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TECHNOLOGY

**How is ADNOC Turning the
Technological Tide to Drive Decarbonization?**

Executive Summary

From stone tools millennia ago to the marvels of artificial intelligence today, technology plays a pivotal role in our ability to evolve. This bond is getting dramatically stronger amid the energy trilemma – a paradigm shift which affects every one of the 8bn people on the planet, as well as its ecological systems. The need to simultaneously meet rising energy demand, support the climate agenda, and deliver continued economic growth means the stakes have never been so high. Climate technologies are the urgently needed relief valve on this pressure cooker and ADNOC is determined to stay at the cutting-edge of innovation to support the UAE and beyond – **by creating innovations, not just using them.**

Source: Gulf Intelligence researched, wrote, and produced this Special Report with interviews arranged by ADNOC and market insights. Any further use of this material must cite Gulf Intelligence and the full title of the report.



Moving the needle once is not easy; moving it continuously is extraordinarily difficult. However, the UAE is committed to doing just that. Years of proactive R&D and delivering on ambitious roadmaps – well before decarbonization was in daily news headlines – means the nation is now fast emerging as the regional hub and global influencer for climate technology. Such unique foresight will be highlighted when the UAE hosts COP28 this November, the world’s biggest annual climate gathering. As His Excellency Dr. Sultan Ahmed Al Jaber, Minister of Industry and Advanced Technology, COP28 President-Designate, Chairman of Masdar, and the Managing Director and Group CEO of ADNOC, said: “Maximum energy, minimum emissions.”

ADNOC has been an engine of innovation in this journey, underpinned by its ethos of always pushing the boundaries. The energy giant’s growing list of first-of-its-kind projects reflects its belief that embedding a culture of positive disruption lies at the core of creating and rolling out climate technologies, both improving existing tools and applying brand new ideas. This proactively protects lives, the environment, and the economy – the ultimate win.

ADNOC chooses to view what some describe as a tsunami of challenges in the trilemma as a treasure box of opportunities. Finding answers to some of the world’s most complex questions will take time and huge reserves of money and talent. Yet those able to pin down solutions – as ADNOC is actively doing, alongside valued partners – will have a far sharper and stable commercial edge as we head farther into the uncharted territory of a rapidly changing climate.



“More than ever, the world needs a practical and responsible approach to the energy transition – one which is both pro-growth and pro-climate. ADNOC is delivering tangible actions in support and will fast-track significant investments into landmark clean energy, low-carbon, and decarbonization technology projects.”

His Excellency Dr. Sultan Ahmed Al Jaber, Minister of Industry and Advanced Technology, COP28 President-Designate, Chairman of Masdar, and the Managing Director and Group CEO of ADNOC

ADNOC plans to keep exploring every innovation possible – a journey of discovery baked into its DNA for decades (see page 5: *Linchpin of positive disruption*). There is often a misconception that this means deploying the newest and shiniest technologies. While there is great value in seeking novel solutions, many of the most impactful deployments come from technologies that have

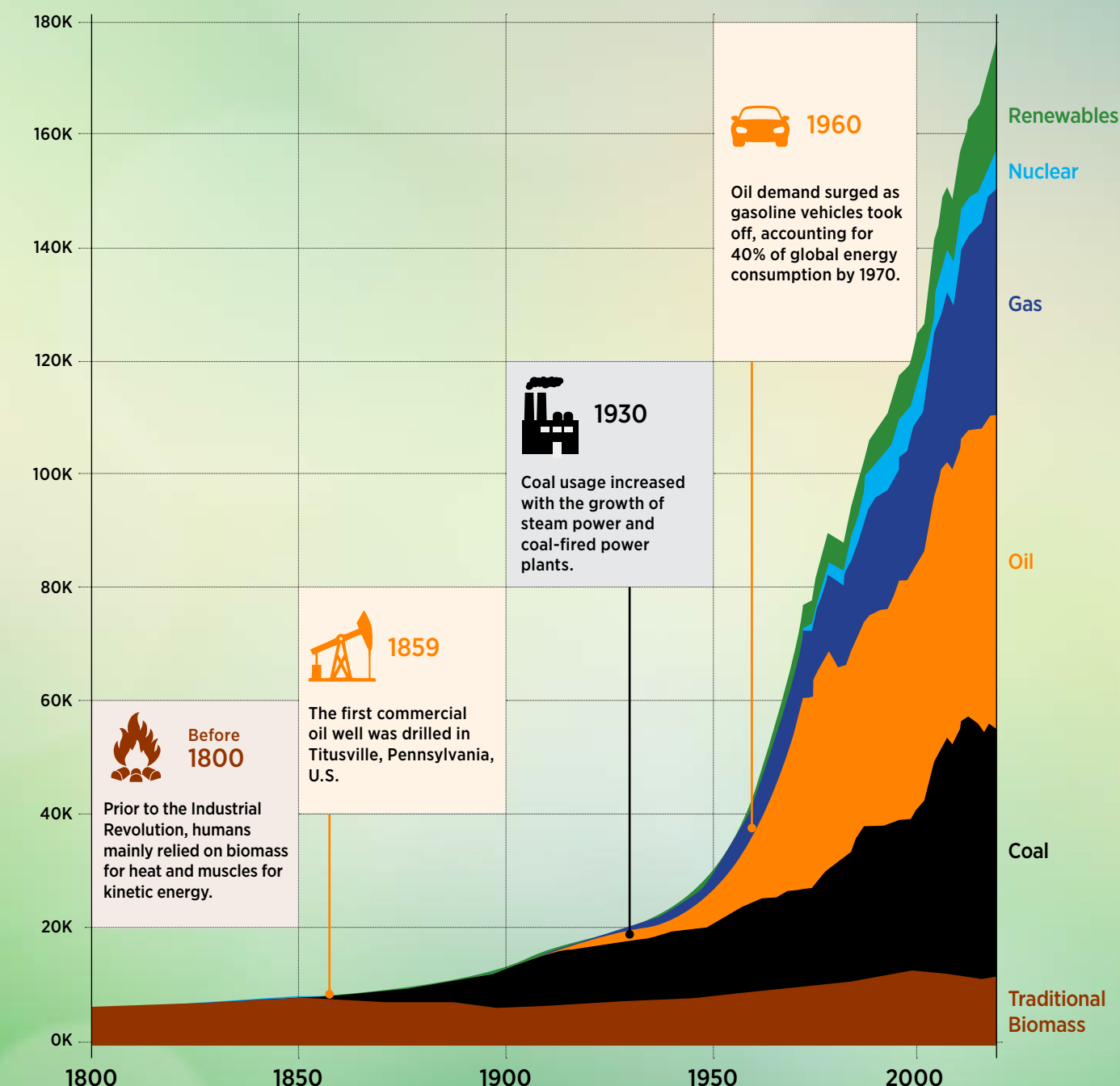
been proven to work elsewhere. For instance, ADNOC is nearing the completion of a \$600mn waste heat recovery project at ADNOC Refining’s power and water plant in Ruwais. This is not a new technology, yet it will produce an extra 230MW of electricity a day and 62,400 cubic meters of distilled water a day – without incurring any further greenhouse gas (GHG) emissions.

The Energy-Tech Nexus since 1800

Here’s how the global energy mix has evolved over the last 220 years, spurred by advances in technology.

GLOBAL PRIMARY ENERGY CONSUMPTION BY SOURCE 1800-2020

Terrawatt-hours (TWh)



Source: World Economic Forum

Linchpin of positive disruption

\$15bn

is what ADNOC has earmarked for landmark decarbonization projects by 2030, including carbon capture, electrification, new CO₂ absorption technology, and enhanced investments in hydrogen and renewables.

2050

is when ADNOC – one of the world's biggest energy companies – plans to achieve Net Zero.

7yrs

left for ADNOC to achieve its goal to reduce its carbon intensity by 25%.

1st

The successful completion of ADNOC's AI Reyadah CCUS facility in 2016 – the region's first commercial-scale CCUS facility – marked an important milestone in the UAE's decarbonization journey.

100%

Since January 2022, ADNOC has received all its grid power supply from Emirates Water and Electricity Company's (EWEC) nuclear and solar energy sources – making it the first major company in the industry to decarbonize its power at scale through a clean power agreement of this kind.

\$3.8bn

deal will enable ADNOC to build a first-of-its-kind sub-sea transmission network in the Middle East and North Africa (MENA) – potentially cutting ADNOC's offshore carbon footprint by 50%.

\$38bn

has been driven back into the UAE's economy by ADNOC's In-Country Value (ICV) program since 2018. Plus, ADNOC is galvanizing potential for local manufacturing to ensure more innovation and ICV in this field: strengthening its supply chain, investing in uplifting the local workforce, and increasing the country's intellectual property (IP).

UAE moves center stage

1st

nation in the Middle East to declare a Net Zero target, specifying 2050 when other major energy economies set 2060 deadlines.

#2

The UAE is hosting COP28 this November – the world's biggest annual climate gathering – following COP27 in Egypt last November. This marks the first time a COP has been held consecutively in MENA and can help galvanize technologies that particularly support emerging economies.

\$163.5bn

is what the UAE is investing in clean and renewable energy projects over the next three decades as it aims to achieve Net Zero by 2050.¹

\$20bn

is being allocated by the UAE and the US to fund 15 new gigawatts of clean and renewable energy projects in the US by 2035 – the first wave of investment in their \$100bn clean energy partnership.²

31st

is the UAE's overall ranking in the Global Innovation Index (GII) 2022³ – an impressive score for a nation which has only just celebrated its 52nd year of independence.

3rd

is the UAE's ranking in the GII 2022 for ICT access – fundamental to spurring technological innovation and learnings – and 7th for global brand value,⁴ key to continually attracting coveted investors.

Sources: ¹ The National; ² The National; ³ Global Innovation Index (GII) 2022; ⁴ GII 2022.

Global rethinks

#1

Investment in low carbon technologies reached parity with capital deployed in support of fossil fuel supply in 2022.¹

2022

saw investment in the low carbon energy transition total \$1.1trn – a record high.²

\$10trn

global energy bill was forecast for 2022,³ primarily due to the Russia-Ukraine war – an unsustainable dynamic for billions of people. Effectively using technologies for energy efficiency, for example, can dramatically reduce this bill.

1.1%

growth in the share of renewables in the global energy mix between 2000-2010 – at a time when solar and wind power were not very cost-competitive – shows how imperative the rise of affordable and scalable technologies are to sparking major change.⁴

\$1.4trn

of clean energy investments in 2022 means that such support has been growing at an average rate of 12% since 2020⁵ – starkly correlated to the dramatic reduction in the cost of solar and wind power generation in recent years.

200yrs

Technological innovations are the biggest drivers of the five energy transitions over the last two centuries,⁶ including the latest push to cleaner energy.

2015

The spend in renewable energy differs greatly across the globe. Spending rates in emerging and developing economies – bar China, the world's second biggest economy – are eight years behind developed nations.⁷ Technologies are vital to levelling the landscape.

1859

was when Edwin L. Drake built the first commercial oil well in Pennsylvania.⁸ It was scalable technology that enabled this small project to evolve over the decades into a market which has played a fundamental role in the maturation of the global economy – and is the beating heart of the UAE's astonishing growth over the last two decades.

Sources: ¹ BloombergNEF; ² BloombergNEF; ³ International Energy Agency (IEA); ⁴ World Economic Forum (WEF); ⁵ WEF; ⁶ WEF; ⁷ WEF, IEA; ⁸ Britannica.



Taking the reins

Explore every technology possible to drive value, ensure efficiency, safety, and sustainability – that is ADNOC's focus as a world-leading climate innovator. Meeting the extremely high demands of the global energy trilemma calls for nothing less. ADNOC has pledged to cut its carbon intensity by 25% in a very short seven years and reach Net Zero by 2050, an even more challenging goal. Reaching these targets while boosting its oil production capacity to 5mn b/d by 2027 – three years earlier than the initial 2030 target – highlights ADNOC's ability to thrive in the trilemma. Supporting energy security while achieving the least carbon intensive barrel, as well as growing investments in lower carbon energy through its shareholding in Masdar, is no small feat.

50%

rise in global energy demand this decade, so ADNOC's pioneering work in reducing the carbon intensity of every barrel lays a valuable framework for other companies and countries to follow.¹

50%

increase in global energy use is anticipated by 2050² – the same time as the world needs to reach Net Zero.

40%

of global CO₂ emissions are generated by the energy industry.³ While critical to preserving stability, energy stakeholders must also take urgent steps to better utilize technologies to cut their environmental impact.

89%

of GHG emissions from the energy sector come from energy combustion and industrial process, hence the urgent focus on using technologies to understand and address carbon intensity measurements.⁴

2mn b/d

rise in global oil demand this year will see the world's total demand reach a record high of 101.9mn b/d.⁵

x3

Annual clean energy investment worldwide must more than triple by 2030 to around \$4trn for the world to have a chance of reaching Net Zero by 2050.⁶

Sources: ¹ International Energy Agency (IEA); ² Energy Information Administration (EIA); ³ World Bank; ⁴ IEA; ⁵ IEA; ⁶ IEA.



Every technological option is on the table, backed by \$15bn which ADNOC has earmarked for landmark decarbonization projects up to 2030. Carbon capture, electrification, new CO₂ absorption technology, and enhanced investments in hydrogen and renewables are all on the priority list as the energy leader plays its part in propelling a diversified energy basket. A cookie cutter approach to technology creation will not work. ADNOC will continue to build its ecosystem of partners based on the operational needs of its businesses, leading to tailored and highly effective relationships – a cornerstone of the company’s global reputation.

“Children always ask why; something we must do much more of. As an industry, we need that curiosity, both independently and within partnerships, to figure out the next steps in the energy transition. We must always ask: how can we do better?”

Sophie Hildebrand, Chief Technology Officer, ADNOC

“As we continue to transform our business, we invite technology and industry leaders to partner with us – to collectively drive real and meaningful action that embraces the energy transition. This strategic, multi-billion-dollar initiative underscores our leadership as a global provider of lower carbon energy,” shared

His Excellency Dr. Sultan Ahmed Al Jaber, Minister of Industry and Advanced Technology, COP28 President-Designate, Chairman of Masdar, and the Managing Director and Group CEO of ADNOC.

An ethos of delivery and transparency must be woven into the DNA of every partnership. Amidst a myriad of information



surrounding the energy transition, being able to have frank and open conversations with new partners is paramount. The climate change clock is ticking too fast for circuitous conversations, twisted in bureaucratic red tape. Teams can work openly together to create valuable new technologies, or significantly improve the application of existing ones, without jeopardizing sensitive IP.

Being able to deliver is equally vital. Many corporate promises are being made in today’s ever-shifting landscape, affecting schedules and budgets. Of course, this is accepted as ‘business as normal in abnormal times’ to a degree, but overall reliability is imperative to enabling ADNOC to move with speed and certainty.

“Understanding what companies

– big or small – have done elsewhere and how they have tackled kinks in the system is essential to any potential or existing cooperations. There may be new kinks as we work together, but having that proof of concept saves a lot of crucial time,” said Sophie Hildebrand, the Chief Technology Officer at ADNOC.

ALL SHAPES AND SIZES

Larger partners like Baker Hughes, NOV, Honeywell, SLB and others bring a wealth of industry knowledge and experience – all excellent partners who support ADNOC’s dual journey of stability and ambition.

In a show of the power of togetherness, ADNOC and Abu Dhabi National Energy Company (TAQA), joined Mubadala as



8yrs

The UAE’s ‘Make it in the Emirates’ program is central to the country’s strategy to double the contribution of the industrial sector to its GDP to \$81bn by 2031.

23

agreements were signed between ADNOC and UAE and international companies in March this year for local manufacturing opportunities across a wide range of critical industrial products, worth \$4.63bn.

100+

ADNOC has committed to locally manufacture more than one hundred products in its procurement pipeline by 2030, worth \$19bn.

2.8x

growth in the global demand for reinforced thermoplastic pipelines (RTP) is expected by 2026, reaching more than 40,000km – equivalent to circling the globe. ADNOC hopes to help spur its local manufacturing ecosystem in this space.

20

global suppliers of RTP products worldwide have a combined capacity of 5,000km, which means there is plenty of room for ADNOC’s manufacturing ambitions.

2.6mn

mangrove seedlings will be planted across Abu Dhabi by ADNOC as it uses innovative drone technology, as part of the company's commitment to plant up to 10mn mangroves across the Emirate by 2030. This forms part of the UAE's goal to plant 100mn mangroves within seven years.

2,000

seeds can be planted in just eight minutes using drones. Mangroves can provide a living defense against the impact of climate change, by preventing erosion, stabilizing Abu Dhabi's coastlines, and enhancing biodiversity.



shareholders in Masdar, the Emirate's flagship clean energy company and technology innovator. Already, Masdar is active in more than 40 countries across six continents and has developed and invested in worldwide projects with a combined value of over \$30bn – making it a coveted ally in ADNOC's technological evolution (see page 23: *Energies of the future: Boosting predictability*).

Plus, ADNOC Logistics & Services unveiled its Integrated Logistics Services Platform (ILSP) this year, marking one of the largest turnkey offshore logistics offerings in the world. The enhanced efficiencies

“Increasing manufacturing locally is a win-win and there is everything that companies need here in the UAE. It's good for the workforce, it's good for the community, and it's good for shrinking carbon footprints as products aren't being shipped and flown across the world as frequently.”

Sophie Hildebrand, Chief Technology Officer, ADNOC

of this end-to-end management of logistics and maritime operations will help trim CO₂ emissions and again see more than 80% of the \$2.6bn contract value flow back into the UAE's economy.

Efforts to reduce the CO₂ impact of assets while bolstering

efficiency and output extend overseas, such as ADNOC's private technology innovation endeavor with TWI and Saudi Aramco Technologies Company (SATC) to form the Non-metallic Innovation Centre (NIC) in the British city of Cambridge.



What's next?

There is great potential for solar and battery-based technologies to help decarbonize field operations in remote areas that are not connected to the national grid. ADNOC is currently working with a company to produce a battery energy storage system using recycled second life batteries from electric vehicles (EVs). There is also a growing demand for autonomous and semi-autonomous devices to operate across energy companies' assets. Things like aerial drones (see left), land-based robots, and underwater inspectors have recently been piloted across the company's sites with much success. They serve to protect workers from hazardous situations and generally lower GHG emissions through better inspection procedures. Many local companies, such as EDGE, are excelling in this field and more growth is anticipated as the UAE encourages local manufacturing hubs.

NIMBLE ALLIES

Joint interests are far from limited to the most powerful plays in energy and tech. The smallest innovators can also have great impact, so small and medium-sized enterprises (SMEs) and entrepreneurs are very much in ADNOC's line of sight. In another 'first', ADNOC announced a project with the Fujairah Natural Resources Corporation (FNRC), Masdar, and 44.01 to pilot carbon capture and mineralization (CCM) technology within rock formations found in Fujairah – the first CCM project by an energy company in

the Middle East. ADNOC is also supporting other energy transition tech start-ups – specializing in batteries made from agricultural waste and direct capture of CO₂ from the air, for example – through its engagement with the TechX Clean Energy Accelerator program.

GREAT MINDS DON'T THINK ALIKE

Highly astute to the challenges ahead, curating an advanced and digitally capable talent pool is non-negotiable. The ADNOC Research and Innovation Center (ADRIC) has recently relaunched, serving as a

dedicated hub for R&D efforts to advance technologies relating to digitization, data analytics, robotics, and sustainable production, among others. ADNOC also supports a range of academic institutions in the UAE, such as the Mohammed Bin Zayed University for Artificial Intelligence (MBZUAI) and Khalifa University, with relationships extending beyond the UAE's borders to places like the University of Manchester in the UK – one of the world's leading R&D centers for graphene.

Source: ¹ MEED

But why?

We are all creatures of habit, but the energy trilemma means we must be more open to change. Agility is paramount. ADNOC is home to approximately 50,000 employees, as well as connections to hundreds of thousands of employees via its joint ventures and even more in its community of customers. Each individual is a mini hub of ideas, experiences, and skills. Instilling a culture which encourages constant questioning across this in-house reservoir of intellectual bandwidth immediately creates an invaluable sounding board. Our learning never ends and so the more we share – be it mainstream or off-piste – the faster we can build a troubleshooting ecosystem which solves problems far faster. Speed is essential; the very present threat of climate change means the Intergovernmental Panel on Climate Change (IPCC) has issued a 'survival guide for humanity'.

A true dawn for CCS

As we build the energy systems of tomorrow, we must also make the energy we use today cleaner. The start-stop approach to building a carbon capture and storage (CCS) market since 1972 has truly turned a corner in the last five years – and thankfully, for it is one of the central pillars of decarbonization. ADNOC is front and center of this journey in the Middle East, completing the region's first commercial-scale CCUS project in 2016, a head start in global terms too. For heavy-emitting industries like power, steel, cement, oil and gas, and chemicals, CCS has the potential to radically reduce environmental footprints, capturing more than 90% of CO₂ emissions.¹ Take a moment to consider the magnitude of that data point – on global energy stability, on environmental protection, on economic growth.



Half a century on, appetite to leverage this critical technology to make Net Zero possible is at an all-time high. Global capture capacity of CCS projects in the project pipeline was 244mn metric tons per annum (Mtpa) in 2022 – a 44% climb year-on-year.² The end of 2021 saw approximately 40mn Mtpa captured across 29 operational CCS facilities worldwide, versus 12mn Mtpa

“Accelerating CCS needs two key enablers: the right technology and the right regulatory framework. Overarching both is the partnership mindset – a vision based on mutual ambition and benefit.”

Musabbeh Al Kaabi, ADNOC Executive Director for Low Carbon Solutions and International Growth

from the end of 2015, when only 15 large-scale CCS projects were operational.³ Plus, there are 30

commercially operating CCS facilities, 11 facilities in construction, and 153 in various stages of

development⁴ (consider the latter figure with caution until proverbial spades hit the soil).

Against this increasingly collaborative and competitive backdrop, ADNOC's established customer base and reputation for producing energy at a lower carbon footprint for low cost over a 60-year legacy stands it in good stead. This dynamic

is complemented by the UAE's financial bandwidth – 7.6% growth in GDP in 2022⁵ – and its engineering capabilities, elevated by the 'Make it in the Emirates' ten-year strategy.

AHEAD OF THE CURVE

ADNOC's Al Reyadah project is the Middle East's first commercial-scale CCUS facility. This pioneering

project currently has 800,000 t/yr of CO₂ capture capacity, with ADNOC's plans to drive capacity 500% higher to 5mn t/yr by 2030 across its portfolio of CCUS activity. This extremely ambitious target sets the tone for what others in the UAE, the Middle East, and indeed the world, can achieve. Al Reyadah processes the CO₂ captured

“A responsible producer will ensure it deploys the right technologies under the right framework of procedures with the right monitoring systems – all to ensure security of supply and minimal emissions. It is a delicate balance, which lies at the core of the UAE’s evolving CCS market.”

Musabbeh Al Kaabi, ADNOC Executive Director for Low Carbon Solutions and International Growth

from Emirates Steel Industries, which is then injected into onshore oilfields to safely store the CO₂. ADNOC recently announced the world’s first fully sequestered CO₂ injection project, which forms part of the \$15bn the company has allocated to decarbonizing its assets. Once operational, the project will initially fully sequester a minimum of 18,000 t/yr of CO₂ captured from Fertiglobe’s UAE operations for injection – equivalent to 45mn miles in a vehicle,⁶ roughly the distance to Venus⁷ – in Abu

Dhabi’s onshore carbonate aquifers, supporting ADNOC’s ongoing efforts to safely capture and store CO₂ from its operations. ADNOC used its extensive 3D seismic survey and state-of-the-art subsurface modelling capacity to pin down the best geological formations.

Two other promising CCS pilot projects are also underway. One permanently turning CO₂ into rock as part of a project with the Fujairah Natural Resources Corporation and 44.01 – recent winners of the Earthshot Prize for Climate – to suck

CO₂ from the atmosphere using a direct air capture device. The whole process will be powered by clean energy from Masdar, which effectively makes the pilot carbon negative. While in the early stages, success would be a gamechanger – enabling ADNOC to mineralize billions of tons of CO₂. Building on its commitments in this space, ADNOC has recently joined the REX-CO₂ consortium, a collection of 16 organizations dedicated to sustainably storing CO₂ within existing wells.

500%

increase in ADNOC’s carbon capture capacity is expected by 2030, up from 800,000 t/yr today.

2bn

tons of CO₂ are being removed from the atmosphere each year through human intervention, yet only 0.1% currently comes from CO₂ removal initiatives.¹

30x

increase in the rate of removing carbon from the atmosphere over the next decade to avoid the worst effects of warming.²

1,300x

removal by 2050 – a stark reflection of how much work urgently needs doing.³

90%

of global public spending on energy R&D went to clean-energy technologies, yet the lowest share of that was allocated to technologies relating to CCS, hydrogen, and fuel cells.⁴

10x

more carbon per hectare can be stored by mangroves than terrestrial forests, highlighting the effectiveness of nature-based solutions (which simultaneously support ecological systems).

\$7bn

is the anticipated value of the CCS market worldwide by 2028, climbing by a 19.5% compound annual growth rate (CAGR) from 2021.⁵

27%

Carbon capture is expected to contribute to more than one-quarter of the needed reductions in emissions in the cement, iron, steel, and chemicals industries.⁶

0.15%

is ADNOC’s new upstream methane intensity target by 2025 – the lowest in the Middle East.

16

leading organizations around the world are part of the REX-CO₂ Consortium, which ADNOC recently joined.

Sources: ¹ University of Oxford; ² University of Oxford; ³ University of Oxford; ⁴ International Energy Agency (IEA); ⁵ Fortune Business Insights; ⁶ World Economic Forum (WEF), IEA.

The power of price

CCS projects will need a regulatory framework and incentive program, including pricing, to help invigorate stakeholders’ blueprints, many full of potential. Having a more comprehensive approach to pricing carbon will give producers more license to operate, deepening commitment and in turn, driving accountability and increasing the flow of capital into R&D to make CCS technologies even more efficient and scalable.

For one, the US has introduced significant policies and laws, most notably the Inflation Reduction Act (IRA), which provides enhancements to the 45Q tax credit for CCS. Early analysis suggests the IRA could increase the deployment of CCS by thirteenfold – well over 110 Mtpa – by 2030 compared to existing policy.⁸ Weaving in similar support is key for Middle Eastern nations’ ability to keep pace with global developments. Canada’s 2022 Federal Budget includes a CCUS Tax Credit and the development of a CCUS strategy, the Danish Government has committed \$5.5bn for CCS over ten years, the Dutch Government has more than

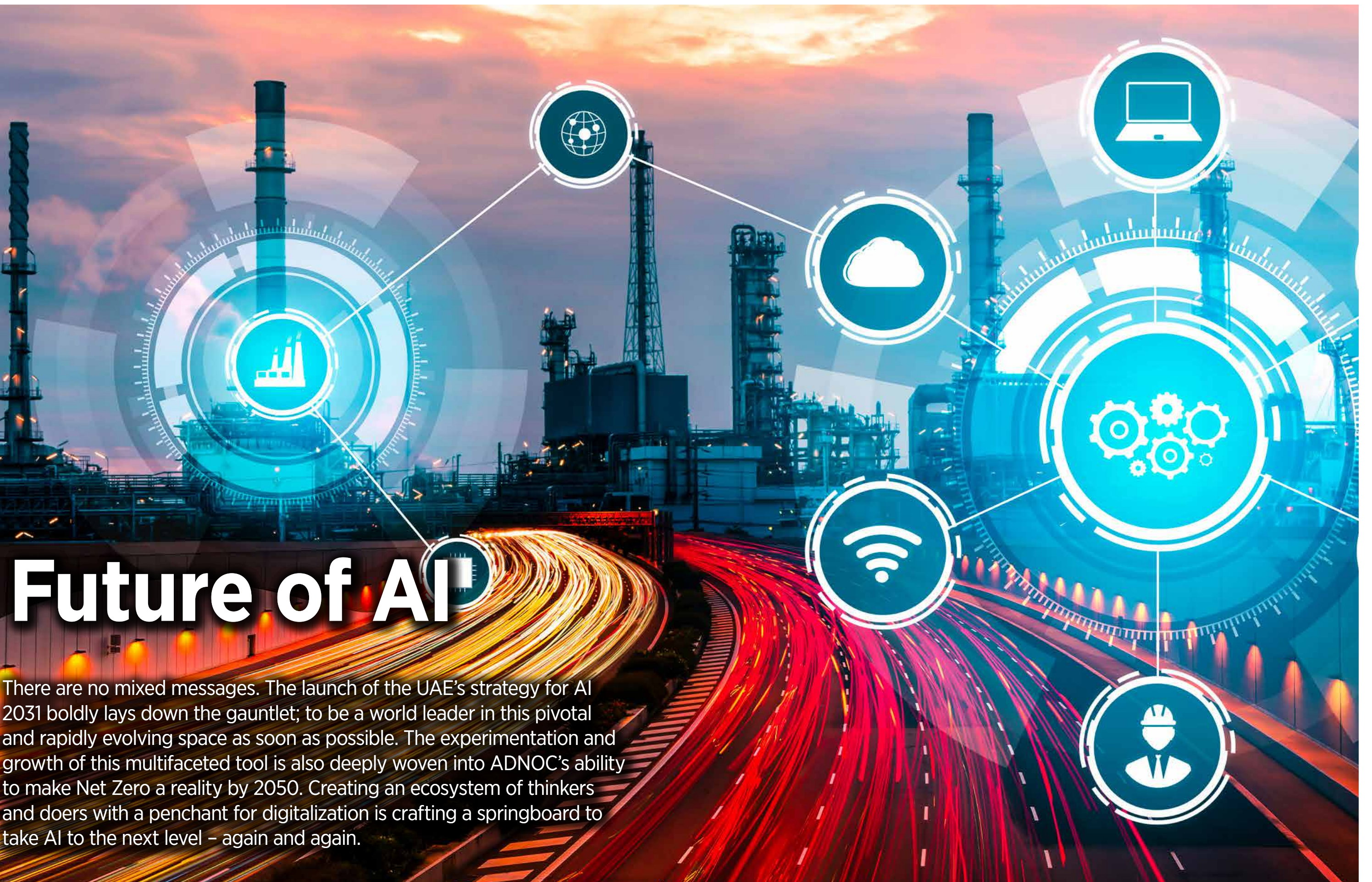
doubled the Sustainable Energy Transition Scheme (SDE++) program since its launch to \$14.4bn, and Poland, Bulgaria, and Finland are entering the CCS market for the first time due to the EU Innovation Fund’s granting program.

In the Asia Pacific region, Thailand announced its first CCS project, China’s first 1mn ton project commenced operations, and Australia saw new project announcements in Victoria and Western Australia, plus notable progress in the Northern Territory.⁹ Such frameworks are imperative, but so is embracing a new style of collaboration – one which runs back and forth throughout the supply chain, evolving away from simple transactions isolated to two or three parties.

For example, technology licensors are sharing amine, a chemical used in carbon capture compositions, with piping and pump suppliers to determine the most fit-for-purpose gaskets to reduce costs. This type of alliance is also yielding innovative solutions that reduce project footprints by 30% and require less material to purchase and install.¹⁰



Sources: ¹ World Economic Forum (WEF); ² Global CCS Institute; ³ S&P Global; ⁴ S&P Global; ⁵ Reuters; ⁶ MIT; ⁷ CalTech; ⁸ Global CCS Institute; ⁹ Global CCS Institute; ¹⁰ WEF.



Future of AI

There are no mixed messages. The launch of the UAE's strategy for AI 2031 boldly lays down the gauntlet; to be a world leader in this pivotal and rapidly evolving space as soon as possible. The experimentation and growth of this multifaceted tool is also deeply woven into ADNOC's ability to make Net Zero a reality by 2050. Creating an ecosystem of thinkers and doers with a penchant for digitalization is crafting a springboard to take AI to the next level – again and again.



Cutting through the noise is an integral part of UAE's reputation on the global energy stage – and AI is no different. Major steps are being taken to become a digital icon, with the UAE tackling this chapter of AI with the same vigor that enabled it to rise to the pinnacle of energy markets and become home to one of the globe's highest rates of GDP.¹ “We want the UAE to become the world's most prepared country for AI,” said His Highness Sheikh Mohammed bin Rashid Al Maktoum, UAE Vice President and Prime Minister and Ruler of Dubai. This ambitious tone is fast filtering through to the national workforce. Engineering employees in the UAE expect AI to be the most important industry by 2025 and

“AI models are generating significant value for the energy industry – not only delivering cost savings, but also operational efficiencies and enhancing safety, creating a win-win situation for the industry.”

Omar Al Marzooqi, CEO, AIQ

again in 2030² – coming ahead of design engineering, construction, aerospace, IT, cybersecurity, robotics, environmental science, and others. AI is a linchpin of growth in these other sectors; the more AI matures, the more potential they have. Importantly, AI has the potential to be a pivotal solution in addressing climate change mitigation and adaptation challenges by optimizing energy consumption, enhancing climate

modelling, and enabling smarter decision-making for sustainable practices across various sectors.

PIONEERING EVOLUTION

Proof of ADNOC's early dedication to innovating AI lies in the numbers. More than \$1bn in value was achieved by 2020 with its Panorama Digital Command Center initiative, for example. This was well before the energy trilemma came to the

fore, meaning this large energy company can flex far more easily to increasingly unpredictable market dynamics today. Panorama helps ensure business continuity by enabling real-time decision making through secure remote access to data and analysis across ADNOC's value chain. It aggregates information across ADNOC's 14 specialist subsidiary and joint venture companies and uses smart analytical models, AI, and big data to generate operational insights and recommendations. This initiative is one of many digital transformation initiatives by ADNOC to embed cutting-edge technology across its entire value chain and deliver on its Oil & Gas 4.0 mission to stay ahead of the world's growing demand for energy.

Just one year later, ADNOC's Thamama Center generated \$1.1bn in value enabled by advanced technology and digitalization in 2021. This Center enables ADNOC to integrate AI, advanced analytics, and cloud computing into its reservoir management and subsurface workflows to enhanced oil recovery (EOR) and improve

production efficiency by more than 10%. ADNOC is working on over 15 new digitalization projects in Thamama that offer the potential to deliver around \$500mn in additional value per year when they are fully deployed over the coming years.

Plus, ADNOC and Honeywell embarked on one of the largest predictive maintenance projects in the oil and gas industry, with the partnership agreement stretching from 2019-2029. This sees ADNOC utilizing Honeywell's state-of-the-art asset monitoring and predictive analytics platform to maximize asset efficiency and integrity across ADNOC's upstream and downstream operations, leveraging AI technologies like machine learning and digital twins. Critically, this helps predict equipment stoppages, reduce unplanned equipment maintenance and downtime, increase reliability and safety, and enable substantial cost savings for ADNOC – all of which supports the company's 2030 smart growth strategy. Other innovations that leverage digitalization are reflected in the creative and rapid work by

AIQ (see page 22: Case study).

HOLISM WORKS

Developing AI is not a box ticking exercise. A radical transformation in data acquisition, transmission and cloud storage and computing capabilities is required across industries – particularly in the energy sector to realize a strategic transition into cleaner energy. A central part of this transition is integrating AI software tools into the energy sector to streamline efficiencies across operations, maximize production, and minimize carbon emissions. Accordingly, AIQ was launched in 2020 as a joint venture by ADNOC and G42, an Abu Dhabi-based AI and cloud computing company. Over the last three years, AIQ has focused on identifying pinchpoints in the energy industry by talking to operators and being ‘close to the action’ along the entire supply chain to create bespoke AI solutions that support energy and industrial operational strategies. These are not blueprints, but real and scalable ideas that are meeting customers' KPIs (see more: Use Cases).

2023

will see spending on AI in the Middle East and Africa (MEA) reach \$3bn.¹

#1

MEA will see the fastest growth in the rate of spending worldwide over the coming years.²

29.7%

CAGR in MEA's spend on AI is expected from 2022-2026, reaching \$6.4bn in 2026.³

\$2trn

is the anticipated value of the global AI market by 2030, growing nearly twentyfold on current levels.⁴

Sources: ¹ International Data Corporation (IDC); ² IDC; ³ IDC; ⁴ Statista; ⁵

2017

saw the government's launch of the UAE Strategy for AI 2031, which aims to position the country as a global leader in this rapidly evolving field within eight years.

1st

The UAE appointed Omar Bin Sultan Al Olama as the country's Minister of State for AI in 2017 – the first such appointment worldwide.

20%

The digital economy will contribute one-fifth to the UAE's non-oil GDP by 2031, up from 11.7% today.⁵

#1

Founded in 2019, Mohamed bin Zayed University of Artificial Intelligence (MBZUAI) in Abu Dhabi is the only graduate-level university in the world singularly developing AI tools.

UAE's Vision for AI 2031

1. Build a reputation as an AI destination
E.g. UAE brand.

Leadership

2. Increase the UAE's competitive assets in priority sectors through deployment of AI.
E.g. proof of concept in priority sectors.

3. Develop a fertile ecosystem for AI.
E.g. Applied AI accelerator.

4. Adopt AI across government services to improve lives.
E.g. National AI challenges.

AI activity

5. Attract and train talent for future jobs enabled by AI.
E.g. Public AI basic training.

6. Bring world-leading research capabilities to work with target industries.
E.g. Key thinkers program.

7. Provide the data and supporting infrastructure, essential to become a test bed for AI.
E.g. Secure data infrastructure.

8. Ensure strong governance and effective regulation.
E.g. Intergovernmental panel on AI.

Foundation

"AIQ's innovative AI technology is at the forefront of driving the transition to a more sustainable future. With a focus on reducing the energy sector's carbon emissions and environmental impact, we are making significant progress towards achieving the UAE's commitment to Net Zero Carbon by 2050."

Omar Al Marzooqi, CEO, AIQ

This proactive tone of cooperative brainstorming is continually reinforced from the top-down. For one, the UAE Council for Artificial Intelligence and Blockchain is tasked with proposing policies to create an AI-friendly ecosystem, advance research in the sector, and promote collaboration between the public and private sectors, including international institutions. The UAE Government also launched the Coders HQ, a transformational project that re-defines local coding communities, in partnership with more than 40 companies in the UAE and worldwide. Plus, Abu Dhabi's

global tech ecosystem, Hub71, focuses on building globally enduring homegrown tech companies. Creating a symbiotic environment between start-ups, corporates, government, and investors is very much the heartbeat of Hub71's progress.

WE ARE WHAT WE THINK

AI is not about technology and numbers; it is about people. Without doubt, it will not reach its full potential without investing in changing how we think – creatively and critically. Any companies missing this decisive link in the evolution of AI risk seeing their proverbial house of cards collapse.

In the UAE, the pipeline of talent for AI is taken very seriously.

For example, Mohamed bin Zayed University of Artificial Intelligence (MBZUAI) in Abu Dhabi celebrated its inaugural commencement this year with 52 students from 24 countries – equivalent to more than 10% of the nations on earth – receiving post-graduate degrees in the key AI fields of computer vision and machine learning.³ At commencement, more than half (63%) of the inaugural class had confirmed employment, PhD placements, paid internships, or launched start-ups. That 91% of the graduates will remain in the UAE

reflects how the government has created an appealing workplace and avoided 'brain drain' – a threat to many nations' ability to curate their own AI technology and IP.

Inspiring the next generation of AI experts is not a nice-to-have; they are urgently needed thinkers, fundamental to finding answers amid the glut of questions posed by the global trilemma. Their indispensable focus on solving

"For our AI systems to work, collaboration is vital – no one is a master of everything. We need the input of every key stakeholder to achieve a desired impact."

Ghanim Hableel, Data Science & Sustainability Lead at AIQ and a PhD Candidate at Columbia University

real-world national and global challenges carries great meaning across many sectors, including

energy, healthcare, transport, logistics, environment, smart cities, manufacturing, and fintech.⁴

Sources: ¹Worldometer; ²UK-based Institution of Engineering and Technology (IET), The National; ³PRNewswire; ⁴Arabian Business

USE CASES

Using data to achieve positive disruptions is the best chance we collectively have of reaching Net Zero by 2050. Accordingly, AIQ focuses on developing AI tools that have a real and measurable impact: boosting efficiency, streamlining impact, and reducing CO₂ emissions.

For one, AIQ has invented a web-based AI-powered machine learning approach to provide the next generation of reservoir characterization and management tools for Borehole Image and Thin Section interpretations. An assessment which used to take weeks now takes minutes. This also reduces the high risk of human error and enhances the ability to scale or to integrate with other workflows, while enhancing the safety, economic, and environmental outlook – all of which ultimately feeds into reputational strength.

AIQ is also making significant headway in the drilling sector, a very intense Capex world. Intelligent drilling operations are highly useful at a time when annual oil demand has climbed by 2.7mn b/d to 101.9mn b/d and when ADNOC is striving to reach 5mn b/d of production by 2027 – three years earlier than initially planned. This efficiency and extra visibility also feeds into reducing companies' environmental impact. Leveraging near real-time drilling data and predictive AI means AIQ can help improve day-to-day digital drilling solutions, from operations reporting to advanced alarm systems detecting precursor events leading to stuck-pipe incidents, and much in-between. With the proof of concept successfully completed, AIQ is preparing to scale up the project to its full value.

Smart solutions for logistics are in AIQ's wheelhouse too, with AI tools currently deployed on 90 ships in the ADNOC L&S Fleet. AIQ and ADNOC co-designed a comprehensive edge-AI solution to drive the HSE culture amongst staff. The tool automatically detects HSE violations with a focus on Personal Protective Equipment (PPE) compliance for crew members, delivering instant alerts for incidents such as person overboard, slip-and-fall events, or missing helmets. This user-friendly application can rapidly be deployed and customized to any industrial environment; potential which has sparked rising appetite for smart rigs and smart plants.

The in-depth development of the AI Emissions Platform is also well underway – a potential gamechanger for how ADNOC and others manage their strategies. Once up and running, the emissions platform will tap into all the data sources within ADNOC's value chain of emitting assets, such as gas turbines, boilers, and heaters, etc. Thousands of data points need monitoring, extending from upstream to shipping. AIQ is aggregating these data sources into one platform, helping form the bedrock of an algorithm to forecast the rate of CO₂ emissions over the next five years – highly coveted intel for decision makers across the energy markets. One of the goals of this system is to enable end users, like ADNOC, to generate all the necessary data points for their emitting assets – historical, current, anticipated – for their Environment, Social, and Governance (ESG) report with the click of a few buttons.

"The power of putting massive amounts of information together and making decisions based on that information in near real-time is something a team simply could not do manually. There is no comparison between people and AI in this space, but that does not mean both are not integral; AI needs our input to work," shared Ghanim Hableel, Data Science & Sustainability Lead at AIQ and a PhD Candidate at Columbia University.

There are also plans for the AIQ Autonomous Well Control project to continuously monitor and optimize flowing conditions of thousands of wells, helping them simultaneously meet oil and gas targets while protecting the health of the reservoir – key to supporting energy security.

The specificity of the data is a meaningful step in providing the layers of insight we increasingly need and expect from our data. Many ESG reports from energy companies tend to share aggregated data for the year, but AIQ is determined to show daily or monthly figures at the very least. This forecasting element is also very promising for trading, especially with the introduction of the carbon border adjustment mechanism (CBAM) in Europe, for example, and the rise of voluntary carbon offsetting in the Arab Gulf. Having detailed emissions data means companies can more accurately anticipate growth models, risk parameters, investors' flexibility, and embolden customers who are keen to shrink their carbon footprint.

Source: ¹WAM.

Energies of the future: Boosting predictability

All creative and practical hands must be on deck to ensure we – the world’s population of 8bn – avoid checkmate as the energy trilemma gains extraordinary speed. Progress is certainly on the right trajectory, with global investments in energy transition technologies reaching a record high of \$1.3trn in 2022.¹ But this is just the beginning of the marathon journey to rewrite global energy norms to make Net Zero a reality by 2050. Yearly investments must hit \$5trn in order to meet the criterion of the Paris Agreement, with renewables soaring to account for 91% of the global energy mix by mid-century – more than tripling on volumes today.² Therein lies the invaluable thinking that makes Masdar – a clean energy powerhouse which consolidates the renewable energy and green hydrogen efforts of ADNOC, TAQA, and Mubadala – so unique.

It is not just a case of making future energies greener. They must be extremely tough, too. Getting the technological framework right is critical to creating a resilient energy system which can adapt to the upcoming impacts of climate change – droughts, floods, heatwaves, mega storms, and much more. Part of this means diversifying the range of tools available; squeezing maximum operational and environmental efficiency from existing assets while applying all the lessons learned so far to develop innovative, greener technologies from scratch.

Progress has been made, notably in the power sector where renewables account for 40% of installed power

“We look at each market specifically and then try to find a tailored solution. Then, we see how that system can support other markets elsewhere too. Every situation is unique, but we can leverage commonalities if we work together. Unity equals speed.”

Ibraheem Almansouri, Head of Engineering, Masdar

generation globally, contributing to an unprecedented 83% of global power additions in 2022. But to meet ambitions laid out in Paris in 2015, deployment levels must grow from some 3,000GW today to more than 10,000GW in 2030 – an average of 1,000GW annually.³

To help resolve the intermittency gap while the global renewable power market evolves, Masdar Arlington Energy was formed in

2022 to unite the Abu Dhabi-based innovator with the UK’s largest developer of battery energy storage. Together, the companies aim to enable the development, construction, and commercial operations of a 5GWh+ battery energy storage system (BESS) pipeline in the UK. Developing a platform for strategic investment and asset management of clean energy portfolios including

new technologies is part of the gameplan too, ultimately providing a more resilient and flexible energy resource to support the grid and help nations achieve their Net Zero objective.

Green hydrogen is also emerging as an apex energy of the future. The \$4bn global market in 2022 could reach \$331bn within a decade, posting an astonishing 54.98% CAGR⁴, with global hydrogen demand spanning 150-500mn t/yr by 2050.⁵ As part of its ambitious diversification, the UAE aims to capture 25% of the global hydrogen fuel market by 2030 – leveraging half a century of energy expertise and its location at the heart of east-west trade routes.

In support, and amongst many other hydrogen-related undertakings, Masdar recently inked a MoU with four Dutch companies to explore the development of a green hydrogen supply chain between Abu Dhabi and Amsterdam. The deal with the Port of Amsterdam, SkyNRG, Evos Amsterdam, and Zenith Energy will include investigations into green hydrogen's potential in sustainable

20%

Masdar is active in 40 countries – equivalent to one-fifth of the nations on the planet.

\$30bn

is the combined value of the projects Masdar has invested in, with a total electricity generation capacity of more than 20GW.

30mn

tons of CO₂ emissions will be displaced every year by these projects.

Source: Masdar

“At COP28, I would like to see more progress on long-term energy storage options. There are many R&D efforts in this space already; all with advantages and disadvantages. We must work collectively to find the best solutions and scale them up for widespread deployment as soon as possible.”

Ibraheem Almansouri, Head of Engineering, Masdar

aviation fuels (SAF), steelmaking, shipping, and wider offtake opportunities.

Such alliances point to a pillar of Masdar's success: an international footprint underpinned by a reputation of ambition, reliability, and innovation. For one, Masdar is part of a joint venture for the London Array, one of the largest

offshore wind farms in the world. The 175 wind turbines power more than 500,000 homes in the UK and have displaced nearly 10mn tons of CO₂ emissions since operations started in 2013. Covering 100 square kilometers, the project includes more than 400km of cabling – equivalent to the distance from Abu Dhabi to Muscat.⁵

Sources: ¹ International Renewable Energy Agency (IRENA); ² IRENA; ³ IRENA; ⁴ Precedence Research; ⁵ Gulf Intelligence.

2021

saw wind electricity generation increase by a record high of 273TWh. This was 55% higher than the growth achieved in 2020 and was the highest among all renewable power technologies.¹

606%

increase in solar power generation capacity is what Abu Dhabi-based utility Emirates Water and Electricity Company (EWEC) is aiming for by 2030, reaching 7.3GW.²

0.5%

is how much geothermal makes up of the renewables-based installed capacity for electricity generation, heating, and cooling worldwide – representing vast volumes of untapped potential.³

24.53%

CAGR in the floating solar panel market is expected by 2030, reaching \$4.25bn.⁴

2030

could see the gap between global demand and supplies of fresh water reach 40%, so all energies of the future must seriously consider water preservation and water reuse.⁵

85%

of global renewable energy investment benefited less than 50% of the world's population in 2022, with Africa only accounting for 1% of additional capacity.⁶ Such discrepancy is one of the reasons Masdar's operations span six continents, including operations in four African nations.

Sources: ¹ IEA; ² EWEC; ³ IRENA; ⁴ Market Research Future (MRFR); ⁵ Morgan Stanley; ⁶ IRENA.



CASE STUDY Master of firsts

A 17-year track record in green energy is rare. From its first floating solar PV project to the Middle East's first commercial waste-to-energy deal and much in between, Masdar has pushed a technological narrative for nearly two decades of: we can do more with less for less. With an ethos rooted in innovation, Masdar is now one of the world's fastest growing renewable energy companies, aiming to reach a total portfolio capacity of at least 100GW by 2030. In December 2022, three UAE energy champions – TAQA, ADNOC, and Mubadala – joined forces as shareholders in Masdar to create a truly global beacon of clean energy. With the backing of these powerhouses, there are no limits, heralding another dynamic chapter for ADNOC.

Masdar's inaugural floating solar PV plant, under a power purchase agreement (PPA) with the nation's state-owned electricity company PLN, also marks its debut renewable energy project in Southeast Asia. The 145MW plant will help the largest energy user in the Association of Southeast Asian Nations (ASEAN) region – and the world's fourth most populated nation¹ – as it aims to have renewables account for 23% of its energy mix by 2025, rising to 31% by 2030.

Masdar was integral to the development of a 230MW solar PV project in the Republic of Azerbaijan as well, heralding the country's first foreign investment-based independent utility scale solar project structured as a PPP. Half a billion kilowatt-hours of electricity will be generated

annually once operations start this year – enough to support 110,000 homes, reduce emissions by 200,000 t/yr, and create local jobs. Masdar also recently wrapped up the financial close of the largest solar development program in Central Asia: three solar projects with a combined capacity of 900MW in Uzbekistan.

Closer to home, Masdar and BEEAH Group, the Middle East's leading and award-winning environmental management company, have developed a cutting-edge waste-to-energy plant in the Emirate of Sharjah – the first such commercial project in the Middle East. The facility will process more than 37.5 t/hr of municipal solid waste – roughly equivalent to the weight of nine African elephants² – to generate 30MW of net electric power. It supports the UAE's goal to divert 75% of its solid waste from landfills, while displacing 450,000 tons of CO₂ emissions per year. Plus, Masdar made its first entry into geothermal energy in February this year – key to continually evolving its diverse energy offering – with a strategic investment in Indonesia's Pertamina Geothermal Energy (PGE), one of the world's largest geothermal players. Shortly after, Masdar signed a five-year MoU advancing ADNOC Drilling's plans to further expand its industry-leading offering with geothermal energy and continuously develop new sources of revenue growth.

To the west, Masdar and its partners are developing a 300MW utility-scale PV solar power plant in the Saudi city of Jeddah. This project utilizes the latest technology, combining bifacial PV modules with mounting structures that use single axis tracking technology to maximize energy generation by following the sun's position throughout the day.

Sources: ¹ World Population Review; ² Gulf Intelligence.

• GI Special Report was produced with the cooperation of ADNOC



Gulf Intelligence (GI) is the leading strategic consulting group in the Middle East focused on the international energy and natural resources industry. The UAE-based firm uses more than 12+ years of operational experience in the region to offer trusted, fully compliant, and strategic advice. The GI consultancy provides expert and hands-on assistance to international clients looking for opportunities or seeking solutions in the Arab Gulf, as well as supporting national energy stakeholders expand their global engagement.



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