTURE & ECOSYSTEM ENABLERS
Accelerating infrastructure growth for a thriving ecosystem: Scaling up Saudi Arabia's deep tech ecosystem

The research ecosystem in Saudi Arabia has witnessed significant enhancements over the past decade.

Saudi Arabia's research ecosystem has significantly improved in the past decade, with a 75% increase in active researchers since 2015. The country is expanding its research infrastructure with the aim of accommodating 140,000 researchers by 2030, marking a sevenfold increase from the current 20,000 researchers in the country. The university network is also experiencing growth, with more than two-thirds of universities having been established after 2000, including prestigious institutions like KAUST, which currently ranks among the top universities in the country.[1]

1st
Amongst Arab countries for research quality in the Nature Index

The quality of research output in Saudi Arabia is steadily improving, laying the foundation for a robust deep tech ecosystem.

For three consecutive years, the nation has consistently secured the top spot in research quality within the MENA region, as per the 2022 Nature Index tables. It also maintains a steadfast global position of 30th, a rank it has held for over six years. These achievements establish Saudi Arabia as a leading scientific nation, with institutions like KACST as well as KAUST's cutting-edge research labs prominently contributing to these advancements.[2]

5
Saudi-based researchers ranked in the world's best 2% scientists by Stanford in 2022[3]

Research-to-tech transfer relies on university grants and increasing collaboration opportunities.

In Saudi Arabia, research-to-tech transfer benefits from university grants and funding options like KAUST's and Community Jameel's initiatives as well as RDIA's national support for researchers. Despite these, local startups are asking for more R&D collaboration with universities, in order to power their growth. To this end, the National Technology Development Program (NTDP) aids startups through programmes like Next Era and MVPLab, offering financial incentives and IP support. Furthermore, KAUST's and KFUPM's equity-free strategies appeal to scientists and entrepreneurs, unlike countries where universities retain full IP. Saudi Arabia has recently accelerated patent registration and lab access.

To further strengthen the deep tech ecosystem, there is a need to expand the network of sector-specific incubators and accelerators.

As Saudi Arabia forges ahead with the development of a network of incubators and accelerators, most of them are not specialised enough to meet the specific needs of deep tech startups. However, the emergence of initiatives like The Garage, the Center of Digital Entrepreneurship (CODE) and Fountech Labs fill this gab, offering tailored support and valuable resources to startups.

25%
Of incubators and accelerators in Saudi Arabia include deep tech verticals

Emerging initiatives are actively facilitating the entry of foreign scaleups, thereby accelerating the growth of the ecosystem.

These scaleups offer valuable opportunities, jobs, and expertise, yet they face hurdles from lengthy legal processes and limited recruitment options. Initiatives like KAUST's Destination Deep Tech programme are emerging to streamline the installation process while more connections with diverse industries and partnerships, as exemplified by Wa'ed Ventures, are needed. Hubs like NEOM and startup-friendly government procurement can speed up tech adoption and partnerships.

1. Oldest universities in Saudi Arabia, 4icu.org
2. Nature Index website; Egypt maintains its positions in Nature Index 2021 annual tables despite pandemic, Zawya, 2021
3. Five researchers from Saudi university named in Stanford's 'World's Top 2% Scientists' list, Arab News, 2022

4. TALENT
Increasing the deep tech talent pool: Empowering founders with managerial & technical expertise

Access to deep tech talents, particularly business managers and top level scientists, is key for deep tech founders.

Saudi Arabia has a unique opportunity to leverage its large population of young nationals by investing in and expanding its STEM programmes.
Since the early 2000s, the Kingdom is actively establishing and enhancing STEM-focused schools and universities with a total student population of about 2,000,000 (all universities combined). The country is thus rapidly progressing toward its 2030 RDI goal of five universities in the top 200 of international rankings, whereas three have already made it (KAU, KSU and KAUST).[1]

$49B
Spent on the education system, the first budget of the Saudi government in 2022[2]

The number of women enrolled in STEM degrees has greatly increased and now accounts for 60% of the Science graduates in Saudi Arabia, a higher value than EU's 34% in 2022.[3,4]

In line with Vision 2030, KSA implemented initiatives such as the Women Empowerment Program in Technology by MCIT with the objective of reducing the gender gap. In light of efforts such as the Princess Nourah University collaboration with DELL in 2018 - training women in fields such as data science & big data analytics and cloud computing - or the Apple Developer Academy, Saudi Arabia now occupies the 10th position overall in the 2022 Gender Digital Divide Index, ranking first in the Arab World.[5]

On the other hand, the brain drain has become a significant challenge as skilled professionals, particularly in the deep tech sector, are often lured away by the prospect of better opportunities, higher salaries and improved quality of life in Western countries.

In 2018, 81% of MENA researchers wanted to emigrate, in contrast with declining Saudi student numbers abroad (100,000 to 56,000) due to diplomacy and scholarship changes.[2]

To increase opportunities for locals, Saudi Arabia is progressively enacting a regulatory framework conducive to fostering a business-friendly environment.

The World Bank's "Ease of Doing Business 2020" ranking showed Saudi Arabia's significant improvement, rising from 92nd place in 2018 to 62nd place in 2019.[4] This rise is driven by around 600 regulatory reforms in the last six years including tax reductions and eased labour regulations.[5] Furthermore, Saudi Arabia's special economic zones and premium residency visa are working to attract international talent by introducing progressive legislation and enticing fiscal benefits, encompassing exemptions for expats and their families during the pivotal first five years of residency.
In 2022, 50,000 foreign students were present in the country, highlighting the success of Saudi Arabia to attract international talents.[6]

~ 600
Regulatory reforms in the past six years[7]

4
Special economic zones created in 2023

Through comprehensive initiatives, education programmes and support networks, a substantial shift has been initiated toward entrepreneurship in KSA.

The country has launched a range of initiatives to nurture entrepreneurship, including the International Schools Attraction Program, Misk Foundation, and MBSC College, aimed at fostering the development of new entrepreneurs.
Additionally, KAUST Innovation, MCIT CODE and The Garage among others provide crucial support to local and international founders, while programmes like Destination Deep Tech and the Entrepreneurship License by the MCIT and MISA are specifically facilitating the settlement of foreign talent in the country. As a consequence, Saudi Arabia has experienced a remarkable growth in the establishment of small and medium-sized, alongside a shift toward entrepreneurship.

1. Vision 2030, Education in Saudi Arabia, hmc.org
2. Education takes biggest chunk of Saudi public spending in 2022, Arab News, 2021
3. The rise of Saudi women in STEM, VisitSaudi.com
4. Women in STEM in the EU, EUStudent Think Tank
5. GDD Index 2022
6. Over 50,000. students register for the “Study in Saudi Arabia” program, Zawya.
7. Saudi Arabia: the fastest growing economy fighting for its future, MFAT.org, Nov 2022

5. POLICY, REGULATIONS AND GOVERNMENT INCENTIVES

Laying the policy groundwork through Saudi Arabia's Vision 2030: Supporting the development of a strong and attractive deep tech ecosystem

Vision 2030 supports a new era for the Saudi entrepreneur ecosystem, centered around deep technologies.

The Kingdom of Saudi Arabia shows a strong political will to encourage the development of new industries and a growing entrepreneurial culture. The international economic context, marked by deep transformation in the energy sector, and the transition to non-oil industries, is now opening the opportunity for a diverse, sustainable, and prosperous economy for the Kingdom of Saudi Arabia. In order to achieve these ambitions, the country will increase its RDI spending tenfold, going from $2.4B in 2019 to about $28B by 2040.[1]

Saudi Arabia aims to increase RDI spending
x10
by 2040

Thanks to easier regulations and incentives for company establishment, KSA is now a welcoming place for international investors.

Saudi Arabia has made notable strides in improving the investment climate by attracting foreign investment and bolstering local investment through initiatives like the MISA license and tax exemptions, leading to the country surpassing the National Industry Strategy's investment target by 112.4% in 2021.[2]

Q2 2022 saw
49
investment deals,

90%
of them operated by new investors in the country

Significant efforts are being done to strengthen the local talent workforce as well as to attract and retain the best global talent.

The implementation of regulatory measures and government schemes aimed at providing better training to Saudi students and facilitating their integration into the professional world has the potential to greatly benefit the deep tech industry.

Saudi Arabia has established various national institutions that focus on providing funding, creating a supportive regulatory environment, and offering incentives specifically tailored to deep tech initiatives.

The government's creation of organisations like the Saudi Data & AI Authority (SDAIA), the National Technology Development Program (NTDP), the National Industrial Development and Logistics Program (NIDLP), The Research, Development and Innovation Authority (RDIA) as well as Saudi Authority for Intellectual Property (SAIP) demonstrates a recent push to boost deep tech infrastructure.[1]

1. National Aspirations and Priorities for RDI initiative, 2022
2. Economic and Investment Monitor, Invest Saudi, 2022

Key deep tech trends to watch

Leading countries are to grab onto upcoming deep tech trends for their sustainability, digital economy and prosperity

Characterised by unique, protected or hard-to-reproduce technological or scientific advances, deep technologies (or deep tech) lie at a crossroads between global imperatives and scientific progress. Bringing hope to tackling existing and upcoming environmental and societal challenges, said technologies are, however, yet to prove their impact and sometimes viability as market access and scalability are hindered by a number of obstacles, from capital requirements to lack of technological understanding.

To ensure mandatory sustainability and overall resilience of societies, leading economies such as Saudi Arabia will have to select and invest in the most impactful solutions, that fall into the main 'deep tech areas'. In our assessment, selection criteria were balanced between (1) current and global indicators of innovation, such as number of startups and fundraisings and (2) evolution potential with expected Compound Annual Growth Rate (CAGR), market size and importance in regard to Saudi Arabia's established strategies and upcoming initiatives.

How did we select the most promising deep tech areas?

Present[1,2]

Worldwide Startup Presence	Number of startups applicable to the area
Overall Funds Raised	Funds raised in the area by all startups in 2022 (Equity)
Mature Funding Trends	Cumulative funding for deep tech companies Series B and above, 2021-2022
Early-Stage Traction	Growth of startup applications per industry from the Hello Tomorrow Global Challenge
2022 Market Size	Global market size of the area and/or its constituents in 2022

Future[3,4]

2030 Market Size	Global market size of the area and/or its constituents in 2030
CAGR	Compound Annual Growth Rate of the area and/or its constituents
KSA - Vision 2030	Vision Realization Program for the reform blueprint in Saudi Arabia
KSA - RDIA Direction	Sectors highlighted by the Saudi RDIA strategy
KSA - DE Direction	Sectors highlighted for the Saudi National Digital Economy Strategy

Selected deep tech areas

Advanced computing is a technology enabler across all deep tech areas

- **Universal health**
- **Sustainable food systems**
- **Environment safeguarding**
- **Cleaner energies**
- **Resilient cities**
- **Advanced manufacturing**
- **Space exploration**

1. Hello Tomorrow and Tracxn databases, 2023 data
2. Dealroom data
3. Global market size and CAGR from 2022 or 2023 reports established by Grand View Research, Precedence Research, Verified Market Research, Business Research Company, Markets and Markets, and Statista
4. Official statement from Vision 2030 website and subsequent directives

1.
Universal Health: A connected and personalised healthcare journey for all

Pressed by the never-before-seen impact of the COVID-19 pandemic, the healthcare sector has experienced dramatic changes, from adoption of digital technologies to accelerated timelines and new business models.

Public and private organisations have had to rethink ways in which they operate and partner, as ecosystems were structured and restructured to deliver diagnoses and care to patients across the globe.
The new normal is for health management to be completely digital and connected, with a soon-to-be development of tailored, if not entirely personalised, solutions as patients look for integrated journeys instead of single services delivered by isolated stakeholders.

Globally
1 in 6
People will be aged 60 years or over by 2030[1]

Three major trends are shaping the future of healthcare.[1,2,3]

Data-driven healthcare, which aims to improve patient outcomes, optimise healthcare processes and enable evidence-based decision-making through digital technologies.

These companies are leveraging **upgraded sensors** to capture data at the closest level and enable real-time, personalised diagnostics and treatment. In addition, data collection is complemented by the application of **artificial intelligence** and **machine learning** to analyse said data and predict outcomes in research, patient monitoring and care.

For instance, Alamar Biosciences' attomolar sensors or QDTI's quantum sensors are able to capture medical-grade data to help the understanding, diagnosis and tracking of diseases and health conditions that were previously unattainable.

However, on top of manufacturing hurdles to minimise sensor size and maximise capacities, legislations and high costs may prevent universal adoption of such technologies.

~50%
Of global investments in deep tech startups are going to life science technologies[2]

Precision medicine, which leverages advanced in data analytics and biotechnology to deliver personalised treatments to the patient.

Indeed, the integration of **multi-omics** (information beyond the genome, such as the microbiome, etc.) will make it possible to truly understand the multitude of factors impacting individuals' health. Such evolution also paves the way for **engineered therapeutics**, such as Quell Therapeutics' autoimmune disease treatment based on engineered T-cells, developed in collaboration with AstraZeneca.

Nevertheless, translating large datasets into efficient and affordable therapies remains a technical challenge, and cell and gene therapies are hindered by complex regulations and safety evaluations.

Regenerative medicine, which targets tissue and organ regeneration, thanks to next-generation sequencing and engineered biomaterials.

Scientific advances are making it increasingly possible to leverage the **body's natural ability to mend and heal**. Despite oncology being the most sought-after application (cancer is one of the primary causes of death worldwide), areas of focus for the field seem to be unlimited.

Companies like Medical Inventi are developing a bone-substituting biomaterial and Medjeduse is proposing a spinal cord-healing medical device.

However, high development and final costs, as well as the stringent regulatory approvals required, are **engineered tissues'** biggest challenges in adoption.

1. World Health Organisation (WHO), 2022
2. Deep Tech: The Great Wave of Innovation, BCG x Hello Tomorrow, 2021

1. Deep dive on data-driven Healthcare

How Saudi Arabia is leveraging its computing and AI capabilities to provide advance healthcare services?

Opportunities	Key levers	Saudi Arabia
Developing hardware for real-time data collection and processing	**Advanced computing infrastructures**	Strategic partnership with Saudi Excellence Co. and Cloudsky (2023) Establishment of the Cloud Computing Special Economic Zone (2023) King Abdullah International Medical Research Centre powered by Oracle Cloud
	New sensing capacities	Dedicated research from Sensors Lab at KAUST
Increasing pool of talent with combined biology and data science knowledge	**Local education toward multidisciplinary knowledge in medicine**	Changes expected with the privatisation of several Academic Medical Centres
	Preferential policies to attract foreign talent and entrepreneurs	600 regulatory reforms in the last six years, ranging from reduced taxations and labour regulations KAUST Destination Deep Tech and Entrepreneurship License helping foreign talent to settle in the country
Enhancing procedures ensuring healthcare facilities & patient adoption	**Aligned standards and regulations for data access and use**	Development of a unified national electronic health record system in the works based on the National Platform for Health Information Exchange Services Personal Data Protection Law (2021) which covers health data. Also reviewed in the Health Sector Transformation Program Goal to digitalise 70% of patient activities by 2030 with adequate regulations
	Public budget allocated	$1.5B allocated for healthcare IT and digital transformation programmes by the government, on top of the $50.3B budget allocated in 2023 for healthcare and social development
	Publicly-backed initiatives for data-driven health	SEHA Virtual Hospital with a live network of 130 connected hospitals Healthcare as one of the focus pillars for the Saudi Data & AI Authority Private-Public partnerships including MOH with Alphaiota, IQVIA and Phillips with SDAIA. Strengthening through SPInE
	Reimbursement schemes and codes	Discussions around a new national insurance fund for managing reimbursements

2.
Cleaner energies: A future energy system based on low-carbon technologies

The Intergovernmental Panel on Climate Change (IPCC) Assessment Reports and observable impacts of climate change are driving the energy industry to adapt in order to achieve the Paris agreement targets.

In addition to strong energy efficiency measures and change in consumer habits, the clean energy transition requires the development of a resilient and sustainable system composed of mass electrification combined with reliable energy storage, energy efficient processes and a mix of diverse alternative energy sources.
However, the energy transition still holds a lot of challenges, such as tensions in the supply of critical minerals or the technical difficulties to store and transport alternative fuels.

1:1.7
Globally, the ratio of investments in favour of renewable energies with respect to oil & gas (compared to a 1:1 ratio five years ago)[1]

Three major trends are helping to accelerate the transition of the energy sector

The development of new and improved **low-carbon energies** to complement existing renewable solutions.

Based on new technologies, **next-generation renewable energies** are being developed, such as Heliatek's flexible photovoltaic panels, Eavor's closed-loop geothermal energy system or the ocean wave harvesting technology from Calwave.

The **nuclear sector** is also being disrupted by a new reactor with high levels of combustible recyclability and small and modular designs, such as for newcleo and Hexana. Fusion is also getting closer to reality, thanks to technological advances like CFS's superconducting magnets.

Furthermore, cheaper and more efficient **carbon capture** technologies are being developed thanks to innovative sorbents like C-Quester.

These technologies, however, are facing multiple challenges on the technical side (high costs compared to fossil fuels, long deployment times, raw material supply etc.) and their scaling is closely dependent on long-term political choices.

$15 billion
2022 was a record year for investments in cleaner energies deep tech startups[2]

Clean fuels are being developed for applications that cannot be electrified. Their development is accelerated thanks to new regulations and incentives, such as Canada's new Clean Fuel Standard or EU's sustainable aviation fuel obligation for aircraft operators.

On top of alternative fuels, **green hydrogen** holds a huge market and application potential. Cheaper and more efficient electrolysers will reach the market, thanks to technologies such as Naco's nanocoating allowing to boost electrolyser cells while reducing the use of expensive noble metals.

CO_2-based fuels valorising captured CO_2 are also attracting strong interest, thanks to technological advances, such as Air Company's single-step conversion process.

Alternative fuels are facing strong economic challenges to compete with fossil fuels and their industrial scaling to global impact might take a long time (a few decades).

Eventually, the energy transition cannot happen without reliable and long-term **batteries and energy storage systems**.

Companies are now improving existing lithium-ion technology, whereas new chemistries and systems are being developed. It is the case for BeFC, who provides a non-metal, paper-based battery for low-power electronics or Sinergy Flow's upcycled sulphur-based electrolytes.

Eventually, Gravitricity's alternative storage system based on gravity could help for very long-duration, grid applications.
New batteries and storage systems are still facing cost-parity challenges when compared to lithium-ion technology, which is still dominating the market.

1. IEA, 2023
2. Pitchbook, Crunchbase and Tracxn data

2. Deep dive on clean fuel

Thanks to its historic Oil & Gas infrastructure, Saudi Arabia is implementing alternative fuels production capacity

Opportunities	Key levers	Saudi Arabia
Developing and adapting infrastructure to new fuels	**Development of dedicated pipelines & transportation networks**	Dedicated hydrogen pipeline networks in industrial cities Jubail and Yanbu (2021) Air Liquide & Saudi Industrialization and Energy Services Company (TAQA) joint venture for expansion of oxygen, nitrogen and hydrogen pipelines (2021)
	Deployment of new-generation public & private transport	Saudi Railway Company & Alstom joint venture for deployment of hydrogen-powered trains by the end of 2023 Deployment of hydrogen-powered buses in key economic areas by the end of 2024 $30M participation in ZeroAvia's Series B to secure the deployment of 40-80 zero-emission aircrafts in the country by 2030
	Creation of urban support infrastructure	ENOWA (NEOM) & Air Products Qudra MoU with the Royal Commission for Jubail for the establishment of a hydrogen refuel centre
	Creation of dedicated CCUS hubs	Saudi Aramco's CO_2 CCUS hub in Hawiyah
Improving the logistics for production and storage of alternative fuels	**Construction of large scale production facilities to satisfy demand**	Development of the $5B Helios green hydrogen plant, targeting 650 tons of production per day (fully operational in 2026) Discussion around the introduction of 17 GW of nuclear capacity by 2040 for the production of pink hydrogen
	Novel storage technologies deployment	Construction of a cryogenic hydrogen tank with a 3150m3 storage capacity by Cryospain Agreement for hydrogen fuel cells production between Saudi Rails Company and Princess Noura University
Establishing adequate regulations for adoption of clean fuels	**National & international strategies for mass adoption**	Saudi Arabia's National Strategy for Circular Carbon Economy (CCE) & regulatory strategy for CCUS Finalization of Hydrogen National Strategy to attract $36B investments by 2030
	Public incentives for adoption and ecosystem development	Subsidies for captured CO_2, government grants & direct investments in CCUS projects

3.
Sustainable food systems: Delivering food security and healthy nutrition

The United Nations has identified three important challenges across our global food systems to be addressed in the next decade: eradicating hunger, producing more food with fewer resources and feeding ourselves more sustainably.

The world's population is expected to grow from 7.3 billion people to 9.8 billion people by 2050. As a result, global food production will need to increase by more than 70% with just 5% more agricultural land available.
The food and agriculture industry is at a crossroads. How can the world's oldest sector balance continuous growth and depleting resources? How can it convert the current 26% of global greenhouse gas emissions it produces into nutrients? How can extensive habits tend to nutrition and food safety for all?

45%
Of the world's agricultural land is subject to continuous or frequent drought[1]

Three major trends are answering the challenges of the future of food and agriculture:[1,2]

Alternative ingredients are receiving increasing interest to reduce global land and resources use. Companies in the field are leveraging several technologies, such as synthetic biology, precision fermentation and advanced chemistry.

Because of its high impact, the meat sector was the first tackled through **cell-based meat**. For instance, Aleph Farms already commercialises lab-grown beef products. However, strong technical barriers persist, such as the use of foetal bovine serum as a nutrient medium, and non-animal alternatives need to be developed.

The use of synthetic biology also drives the development of **biomanufactured ingredients**. Companies use native or genetically engineered organisms with bioinformatic platforms (Protera) and source nutrients from organic waste or even CO_2 (Solar Foods) to produce functional ingredients for the industry.

Overall, high cost barriers linked to bioreactors, scaling and energy use are currently hindering the development of such products.

Precision farming which aims to minimise the use of resources and limit waste and pollution through digital technologies, automation and biology.

In order to adapt to increasing extreme conditions, drought and disease-resistant crops are being selected, thanks to the automation of field data collection. For instance, Phenospex provides high throughput phenotyping, thanks to their automated imaging and sensors technologies, and companies like NAPIGEN are using gene editing to develop hybrid crops with increased yield.

Companies like Greeneye Technology use embarked computer vision technology to use the right amount of chemicals in the field.

Such new technologies require high internet bandwidth in remote areas and farmer adoption, both of which represent a key challenge today.

Regenerative agriculture which will allow soils to recover (density, health, biodiversity, etc.) and will result in improved water cycle, carbon drawdown and limited nitrogen pollution.

A first group of companies are focusing on biocontrol, which aims to maximise yield without using chemicals. Some are using bacteria-eating organisms, such as EcoPhage, or pheromones to drive insects, such as Agriodor, or even RNAi to "turn off" specific genes in pests, such as AgroSpheres.

Then, a whole class of companies are rejuvenating soils through carbon and pollutant sequestration, such as Living Carbon, and are introducing benefitting organisms, such as Pivot Bio and their nitrogen fixing bacteria.
Monitoring and improving the efficiency of these practices is still an ongoing key challenge.

1. Building more drought-resilient crops through science, University of Adelaide Newsroom, 2021
2. The Business Research Company report, 2023

3. Deep dive on precision farming

Initiatives such as the National Center for Vegetation Cover Development and Combating Desertification (NCVC) are driving the adoption of innovative farming practices

Opportunities	Key levers	Saudi Arabia
Developing hardware & software for sensors and autonomous machinery	**Advanced computing infrastructures**	Strategic partnership with Saudi Excellence Co. and Cloudsky (2023) Establishment of the Cloud Computing Special Economic Zone (2023)
	Machinery with embarked and interoperable sensors	Dedicated research from Sensors Lab at KAUST
	Energy harvesting & connectivity (field & urban)	Discussions of renewables for vertical farming
	Regulations for data ownership	The New Telecommunications and Information Technology Act brings general guidelines (2022)
Selecting and breeding resistant crops	**Forward-thinking regulations for GMOs**	Follows Gulf Standardization Organization Allows importation of genetically-modified plant products only (to be labelled if they contain over 1% of genetically-engineered ingredient)
	Bioinformatics capacities including phenotype and genotype database	Centre for Desert Agriculture at KAUST Vegetable crop breeding and improvement at KSU
	Speed breeding facilities	Speed breeding programme at KAUST
Increasing adoption from farmers and consumers	**Dedicated centre of governmental body**	Precision Agriculture Research Chair (PARC) at KSU
	Development initiatives for farmers	Saudi Agricultural Development Fund for financial support in implementation
	Large scale initiatives from public or public-private partnerships	National projects such as Red Sea Global, NEOM Vertical farms (Nadec and Pure Harvest Smart Farms, or the Public Investment Fund and AeroFarms)

4.
Resilient cities: Building sustainable, intelligent and liveable cities

Estimations suggest that urban areas are accountable for a significant 75% of global CO_2 emissions, with transportation and building sectors emerging as principal contributors to this substantial figure.

These numbers are projected to rise with the increase in global urbanisation. Indeed, urban areas are currently home to 55% of the global population, a percentage predicted to rise to 68% by 2050. This forecast implies that the ongoing urbanisation trend - the steady migration of the human population from rural regions to urban settings - along with the overall global population growth could contribute to an additional 2.5 billion individuals in urban territories by 2050.

68%
Of the world's population should live in urban areas by 2050[1]

Three major trends are changing the way we will live in cities in the future:[1,2,3]

Improved construction methods and materials will reduce the sector's carbon footprint while providing buildings adapted to a changing climate.

Cement and concrete are some of the top emitting industries and are not being adapted to the extreme temperatures. Some companies are trying to develop low-carbon and insulating alternatives, such as BioZeroc's carbon-negative concrete harnessing biotechnology and wastes, and circular, acoustic and thermal-insulating building materials, such as Mykor.

The use of connected sensors, IoT and smart materials is also developing to optimise heating and cooling as well as to anticipate logistics and maintenance needs in order to decrease operational costs of construction. A company like Cover provides a suite of built-in furniture and housing products that allow for complete autonomous and smart living.

However, despite mature technologies, alignment on standards due to national and international disparities impedes proper scaling and adoption, especially for new construction materials.

Hubs of the future will answer last mile delivery, traffic and pollution issues, thanks to autonomous fleets, smart traffic management softwares and digital technologies.

Artificial intelligence software is being developed to allow for connected and autonomous vehicles (CAVs) to reach the market. Companies like VisualARise are improving safety and autonomy, thanks to MEMS sensors which are able to produce near-instant 4D representations of their surroundings.

Others are leveraging the air space, such as Lilium's vertical take-off and landing jets or Meituan's drone delivery services.

However, a large-scale adoption of CAVs and other transportation means will require international coordination and modernisation of infrastructure, which is a key challenge in cities.

Sustainable utilities are expanding to provide the necessary services (water treatment, energy distribution, etc.) for growing cities.

Circularity of goods and resources, such as water in dense cities, is a strong need. Oxyle provides a decentralised wastewater treatment technology based on proprietary nanocatalysts that can eradicate most micropollutants to below the average detection level.
However, advancements in utilities are yet to be fully scaled, as common creation and sharing of value clashes with existing practices.

Eventually, smart energy grids and software are needed to match production and demand in real-time. IBM or Atos can provide their infrastructure and computing capacities directly to public entities while companies like Ionate will bring upgraded transformers based on magnetic materials for improved grid stability.
Shifting power grids requires upgrade of physical and digital infrastructures, heavily affecting countries with a rapid expansion.

1. 68% of the world population projected to live in urban areas by 2050, says UN, UN, 2018

4. Deep dive on hubs of the future

Accelerated by new construction projects, many smart infrastructures are being deployed to build futuristic mobility and logistics hubs

Opportunities	Key levers	Saudi Arabia
Developing adequate hardware and software	**Advanced computing infrastructures**	Riyadh is the 3rd Smartest Capital of G20 Member States on IMD Index of Smart Cities[1] Establishment of the Cloud Computing Special Economic Zone (2023) Oracle partnership for cloud and information computing. Backed with MCIT's $18B Data Centre Plan (2020)
	New sensing capacities	Dedicated research from Sensors Lab at KAUST Riyadh Urban Observatory implemented by Royal Commission for Riyadh City (RCRC)
	Connectivity advancements	5G and FTTH Network Adoption and Expansion Plan with the Saudi Vision Cable Signed MoU with Huawei for AI and 5G More than 150,000 streetlights already controlled in Saudi Arabia by the inteliLIGHT smart street lighting
Ensuring national-scale implementation	**Autonomous driving legislation**	Partnership with EasyMile for establishing comprehensive regulations for autonomous driving in Saudi Arabia
	Public resources allocated (budget and measures)	Smart Government Strategy and National Transport and Logistics Strategy Tonomus by NEOM as cognitive city national project 15% of public transport vehicles expected to be autonomous by 2030 $160B allocated by the Ministry of Transport to help the country transform and improve its transportation infrastructure
	Large-scale connected mobility projects (public or public-private)	Riyadh Metro and Riyadh Rapid Bus Transit System 22 projects worth over $134B through Vision 2030 International cooperation fostered such as hydrogen train with Alstom and 360 Mobility Plan with RATP Dev

1. MCIT News, "Riyadh" 3rd Smartest Capital of G20 Member States

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